REPORT ON

GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL SUBDIVISION
3270 SIXTH LINE
OAKVILLE, ONTARIO

PREPARED FOR:

ARGO DEVELOPMENTS CORPORATION

PREPARED BY:

DS Consultants Ltd.

Project No : 17-508-10
Date : April 2, 2018

DS CONSULTANTS LTD.
6221 Highway 7, Unit 16
Vaughan, Ontario, L4H 0K8
Telephone: (905) 264-9393
www.dsconsultants.ca

Table of Contents

DRAWINGS

1. INTRODUCTION

DS Consultants Limited (DSCL) was retained by Argo Development Corporation to undertake a preliminary geotechnical investigation for the proposed development at 3270 Sixth Line in Oakville, Ontario.

It is understood that the project will entail a residential subdivision consisting of single family houses, roads and sewers.

The purpose of this geotechnical investigation was to obtain information about the subsurface conditions by means of a limited number of boreholes and from the findings in the boreholes to make preliminary recommendations pertaining to the geotechnical design of underground utilities and subdivision roads and to comment on the foundation conditions for general house construction.

This report is provided on the basis of the terms of reference presented above and, on the assumption, that the design will be in accordance with the applicable codes and standards. If there are any changes in the design features relevant to the geotechnical analyses, or if any questions arise concerning the geotechnical aspects of the codes and standards, this office should be contacted to review the design. It may then be necessary to carry out additional borings and reporting before the recommendations of this office can be relied upon.

The site investigation and recommendations follow generally accepted practice for geotechnical consultants in Ontario. The format and contents are guided by client specific needs and economics and do not conform to generalized standards for services. Laboratory testing for most part follows ASTM or CSA Standards or modifications of these standards that have become standard practice.

This report has been prepared for Argo Development Corporation and its designers. Third party use of this report without DS Consultants Limited (DSCL) consent is prohibited. This report has been prepared for Associated Engineering (Ontario) Ltd and the Region of Peel. Third party use of this report without DS Consultants Ltd consent is prohibited.

2. FIELD AND LABORATORY WORK

DSCL drilled thirteen (13) boreholes (BH17-1R to BH17-7R, BH17-1N to BH17-3N & BH17-1T to BH17-3T) at the subject site in November 2017 to depths ranging from 3.1 to 5.0m. All boreholes were drilled to shale bedrock. Boreholes were drilled with solid and hollow stem continuous flight auger equipment by a drilling sub-contractor under the direction and supervision of DSCL personnel. Samples were retrieved at regular intervals with a 50 mm O.D. split-barrel sampler driven with a hammer weighing 624 N and dropping 760 mm in accordance with the Standard Penetration Test (SPT) method. The samples were logged in the field and returned to the DSCL laboratory for detailed examination by the project engineer and for laboratory testing.

As well as visual examination in the laboratory, all soil samples were tested for moisture contents. Four (4) soil samples were subjected to grain size analyses and Atterberg Limits testing.

Water level observations were made during drilling and in the open boreholes at the completion of the drilling operations. Monitoring wells were installed in six (6) boreholes (BH17-1R, BH17-7R, BH17-2N, BH17-1T, BH17-2T and BH17-3T) for groundwater level monitoring.

The surface elevations at the borehole locations were surveyed by DSCL staff using differential GPS system.

3. SITE AND SUBSURFACE CONDITIONS

The entire property covers an area of approximately 12.58 hectares (31.08 acres) and historically been used for agricultural purposes. A portion of the property was occupied by a cell Tower for approximately 15 years. The subject property is currently vacant of structures and majority of the site is agricultural field/farmland.

The borehole locations are shown on Drawing 1. Notes on sample description are presented on Drawing 1A. The subsurface conditions in the boreholes are presented in the individual borehole logs (Drawing Nos. 2 to 14 inclusive). The subsurface conditions in the boreholes are summarized in the following paragraphs.

3.1 Soil Conditions

Topsoil/ Fill Material: In the boreholes, a 125 to 300 mm thick layer of surficial topsoil was found at boreholes BH17-1R to BH17-7R and BH17-1N to BH17-3N. The thickness of the topsoil in each borehole was shown in the borehole log. It should be noted that the thickness of the topsoil explored at the borehole locations may not be representative for the site and should not be relied on to calculate the amount of topsoil at the site.

Underneath the topsoil, fill material was found in three (3) boreholes (BH17-1T to BH17-3T) drilled in the Tower area, extending to depths of 1.5 to 3.1m. The fill consisted of upper 150mm thick layer of granular fill, overlying loose to compact clayey silt to sandy silt with trace to some inclusions of topsoil/organics, and shale and wood fragments.

Weathered/Disturbed Till: In the boreholes BH17-1R to BH17-7R and BH17-1N to BH17-3N, a weathered/disturbed layer of native clayey silt was encountered, extending to a depth of about 0.6 to 1.0m below the existing grade. This weathered/disturbed soil was present in a firm to stiff consistency, with occasional very stiff layers.

Silty Clay Till: Native soil consisting of silty clay till was found in all the boreholes, except BH17-1T & BH17-2T, below fill material or weathered/disturbed native, extending to the shale bedrock. The silty clay till was present in a stiff to hard, generally hard consistency, with measured SPT 'N' values ranging

from 12 to over 50 blows per 300 mm. The till is known to contain layers and pockets of sand. Large boulders are also known to be present in the till.

Grain size analyses of four (4) silty clay till samples (BH17-1R/SS2, BH17-4R/SS2, BH17-1N/SS2 and BH17-3N/SS2) were conducted and the results are presented on Drawing 15, with the following fractions:

Clay: 20 to 25%
Silt: 49 to 57%
Sand: 15 to 20%
Gravel: 3 to 12%

Atterberg limits tests of four (4) silty clay till samples (BH17-1R/SS2, BH17-4R/SS2, BH17-1N/SS2 and BH17-3N/SS2) were conducted. Based on the test results, the soil is classified as inorganic clay of low plasticity (CL).The results are shown on the borehole logs and are summarized as follows:

Liquid limit (W_L): 28 to 31%
Plastic limit (W_P): 17 to 18%
Plasticity index (PI): 11 to 13

Shale Bedrock: Shale bedrock of Queenston Formation was encountered at all the borehole locations below depths ranging from 1.5 to 4.5m, corresponding to Elevations 171.1 to 172.8 m. The shale bedrock was not proven by core drilling. The depth and elevation of the shale bedrock surface in the boreholes are listed on Table 1 below.

Table 1: Depth and Elevation of Shale Bedrock Surface

Borehole No.	Depth of Shale Bedrock Surface below Existing Ground (m)	Approximate Elevation of Shale Bedrock Surface (m)
BH17-1R	4.6	172.6
BH17-2R	4.6	171.6
BH17-3R	2.3	172.4
BH17-4R	2.3	172.4
BH17-5R	3.1	172.4
BH17-6R	2.5	172.3
BH17-7R	3.5	171.1
BH17-1N	2.3	172.1
BH17-2N	2.3	171.8
BH17-3N	3.1	171.7
BH17-1T	2.3	172.2
BH17-2T	3.1	171.3
BH17-3T	1.5	172.8

Commonly the till overlying the shale contains slabs of limestone which would give a false indication of the bedrock level. Similarly, the depth of weathering cannot be determined accurately due to the presence of limestone layers.

The shale bedrock generally contains layers of sandstone, limestone and dolostone. Typically, the hard layers comprise about 15 to 20 percent of the unit. However, higher concentrations of hard layers can be present. The hard layers are usually less than 100 to 150 mm thick, but some layers are much thicker. The thicker layers have been observed to be as much as 750 to 900 mm at other sites. The layers are actually lenses and they can vary significantly in thickness over short distance.

Methane gas is anticipated in the bedrock. Appropriate care and monitoring is essential in all confined bedrock excavations, particularly for caissons. Stress relief features such as folds and faults are common in the shale bedrock. **Appendix B** presents more details and general comments about the shale bedrock.

3.2 Groundwater Conditions

No groundwater was found in the boreholes during drilling or upon completion of drilling. The stabilized groundwater levels observed in the monitoring installed in the boreholes are listed on Table 2.

