

**2501563 Ontario Inc.**

**Proposed Residential Development  
McDonald Property, east of Grey Road 28  
Town of Hanover, Ontario**

Geotechnical Engineering Report | 163-P-0011767-0-01-100



Prepared by:

  
**Montana Wilson, M.Eng., P.Eng., PMP**  
Team Leader



Reviewed by :

  
**Vanessa Marshall, M.Eng., P.Eng.**  
Consulting Engineer

# TABLE OF CONTENTS

<b>INTRODUCTION .....</b>	<b>1</b>
<b>1 INVESTIGATION PROCEDURE.....</b>	<b>2</b>
1.1 Fieldwork .....	2
1.2 Laboratory Testing.....	3
<b>2 SUMMARIZED CONDITIONS .....</b>	<b>3</b>
2.1 Site Description .....	3
2.2 Subsoil Conditions .....	3
2.2.1 Topsoil .....	4
2.2.2 Fill .....	4
2.2.3 Sand .....	4
2.2.4 Glacial Till .....	5
2.3 Groundwater .....	5
<b>3 DISCUSSIONS AND RECOMMENDATIONS .....</b>	<b>6</b>
3.1 General .....	6
3.2 Site Grading.....	6
3.3 Site Servicing.....	7
3.3.1 Excavations and Dewatering.....	7
3.3.2 Pipe Bedding .....	8
3.3.3 Trench Backfilling .....	9
3.4 Pavements.....	10
3.4.1 Pavement Design .....	10
3.4.2 Subdrains.....	11
3.4.3 Curbs and Sidewalks.....	11
3.5 Residential Buildings .....	12
3.5.1 Foundations.....	12
3.5.2 Basements.....	13
<b>4 STATEMENT OF LIMITATIONS.....</b>	<b>15</b>

## Tables

Table 1: Sand Particle Size Distribution Analyses.....	4
Table 2: Groundwater Level measurements from Standpipes .....	5
Table 3: Compaction Specifications .....	7
Table 4: Pavement Designs .....	10

## TABLE OF CONTENTS

### Appendices

Appendix 1	Drawings
Appendix 2	Borehole Logs
Appendix 3	Figures
Appendix 4	Photographs

## Property and Confidentiality

"This engineering document is the property of Englobe Corp. and, as such, is protected under Copyright Law. It can only be used for the purposes mentioned herein. Any reproduction or adaptation, whether partial or total, is strictly prohibited without having obtained Englobe's and its client's prior written authorization to do so.

Test results mentioned herein are only valid for the sample(s) stated in this report.

Englobe's subcontractors who may have accomplished work either on site or in laboratory are duly qualified as stated in our Quality Manual's procurement procedure. Should you require any further information, please contact your Project Manager."

**2501563 Ontario Inc.**

**c/o WSP Canada**

101-14<sup>th</sup> Avenue

Hanover, ON N4N 3W1

Attention: Mr. Travis Burnside, P.Eng.

REVISION AND PUBLICATION REGISTER		
Revision N°	Date	Modification And/Or Publication Details
0A	2016-12-21	DRAFT Report Issued
00	2016-12-22	Report Issued

DISTRIBUTION	
1 electronic copy / 1 hard copy	WSP Group, Mr. Travis Burnside
1 electronic copy / 1 hard copy	File

SW

## INTRODUCTION

Englobe Corp. (Englobe) was retained by WSP Canada on behalf of 2501563 Ontario Inc. to carry out a geotechnical investigation at the site of a proposed residential development in the Town of Hanover, Ontario. This work was authorized by Mr. Travis Burnside, P.Eng. of WSP Canada on behalf of 2501563 Ontario Inc. in a letter dated October 19, 2016 following submission of a detailed proposal.

The project involves the proposed construction of a new residential subdivision on a vacant agricultural field (McDonald Property) east of Grey Road 28 in the Town of Hanover, Ontario at the location shown on Drawing 1, in Appendix 1. It is understood the lands are designated for residential streets and houses and there will be an entrance to the subdivision at the intersection of Grey Road 28 and 14<sup>th</sup> Street. The subdivision will be serviced with watermain, sanitary and storm sewers.

The purpose of the investigation was to determine the subsurface soil and groundwater conditions at the site and, based on that information, prepare this engineering report with geotechnical recommendations pertaining to the development including site grading, site servicing, pavement construction, house construction, and excavations and dewatering. This report does not address site environmental issues or slope stability concerns.

# **1 INVESTIGATION PROCEDURE**

## **1.1 FIELDWORK**

The fieldwork for this investigation was carried out on November 28, 2016 and involved the drilling of six boreholes (Boreholes BH-01-16 to BH-06-16) to depths of 3.7 to 6.7 m. The locations of the boreholes are shown on the Site Plan, Drawing 2 in Appendix 1.

Public utility companies were contacted prior to the start of drilling activities in order to demarcate underground utilities near the boring locations.

The boreholes were advanced with a D50T track mounted drillrig equipped with continuous flight hollow stem augers supplied and operated by a specialist drilling contractor.

In the boreholes, representative samples of the overburden were recovered at regular intervals throughout the depths explored. Standard Penetration Tests (SPT) were carried out during sampling operations in the boreholes using conventional split spoon equipment. The SPT N-values recorded are plotted on the borehole logs in Appendix 2.

Samples of the cohesive soils were tested using a hand-held pocket penetrometer to determine approximate shear strengths. The pocket penetrometer test results are plotted on the borehole logs in Appendix 2.

Standpipes were installed in Boreholes BH-01-16, BH-03-16, BH-05-16 and BH-06-16, to allow measurement of groundwater levels. The standpipes installations comprise 19 mm diameter pipes with slotted screens, as well as bentonite seals near the ground surface. Details of the installations and groundwater observations and measurements are provided on the borehole logs in Appendix 2.

The standpipes were installed in accordance with Ontario Regulation 903, as amended which provides requirements for wells in the Province of Ontario. The regulation encompasses test holes, and provides detailed requirements for monitoring well construction, test hole sealing, well record submission, drilling contractor licensing, well tagging, protective covers, and decommissioning.

A licensed well technician must properly decommission all standpipes before construction according to Regulation 903 of the Ontario Water Resources Act. Upon completion of drilling, the remaining boreholes were backfilled with bentonite.

The fieldwork was monitored throughout by a member of our geotechnical engineering staff, who documented the drilling procedures; recorded the results of the SPT and pocket penetrometer tests; documented the soil stratigraphies; monitored the groundwater conditions; documented the installation of the standpipes and, cared for the recovered soil samples.

The borehole locations and ground surface elevations were surveyed by WSP Canada Inc. and provided to Englobe on a pdf document. The elevations provided are understood to be geodetic.

## **1.2 LABORATORY TESTING**

All soil samples secured during this investigation were returned to our laboratory for visual examination, as well as moisture content tests. The moisture content test results are plotted on the borehole logs in Appendix 2. The geotechnical laboratory tests carried out on selected samples of the major subsurface soils from the investigation comprised the following:

- ▶ one particle size distribution analysis with results plotted on Figure 1 in Appendix 3;
- ▶ two grain size distribution analyses with results plotted on Figure 1 in Appendix 3; and,
- ▶ one standard Proctor moisture-density test with results plotted on Figure 2 in Appendix 3.

The soil samples will be stored for a period of three months from the date of sampling. After this time, they will be discarded unless prior arrangements have been made for longer storage.

## **2 SUMMARIZED CONDITIONS**

### **2.1 SITE DESCRIPTION**

The subject property is located in the east edge of Hanover. The property is bordered on the west by Grey Road 28; on the south by commercial properties and a Walmart Superstore; on the east by forested areas, fields; and to the north by forested areas.

The property currently comprises mostly of an agricultural field surrounded by trees. The ground surface at the site slopes down from east to west (Elevation 286.0 m to Elevation 277.0 m). A total topographic relief of approximately 9.0 m. It is noted the ground surface slopes down at the eastern property line to the Saugeen River, located east of the site.

### **2.2 SUBSOIL CONDITIONS**

We refer to the appended borehole logs for detailed soil descriptions and stratigraphies; results of SPT and pocket penetrometer testing; moisture content profiles; and, groundwater observations and measurements.

In general, the subsurface stratigraphy contacted at the site comprises topsoil or fill, overlying sand and glacial till. Descriptions of the various soil deposits encountered are provided in the following subsections.



### 2.2.1 Topsoil

Topsoil was encountered surficially at Boreholes BH-01-16 to BH-04-16 and is 280 to 460 mm thick. The topsoil comprises loose black sandy silt and was very moist to wet at the time of the fieldwork.

### 2.2.2 Fill

Fill was encountered surficially in Boreholes BH-05-16 and BH-06-16 and is 1.5 m thick. Both boreholes are located on the west edge of the property on a trail leading to the agricultural field. The fill ranges in composition from black sandy silt with some gravel and organics (topsoil) to brown and grey silty sand. SPT N-values measured in the fill range from 2 to 9 blows per 300 mm penetration of the split spoon sampler indicating a loose to very loose relative density. The fill was wet at the time of fieldwork.

### 2.2.3 Sand

Sand was encountered beneath the topsoil or fill in all of the boreholes. The sand extends below the termination depth of Boreholes BH-02-16, BH-04-16, BH-05-16 and BH-06-16. Alternating layers of glacial till were present in Boreholes BH-01-16 and BH-03-16 within the sand deposits. The sand ranges in composition from brown sand with some silt to brown gravelly sand and silt. The results of two grain size distribution analyses conducted on samples of the sand are plotted on Figure 1 in Appendix 3 and are summarized on the following table:

Table 1: Sand Particle Size Distribution Analyses

BOREHOLE NUMBER	SAMPLE DEPTH (m)	GRAVEL (%)	SAND (%)	FINES (%)
BH-01-16	6.10 – 6.71	7	78	15
BH-05-16	2.29 – 2.90	0	90	10

SPT N-values measured in the sand deposits range from 10 to 33 blows per 300 mm penetration of the split spoon sampler, indicating a compact to dense relative density. In-situ moisture contents of the sand range from 11 to 22% indicating very moist to saturated conditions.

The results of a standard Proctor moisture-density test conducted on a sample of sand and silt from Borehole BH-03-16 is provided on Figure 2 in Appendix 3 and indicate a maximum dry density of 2.073 t/m<sup>3</sup> at an optimum of moisture content 9.7%.



#### 2.2.4 Glacial Till

Glacial till was encountered in between sand layers in Boreholes BH-01-16 and BH-03-16 at depths between 1.5 to 2.0 m. The glacial till is 1.1 to 2.6 m thick and range in composition from sand with some silt and trace gravel to silty clay with some sand. The results of a particle size distribution analysis completed on a sample of the till are plotted on Figure 1 in Appendix 3 and indicates the sample contains 40% clay, 32% silt and 28% sand. SPT N-values in the till range from 18 to 27 blows per 300 mm penetration of the split spoon sampler indicating a compact relative density. Shear strengths measure with pocket penetrometers on the cohesive till range from 150 to 200 kPa. In-situ moisture contents of the till range from 16 to 23% indicating drier then the plastic limit or wet to saturated conditions.

