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Geotechnical Investigation for a Proposed Development of a Commercial Property at 12476 Highway 50 Caledon, Ontario

Report # 5277 – BVD Caledon
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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

1.1 Proposed Construction

Mr. Bikram Dhillon representing BVD Petroleum (the Client), retained the services of A & A Environmental Consultants Inc. (A&A) to conduct a geotechnical investigation for a proposed development of a five-storey hotel building and parking lot on a property located on 12476 Highway 50, Caledon, Ontario. Five boreholes were to be advanced and sampled for this geotechnical investigation. The information obtained is used to provide recommendations that will allow for the design of foundations and pavements at the site. See Section 4.0 for additional details of the proposed development.

1.2 Purpose and Limitations of Report

The purpose of this study is to provide geotechnical information, recommendations and comments for the design and construction of the proposed development. The number of boreholes has been selected to provide representative information sufficient to determine parameters needed for design, specifications and construction of the proposed development. Conditions elsewhere near or beneath the footprint of the structures may be found to differ, during construction, from those at the borehole locations. Should this occur, the contractor should contact the design engineer for recommendations as how to best proceed and what changes if any, should be made.

The information in this report is intended for this specific proposed structure and has been prepared for the client, and their nominated engineers and designers. It is assumed that the designers will use all appropriate contemporary standards, governing regulations, and codes in the performance of their work. Third party use or reproduction, in part or in full, of this report is prohibited without written authorization from A&A. This report is also subject to the Statement of Limitations which from an integral part of this document.

1.3 Liaison during design and/or Construction

On-going liaison with A&A during the final design and construction phases of the project is recommended to confirm that they are in keeping with the intentions of this report.

2.0 SCOPE OF WORK

2.1 Proposed Scope of Work

The scope of work for the geotechnical investigation of the proposed development is as follows:

- Advance five boreholes to sample for geotechnical analysis. All five boreholes will be advanced to a maximum depth of 3.7 meters below ground level(mbgl).
- Submit select soil samples to a geotechnical laboratory to provide information for the soil samples recovered.
- Prepare a geotechnical report summarizing the results of the field investigation and laboratory testing program, to include discussion of specific concerns that need to be addressed during design and/or construction. Specifically, the report is to include:
    - Site plan showing locations of the boreholes;
    - Borehole records;
    - Recommendations for:
        - Site preparation;
        - Construction dewatering if required;
        - Earthworks;
        - Potential reuse of existing fill materials and/or native soils indicated in the boreholes;
        - Excavation requirements;
        - Geotechnical resistances for foundation designs at ULS and SLS conditions;
        - Lateral earth pressure coefficients for existing soils and typical imported materials;

3.0 SITE DESCRIPTION

3.1 Current Land Use and Location

The site is zoned as being, "CHB – Commercial Highway Bolton" as quoted from the Town of Caledon Zoning By-law 2006-50 and is located 12476 Highway 50, Caledon, Ontario (Figure 1, Appendix A). The approximate UTM coordinates of the site are Zone 17T; 603752 m Easting and 4856787 m Northing. The area inspected is rectangular in shape and is currently vacant.

3.2 Topography and Drainage

The topography of the subject site was observed to be generally flat, with a perceived gentle slope towards the east. It is recorded as approximately 236 meters above sea level (masl) (Figure 4). The area around the subject site ranges from approximately 230 masl southeast to 250 masl northwest. The subject site is within southeast Caledon with surface water expected to flow over the asphalted lot areas towards catchment basins located on the subject site and the surrounding roadways, as well as infiltrate the vegetated yard areas. In addition, surface water may also flow into the unnamed creek flowing east through the property.

The surface deposit in this region, like all of Ontario, was once covered by massive glaciers during the late Wisconsin glacial period. The grinding action of the moving ice masses produced a considerable amount of rock materials, ranging in size from boulders to rock flour which was distributed over the landscape.

The Ministry of Northern Development Mines and Forestry offers a feature for Google Earth ^{TM} that maps various geological types for Ontario:

- The “Paleozoic Geology of Southern Ontario” identifies the site to be within the Georgian Bay Formation, characterized by shale and limestone.
- The “Physiography of Southern Ontario” identifies the east corner of the site to be bevelled till plains in the Peel Plain Regions, with the western area of this site to be Till Plains (Drumlinized) in the South Slope Region.