Table 2: Groundwater Levels Observed in Monitoring

Borehole No.	Date of installation	Date of Observation	Depth of Groundwater Table (m)	Elevation of Groundwater Table (m)
BH17-1R	November 14, 2017	November 16, 2017	Dry	-
		January 9, 2018	4.6	172.6
		January 18, 2018	4.6	172.6
		January 24, 2018	4.6	172.6
BH17-7R	November 14, 2017	November 16, 2017	Dry	-
		January 9, 2018	Dry	-
		January 18, 2018	2.5	172.1
		January 24, 2018	2.1	172.5
BH17-2N	November 14, 2017	November 16, 2017	Dry	-
		January 9, 2018	Dry	-
		January 18, 2018	2.5	171.6
		January 24, 2018	1.2	172.9
BH17-1T	November 15, 2017	November 16, 2017	Dry	-
		January 9, 2018	3.3	171.2
		January 18, 2018	2.2	172.3
		January 24, 2018	1.1	173.4
BH17-2T	November 15, 2017	November 16, 2017	Dry	-
		January 9, 2018	Dry	-
		January 18, 2018	3.1	171.3
		January 24, 2018	3.1	171.3
BH17-3T	November 15, 2017	November 16, 2017	2.5	171.8
		January 9, 2018	dry	-
		January 18, 2018	1.4	172.9
		January 24, 2018	0.6	173.6

It should be noted that the groundwater levels can vary and are subject to seasonal fluctuations in response to major weather events.

4. DISCUSSION AND RECOMMENDATIONS

It is proposed to develop the site as a residential subdivision. The lots will therefore be serviced by a network of roads, watermains and storm and sanitary sewers.

4.1 Roads

The investigation has shown that the predominant subgrade soil, after stripping the topsoil, loose fill and any other organic and otherwise unsuitable subsoil, will generally consist of clayey silt and silty clay till.

Based on the above and assuming that traffic usage will be residential minor local or local, the following minimum pavement thickness is recommended for roads to be constructed within the subdivision:

40 mm HL3 Asphaltic Concrete

50 mm HL8 Asphaltic Concrete

150 mm Granular 'A'

350 mm Granular 'B'

For collector streets/bus routes, the following minimum pavement thickness is recommended:

40 mm HL3 Asphaltic Concrete

80 mm HL8 Asphaltic Concrete

150 mm Granular 'A'

400 mm Granular 'B'

These values may need to be adjusted according to the Town of Oakville Standards. The site subgrade and weather conditions (i.e. if wet) at the time of construction may necessitate the placement of thicker granular sub-base layer in order to facilitate the construction. Furthermore, heavy construction equipment may have to be kept off the newly constructed roads before the placement of asphalt and/or immediately thereafter, to avoid damaging the weak subgrade by heavy truck traffic.

4.1.1 Stripping, Sub-excavation and Grading

The site should be stripped of all topsoil, loose fill and any organic or otherwise unsuitable soils to the full depth of the roads, both in cut and fill areas.

Following stripping, the site should be graded to the subgrade level and approved. The subgrade should then be proof-rolled, in the presence of the Geotechnical Engineer, by at least several passes of a heavy compactor having a rated capacity of at least 8 tonnes. Any soft spots thus exposed should be removed and replaced by select fill material, similar to the existing subgrade soil and approved by the Geotechnical Engineer. The subgrade should then be re-compacted from the surface to at least 98% of its Standard Proctor Maximum Dry Density (SPMDD). The final subgrade should be cambered or

otherwise shaped properly to facilitate rapid drainage and to prevent the formation of local depressions in which water could accumulate.

Owing to the clayey (i.e. impervious) nature of the subsoil at the site, proper cambering and allowing the water to escape towards the sides (where it can be removed by means of subdrains) is considered to be beneficial for this project. Otherwise, any water collected in the granular sub-base materials could be trapped thus causing problems due to softened subgrade, differential frost heave, etc. For the same reason damaging the subgrade during and after placement of the granular materials by heavy construction traffic should be avoided. If the moisture content of the local material cannot be maintained at ±2% of the optimum moisture content, imported granular material may need to be used.

Any fill required for re-grading the site or backfill should be select, clean material, free of topsoil, organic or other foreign and unsuitable matter. The fill should be placed in thin layers and compacted to at least 95% of its SPMDD. The degree of compaction should be increased to 98% within the top 1.0 m of the subgrade, or as per the Town Standards. The compaction of the new fill should be checked by frequent field density tests.

4.1.2 Construction

Once the subgrade has been inspected and approved, the granular base and sub-base course materials should be placed in layers not exceeding 200 mm (uncompacted thickness) and should be compacted to at least 100% of their respective SPMDD. The grading of the material should conform to current OPS Specifications.

The placing, spreading and rolling of the asphalt should be in accordance with OPS Specifications or, as required by the local authorities.

Frequent field density tests should be carried out on both the asphalt and granular base and sub-base materials to ensure that the required degree of compaction is achieved.

4.1.3 Drainage

The Town of Oakville requires the installation of full-length subdrains on all roads. The subdrains should be properly filtered to prevent the loss of (and clogging by) soil fines.

All paved surfaces should be sloped to provide satisfactory drainage towards catchbasins. As discussed in Section 4.1.1, by means of good planning any water trapped in the granular sub-base materials should be drained rapidly towards subdrains or other interceptors.

4.2 Sewers

As a part of the site development, a network of new storm and sanitary sewers is to be constructed. It is assumed that the trenches are generally within 4 to 5 m below the existing grade.

4.2.1 Trenching

Based on the boreholes, the trenches will be dug through the fill material or weathered/disturbed clayey silt followed by silty clay till. No major problems due to groundwater seepage are anticipated during construction in trenches dug through the clayey soils and shale bedrock. It is expected that any seepage, which occurs during wet periods or from the wet sand seams/layers in the till, can be removed by pumping from sumps.

Excavations can be carried out with heavy hydraulic backhoe. Excavation of the shale can be carried out using heaviest available single tooth ripper equipment. The limestone beds may overly the shale bedrock surface at some locations and it may be necessary at some locations to utilize jackhammer type equipment to "open" the limestone layers for the ripper.

The sides of excavations in the natural strata above groundwater can be expected to be temporarily stable at relatively steep side slopes for short periods of time but they should be cut back at slopes no steeper than 1:1 in order to comply with the safety regulations. If steep side slopes are required, the sides should be supported by braced skeleton or close sheeting.

All excavations must be carried out in accordance with the most recent Occupational Health and Safety Act (OHSA). In accordance with OHSA, the fill above the water table can be classified as Type 3 soil. The very stiff to hard silty clay till can be classified as Type 2 Soil above the groundwater table and Type 3 below the groundwater table.

4.2.2 Bedding

The undisturbed native soil will provide adequate support for the sewer pipes and allow the use of normal Class B type bedding. The recommended minimum thickness of granular bedding below the invert of the pipes is 150 mm. The thickness of the bedding may, however, have to be increased depending on the pipe diameter or in accordance with local standards or if wet or weak subgrade conditions are encountered, especially when the soil at the trench base level consists of wet, dilatant silt. The bedding material should consist of well graded granular material such as Granular 'A' or equivalent. After installing the pipe on the bedding, a granular surround of approved bedding material, which extends at least 300 mm above the obvert of the pipe, or as set out by the local Authority, should be placed. Where the bedding falls below the anticipated water table, the bedding stone must be surrounded with a geotextile filter cloth.

To avoid the loss of soil fines from the subgrade, uniformly graded clear stone should not be used unless, below the granular bedding material, a suitable, approved filter fabric (geotextile) is placed. The geotextile should extend along the sides of the trench and should be wrapped all around the poorly graded bedding material.

For deep trenches, i.e. more than 2.0 m below the shale surface, a minimum 50 mm thick polystyrene etc. layer will be required at both sides of the pipe to avoid rock squeezing. The polystyrene layer should extend vertically to at least 0.3 m above the pipe. The rock trench should be wide enough so that at each side, the horizontal distance between the pipe side and the cut rock surface is at least 0.3 m.

4.2.3 Backfilling of Trenches

Based on visual and tactile examination, the on-site excavated inorganic clayey silt and silty clay deposits, free from topsoil and organics are considered to be suitable for re-use as backfill in the service trenches provided their moisture contents at the time of construction are at or near optimum.

Granular B material should be used as backfill for trenches located under slab on grade or paved areas. Compaction of the granular soils should be carried out with vibratory compactors and loose lifts not exceeding about 200 mm.

The clayey till especially when its consistency is hard is likely to be excavated in cohesive chunks or blocks and will be difficult to compact in confined areas. For use as backfill, the clayey material will have to pulverized and placed in thin layers. The clayey soils will have to be compacted using heavy equipment suitable for these soils which may be difficult to operate in the narrow confines of the trenches. Unless the clayey materials are properly pulverized and compacted in sufficiently thin lifts post-construction settlements could occur. Their use in narrow trenches such as laterals (where heavy compaction equipment can not be operated) may not be feasible.