### 2.3 GROUNDWATER

Groundwater observations and measurements carried out in the open boreholes are provided on the appended borehole logs. Standpipes were installed in Boreholes BH-01-16, BH-03-16, BH-05-16 and BH-06-16 drilled in various locations on the property. The groundwater level measurements are summarized in the following table:

Table 2: Groundwater Level measurements from Standpipes

BOREHOLE NUMBER	GROUND SURFACE ELEVATION (m)	MEASURED DECEMBER 5, 2016	
		GROUNDWATER DEPTH (m)	GROUNDWATER ELEVATION (m)
BH-01-16	285.26	6.40	278.86
BH-03-16	284.42	5.87	278.55
BH-05-16	278.97	0.83	278.14
BH-06-16	278.10	1.36	276.74

Free groundwater was encountered during drilling operations at a depth of 1.5 m (Elevation 279.1 m) in Borehole BH-02-16 and at a depth of 2.1 m (Elevation 277.9 m) in BH-04-16 measured upon drilling completion.

Local variations and seasonal fluctuations in the groundwater levels within the granular deposits would be expected.

### **3 DISCUSSIONS AND RECOMMENDATIONS**

#### **3.1 GENERAL**

The project involves the proposed construction of a new residential subdivision on a vacant agricultural field and forested area (McDonald Property) east of Grey Road 28 in the Town of Hanover, Ontario at the location shown on Drawing 2, in Appendix 1. It is understood the lands are designated for residential streets and houses. The eighty-two lot subdivision will be serviced with watermain, sanitary and storm sewers.

Based on the results of the geotechnical investigation, the subsurface stratigraphy comprises topsoil or fill overlying sand and glacial till. Free groundwater was noted at depths of 1.5 and 2.1 m in Boreholes BH-02-16 and BH-04-16 upon drilling completion. Groundwater was also measured in the standpipes on December 5, 2016 at depths of 0.8 m to 6.4 m (Elevation 276.7 to 278.9 m).

Based on the results of this geotechnical investigation, the site is considered suitable for the proposed residential development however, shallow groundwater levels will affect design and construction. The following subsections of this report contain geotechnical recommendations pertaining to development of the property including site grading, site servicing, pavements, and residential buildings.

#### **3.2 SITE GRADING**

Area grading of the property will likely be required to prepare the land for the construction of the proposed residential subdivision. A proposed grading plan was unavailable at the time this report was issued.

Prior to carrying out any cutting and engineered fill placement the surficial fill, topsoil, trees and vegetation should be removed from the subject site. In calculating the approximate quantity of soil to be removed, we recommend that the thicknesses of fill and topsoil on the individual borehole logs be increased by 50 mm to account for variations and some stripping of the mineral soil below. The fill and topsoil material could be used for landscaping fill to raise grades in the rear yards of the house lots or in park areas.

In order to minimize the effects of groundwater on the site grading operations, it is recommended that the work be carried out during the normally drier summer months.

Within the low-lying areas of the site where the groundwater table is quite close to the existing ground surface (west side of site) it will likely be necessary to remove the organic deposits with a tracked hydraulic excavator.

Following removal of the fill and topsoil, the exposed subgrade should be inspected by Englobe. Several metres of fill may be required to raise grades in the low-lying areas. The fill required at the site should be placed in maximum 300 mm thick lifts and compacted to the following minimum percentages of standard Proctor maximum dry density (SPMDD):

Table 3: Compaction Specifications

FILL USE	MINIMUM COMPACTION REQUIRED
Structural fill to support houses.	98% SPMDD
Subgrade fill beneath streets or beneath services.	95% SPMDD
Bulk fill in landscaped areas.	90% SPMDD

The major soils likely to be generated from cut areas at the site are sand and silt. Based on the results of insitu moisture content and standard Proctor moisture-density tests, the majority of the on-site excavated soils from above the groundwater table will be suited for reuse as road subgrade fill and structural fill if the grading work is carried out during relatively dry weather. The silt subsoils are generally very moist to wet and will require drying or blending with dry material prior to use as structural fill. If time is not available for drying, then this material should be used as pavement subgrade fill and in landscaped area.

Also, if structural fill operations are carried out in the fall, winter or spring, imported granular material is recommended. If imported fill is required onsite, we recommend structural fill used below buildings consist of clean granular material such as OPSS Granular 'B'. Any imported fill material should be tested and approved by a geotechnical engineer prior to use.

The structural fill pads should extend at least 1.0 m beyond the footing edge of any building and down to the subgrade level at a slope of 1.0 horizontal to 1.0 vertical. A typical detail for structural fill placement beneath house foundations is shown on Drawing 3, in Appendix 1.

Full-time testing by experienced geotechnical personnel should be carried out during fill placement and compaction to examine and approve potential sources of fill material, and to carefully monitor the placement and verify the compaction by in-situ density testing (ASTM D2167 or ASTM 2922).

### 3.3 SITE SERVICING

#### 3.3.1 Excavations and Dewatering

Following site grading operations, the subdivision will be serviced to provide the individual lots with water and sewer services. It is anticipated that the invert levels for the watermain, storm and sanitary sewers will be at conventional depths, approximately 2 to 4 m below finished grade through most of the site. We recommend that Englobe be allowed to check the final site grading and servicing plans for the subdivision to ensure that the exploratory boreholes extend below the design invert elevations.

Temporary excavations to conventional depths for installation of underground pipes at this site must comply with the Ontario Occupational Health and Safety Act and Regulations for Construction Projects. The predominant soils encountered in the boreholes would be classified as Type 3 soils (O. Reg. 213/91, s. 226(4)). Temporary side slopes must be cut at an inclination of 1.0 horizontal to 1.0 vertical or less above the base of excavation as per O. Reg. 213/91, s. 234(2) (exclusive of groundwater effects).

Moderate groundwater seepage was noted at a depth of 0.8 to 1.4 m at Boreholes BH-05-15 and BH-06-15. A positive dewatering system installed by a specialist dewatering contractor may be required if excavations extend below Elevation 277 m in this area. It will be necessary to flatten the excavation side slopes where groundwater seepage is occurring to ensure stability. Every excavation that a worker may be required to enter shall be kept reasonably free of water (O. Reg. 213/91, s. 230).

The design of the dewatering system should be left to the contractor's discretion, and the system should meet a performance specification to maintain and control the groundwater at least 0.30 m below the invert level in order to provide a stable excavation base. Successful dewatering operations will depend on the contractor's own experience, construction techniques, sequencing, and efficiency of work force and plant. Also the dewatering must be in compliance with the Ontario Water Resources Act (OWRA) and the Water Taking and Transfer Regulation (O.Reg. 451/07).

The contractor should evaluate this latter recommendation to ensure that he is in agreement, and he should notify the prime consultant in the event that he feels that an EASR or PTTW will be needed on the basis of his excavation and pipe laying schedule.

The trench side slopes should be periodically/continuously checked for evidence of instability, particularly following periods of heavy rainfall, thawing or when the trench has been left open for an extended period of time. Appropriate remedial action should be taken to ensure the continued stability of the slopes as per O.Reg. 213/91, s. 233. Any trench that is left open must be completely fenced off with heavy duty construction fencing or a barrier.

It is recommended that several test pits be dug during the tendering stage of the project in order that prospective contractors may familiarize themselves with the soil and groundwater conditions to be contacted.

### 3.3.2 **Pipe Bedding**

The subgrade soils beneath the watermain and sewers will comprise native mineral soils or compacted fill placed during the site grading operations. No support problems are anticipated for flexible or rigid pipes founded in the native deposits or compacted on-site soils.

Pipe bedding for water and sewer services should be conventional Class 'B' pipe bedding comprising a minimum 150 mm thick layer of OPSS Granular 'A' aggregate below the pipe invert. The bedding course may be thickened if portions of the subgrade become unduly wet during excavation. Granular 'A' type aggregate should be provided around the pipe to at least 300 mm above the pipe. The bedding aggregate should be compacted to a minimum 95% standard Proctor maximum dry density (SPMDD). Water and sewer lines installed outside of heated areas should be provided with a minimum 1.2 m of soil cover or equivalent insulation for frost protection.

A well-graded clear stone such as Coarse Aggregate for HL4 Asphaltic Concrete (OPSS 1003) wrapped in filter cloth could be used in the sewer trenches as bedding below the spring line of the pipe to facilitate sump pump dewatering, if necessary. The clear stone should be compacted with a plate tamper.

Thrust blocks for the watermain should be designed using current OPSS Standards and shall conform to OPSD 1103.010 and 1103.020. The following soil parameters may be used for thrust restraint design:

- ▶ Angle of internal friction ( $\phi$ ) = 30°
- ▶ Soil cohesion (c) = 0 kPa
- ▶ Soil unit weight ( $\gamma$ ) = 20 kN/m<sup>3</sup>

The interface friction coefficient for granular bedding and smooth ductile iron pipe or PVC pipe would be 0.60. An appropriate factor of safety should be employed.

### 3.3.3 Trench Backfilling

The trench above the specified pipe bedding shall be backfilled with approved native mineral soil excavated from the trench or obtained elsewhere on the project, and shall be placed in uniform layers not exceeding 300 mm in thickness for the full width of the trench compacted to at least 95% standard Proctor maximum dry density (SPMDD).

Based on the results of insitu moisture content and standard Proctor moisture-density test carried out on the native overburden deposits, the majority of the on-site excavated materials will be compactable to the required density if work is carried out in dry summer months. If imported fill is required we recommend OPSS Granular 'B' be used.

If necessary, compensation for wet trench backfill conditions can be made with additional Granular 'B' in the pavement structure. It should be noted, however, that the wet backfill material must be compacted to at least 90% SPMDD or post-construction settlements could occur.

To minimize potential problems, backfilling operations should follow closely after excavation so that only a minimal length of trench is exposed. Care should be taken to protect side slopes of excavations by diverting surface run-off away from the excavations.

If construction extends into the winter, then the backfilling operations should be planned so that exposure of the backfill material to frost is kept to a minimum and to ensure that frozen material is not used as backfill.

Frequent compaction testing by experienced geotechnical personnel should be carried out to examine and approve backfill materials, and to verify that the specified degree of compaction has been achieved.

### 3.4 PAVEMENTS

#### 3.4.1 Pavement Design

Following site grading and servicing operations, the pavement subgrade will comprise native and recompact sand and silt soils or imported granular fill.

The following pavement component thicknesses are recommended based on the proposed pavement usage and the frost susceptibility and strength of the subgrade soils;

Table 4: Pavement Designs

PAVEMENT COMPONENT	RESIDENTIAL STREETS
Asphalt Hot Mix	90 mm
OPSS 1010 Granular 'A' Base	150 mm
OPSS 1010 Granular 'B' Subbase	300 mm

The pavement design is based on the assumption that construction will be carried out during the drier time of the year and that the subgrade soil is stable as determined by proof-rolling inspected by a Geotechnical Engineer. If the subgrade is wet and unstable, additional granular subbase will be required.

Prior to placing the new Granular 'B' subbase course, the pavement subgrade materials should be thoroughly proof-rolled. If any unstable areas are noted, then Granular 'B' thickness may need to be increased to support pavement construction traffic.

Samples of both the Granular 'A' and Granular 'B' aggregates should be tested for conformance to OPSS 1010 prior to utilization on site and during construction. The Granular 'B' subbase and Granular 'A' base courses must be compacted to 100% SPMDD, as verified by insitu density testing.