- The “Quaternary Geology” identifies the site as Halton Till, characterized as being predominantly silt to silty clay matrix, high in matrix carbonate content and clast poor.
- The “Surficial Geology” identifies the site as Till, characterized by clay to silt-textured till (derived from glaciolacustrine deposits or shale).

4.0 PROPOSED DEVELOPMENT

It is understood that the proposed commercial property will consist of the following:

- A 1174 m^2 five-storey building, which will operate as a hotel;
- 118 parking spaces including five accessible parking spaces;
- There will be two access points to the subject site, one off of George Bolton Parkway, and one off of Highway 50.

The general arrangement of the proposed development is illustrated in Figure 3, Appendix A.

5.0 METHOD OF INVESTIGATION

5.1 Field Investigation

A&A engaged a utility locating company to map locations of public and private underground utilities. A&A then scheduled the drilling of boreholes for sampling in accordance with the borehole drilling and sampling plan.

The geotechnical investigation for the planned development consisted of the following activities:

- On February 11, 2020, A&A attended the site located at 12476 Highway 50, Caledon, Ontario.
- Boreholes were advanced using a track mounted drill unit with hollow stem augers. Split spoon samplers were used for standard penetration tests and to obtain soil samples from the boreholes. The stratigraphy in each borehole was recorded in the field at regular intervals and samples collected by the A&A personnel. See Table 1 for each borehole advanced depth and location. Figure 4 in Appendix A depicts the locations of the boreholes in relation to the proposed development. Samples submitted for analysis are to be representative of the boreholes and their location within the proposed development.
- All boreholes were used for geotechnical sampling. All geotechnical boreholes were refilled with low-permeability bentonite pellets.

Table 1 – Borehole Advanced Depths and Location

Borehole	Location	Depth (m)
BH-2	Southwest corner of the site	3.7
BH-3	Central west area of the site	3.7
BH-4	Central west boundary of the site	2.9
BH-5	Northwest portion of the site	2.2
BH-6	Central portion of the site	2.2

5.2 Sampling Procedures

Select samples recovered from the geotechnical investigation were submitted to Orbit Engineering Inc. (Orbit), a certified geotechnical and materials testing laboratory. The scope of the geotechnical laboratory testing program includes the following:

- In-situ water content per ASTM D2216;
- Grain size analyses per ASTM D422 & D2217;
- Atterburg Limits per ASTM 4318;

The results of the laboratory tests are discussed in the text of this report. The results of the moisture content tests are shown on the Borehole Records in Appendix B. The results of the grain size distribution tests are also shown on the borehole records (Appendix B) and are illustrated in Appendix C.

6.0 LABORATORY TESTING AND RESULTS OF INVESTIGATION

6.1 Subsurface Conditions Overview

The borehole logs provided in Appendix B summarize the soil types observed during drilling. Explanation of the symbols and terms used to describe the borehole records are also included in Appendix B.

Select bagged samples taken from the boreholes were analyzed at Orbit for natural moisture content, grain size analysis, and Atterberg limits.

It should be noted that the boundaries between the strata on the borehole records have been inferred from drilling observations and non-continuous sampling. The boundaries generally represent a transition from one soil type to another and should not be inferred to represent an exact plane of geological change. Further, conditions will vary between and beyond the boreholes.

The subsurface conditions encountered in the boreholes typically consist of a thin surface layer of topsoil. This is followed by a layer of silt, which extends between depths of 0.10 mbgl to 3.7 mbgl. The drilling program for this study indicates that the overburden deposits are consistent across boreholes at the approximate proposed foundations depth of 1.2 m.

All boreholes were terminated due to being below the depth of the intended foundation of each borehole location in reference to the site plan or due to drill refusal. The strength variations are detailed in the borehole logs in Appendix B.

The combination of lab results and standard penetration test N values (blows/foot) were then used to estimate geotechnical resistance values. This translation was based on generally accepted, recorded correlations from thousands of similar tests. Soil characteristics for each hole may be found in Appendices B & C.

6.2 Detailed Summary

All five boreholes revealed underlain the surface to be characterised as follows:

- **Layer 1 – Topsoil**

  All of the boreholes encountered a layer of topsoil at the ground surface. The thickness of the topsoil layer ranged from approximately 0 – 0.10 m. The topsoil was dark brown in colour, dry and had no odour in any of the boreholes.