The backfill should be placed in maximum 200 mm thick layers at or near (±2%) their optimum moisture content, and each layer should be compacted to at last 95% SPMDD. Unsuitable materials such as organic soils, boulders, cobbles, frozen soils, etc. should not be used for backfilling.

The on-site excavated soils and especially the clayey soils should not be used in confined areas (e.g. around catchbasins and laterals under roadways) where heavy compaction equipment can not be operated. The use of imported granular fill together with an appropriate frost taper would be preferable in confined areas and around structures, such as catchbasins.

4.3 Engineered Fill

In the areas where earth fill is required for site grading purposes, an engineered fill may be constructed below house foundations, roads, boulevards, etc.

General guidelines for the placement and preparation of engineered fill are presented on **Appendix A**. Bearing capacity values of 150 kPa at SLS and 225 kPa at ULS can be used on engineered fill, provided that all requirements on **Appendix A** are adhered to. To reduce the risk of improperly placed engineered compacted fill, full-time supervision of the contractor is essential. Despite full time supervision, it has been found that contractors frequently bulldoze loose fill into areas and compact only the surface. The inspector, either busy on other portions of the site or absent during “off hours” will be

unaware of this condition. For this reason, we cannot guarantee the performance of the engineered fill, and this guarantee must be the responsibility of the contractor. The owner and his representatives must accept the risk involved in the use of engineered fill and offset this risk with the monetary savings of avoiding deep foundations. This potential problem must be recognized and discussed at a pre-construction meeting. Procedures can then be instigated to reduce the risk of settlement resulting from un-compacted fill.

The following is a recommended procedure for an engineered fill:

1. Prior to site work involving engineered fill, a site meeting to discuss all aspects must be convened. The surveyor, contractor, design engineer and geotechnical engineer must attend the meeting. At this meeting, the limits of the engineered fill will be defined. The contractor must make known where all fill material will be obtained, and samples must be provided to the geotechnical engineer for review, and approval before filling begins.

2. Detailed drawings indicating the lower boundaries as well as the upper boundaries of the engineered fill must be available at the site meeting and be approved by the geotechnical engineer.

3. The building footprint and base of the pad, including basements, garages, etc. must be defined by offset stakes that remain in place until the footings and service connections are all constructed. Confirmation that the footings are within the pad, service lines are in place, and that the grade conforms to drawings, must be obtained by the owner in writing from the surveyor and DSCL. Without this confirmation no responsibility for the performance of the structure can be accepted by DSCL. Survey drawing of the pre and post fill location and elevations will also be required.

4. The area must be stripped of all topsoil and fill materials. Subgrade must be proof-rolled. Soft spots must be dug out. The stripped native subgrade must be examined and approved by a DSCL engineer prior to placement of fill.

5. The approved engineered fill must be compacted to 100% Standard Proctor Maximum Dry Density throughout. Granular Fill preferred. Engineered fill should not be placed (where it will support footings) during the winter months. Engineered fill compacted to 100% SPMDD will settle under its own weight approximately 0.5% of the fill height and the structural engineer must be aware of this settlement. In addition to the settlement of the fill, additional settlement due to consolidation of the underlying soils from the structural and fill loads will occur.

6. Full-time geotechnical inspection by DSCL during placement of engineered fill is required. Work cannot commence or continue without the presence of the DSCL representative.

7. The fill must be placed such that the specified geometry is achieved. Refer to sketches for minimum requirements. Take careful note that the projection of the compacted pad beyond the

footing at footing level is a minimum of 2 m. The base of the compacted pad extends 2 m plus the depth of excavation beyond the edge of the footing.

8. Bearing capacity values of 150 kPa at SLS and 225 kPa at ULS may be used provided that all conditions outlined above are adhered to. A minimum footing width of 500 mm (20 inches) is suggested and footings should be provided with nominal steel reinforcement.

9. All excavations must be done in accordance with the Occupational Health and Safety Regulations of Ontario.

10. After completion of the pad a second contractor may be selected to install footings. All excavations must be backfilled under full time supervision by DSCL to the same degree as the engineered fill pad. Surface water cannot be allowed to pond in excavations or to be trapped in clear stone backfill. Clear stone backfill can only be used with the approval of DSCL.

11. After completion of compaction, the surface of the pad must be protected from disturbance from traffic, rain and frost.

12. If there is a delay in construction, the engineered fill pad must be inspected and accepted by the geotechnical engineer. The location of the structure must be reconfirmed that it remains within the pad.

The inorganic silty clay (till) are considered suitable for use as engineered fill, provided that their moisture contents at the time of construction are at or near optimum. As mentioned before in Section 4.2.3 of this report, the clayey tills are likely to be excavated in cohesive chunks or blocks and will be difficult to compact. They should be pulverized and placed in thin layers not exceeding 150 to 200 mm and compacted using heavy equipment suitable for these types of soils (e.g. heavy sheepsfoot compactors).

4.4 Foundation Conditions

The boreholes show that provided the foundation soil is undisturbed during the construction, in general, soil bearing values 150 kPa at SLS and 225 kPa at ULS are feasible in the undisturbed inorganic natural (native) soils at or below the depths as given in Table 3. These values would be suitable for the use of conventional spread and strip footings to support normal single-family dwellings.

Table 3: Bearing Values and Founding Levels of Footings

BH No.	Founding Soil	Bearing* Capacity at SLS (kPa)	Factored* Geotechnical Resistance at ULS (kPa)	Minimum Depth below Existing Ground (m)	Founding Level At or Below Elevation (m)
BH17-1R	Silty Clay till	150	225	0.8	176.4
BH17-2R	Silty Clay till	150	225	0.8	175.4
BH17-3R	Silty Clay till	150	225	0.8	173.9
BH17-4R	Silty Clay till	150	225	0.8	173.9
BH17-5R	Silty Clay till	150	225	0.8	174.7
BH17-6R	Silty Clay till	150	225	0.8	174.0
BH17-7R	Silty Clay till	150	225	0.8	173.8
BH17-1N	Silty Clay till	150	225	0.8	173.6
BH17-2N	Silty Clay till	150	225	1.0	173.1
BH17-3N	Silty Clay till	150	225	0.8	174.0
BH17-1T	Silty Clay till	150	225	2.3	172.2
BH17-2T	Silty Clay till	150	225	3.1	171.3
BH17-3T	Silty Clay till	150	225	1.5	172.8

*Higher bearing pressure values are available if required

Where the grade needs to be raised, the proposed structures can be supported by spread and strip footings founded on engineered fill for bearing capacity values of 150 kPa at SLS and 225 kPa at ULS. The engineered fill supporting footings should be constructed in accordance with the guidelines presented in **Appendix A**. Other requirements of engineered fill are given in Section 4.3.

Variations in the soil conditions are expected in between the borehole locations, and during construction, the soil bearing pressures should be confirmed by the Geotechnical Engineer.

4.5 Storm-water Management (SWM) Pond

It is understood that a storm-water management pond will be constructed at the subject site in the eastern part of the property. Design details of the proposed SWM Pond are not available to us at the time of writing this report.

Two boreholes BH17-3N and BH17-6R were drilled in the area of the proposed SWM Pond. The subsurface conditions in the boreholes consisted of silty clay till extending to depths of 2.5 to 3.1m, overlying shale bedrock. Groundwater table at site varies from Elevation 171.3 to 172.9m.

Based on the findings of the boreholes drilled, the pond is expected to be generally excavated through the relatively impermeable, stiff to hard silty clay till deposits and into the bedrock. Silty clay till is considered suitable for the construction of the pond. However, if the base of the pond is founded in weathered shale, lining of the pond bottom and sides with a clay liner or geo-synthetic liner will be required.

Water seepage through the sand seams in till and bedding planes/fractures in the bedrock is anticipated but is expected to be controllable by the conventional pumping methods. However, contractor should be prepared to employ elaborate dewatering procedures of the flow from weathered shale becomes severe.

For the design of the pond, the inside side slopes or outside slope of the berms should be no steeper than 3 horizontal to 1 vertical (3H:1V). If sidewall berm construction is required to establish an elevated pond, the berms can be constructed using the on-site silty clay till. The constructed berms are expected to be stable at the maximum proposed slope of 3H:1V. Onsite shale bedrock is considered unsuitable for use in the pond berms as seepage through the shale bedrock constructed berms would be excessive and may cause berm instability. If shale bedrock must be used to construct the pond berms, shale must be completely pulverized and moistened during placement. The materials used to construct the berms must be placed in maximum 300mm thick loose lifts and compacted to 98 percent of the material's SPMDD.

Adequate vegetation cover will be required to provide erosion protection for the exposed pond slopes and installation of temporary erosion control measures may be required until the permanent erosion protection is fully established.