The 90 mm thick layer of asphaltic concrete should comprise a binder layer of HL4 and a surface layer of HL3. It is recommended that the compacted thicknesses be 50 mm of HL4 binder and 40 mm of HL3 surface for residential streets.



The asphaltic concrete paving materials should conform to the requirements of OPSS 1150. The asphalt should be placed and compacted in accordance with OPSS 310. The Performance Graded Asphalt Cement designation for the asphaltic concrete is 58-28.

The need for continuous paving supervision by a qualified pavement technician, and quality control testing during pavement construction cannot be over emphasized.

All materials and construction services required for the work should be in accordance with the applicable sections of the Ontario Provincial Standard Specifications.

#### 3.4.2 **Subdrains**

Portions of the native subgrade soils have poor natural drainage therefore we recommend that where silt is encountered at the subgrade, subdrains be installed continuously along both sides of the street and connected to the catchbasins. Where sand deposits are encountered at the subgrade level it is recommended that subdrain stubs be installed at the catchbasins. This should be confirmed by a geotechnical engineer at the time of subgrade preparation.

The purpose of the subdrains is to remove excess subsurface water in order to improve pavement serviceability and increase the pavement life. A detail for a typical pavement subdrain is provided on Drawing 4, in Appendix 1.

The work of subdrain installation shall be in accordance with OPSS 405 and OPSD 216.021. The subdrain shall be 150 mm diameter perforated pipe conforming to OPSS 1801 or 1840, and wrapped with geotextile conforming to OPSS 1860.

#### 3.4.3 **Curbs and Sidewalks**

The concrete for curb and gutter should be proportioned, mixed, placed, and cured in accordance with the requirements of OPSS 353 and OPSS.MUNI 1350, and shall meet the following specific requirements:

- ▶ minimum 28-day compressive strength = 30 MPa
- ▶ coarse aggregate = 19.0 mm nominal max. size
- ▶ maximum slump = 60 mm
- ▶ air entrainment =  $7.0 \pm 1.5\%$

During cold weather (when the air temperature is at or is likely to fall below 5°C within 96 hours of concrete placement) the freshly placed concrete must be covered with insulating blankets to protect against freezing, as per OPSS 904. Ice and snow must be removed from the area where concrete is to be placed and the concrete must not be placed against frozen ground. All cold weather protection material shall be on site prior to each concrete placement.



The subgrade for the concrete sidewalks should comprise undisturbed native mineral soil or well-compacted fill. A minimum 150 mm thick layer of compacted Granular 'A' type aggregate should be placed beneath the sidewalk slabs. Granular 'A' material shall also extend a minimum of 150 mm beyond the edges of the proposed sidewalk. The subgrade and granular base should be prepared in accordance with the requirements of OPSS 315.

The concrete for the sidewalk shall be according to OPSS.MUNI 1350 and the following:

- ▶ class of concrete = Nominal 28 day compressive strength 30 MPa
- ▶ coarse aggregate = 19 mm nominal maximum size
- ▶ air content =  $7.0\% \pm 1.5\%$ , measured prior to placement
- ▶ slump =  $70 \pm 20$  mm

Field sampling and testing of concrete shall be according to OPSS 904. Three cylinders, unless otherwise notified, from each day's pour should be taken for compressive strength testing. Air entrainment, temperature, and slump tests should be made from the same batch of concrete from which test cylinders are made.

### **3.5 RESIDENTIAL BUILDINGS**

#### **3.5.1 Foundations**

In general, the undisturbed native mineral soils are considered suitable to support residential house foundations. Where the footing levels will be above the existing native mineral soil grade, structural fill will probably be used. House footings constructed on the compact native mineral soil or approved structural fill may be designed using the minimum footing sizes provided in the Ontario Building Code.

Conventional spread footings founded on the undisturbed native mineral soils and approved structural fill may be designed for a factored geotechnical bearing resistance at Ultimate Limit States (ULS) of 225 kPa, and soil bearing resistance at Serviceability Limit States (SLS) kPa of less than 100 kPa.

Properly constructed footings within the native deposits are expected to undergo total settlements of less than 25 mm and differential settlements of less than 12 mm.

All founding surfaces for residential dwellings on structural fill or native soils should be inspected by Englobe personnel prior to placing concrete. The purpose of the inspection is to ensure that the subgrade soils are capable of supporting the house foundations, and to confirm that the house envelope does not extend beyond the limits of the structural fill pad. Where a shallow foundation is to be placed on soil, the soil shall be cleared of loose and unsound material and shall be adequate to support the design load.

The on-site review of the condition of the foundation soil as foundations are constructed is an integral part of the geotechnical design function and cannot be over emphasized. These reviews are required by Section 4.2.2.2 of the Ontario Building Code.

Further geotechnical investigation will be necessary for large structures such as schools, plazas or apartment buildings to provide specific recommendations for design of these structures. The preliminary Site Classification for Seismic Site Response is 'D'.

The native mineral soils are susceptible to disturbance by workers during foundation construction and, therefore, it is recommended that a working slab of lean concrete (mud slab) be placed in the footing areas immediately after excavation and inspection to protect the founding soils during placement of formwork and reinforcing steel.

The subgrade soils are considered to be frost susceptible and must be protected from freezing at all times including during construction. The exterior footings or footings in unheated areas should be provided with a minimum 1.20 m of earth cover upon final grading for frost protection.

### 3.5.2 Basements

It is recommended basement floor slabs be installed above the groundwater levels and Englobe review grading plans once complete.

House basements at this site must be provided with perimeter weeping tile systems as per the Ontario Building Code (Section 9.14). The drain tile or pipe should be laid on undisturbed or well-compacted soil so that the top of the tile or pipe (minimum 100 mm diameter) is below the bottom of the basement floor slab.

The top and sides of the drain tile or pipe shall be surrounded with not less than 150 mm of crushed stone or other clean coarse granular material containing no more than 10% of material that will pass the 4 mm sieve. The crushed stone should be wrapped with filter cloth. The weeping tile must drain to a suitable frost-free outlet or sump. The sump shall be equipped with an automatic pump that will discharge the water into a sewer, drainage ditch or dry well.

The portion of the exterior basement wall below finished ground level must be damp-proofed as per Section 9.13.2 of the Ontario Building Code (2012). The excavated soils at many of the lots in the subdivision will comprise free-draining sand materials which are well-suited for use as basement wall backfill. Where silt soils are used for basement wall backfill, a manufactured drainage layer is recommended. The basement wall backfill should be graded to allow drainage away from the foundation.

The basement walls should be designed to resist the lateral earth pressure. For calculating the lateral earth pressure, the coefficient of earth pressure (K) may be assumed as 0.5 for cohesionless sand soils and 1.0 for silt and clay (Section 24.12.3.3 CFEM). The bulk unit weight of the retained backfill may be taken as 20 kN/m<sup>3</sup> for well-compacted soil.

An appropriate factor of safety should be employed.

The subgrade for the basement floor slabs should comprise undisturbed native soil or well-compacted fill. A minimum 100 mm thick layer of coarse clean granular material containing not more than 10% material that will pass a 4 mm sieve shall be placed beneath slabs in houses as per Section 9.16.2 of the Ontario Building Code. If the subgrade soil is wet, we recommend that Englobe be notified and subfloor weeping tiles be placed and connected to the sump pit.

If a moisture-sensitive floor finish is to be applied to the slab, then we recommend that a 15 mil polyethylene moisture vapor barrier be installed directly beneath the slab as per Article 9.13.2.7 of the Ontario Building Code. The purpose of the vapour barrier is to reduce moisture transfer by diffusion as per Article 5.5.1.2 of the Ontario Building Code. Joints in the vapour barrier should be lapped not less than 100 mm. If a moisture vapour barrier is used, then the slab should be continuously wet-cured for at least 96 hours to prevent severe curling.

## 4 STATEMENT OF LIMITATIONS

The geotechnical recommendations provided in this 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 at the time of report preparation, we recommend that we be retained during the final design stage to verify that the geotechnical recommendations have been correctly interpreted in the design. Also, if any further clarification and/or elaboration are needed concerning the geotechnical aspects of the project, Englobe should be contacted. We recommend that we be retained during construction to confirm that the subsurface conditions do not deviate materially from those encountered in the test holes and to ensure that our recommendations are properly understood.

The geotechnical recommendations provided in this report are intended for the use of the owner and its retained designer. They are not intended as specifications or instructions to contractors. Any use which a contractor makes of this report, or decisions made based on it, are the responsibility of the contractor. The contractor must also accept the responsibility for means and methods of construction, seek additional information if required, and draw their own conclusions as to how the subsurface conditions may affect their work. Englobe accepts no responsibility and denies any liability whatsoever for any damages arising from improper or unauthorized use of the report or parts thereof.

It is important to note that the geotechnical investigation involves a limited sampling of the site gathered at specific test hole locations and the conclusions in this report are based on this information gathered. The subsurface geotechnical, hydrogeological, environmental and geologic conditions between and beyond the test holes will differ from those encountered at the test holes. Also such conditions are not uniform and can vary over time. Should subsurface conditions be encountered which differ materially from those indicated at the test holes, we request that we be notified in order to assess the additional information and determine whether or not changes should be made as a result of the conditions.

It must be recognized that the passage of time, natural occurrences and direct or indirect human intervention at or near the site have potential to alter the subsurface conditions. If during construction the soil or groundwater is found not to be of the type or in the condition used in design and as indicated on the drawings, the design shall be reassessed by the designer. If during construction, climatic (i.e. rain, frost etc.) or any other conditions (i.e. seepage, excavations etc.) have changed the properties of the soil or groundwater, the design shall be reassessed by the designer as per Section 4.2.2.3 of the Ontario Building Code.

## **Appendix 1 Drawings**

Drawing 1: Location Plan

Drawing 2: Site Plan

Drawing 3: Typical Structural Fill Detail

Drawing 4: Typical Pavement Subdrain Detail

10 cm

5

4

3

2

1

0



# NOTES :

- 1-REFERENCE : © OpenStreetMap contributors (2016)
- 2-Drawing scale may be distorted due to file conversion and/or copying.  
Measurements taken from the drawing must be verified in the field.

0 200 400 600 800 1000 m

SCALE 1:20,000

Project

## GEOTECHNICAL INVESTIGATION McDONALD PROPERTY SUBDIVISION

Town of Hanover, Ontario

Title

### LOCATION PLAN



25, Market Place  
Stratford (Ontario) N5A 1A4  
Telephone : 519.273.0101  
Fax : 519.273.7188

Prepared **K. Staples**Drawn **K. Staples**Checked **M. Wilson**Discipline **Geotechnical**Scale **1 : 20,000**Date **2016-12-08**

Project manager

**M. Wilson**

Sequence no.

**01 of 04**

M. dept.

**163**

Project

**P-0011767-0-01-100-01**

Disc.

**GE**

Dwg no.