- **Layer 2 – Silt**

  The topsoil is underlain with a native layer of silt from 0.10 to 3.7 mbgl. This was brownish gray in colour, moist and had no odour in any of the boreholes. There was an average of 20 to 30 blows/foot within this layer which is considered very stiff. All boreholes were terminated within this layer.

Atterberg limits testing was carried out on all five samples of this deposit and measured plasticity for all the samples. The liquid limit varied from 18.18% to 27.34%. The plastic limit varied from 23.66% to 34.10%. The plasticity index varied from 2.98% to 10.00%. The water content varied from 14.6% to 24.9%. Based on the results, all five of the boreholes are considered silt with low plasticity in nature.

6.3 Summary of Subsurface Conditions to Anticipated Depths of Construction

In the following tables (Tables 2–4), the relevant properties of the various deposits are briefly described. For details of the subsurface conditions, reference should be made to the individual borehole logs.

It should be noted that the soil boundaries indicated on the borehole logs are obtained from non-continuous sampling and observations during drilling. These boundaries reflect transition zones, for the purpose of geotechnical design, and should not be interpreted as exact planes of geological change. The "Notes on Sample Description" preceding the borehole logs are an integral part of and should be read in conjunction with this report.

Table 2 – Typical Values of Moisture Content

BH #	Depth (m)	Soil Description	Water Content (%)
BH-2	2.29 – 2.89	Silt, trace sand	18.5
BH-3	3.05 – 3.66	Silt, trace sand	16.8
BH-4	2.29 – 2.89	Silt	14.6
BH-5	1.52 – 2.13	Silt, trace clay, trace sand	15.5
BH-6	0.76 – 1.37	Silt, trace clay, trace sand	24.9

Table 3 – Typical Values of Atterburg Limits (%)

BH #	Depth (m)	Soil Description	Atterburg Limits		
			W_L	W_P	I_P
BH-2	2.29 – 2.89	Silt, trace sand	21.67	29.29	7.53
BH-3	3.05 – 3.66	Silt, trace sand	20.69	23.66	2.98
BH-4	2.29 – 2.89	Silt	22.44	30.31	7.87
BH-5	1.52 – 2.13	Silt, trace clay, trace sand	18.18	28.18	10.00
BH-6	0.76 – 1.37	Silt, trace clay, trace sand	27.34	34.10	6.76

Table 4 – Sieve and Hydrometer Analysis

BH #	Grain Size Content (%)				Sample Depth	Sample Description
	Gravel	Sand	Silt	Clay	m	
BH-2	---	1	99	---	2.29 – 2.89	Silt, trace sand
BH-3	---	1	99	---	3.05 – 3.66	Silt, trace sand
BH-4	---	---	100	---	2.29 – 2.89	Silt
BH-5	---	1	94	5	1.52 – 2.13	Silt, trace clay, trace sand
BH-6	---	1	94	5	0.76 – 1.37	Silt, trace clay, trace sand

6.4 Summary of SPT testing

Summary of the SPT test results for the variation of N values with depth is presented in Table 5. Based on the In-situ testing measurements, the silt soil of very stiff consistency ($15 < N < 30$) was observed within the zone of major stressing of foundations for the proposed development.

Table 5 – Variation of N value with Depth

Depth (mbgl)	SPT N-values (blows/300 mm penetration)				
	BH-2	BH-3	BH-4	BH-5	BH-6
0.0 to 0.46	30	10	11	11	2
0.76 to 1.22	48	19	26	34	20
1.52 to 1.98	96	29	58	74	50
2.29 to 2.74	89	61	78	----	----
3.05 to 3.35	>100	75	----	----	----

6.5 Groundwater Conditions

Groundwater and surface water are expected to flow towards the natural slope of the ground surface. The site is mostly flat with slight sloping towards the east boundary of the subject site. The groundwater table is inferred to be located approximately 1.3 to 5.4 mbgl. Groundwater levels are not anticipated to have stabilized during the short term of the investigation. Seasonal variations in the water table should be anticipated, with higher levels occurring during wet weather conditions and lower levels occurring during dry weather conditions.