It is recommended that once the final design for the pond has been completed, the design be reviewed by our office for further information and detailed geotechnical recommendations.

5. GENERAL COMMENTS AND LIMITATIONS OF REPORT

DS Consultants Ltd (DSCL) should be retained for a general review of the final design and specifications to verify that this report has been properly interpreted and implemented. If not accorded the privilege of making this review, DSCL will assume no responsibility for interpretation of the recommendations in the report.

This report is intended solely for the Client named. The material in it reflects our best judgment in light of the information available to DSCL at the time of preparation. Unless otherwise agreed in writing by DSCL, it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity, it is written to be read in its entirety.

The sub-surface conditions are interpreted as relevant to the design and construction of the proposed sanitary sewer. Comments relating to construction are intended for the guidance of the design engineer to establish constructability and must not be considered as being specifications or recommendations to the prospective contractors, or as being the only suitable methods. Prospective contractors should evaluate all of the factual information, obtain additional subsurface information as they might deem necessary and should select their construction methods, sequencing and equipment based on their own experience in similar ground conditions. The readers of this report are also reminded that the conditions

are known only at the borehole locations and in view of the generally wide spacing of the boreholes, conditions may vary significantly between boreholes.

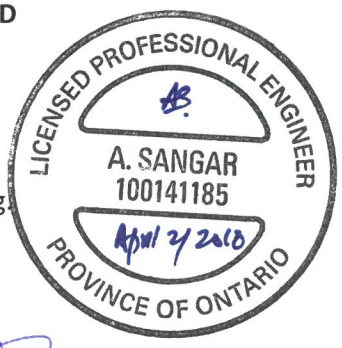
The conclusions and recommendations given in this report are based on information determined at the test hole locations. The information contained herein in no way reflects on the environment aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the test holes may differ from those encountered at the test hole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the test hole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

The design recommendations given 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.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. DSCL accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report. We accept no responsibility for any decisions made or actions taken as a result of this report unless we are specifically advised of and participate in such action, in which case our responsibility will be as agreed to at that time.

We trust that the information contained in this report is satisfactory. Should you have any questions, please do not hesitate to contact this office.

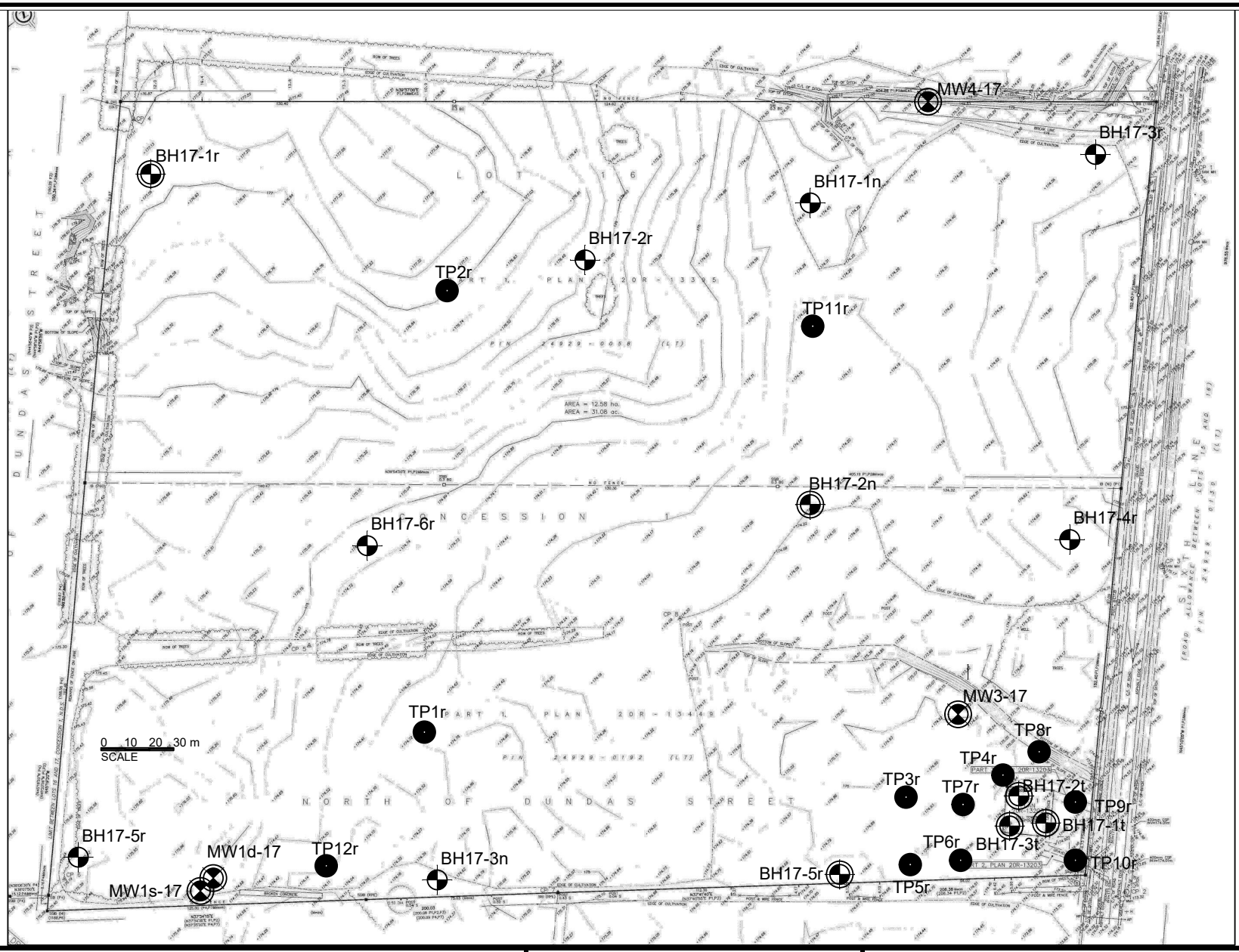
DS CONSULTANTS LIMITED



Alka Sangar, M.Eng., P.Eng.

Shaheen Ahmad, M.A.Sc., P.Eng.

Drawings



TP1r - Test Pit Location DS

BH17-7r - Monitoring Well DS

BH-5r - Borehole DS

MW1s-17 - Monitoring Well Burnside

Title: Borehole & Test Pit Location Plan

DS CONSULTANTS LTD.
6221 Highway 7, Unit 16
Vaughan, Ontario, L4H 0K8
Telephone: (905) 264-9393
www.dsconsultants.ca

Project: GEOTECHNICAL INVESTIGATION
3270 SIXTH LINE, OAKVILLE, ON

Client: AGRO DEVELOPMENT CORPORATION

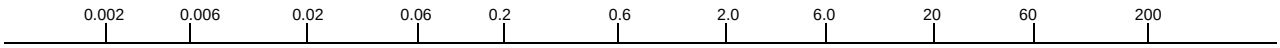
Drawn:	LPV	Scale:	As Shown
Approved:	SA	Project No.:	**17-508-10**
Date:	APRIL, 2018	Figure No.:	1

Drawing 1A: Notes On Sample Descriptions

1. All sample descriptions included in this report generally follow the Unified Soil Classification. Laboratory grain size analyses provided by DSCL also follow the same system. Different classification systems may be used by others, such as the system by the International Society for Soil Mechanics and Foundation Engineering (ISSMFE). Please note that, with the exception of those samples where a grain size analysis and/or Atterberg Limits testing have been made, all samples are classified visually. Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems.

ISSMFE SOIL CLASSIFICATION

CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE		



EQUIVALENT GRAIN DIAMETER IN MILLIMETRES

CLAY (PLASTIC) TO	FINE	MEDIUM	CRS.	FINE	COARSE
SILT (NONPLASTIC)	SAND			GRAVEL	

UNIFIED SOIL CLASSIFICATION

2. Fill: Where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc., none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional preliminary geotechnical site investigation.

3. Till: The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

LOG OF BOREHOLE BH17-1R

PROJECT: Geotechnical Investigation- Proposed Residential Subdivision
CLIENT: Argo Development Corporation
PROJECT LOCATION: 3270 Sixth Line, Oakville, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1

DRILLING DATA
Method: Solid Stem Augers
Diameter: 150mm
Date: Nov-14-2017

REF. NO.: 508-10
ENCL NO.: 2

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION
177.2							
177.0 0.0	**TOPSOIL:** 125mm						
0.1	**CLAYEY SILT:** some sand, reddish brown, moist, stiff (weathered/disturbed)		1	SS	10		177
176.4							
0.8	**SILTY CLAY TILL:** some sand, trace gravel, reddish brown, moist, hard		2	SS	30		176
			3	SS	29		175
			4	SS	39		
			5	SS	50/ 100mm		174
172.6							173
4.6	**SHALE:** Queenston Formation, reddish brown, weathered		6	SS	50/ 125mm	W. L. 172.6 m Jan 18, 2018	
172.3							
4.9	**END OF BOREHOLE**						

Notes:
1) Borehole dry and open upon completion.
2) Monitoring Well installed upon completion.