**00100**

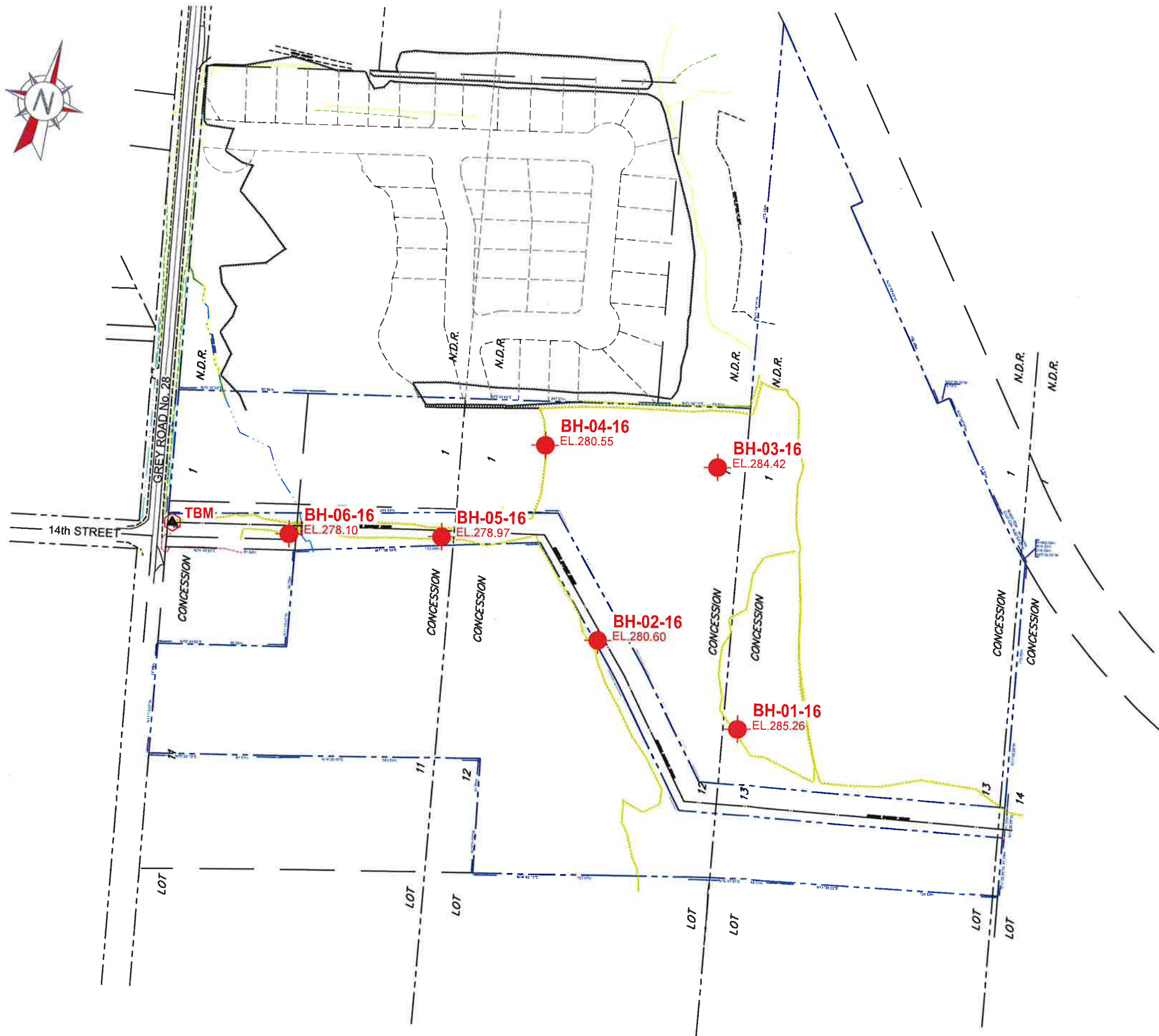
Rev.

**00**




G:\163P-0011767\24\_CAD\163P-0011767-0-01-100-01\_DWG001.DWG



10 cm  
5  
4  
3  
2  
1  
0

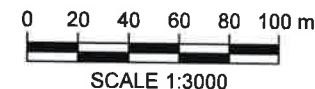


**LEGEND :**

-  BOREHOLE LOCATION
-  EL.285.26 GROUND SURFACE ELEVATION (m)
-  TBM TEMPORARY BENCHMARK

**NOTES :**

- 1-REFERENCE : Base drawing provided by WSP Canada Inc., Drawing Number 161-04890-SP1 dated July 2016, Filename: 161-04890 Site Plan.dwg
- 2-TEMPORARY BENCHMARK : Southeast corner of concrete transformer vault at the intersection of 14th Street and Grey County Road No. 28. Elevation : 280.10 m (Geodetic)
- 3-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.



Project

**GEOTECHNICAL INVESTIGATION  
McDONALD PROPERTY  
SUBDIVISION**

Town of Hanover, Ontario

Title

**SITE PLAN**



25, Market Place  
Stratford (Ontario) N5A 1A4  
Telephone : 519.273.0101  
Fax : 519.273.7188

Prepared **K. Staples**

Drawn **K. Staples**

Checked **M. Wilson**

Discipline **Geotechnical**

Scale **1 : 3000**

Date **2016-12-19**

Project manager

**M. Wilson**

Sequence no.

**02 of 04**

M. dept.

Project

**163**

**P-0011767-0-01-100-01**

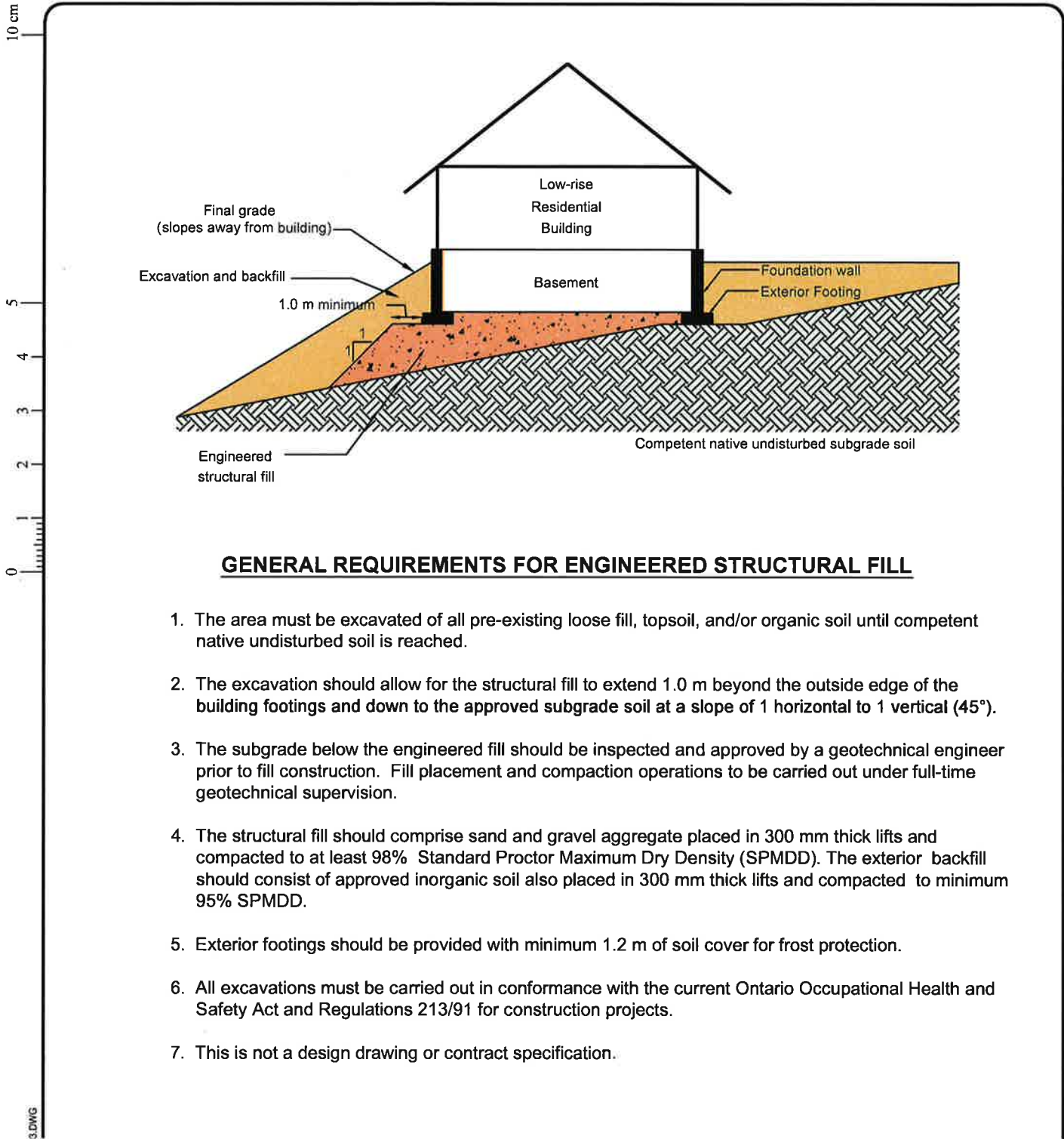
Disc.

Dwg no.

Rev.

**GE 002 00**





**GENERAL REQUIREMENTS FOR ENGINEERED STRUCTURAL FILL**

1. The area must be excavated of all pre-existing loose fill, topsoil, and/or organic soil until competent native undisturbed soil is reached.
2. The excavation should allow for the structural fill to extend 1.0 m beyond the outside edge of the building footings and down to the approved subgrade soil at a slope of 1 horizontal to 1 vertical (45°).
3. The subgrade below the engineered fill should be inspected and approved by a geotechnical engineer prior to fill construction. Fill placement and compaction operations to be carried out under full-time geotechnical supervision.
4. The structural fill should comprise sand and gravel aggregate placed in 300 mm thick lifts and compacted to at least 98% Standard Proctor Maximum Dry Density (SPMDD). The exterior backfill should consist of approved inorganic soil also placed in 300 mm thick lifts and compacted to minimum 95% SPMDD.
5. Exterior footings should be provided with minimum 1.2 m of soil cover for frost protection.
6. All excavations must be carried out in conformance with the current Ontario Occupational Health and Safety Act and Regulations 213/91 for construction projects.
7. This is not a design drawing or contract specification.