Water Level Readings:

Date	Water Level (mbgs)
Nov. 16, 2017	dry
Jan. 9, 2018	4.6
Jan. 18, 2018	4.6
Jan. 24, 2018	4.6

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH (kPa)
○ UNCONFINED + FIELD VANE & Sensitivity
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

METHANE AND GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
3	20	57	20

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+3, ×3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

DS SOIL LOG PROJECT 508-10 - OAKVILLE-ARGO - GEO.GPJ DS.GDT 18-6-5

LOG OF BOREHOLE BH17-2R

PROJECT: Geotechnical Investigation- Proposed Residential Subdivision
CLIENT: Argo Development Corporation
PROJECT LOCATION: 3270 Sixth Line, Oakville, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1

DRILLING DATA
Method: Solid Stem Augers
Diameter: 150mm
Date: Nov-14-2017

REF. NO.: 508-10
ENCL NO.: 3

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION
176.2							
0.0 / 175.9	**TOPSOIL:** 300mm		1	SS	16		176
0.3 / 175.4	**CLAYEY SILT:** some sand, reddish brown, moist, stiff (weathered/disturbed)						
0.8	**SILTY CLAY TILL:** some sand, trace gravel, occasional cobble/boulder, reddish brown, moist, hard		2	SS	34		175
			3	SS	34		
			4	SS	38		174
			5	SS	60		173
171.6							172
4.6 / 171.2	**SHALE:** Queenston Formation, reddish brown, weathered		6	SS	50/ 75mm		
5.0	**END OF BOREHOLE** Notes: 1) Borehole dry and open upon completion.						

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH (kPa)
○ UNCONFINED + FIELD VANE & Sensitivity
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

METHANE AND GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

DS SOIL LOG PROJECT 508-10 - OAKVILLE-ARGO - GEO.GPJ DS.GDT 18-6-5

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+3, ×3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

LOG OF BOREHOLE BH17-3R

PROJECT: Geotechnical Investigation- Proposed Residential Subdivision
CLIENT: Argo Development Corporation
PROJECT LOCATION: 3270 Sixth Line, Oakville, ON
DATUM: Geodetic
BH LOCATION: See Drawing 1

DRILLING DATA
Method: Solid Stem Augers
Diameter: 150mm
Date: Nov-14-2017

REF. NO.: 508-10
ENCL NO.: 4

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
174.7												
174.5 0.2	**TOPSOIL:** 150mm											
	CLAYEY SILT: some sand, reddish brown, moist, stiff (weathered/disturbed)		1	SS	8		174					
173.9 0.8	**SILTY CLAY TILL:** some sand, trace gravel, occasional cobble/boulder, reddish brown, moist, hard		2	SS	38							
			3	SS	43		173					
172.4 2.3	**SHALE:** Queenston Formation, reddish brown, weathered		4	SS	50/ 75mm		172					
							171					
170.7 4.0	**END OF BOREHOLE** Notes: 1) Borehole dry and open upon completion.											

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: +3, ×3: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

DS SOIL LOG PROJECT 508-10 - OAKVILLE-ARGO - GEO.GPJ DS.GDT 18-3-13

LOG OF BOREHOLE BH17-4R

PROJECT: Geotechnical Investigation- Proposed Residential Subdivision
CLIENT: Argo Development Corporation
PROJECT LOCATION: 3270 Sixth Line, Oakville, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1

DRILLING DATA
Method: Solid Stem Augers
Diameter: 150mm
Date: Nov-14-2017

REF. NO.: 508-10
ENCL NO.: 5

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS "N" 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
174.7												
0.0 / 174.5	**TOPSOIL:** 200mm											
0.2 / 174.1	**CLAYEY SILT:** some sand, reddish brown, moist, stiff (weathered/disturbed)		1	SS	11							
0.6	**SILTY CLAY TILL:** some sand, trace gravel, occasional cobble/boulder, reddish brown, moist, hard		2	SS	42		174					5 15 56 23
1			3	SS	50/ 125mm		173					
2 / 172.4												
2.3	**SHALE:** Queenston Formation, reddish brown, weathered		4	SS	50/ 25mm		172					
3			5	SS	50 / no penetration							
4 / 170.4							171					
4.3	**END OF BOREHOLE** Notes: 1) Borehole dry and open upon completion.											

DS SOIL LOG PROJECT 508-10 - OAKVILLE-ARGO - GEO.GPJ DS.GDT 18-6-5

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

LOG OF BOREHOLE BH17-5R

PROJECT: Geotechnical Investigation- Proposed Residential Subdivision
CLIENT: Argo Development Corporation
PROJECT LOCATION: 3270 Sixth Line, Oakville, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1

DRILLING DATA
Method: Solid Stem Augers
Diameter: 150mm
Date: Nov-14-2017

REF. NO.: 508-10
ENCL NO.: 6

SOIL PROFILE (m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION
175.5 / 0.0	**TOPSOIL:** 300mm		1	SS	6		175
175.2 / 0.3	**CLAYEY SILT:** some sand, reddish brown, moist, stiff (weathered/disturbed)						
174.7 / 0.8	**SILTY CLAY TILL:** some sand, trace gravel, occasional cobble/boulder, reddish brown, moist, hard		2	SS	22		174
			3	SS	37		
			4	SS	50/ 125mm		173
172.4 / 3.1	**SHALE:** Queenston Formation, reddish brown, weathered		5	SS	50/ 100mm		172
171.8 / 3.7	**END OF BOREHOLE** Notes: 1) Borehole dry and open upon completion.						

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)
SHEAR STRENGTH (kPa) (20 40 60 80 100)
○ UNCONFINED + FIELD VANE & Sensitivity
● QUICK TRIAXIAL × LAB VANE

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%) (10 20 30)

POCKET PEN. (Cu) (kPa)
NATURAL UNIT WT (kN/m³)
METHANE AND GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+3, ×3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

LOG OF BOREHOLE BH17-6R

PROJECT: Geotechnical Investigation- Proposed Residential Subdivision
CLIENT: Argo Development Corporation
PROJECT LOCATION: 3270 Sixth Line, Oakville, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1

DRILLING DATA
Method: Solid Stem Augers
Diameter: 150mm
Date: Nov-14-2017

REF. NO.: 508-10
ENCL NO.: 7

SOIL PROFILE (m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
174.8												
0.0 / 174.7	**TOPSOIL:** 150mm											
0.2 / 174.0	**CLAYEY SILT:** some sand, reddish brown, moist, stiff (weathered/disturbed)		1	SS	9							
0.8 / 172.3	**SILTY CLAY TILL:** some sand, trace gravel, reddish brown, moist, hard		2	SS	37		174					
			3	SS	42		173					
2.5 / 171.7	**SHALE:** Queenston Formation, reddish brown, weathered		4	SS	50/ 25mm		172					
3.1	**END OF BOREHOLE** Notes: 1) Borehole dry and open upon completion.											

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+ 3, × 3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

LOG OF BOREHOLE BH17-7R

PROJECT: Geotechnical Investigation- Proposed Residential Subdivision
CLIENT: Argo Development Corporation
PROJECT LOCATION: 3270 Sixth Line, Oakville, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1

DRILLING DATA
Method: Solid Stem Augers
Diameter: 150mm
Date: Nov-15-2017

REF. NO.: 508-10
ENCL NO.: 8

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m
174.6					
0.0 / 174.4	**TOPSOIL:** 150mm				
0.2 / 173.8	**CLAYEY SILT:** some sand, reddish brown, moist, stiff (weathered/disturbed)		1	SS	8
0.8 / 171.1	**SILTY CLAY TILL:** some sand, trace gravel, occasional cobble/boulder, reddish brown, moist, hard		2	SS	36
3.6 / 171.0	**SHALE:** Queenston Formation, reddish brown, weathered				
3.6	**END OF BOREHOLE**				

Notes:
1) Borehole dry and open upon completion.
2) Monitoring Well installed upon completion.