G:\163P-0011767-0-01-100-01\_DWG003.DWG

Project  
**GEOTECHNICAL INVESTIGATION**  
**MCDONALD PROPERTY**  
**SUBDIVISION**  
Town of Hanover, Ontario

Title  
**STRUCTURAL FILL PAD**  
**FOR HOUSE ON SLOPING GROUND**



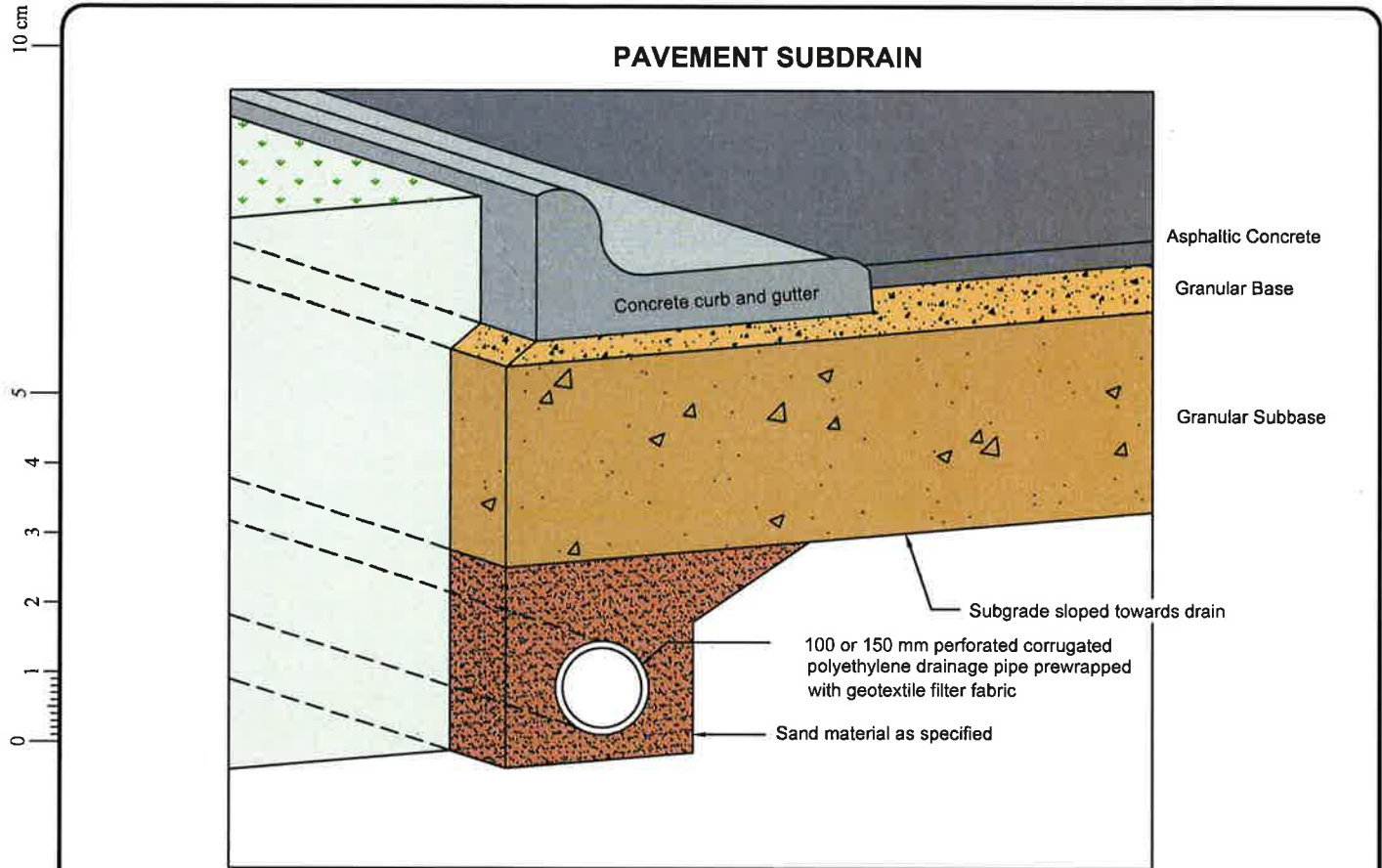
25, Market Place  
Stratford (Ontario) N5A 1A4  
Telephone : 519.273.0101  
Fax : 519.273.7188

Prepared **K. Staples**  
Drawn **K. Staples**  
Checked **M. Wilson**

Discipline **Geotechnical**  
Scale **NTS**  
Date **2018-12-19**

Project manager  
**M. Wilson**  
Sequence no.  
**03 of 04**

M. depl.	Project	Disc.	Dwg no.	Rev.
<b>163</b>	<b>P-0011767-0-01-100-01</b>	<b>GE</b>	<b>003</b>	<b>00</b>



#### GENERAL REQUIREMENTS FOR PAVEMENT SUBDRAINS

1. Perforated corrugated polyethylene drainage pipe shall meet the requirements of OPSS 1840.
2. Pipe filter fabric conforming to OPSS 1860 for geotextile Class 1 with a filtration opening size of 150 to 450 microns shall be supplied on all sections of perforated pipe.
3. The open upstream ends of pipes should be capped.
4. Subdrain pipes to be set on at least 1% grade draining to a positive frost-free outlet. If the subdrains are outletted to a ditch then the last 1.5 m of the outlet pipe should consist of a corrugated galvanized steel pipe equipped with a rodent gate.
5. Bedding and backfill material shall be concrete sand meeting the gradation requirements of OPSS 1002 (Fine Aggregate for Concrete).
6. This is not a design drawing or contract specification.

Project

**GEOTECHNICAL INVESTIGATION**  
**McDONALD PROPERTY**  
**SUBDIVISION**

Town of Hanover, Ontario

Title

**SUBDRAIN BENEATH CURB**  
**OF ASPHALT PAVEMENT**



25, Market Place  
Stratford (Ontario) N5A 1A4  
Telephone : 519.273.0101  
Fax : 519.273.7188

Prepared **K. Staples**  
Drawn **K. Staples**  
Checked **M. Wilson**

Discipline **Geotechnical**  
Scale **NTS**  
Date **2016-12-19**

Project manager  
**M. Wilson**  
Sequence no.  
**04 of 04**

M. dpt.	Project	Disc.	Dwg no.	Rev.
<b>163</b>	<b>P-0011767-0-01-100-01</b>	<b>GE</b>	<b>00400</b>	

## **Appendix 2   Borehole Logs**

List of Abbreviations  
Boreholes BH-01-16 to BH-06-16

LIST OF ABBREVIATIONS

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

Sample Types		Soil Tests and Properties	
AS	Auger Sample	SPT	Standard Penetration Test
CS	Core Sample	UC	Unconfined Compression
RC	Rock Core	FV	Field Vane Test
SS	Split Spoon	ø	Angle of internal friction
TW	Thinwall, Open	γ	Unit weight
WS	Wash Sample	w <sub>p</sub>	Plastic limit
BS	Bulk Sample	w	Water content
GS	Grab Sample	w <sub>L</sub>	Liquid limit
WC	Water Content Sample	I <sub>L</sub>	Liquidity index
TP	Thinwall, Piston	I <sub>p</sub>	Plasticity index
		PP	Pocket penetrometer

Penetration Resistances	
Dynamic Penetration Resistance	The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) diameter 60° cone a distance 300 mm (12 in.).  The cone is attached to 'A' size drill rods and casing is not used.
Standard Penetration Resistance, N (ASTM D1586)	The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) required to drive a standard split spoon sampler 300 mm (12 in.)
WH	sampler advanced by static weight of hammer
PH	sampler advanced by hydraulic pressure
PM	sampler advanced by manual pressure

Soil Description		
<b>Cohesionless Soils</b>	<b>SPT N-Value</b>	<b>Relative Density (D<sub>r</sub>)</b>
<b>Compactness Condition</b>	(blows per 0.3 m)	(%)
Very Loose	0 to 4	0 to 20
Loose	4 to 10	20 to 40
Compact	10 to 30	40 to 60
Dense	30 to 50	60 to 80
Very Dense	over 50	80 to 100
<b>Cohesive Soils</b>	<b>Undrained Shear Strength (C<sub>u</sub>)</b>	
<b>Consistency</b>	<b>kPa</b>	<b>psf</b>
Very Soft	less than 12	less than 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1000
Stiff	50 to 100	1000 to 2000
Very Stiff	100 to 200	2000 to 4000
Hard	over 200	over 4000
DTPL	Drier than plastic limit	Low Plasticity, W <sub>L</sub> <30
APL	About plastic limit	Medium Plasticity, 30 < W <sub>L</sub> < 50
WTPL	Wetter than plastic limit	High Plasticity, W <sub>L</sub> > 50

Z:\Style\_L\W\OntarioLog Borehole\_Log\_L\W\OntarioLog - Printed : 2016-12-19 13 h

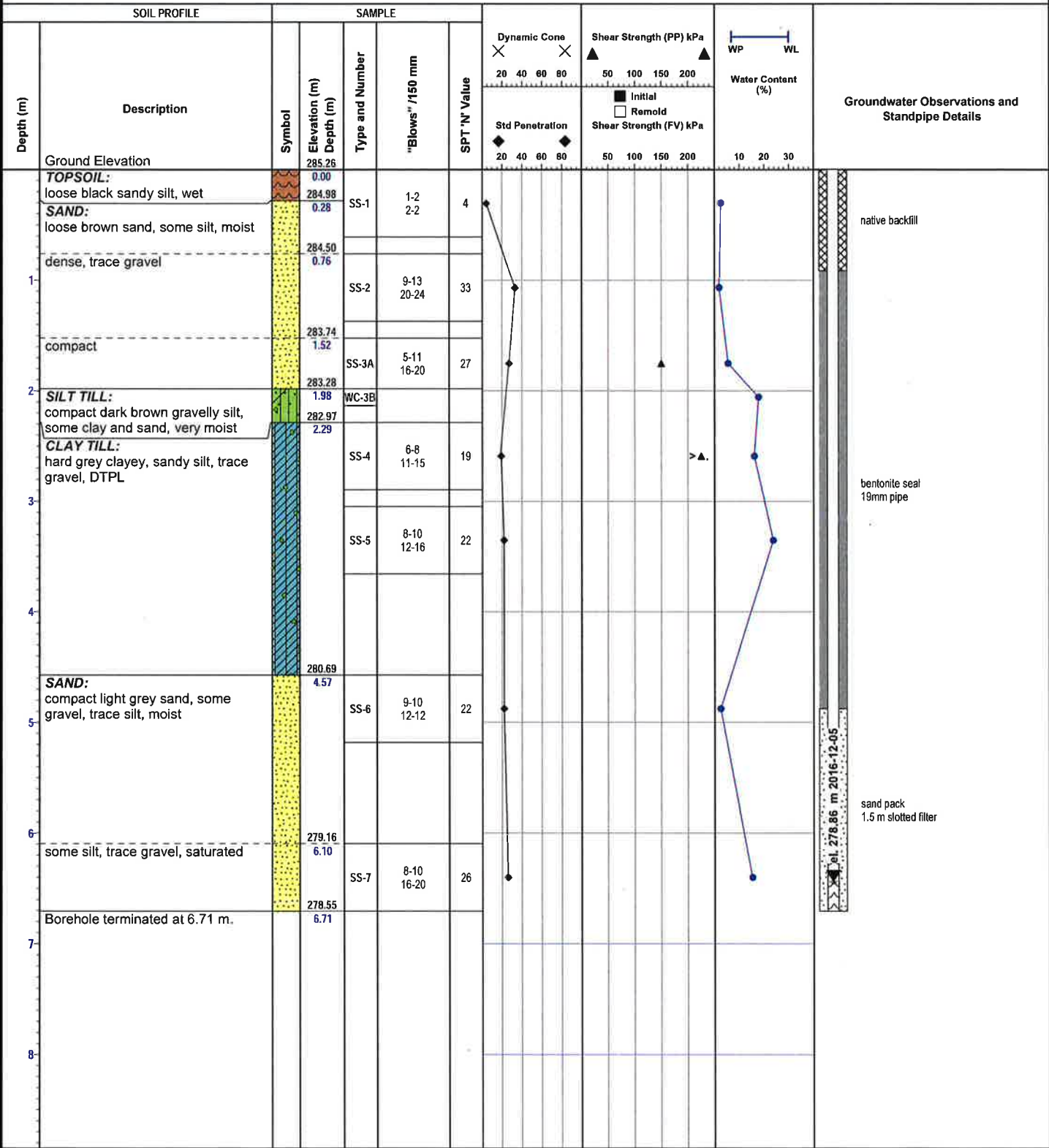
Vertical Scale = 1 : 50.0

EQ-09-Ge-72 R.1 18.02.2011



Ground Elevation: 285.26 m      Borehole Number: BH-01-16  
Northing: 499857 m      Job N°: P-0011767-0-01-100-01  
Easting: 4889616 m      Drill Date: 2016-11-28