Water Level Readings:

Date	Water Level (mbgs)
Nov. 16, 2017	dry
Jan. 9, 2018	dry
Jan. 18, 2018	2.5
Jan. 24, 2018	2.1

GROUND WATER CONDITIONS: W. L. 172.5 m Jan 24, 2018; W. L. 172.1 m Jan 18, 2018

ELEVATION: 174, 173, 171

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH (kPa) (20 40 60 80 100)
○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%) (10 20 30)

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

METHANE AND GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES: +3, ×3: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

DS SOIL LOG PROJECT 508-10 - OAKVILLE-ARGO - GEO.GPJ DS.GDT 18-6-5

LOG OF BOREHOLE BH17-1N

PROJECT: Geotechnical Investigation- Proposed Residential Subdivision
CLIENT: Argo Development Corporation
PROJECT LOCATION: 3270 Sixth Line, Oakville, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1

DRILLING DATA
Method: Solid Stem Augers
Diameter: 150mm
Date: Nov-14-2017

REF. NO.: 508-10
ENCL NO.: 9

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
174.4												
0.0 / 174.2	**TOPSOIL:** 200mm											
0.2 / 173.6	**CLAYEY SILT:** some sand, reddish brown, moist, stiff (weathered/disturbed)		1	SS	5		174					
0.8 / 172.1	**SILTY CLAY TILL:** some sand, trace gravel, reddish brown, moist, hard		2	SS	12		173					12 17 49 22
			3	SS	50/ 100mm							
2.3 / 170.1	**SHALE:** Queenston Formation, reddish brown, weathered		4	SS	50/ 125mm		172					
			5	NR	50/ no penetration		171					
4.3	auger refusal at 4.3m **END OF BOREHOLE** Notes: 1) Borehole dry and open upon completion.											

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: +3, ×3: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

DS SOIL LOG PROJECT 508-10 - OAKVILLE-ARGO - GEO.GPJ DS.GDT 18-6-5

LOG OF BOREHOLE BH17-2N

PROJECT: Geotechnical Investigation- Proposed Residential Subdivision
CLIENT: Argo Development Corporation
PROJECT LOCATION: 3270 Sixth Line, Oakville, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1

DRILLING DATA
Method: Solid Stem Augers
Diameter: 150mm
Date: Nov-15-2017

REF. NO.: 508-10
ENCL NO.: 10

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS / 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION
174.1							
0.0 / 173.9	**TOPSOIL:** 200mm						174
0.2 / 173.1	**CLAYEY SILT:** some sand, reddish brown, moist, stiff (weathered/disturbed)		1	SS	5		
1.0 / 171.8	**SILTY CLAY TILL:** some sand, trace gravel, reddish brown, moist, hard		2	SS	20	W. L. 172.9 m Jan 24, 2018	173
			3	SS	50/ 75mm		172
2.3 / 170.5	**SHALE:** Queenston Formation, reddish brown, weathered		4	SS	50/ 100mm	W. L. 171.6 m Jan 18, 2018	171
			5	SS	50/ 50mm		
3.6	**END OF BOREHOLE**						

Notes:
1) Borehole dry and open upon completion.
2) Monitoring Well installed upon completion.

Water Level Readings:

Date	Water Level (mbgs)
Nov. 16, 2017	dry
Jan. 9, 2018	dry
Jan. 18, 2018	2.5
Jan. 24, 2018	1.2

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH (kPa)
○ UNCONFINED + FIELD VANE & Sensitivity
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

METHANE AND GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

DS SOIL LOG PROJECT 508-10 - OAKVILLE-ARGO - GEO.GPJ DS.GDT 18-6-5

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+3, ×3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

LOG OF BOREHOLE BH17-3N

PROJECT: Geotechnical Investigation- Proposed Residential Subdivision
CLIENT: Argo Development Corporation
PROJECT LOCATION: 3270 Sixth Line, Oakville, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1

DRILLING DATA
Method: Solid Stem Augers
Diameter: 150mm
Date: Nov-15-2017

REF. NO.: 508-10
ENCL NO.: 11

SOIL PROFILE (m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
174.8												
0.0 / 174.8	**TOPSOIL:** 150mm											
0.2	**CLAYEY SILT:** some sand, reddish brown, moist, stiff (weathered/disturbed)		1	SS	12							
174.0							174					
0.8	**SILTY CLAY TILL:** some sand, trace gravel, reddish brown, moist, hard		2	SS	34							3 19 53 25
1			3	SS	50/ 125mm		173					
2			4	SS	50/ 125mm		172					
3 / 171.7												
3.1 / 171.4	**SHALE:** Queenston Formation, reddish brown, weathered		5	SS	50/ 25mm							
3.4	**END OF BOREHOLE** Notes: 1) Borehole dry and open upon completion.											

DS SOIL LOG PROJECT 508-10 - OAKVILLE-ARGO - GEO.GPJ DS.GDT 18-6-5

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: +3, ×3: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

LOG OF BOREHOLE BH17-1T

PROJECT: Geotechnical Investigation- Proposed Residential Subdivision
CLIENT: Argo Development Corporation
PROJECT LOCATION: 3270 Sixth Line, Oakville, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1

DRILLING DATA
Method: Solid Stem Augers
Diameter: 150mm
Date: Nov-15-2017

REF. NO.: 508-10
ENCL NO.: 12

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	ELEVATION
174.5					
0.0	150mm sand & gravel, brown, moist, over **FILL:** clayey silt to silty clay, trace to some organics, wood pieces, trace shale fragments, brown, moist, firm to stiff	1	SS	9	174
		2	SS	5	
		3	SS	8	173
172.2					
2.3	**SHALE:** Queenston Formation, reddish brown, weathered	4	SS	50/ 125mm	172
		5	SS	50/ 25mm	
170.2					
4.3	**END OF BOREHOLE** Notes: 1) Borehole dry and open upon completion. 2) Monitoring Well installed upon completion. 3) Borehole terminated on sound shale. Water Level Readings: Date Water Level (mbgs) Nov. 16, 2017 dry Jan. 9, 2018 3.3 Jan. 18, 2018 2.2 Jan. 24, 2018 1.1				

GROUND WATER CONDITIONS:
- W. L. 173.4 m Jan 24, 2018
- W. L. 172.3 m Jan 18, 2018
- W. L. 171.2 m Jan 09, 2018

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH (kPa) (20 40 60 80 100)
- ○ UNCONFINED
- ● QUICK TRIAXIAL
- + FIELD VANE & Sensitivity
- × LAB VANE

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%) (10 20 30)

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

METHANE AND GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

DS SOIL LOG PROJECT 508-10 - OAKVILLE-ARGO - GEO.GPJ DS.GDT 18-6-5

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

LOG OF BOREHOLE BH17-2T

PROJECT: Geotechnical Investigation- Proposed Residential Subdivision
CLIENT: Argo Development Corporation
PROJECT LOCATION: 3270 Sixth Line, Oakville, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1

DRILLING DATA
Method: Solid Stem Augers
Diameter: 150mm
Date: Nov-15-2017

REF. NO.: 508-10
ENCL NO.: 13

SOIL PROFILE (m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
174.4												
0.0	150mm sand & gravel, brown, moist, over **FILL:** clayey silt to sandy silt, trace to some organics, wood pieces, trace shale fragments, brown, moist, loose to compact		1	SS	11		174					
1			2	SS	9		173					
2			3	SS	5							
			4	SS	11		172		○			
3 171.3												
3.1 171.0	**SHALE:** Queenston Formation, reddish brown, weathered		5	SS	50/ 50mm		W. L. 171.3 m Nov 16, 2017					
3.4	**END OF BOREHOLE** Notes: 1) Borehole dry and open upon completion. 2) Monitoring Well installed upon completion. Water Level Readings: Date Water Level (mbgs) Nov. 16, 2017 3.1 Jan. 9, 2018 3.1											

DS SOIL LOG PROJECT 508-10 - OAKVILLE-ARGO - GEO.GPJ DS.GDT 18-6-5

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+ 3, × 3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

LOG OF BOREHOLE BH17-3T

PROJECT: Geotechnical Investigation- Proposed Residential Subdivision
CLIENT: Argo Development Corporation
PROJECT LOCATION: 3270 Sixth Line, Oakville, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1

DRILLING DATA
Method: Solid Stem Augers
Diameter: 150mm
Date: Nov-15-2017

REF. NO.: 508-10
ENCL NO.: 14

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS / 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION
174.3							
0.0	150mm sand & gravel, brown, moist, over		1	SS	9		174
	FILL: clayey silt to sandy silt, trace to some organics, wood pieces, trace shale fragments, brown, moist, loose to compact					W. L. 173.7 m Jan 24, 2018	
173.3			2	SS	40		
1.0	**SILTY CLAY TILL:** some sand, trace gravel, occasional cobble/boulder, reddish brown, moist, hard						173
172.8						W. L. 172.9 m Jan 18, 2018	
1.5	**SHALE:** Queenston Formation, reddish brown, weathered		3	SS	50/ 100mm		
171.4							172
2.9	**END OF BOREHOLE**		4	SS	50/ 125mm	W. L. 171.8 m Nov 16, 2017	

Notes:
1) Borehole dry and open upon completion.
2) Monitoring Well installed upon completion.