Project: Geotechnical Investigation - McDonald Property Subdivision      Field Tech: M. Dalglish  
Location: Town of Hanover, Ontario      Drill Method: Hollow Stem Augers



Reviewed by: M. Wilson      Drafted by: K. Staples      Sheet: 1 of 1

Notes:



Z:\Style\_LVM\_Ontario\Log Borehole\_Log\_LVM\_Ontario.sty - Printed : 2016-12-19 13 h

Vertical Scale = 1 : 50.0

EQ-09-Ge-72 R.1 18.02.2011



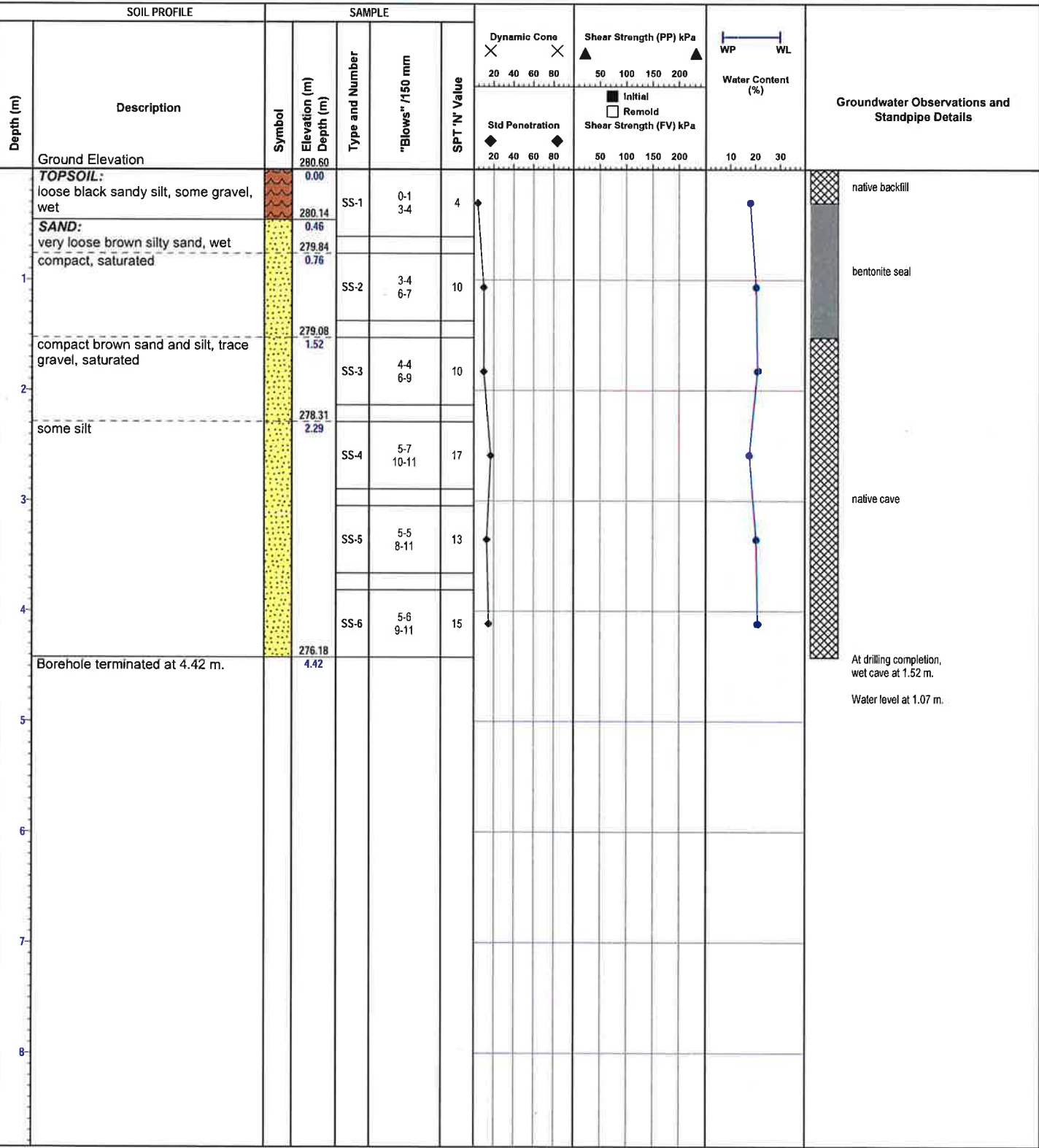
Ground Elevation: 280.60 m      Borehole Number: BH-02-16

Northing: 499726 m      Job N°: P-0011767-0-01-100-01

Easting: 4889662 m      Drill Date: 2016-11-28

Project: Geotechnical Investigation - McDonald Property Subdivision      Field Tech: M. Dalglish

Location: Town of Hanover, Ontario      Drill Method: Hollow Stem Augers



Reviewed by: M. Wilson      Drafted by: K. Staples      Sheet: 1 of 1

Notes: Borehole moved 7.6 m west of original location.

Z:\style\_LVM\_OntarioLog Borehole\_Log\_LVM\_Ontario.sty - Printed : 2016-12-19 13 h

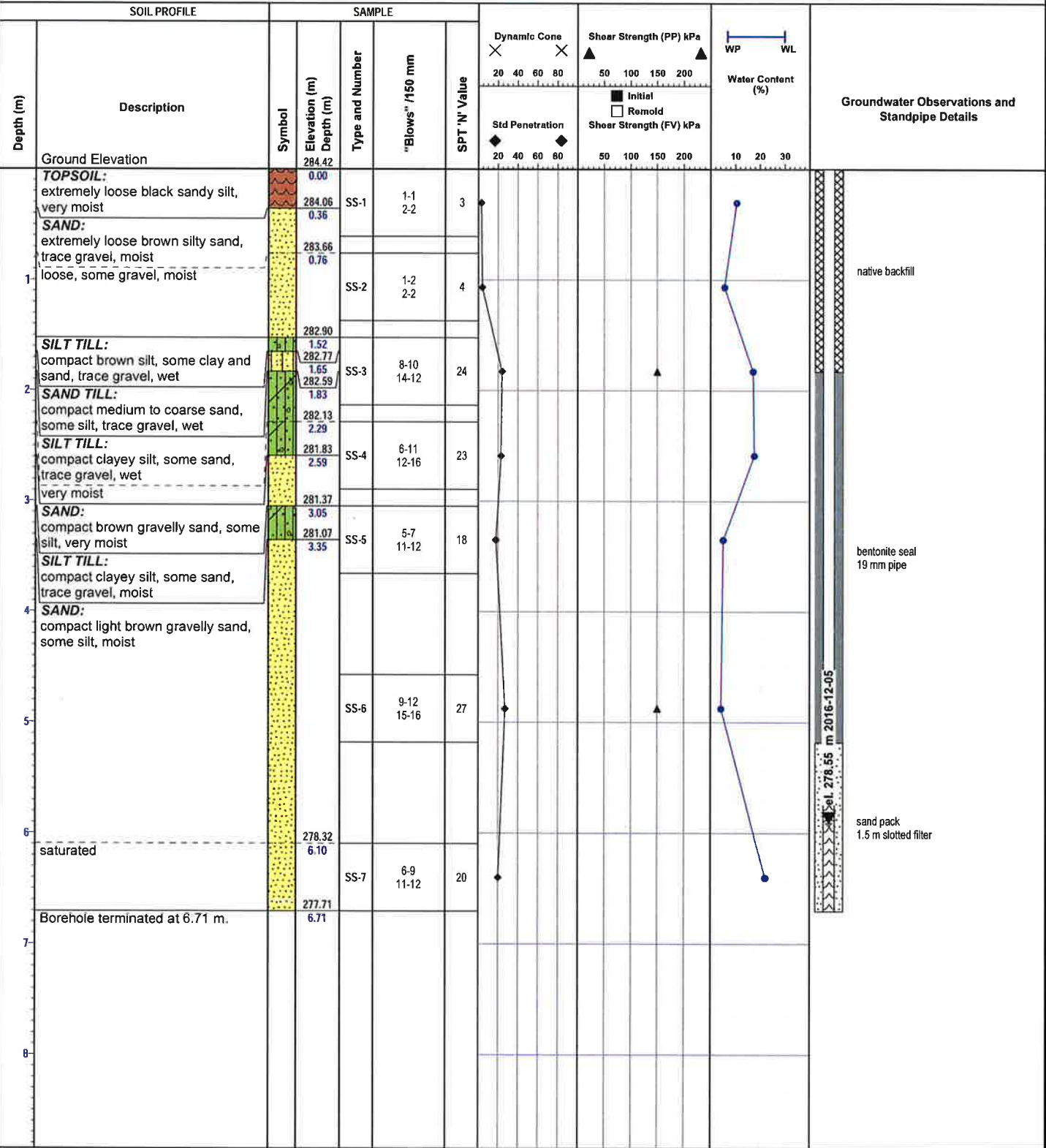
Vertical Scale = 1 : 50.0

EQ-09-Ge-72 R.1 18.02.2011



Ground Elevation: 284.42 m      Borehole Number: BH-03-16  
Northing: 499794 m      Job N°: P-0011767-0-01-100-01  
Easting: 4889790 m      Drill Date: 2016-11-28

Project: Geotechnical Investigation - McDonald Property Subdivision      Field Tech: M. Dalglish  
Location: Town of Hanover, Ontario      Drill Method: Hollow Stem Augers



Reviewed by: M. Wilson

Drafted by: K. Staples

Sheet: 1 of 1

Notes:

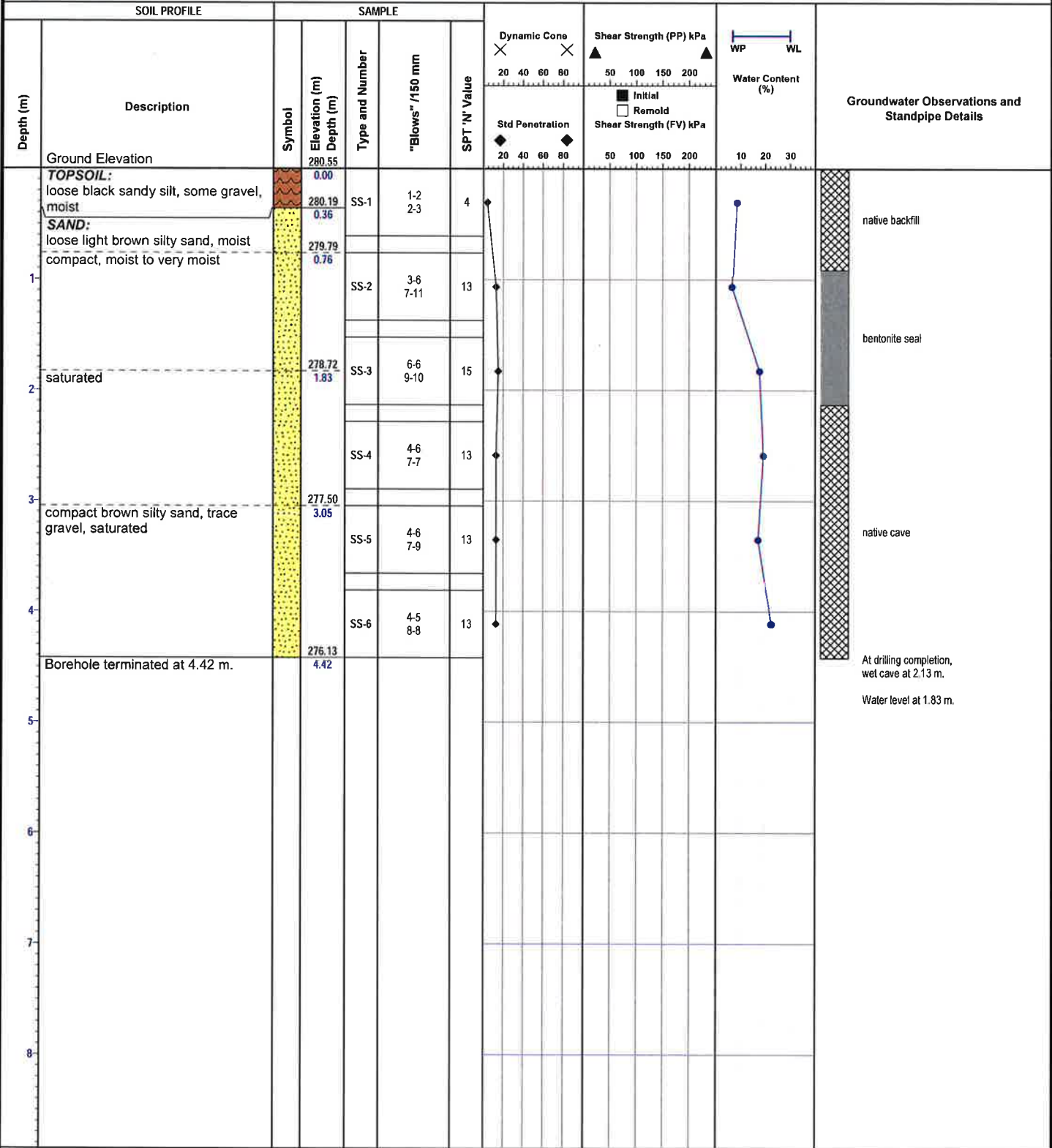


Z:\Syste\_LVM\_Ontario\Log Borehole\_Log\_LVM\_Ontario sy - Printed : 2016-12-19 13 h  
Vertical Scale = 1 : 50.0  
EQ-09-06-72 R.1 18.02.2011



Ground Elevation: 280.55 m      Borehole Number: BH-04-16  
Northing: 499665 m      Job N°: P-0011767-0-01-100-01  
Easting: 4889780 m      Drill Date: 2016-11-28

Project: Geotechnical Investigation - McDonald Property Subdivision      Field Tech: M. Dalglish  
Location: Town of Hanover, Ontario      Drill Method: Hollow Stem Augers



Z:\Style\_LVM\_OntarioLog Borehole\_Log\_LVM\_Ontario sty - Printed : 2016-12-19 13 h

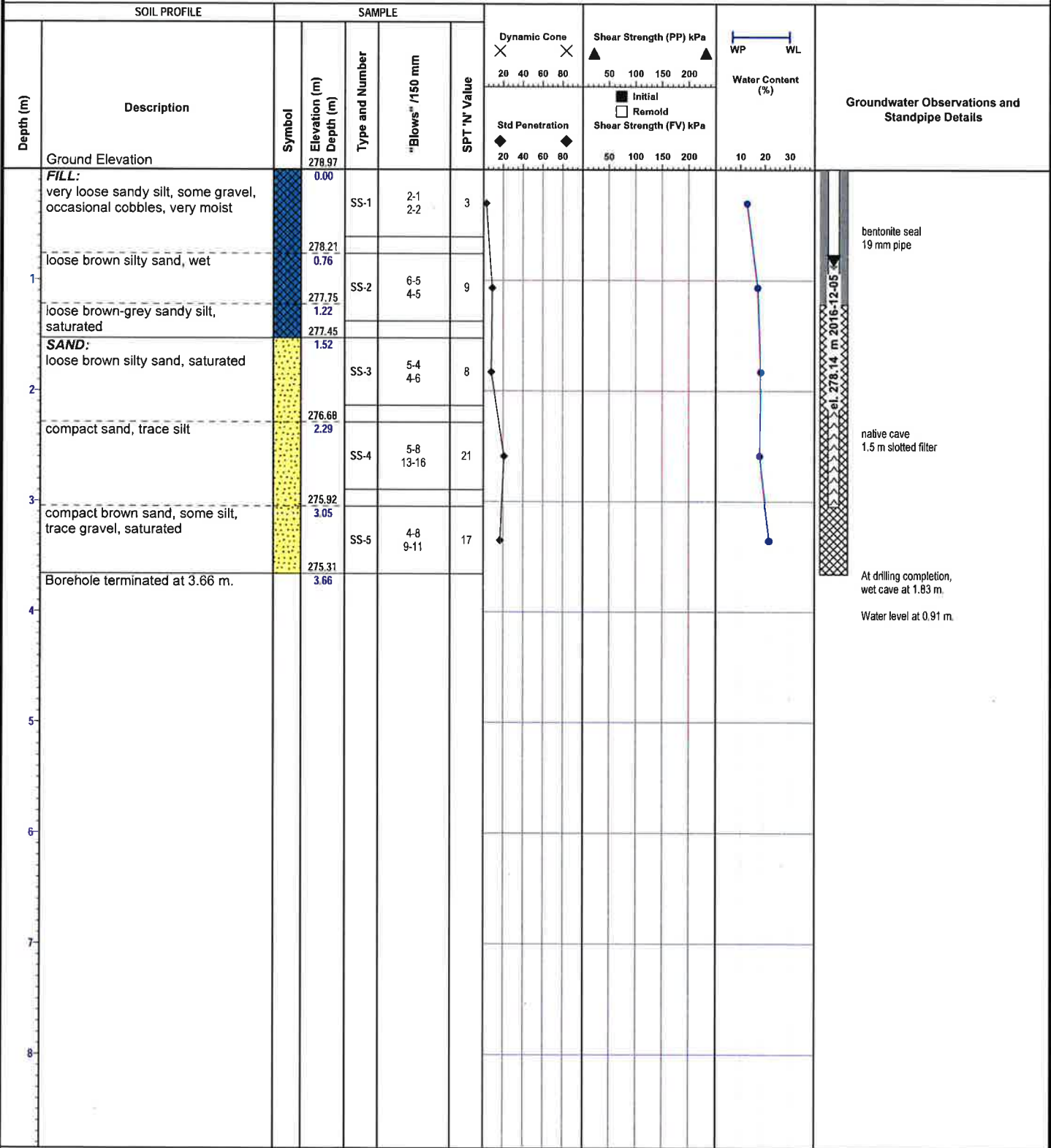
Vertical Scale = 1 : 50.0

EQ-09-Ge-72 R.1 18.02.2011



Ground Elevation: 278.97 m      Borehole Number: BH-05-16  
Northing: 499624 m      Job N°: P-0011767-0-01-100-01  
Easting: 4889686 m      Drill Date: 2016-11-28

Project: Geotechnical Investigation - McDonald Property Subdivision      Field Tech: M. Dalglish  
Location: Town of Hanover, Ontario      Drill Method: Hollow Stem Augers



Reviewed by: M. Wilson      Drafted by: K. Staples      Sheet: 1 of 1

Notes:

Z:\S\Site\_LVM\_OntarioLog Borehole\_Log\_LVM\_Ontario sy - Printed : 2016-12-19 13 h

Vertical Scale = 1 : 50.0

EQ-09-Ce-72 R.1 18.02.2011



Ground Elevation: 278.10 m

Borehole Number: BH-06-16

Northing: 499494 m

Job N°: P-0011767-0-01-100-01

Easting: 4889660 m

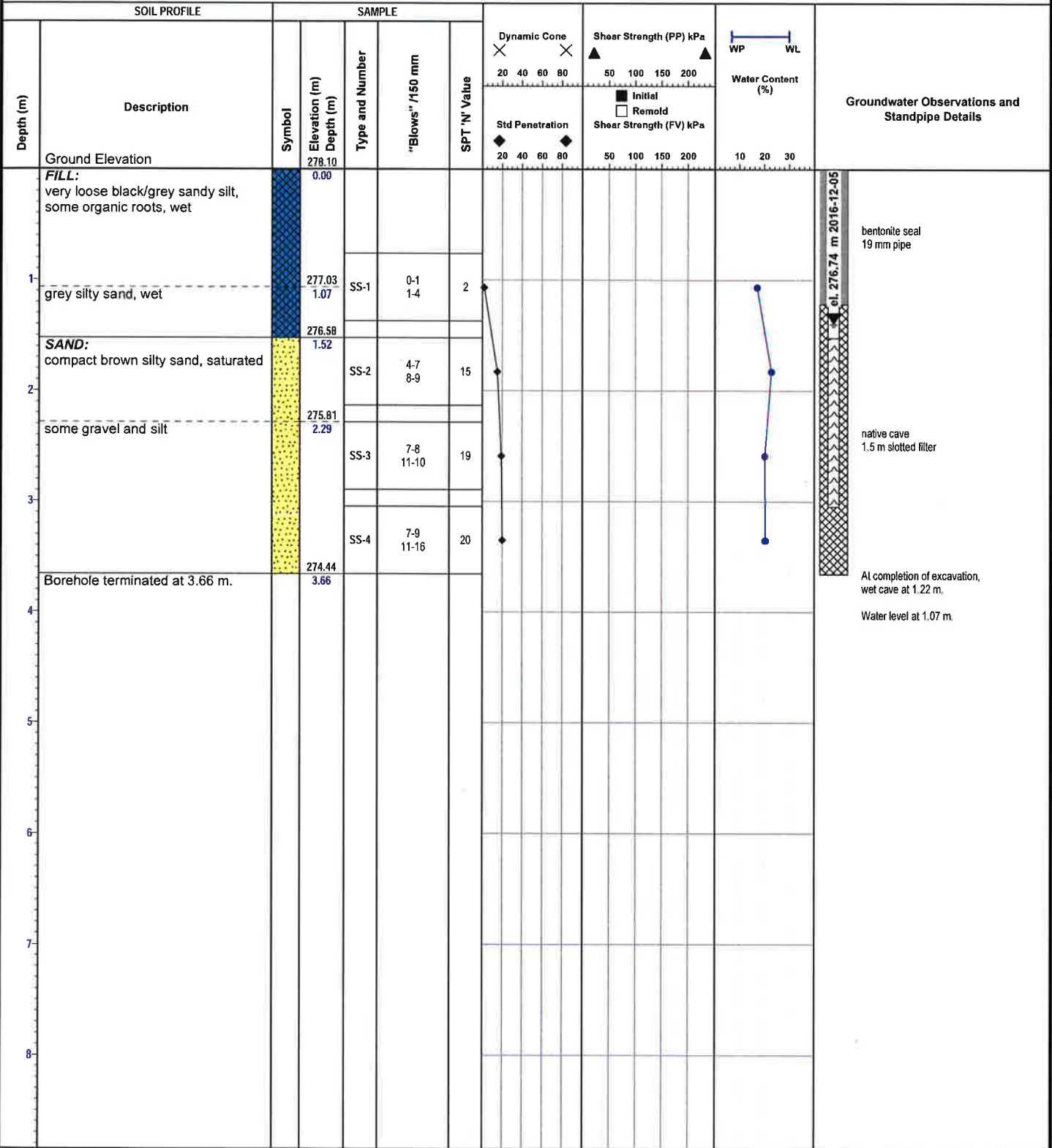
Drill Date: 2016-11-28

Project: Geotechnical Investigation - McDonald Property Subdivision

Field Tech: M. Dalglish

Location: Town of Hanover, Ontario

Drill Method: Hollow Stem Augers



### **Appendix 3   Figures**

Figure 1: Particle Size Distribution Analyses

Figure 2: Standard Proctor Moisture-Density Test Results

Z:\Style\_LVM\_Ontario\Lab\Lab\_Geotec\_80\_Lab\_Particle\_Size\_LVM\_Ontario.STY - Printed: 2016-12-08 14:02:32