Water Level Readings:

Date	Water Level (mbgs)
Nov. 16, 2017	2.5
Jan. 9, 2018	dry
Jan. 18, 2018	1.4
Jan. 24, 2018	0.6

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH (kPa)
○ UNCONFINED + FIELD VANE & Sensitivity
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

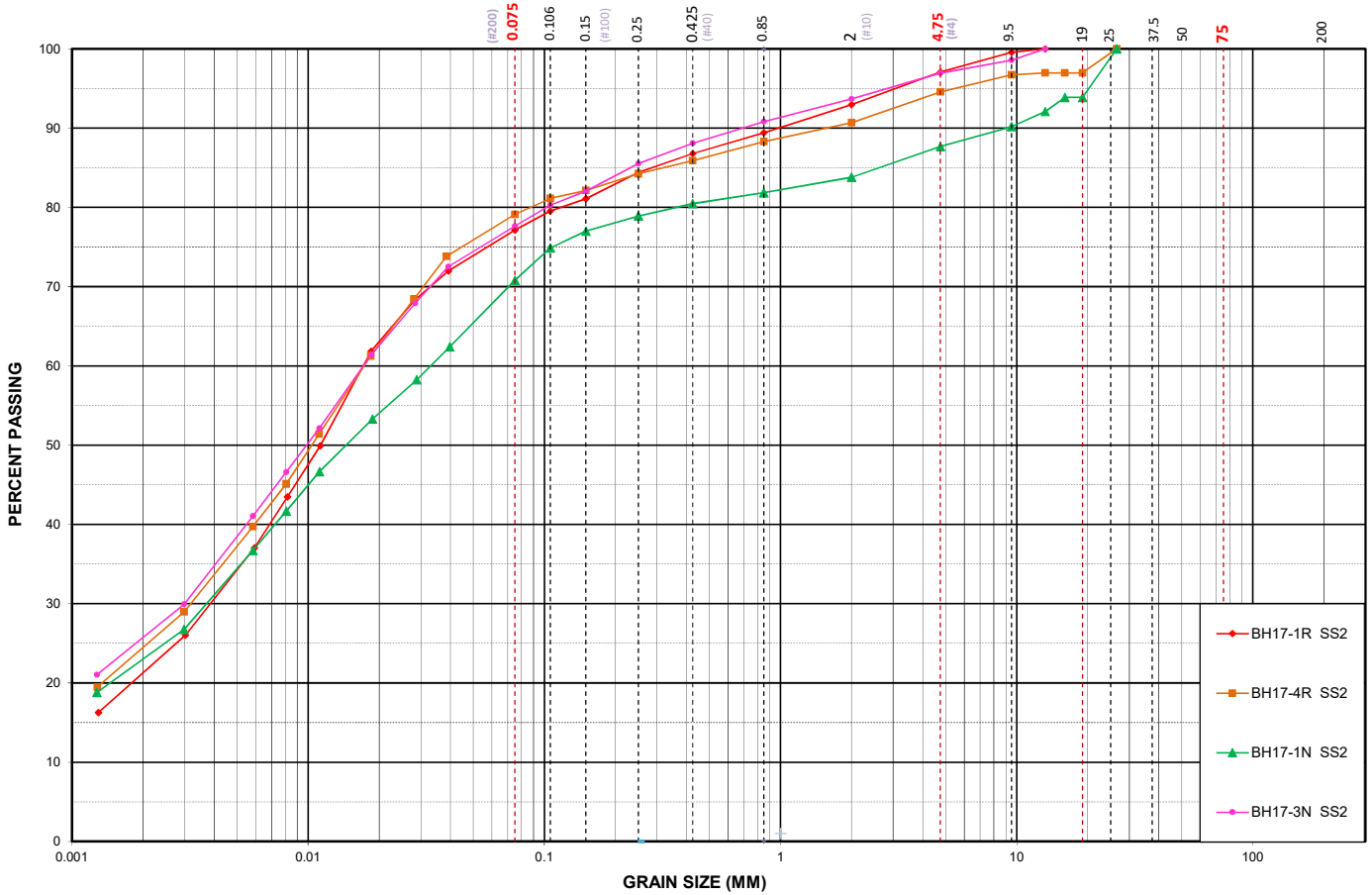
METHANE AND GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

DS SOIL LOG PROJECT 508-10 - OAKVILLE-ARGO - GEO.GPJ DS.GDT 18-6-5

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+3, ×3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

Particle Size Distribution (ASTM-D421/D422)



Silt and Clay		Sand			Gravel		Cobble +
Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	

Specification and Comments:

DS CONSULTANTS LTD.	Project:	**Proposed Low-rise Development**	Tested by :	Peng
	Project No.:	**508-10**	Date:	Jan-21-2018
	Location:	**3270 Sixth Line, Oakville, ON**	Figure No.:	15

Appendix A

General Requirements for Engineered Fill

GENERAL REQUIREMENTS FOR ENGINEERED FILL

Compacted imported soil that meets specific engineering requirements and is free of organics and debris and that has been continually monitored on a full-time basis by a qualified geotechnical representative is classified as engineered fill. Engineered fill that meets these requirements and is bearing on suitable native subsoil can be used for the support of foundations.

Imported soil used as engineered fill can be removed from other portions of a site or can be brought in from other sites. In general, most of Ontario soils are too wet to achieve the 100% Standard Proctor Maximum Dry Density (SPMDD) and will require drying and careful site management if they are to be considered for engineered fill. Imported non-cohesive granular soil is preferred for all engineered fill. For engineered fill, we recommend use of OPSS Granular 'B' sand and gravel fill material.

Adverse weather conditions such as rain make the placement of engineered fill to the required degree of density difficult or impossible; engineered fill cannot be placed during freezing conditions, i.e. normally not between December 15 and April 1 of each year.

The location of the foundations on the engineered fill pad is critical and certification by a qualified surveyor that the foundations are within the stipulated boundaries is mandatory. Since layout stakes are often damaged or removed during fill placement, offset stakes must be installed and maintained by the surveyors during the course of fill placement so that the contractor and engineering staff are continually aware of where the engineered fill limits lie. Excavations within the engineered fill pad must be backfilled with the same conditions and quality control as the original pad.

To perform satisfactorily, engineered fill requires the cooperation of the designers, engineers, contractors and all parties must be aware of the requirements. The minimum requirements are as follows; however, the geotechnical report must be reviewed for specific information and requirements.

1. Prior to site work involving engineered fill, a site meeting to discuss all aspects must be convened. The surveyor, contractor, design engineer and geotechnical engineer must attend the meeting. At this meeting, the limits of the engineered fill will be defined. The contractor must make known where all fill material will be obtained from and samples must be provided to the geotechnical engineer for review, and approval before filling begins.

2. Detailed drawings indicating the lower boundaries as well as the upper boundaries of the engineered fill must be available at the site meeting and be approved by the geotechnical engineer.

3. The building footprint and base of the pad, including basements, garages, etc. must be defined by offset stakes that remain in place until the footings and service connections are all constructed. Confirmation that the footings are within the pad, service lines are in place, and that the grade conforms to drawings, must be obtained by the owner in writing from the surveyor and DS Consultants Ltd (DSCL). Without this confirmation no responsibility for the performance of the structure can be accepted by DSCL. Survey drawing of the pre and post fill location and elevations will also be required.

4. The area must be stripped of all topsoil and fill materials. Subgrade must be proof-rolled. Soft spots must be dug out. The stripped native subgrade must be examined and approved by a DSCL engineer prior to placement of fill.

5. The approved engineered fill material must be compacted to 100% Standard Proctor Maximum Dry Density throughout. Engineered fill should not be placed during the winter months. Engineered fill compacted to 100% SPMDD will settle under its own weight approximately 0.5% of the fill height and the structural engineer must be aware of this settlement. In addition to the settlement of the fill, additional settlement due to consolidation of the underlying soils from the structural and fill loads will occur and should be evaluated prior to placing the fill.

6. Full-time geotechnical inspection by DSCL during placement of engineered fill is required. Work cannot commence or continue without the presence of the DSCL representative.

7. The fill must be placed such that the specified geometry is achieved. Refer to the attached sketches for minimum requirements. Take careful note that the projection of the compacted pad beyond the footing at footing level is a minimum of 2 m. The base of the compacted pad extends 2 m plus the depth of excavation beyond the edge of the footing.