PARTICLE SIZE ANALYSIS

Project: Geotechnical Investigation - McDonald Property Subdivision

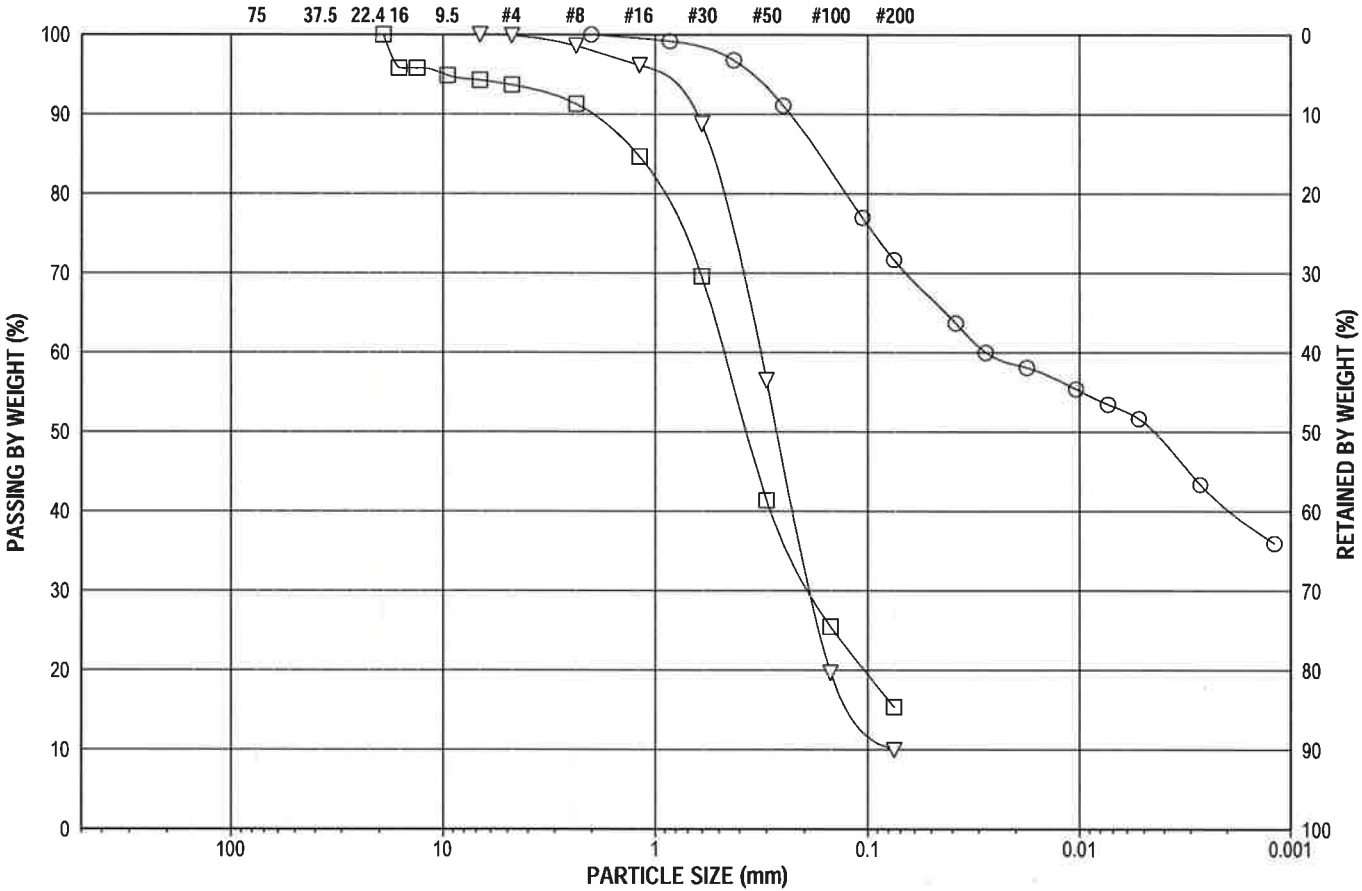
Figure No : 1

Location: Town of Hanover, Ontario

File No : P-0011767-0-01-100-01

UNIFIED SOIL CLASSIFICATION

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	
U.S. SIEVE SIZE IN MILLIMETRES			U.S. STANDARD SIEVE No.			HYDROMETER



Symbol	Borehole n°	Sample n°	Depth (m)	Description
○	BH-01-16	SS-4	2.29 - 2.90	Silty, Sandy CLAY TILL
□	BH-01-16	SS-7	6.10 - 6.71	SAND, some Silt, trace Gravel
▽	BH-05-16	SS-4	2.29 - 2.90	SAND, trace Silt



LABORATORY PROCTOR MOISTURE-DENSITY TEST

PROJECT Geotechnical Investigation - McDonald Property Subdivision

LOCATION Town of Hanover, Ontario JOB NO. P-0011767-0-01-100-01

SAMPLED FROM Borehole BH-03-16, Sample SS-4, Depth 2.29 - 2.90 m

DATE SAMPLED November 30, 2016 SAMPLED BY M. Dalglish

DATE TESTED December 2, 2016 TESTED BY M. Polkiewicz

SOIL TYPE Sand/Silt, trace Gravel MOISTURE CONTENT 19.0%

REMARKS \_\_\_\_\_

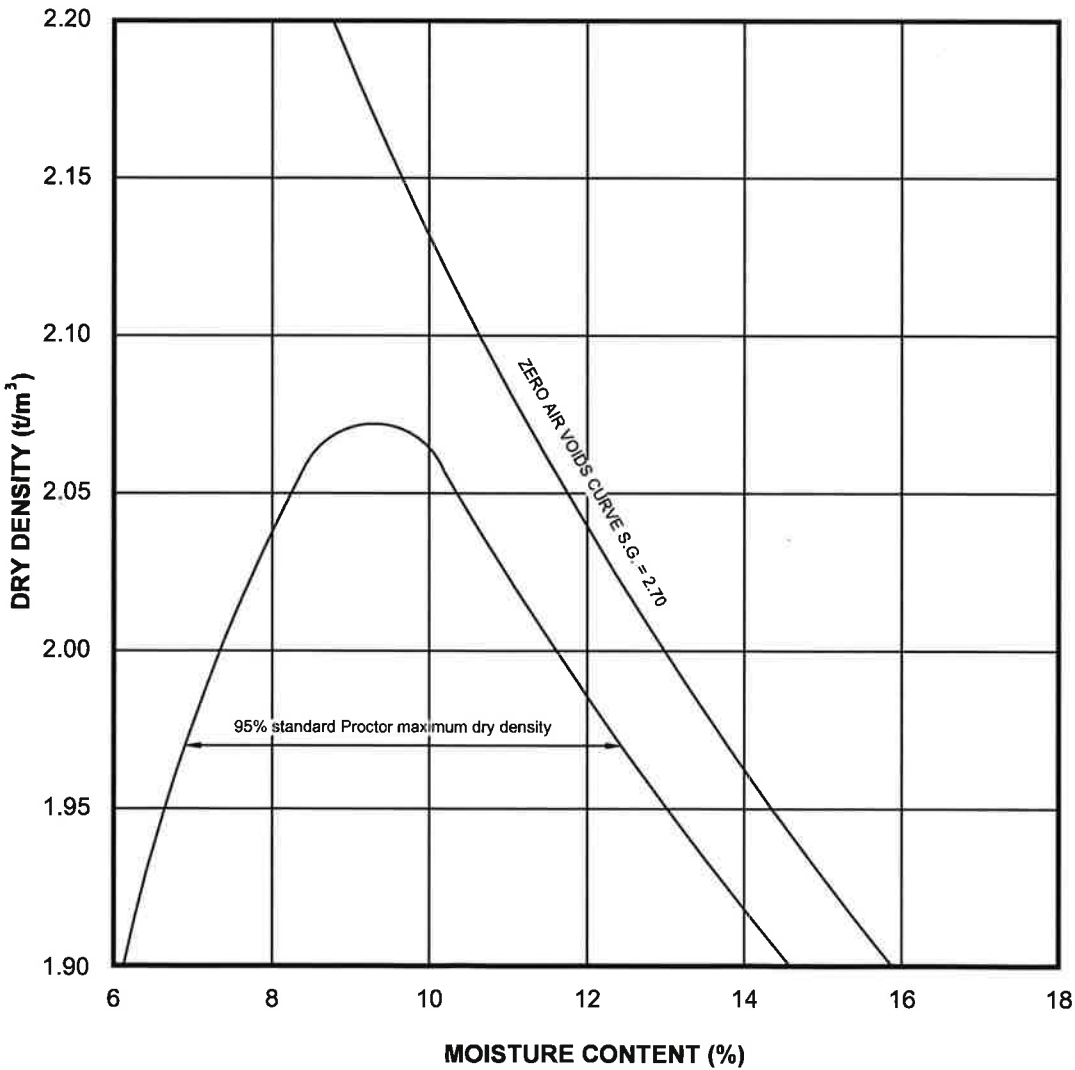
METHOD LS - 706

PROCEDURE: 1 ☒ 2 ☐ 3 ☐

Procedure 1 (Mold Ø - 101.6 mm)  
Procedure 2 (Mold Ø - 101.6 mm)  
Procedure 3 (Mold Ø - 152.4 mm)

MAXIMUM DRY DENSITY 2.073 t/m<sup>3</sup>

OPTIMUM MOISTURE 9.7%



## **Appendix 4   Photographs**

Photos 1 to 8





Photo 1 : Looking south from Borehole BH-01-16.



Photo 2 : Looking east from Borehole BH-03-16.



Photo 3 : Looking south from Borehole BH-03-16.



Photo 4 : Looking east from Borehole BH-04-16.



Photo 5 : Looking north from Borehole BH-02-16.



Photo 6 : Looking east from Borehole BH-02-16.





Photo 7 : Looking south from Borehole BH-02-16.



Photo 8 : Looking east from Borehole BH-06-16.