8. A bearing capacity of 150 kPa at SLS (225 kPa at ULS) can be used provided that all conditions outlined above are adhered to. A minimum footing width of 500 mm (20 inches) is suggested and footings must be provided with nominal steel reinforcement.

9. All excavations must be done in accordance with the Occupational Health and Safety Regulations of Ontario.

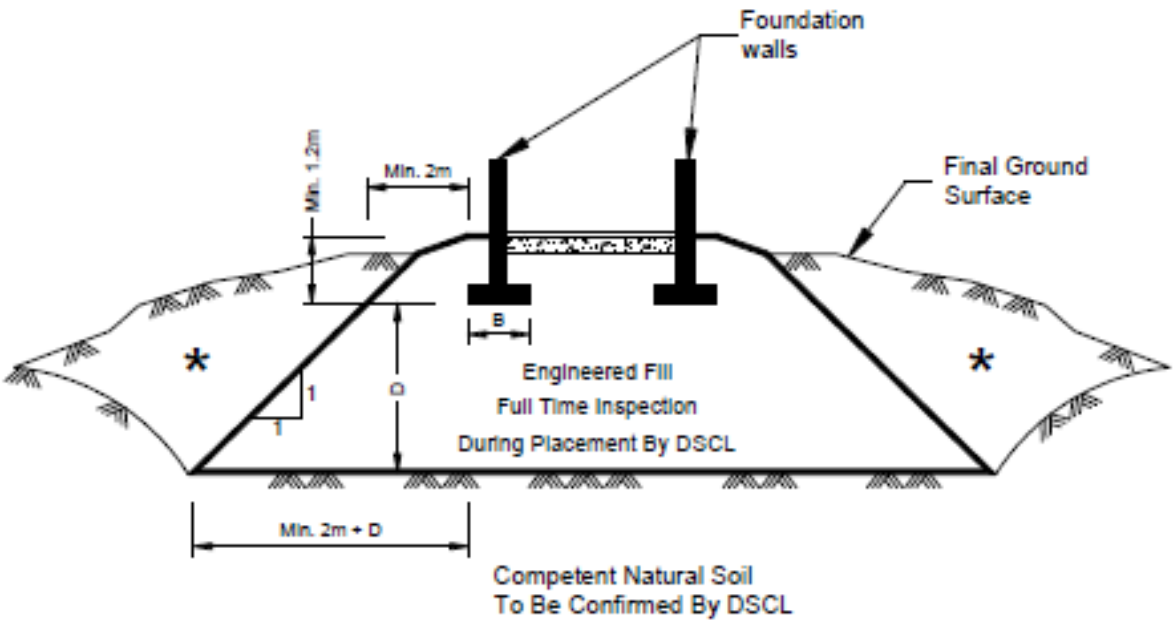
10. After completion of the engineered fill pad a second contractor may be selected to install footings. The prepared footing bases must be evaluated by engineering staff from DSCL prior to footing concrete placements. All excavations must be backfilled under full time supervision by DSCL to the same degree as the engineered fill pad. Surface water cannot be allowed to pond in excavations or to be trapped in clear stone backfill. Clear stone backfill can only be used with the approval of DSCL.

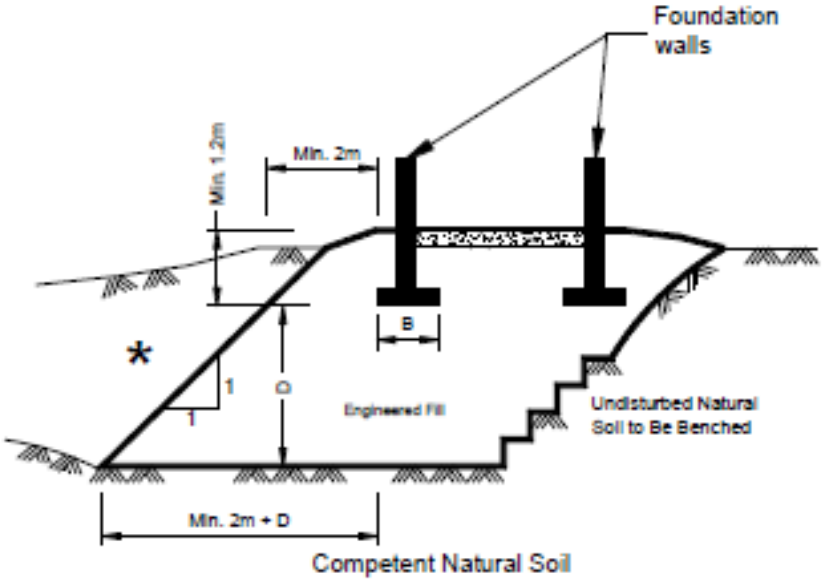
11. After completion of compaction, the surface of the engineered fill pad must be protected from disturbance from traffic, rain and frost. During the course of fill placement, the engineered fill must be smooth-graded, proof-rolled and sloped/crowned at the end of each day, prior to weekends and any stoppage in work in order to promote rapid runoff of rainwater and to avoid any ponding surface water. Any stockpiles of fill intended for use as engineered fill must also be smooth-bladed to promote runoff and/or protected from excessive moisture take up.

12. If there is a delay in construction, the engineered fill pad must be inspected and accepted by the geotechnical engineer. The location of the structure must be reconfirmed that it remains within the pad.

13. The geometry of the engineered fill as illustrated in these General Requirements is general in nature. Each project will have its own unique requirements. For example, if perimeter sidewalks are to be constructed around the building, then the projection of the engineered fill beyond the foundation wall may need to be greater.

14. These guidelines are to be read in conjunction with DS Consultants Ltd report attached.





* Backfill in this area to be as per the DSCL report.

Appendix B

General Comments on Shale Bedrock in GTA

General Comments – Bedrock in Greater Toronto Area

The bedrock that makes spread footings or caissons a popular choice for high-rise foundation support is a shale or shale limestone composition. The highest member, the Queenston Formation, is generally found west of Toronto, while the Georgian Bay Formation underlies most of Metro Toronto, with the Collingwood and Whitby Formations east of Toronto. The Queenston is, relatively speaking, the weaker of the four formations that are likely to support caissons or footings.

The Georgian Bay as well as the Queenston and Collingwood/Whitby Formation are of Middle Ordovician Age. It is defined as the rock unit that overlies the bluish grey shales of the Collingwood Formation and is in turn overlain by the red shale of the Queenston Formation. The Georgian Bay Formation consists of bluish and grey shale with interbeds of sandstone, limestone and dolostone. Towards the west where the Georgian Bay formation underlies the Queenston Formation, the limestone content increases significantly and limestone and/or sandstone may comprise as much as 70 to 90 percent of the bedrock. The hard layers are usually less than about 100 to 150 mm thick but some layers are much thicker. The thicker layers have been observed to be as much as 750 to 900 mm at some sites. The layers are actually lenses and they can vary significantly in thickness over short distances.

The upper portion of the bedrock is commonly weathered for a depth of 600 to 1000 mm and within this weathered zone hard limestone layers or lenses are common. These hard limestone layers can result in contractual problems for augers, and can provide misleading bedrock elevations. Where the weathering is more extensive a shale till layer may be found above the bedrock. In the sound bedrock, the limestone, sandstone, dolostone is hard to very hard.

Stress relief features such as folds and faults are common in the bedrock. In these features, the rock is heavily fractured and sheared, and contains layers of shale rubble and clay. Weathering is much deeper than the surrounding rock in these features and often there is a lateral migration of the stress relief features resulting in sound unweathered bedrock overlying fractured and weather bedrock. The stress relief features are usually in the order of 4 to 6 m wide, but the depth can vary from 4 to 5 m to in excess of 10 m. These features occur randomly.

The bedrock contains significant high locked in horizontal stresses. These stresses can impose significant loads on tunnel walls but the slower rate of construction for basements allows for a relaxation of these stresses and they are not normally a problem for basement construction.

Groundwater seepage below the top 1000 mm is generally small, however, at several locations in Toronto and Mississauga large quantities have been encountered.

Bedding joints in the bedrock are very close-to-close, smooth planar in the shale and rough planar in the limestone. Significant vertical jointing is common.

Where the bedrock was cored, a detailed description of the rock core is appended to the borehole log.

Design features related to the bedrock are discussed in other sections of this report, and these general comments must be considered with these comments.

Methane gas exists in the bedrock, normally below the top 1000 mm and more concentrated with depth. Appropriate care and monitoring is essential in all confined bedrock excavations, particularly caissons and tunnels.