Table 6 – Monitoring Well Details

Project #5277			Project Name: Geotechnical investigation, 12476 Hwy 50, Caledon, ON				
Date:2020-02-27			**Completed By: T. Thornton**				
MW#	**Pipe Size (mm)**	**Water Level (mbgl)**	**Total Depth (mbgl)**	**Volume in Well (L)**	**UTM Coordinates**	**T.O.P Elev. (masl)**	**Water level (masl)**
2	51	1.3	8.6	14.5	17T 603747 mE 4856743 mN	230.8	229.4
5	51	2.2	7.0	9.7	17T 603727 m E 4856796 mN	230.4	228.2
7	51	5.4	6.9	3.0	17T 603796 mE 4856796 mN	230.3	224.9
8	51	2.5	6.9	8.8	17T 603821 mE 4856848 mN	230.2	227.7
BM 230 masl							

7.0 DESIGN DISCUSSION AND RECOMMENDATIONS

7.1 General Considerations

The comments provided in this report are intended only for the guidance of engineers, architects and contractors with a good knowledge of geotechnical designs. The numbers of boreholes investigated are within the recommended number for small sites that show consistent sub surface characteristics. Contractors and/or subcontractors bidding on or undertaking the work should, in this light be reasonably assured that conditions will not vary significantly. They may seek permission from owners to access the site for their own type of investigations, as well may make their own interpretations of the factual borehole results contained in this report. The following general comments are provided with respect to the conditions encountered and the intended scope of development.

7.2 Foundation

BH-2, BH-3, BH-4, and BH-5 were advanced within the proposed five-storey hotel building. The conditions recorded in the boreholes indicate that footings founded at the prescribed elevation and lower would be constructed on hard cohesive soil with medium plasticity. The recommended geotechnical resistances for the building foundations are presented for Ultimate Limit State (ULS) and Serviceability Limit State (SLS) conditions.

The ultimate bearing capacity for a shallow foundation in the soil with the estimated shear strength parameters is calculated for a square footing with a minimum width of $B = 1\,m$. Factored geotechnical bearing resistance at ULS is calculated by applying the geotechnical resistance factor of $\Phi = 0.5$ for shallow foundation designs.

The proposed five-storey hotel building may be founded on the natural soil between 1.2 mbgl and 2.5 mbgl and designed for a geotechnical resistance of 140 kPa at SLS (assuming 25 mm of settlement) and factored ultimate bearing capacity of 230 kPa at ULS.

For any shallow structures, all exterior foundations and foundations in unheated areas must be provided with a minimum soil cover of 1.2 m or equivalent insulation for frost protection. The foundation depths recommended below are with respect to final grading levels. A perimeter drain tile, leading to an outward discharge, should be placed at the exterior face of the foundation wall where any high-water table can cause freeze thaw damage or unacceptable infiltration to the foundation.

Prior to pouring concrete for the footings, the footing subgrade should be cleaned of all deleterious materials such as topsoil, fill, softened, disturbed or caved materials, as well as any standing water. If construction proceeds during freezing weather conditions, adequate temporary frost protection for the footing bases and concrete must be provided. Native soils and engineered fill materials tend to weather rapidly and deteriorate on exposure to the atmosphere and surface water. Hence, foundation bases which remain open for an extended period of time should be protected by a skim coat of lean concrete. It is recommended that all excavated footing bases must be evaluated by a qualified geotechnical engineer to ensure that the founding soils exposed at the excavation base are consistent with the design bearing pressure intended by the geotechnical engineer.

The exposed subgrade should be proof-rolled to minimize differential settlement and to increase the bearing capacity. During the excavation, if loose material is found at the foundation level, the contractor is to remove all the loose material (until the dense soil is reached) and replace it with engineering fill granular material. Given this scenario, a conventional spread footing placed at this level should be founded on engineered fill if it is to have appropriate support. This engineered fill must consist of approved OPSS Granular B Type I (sand and gravel) materials compacted to 98% Standard Proctor Maximum Dry Density (SPMDD). A grade raise may be considered. If this is the case, the proof-rolled and compacted surface of the existing native soils will provide a satisfactory base for the placement and compaction of the engineered fill. Full-time supervision and in-situ density testing should be carried out by a geotechnical engineer during placement of engineered fill beneath all structures and settlement sensitive areas.

Backfilling of foundations shall be carried out with approved OPSS Granular B material provided. it can be placed in maximum 300 mm loose lifts and compacted to a minimum of 98% SPMDD. Filling should continue until the design subgrade elevations are obtained.

7.3 Slab-On-Grade Floor Using Engineered Fill

Prior to construction of the floor slab, all topsoil, construction debris and deleterious materials must be removed from the ground surface. The floor area should then be raised to within 200 mm underside of the floor slab using OPSS Granular B engineered fill or equivalent, placed in maximum 300 mm loose lifts and compacted to 98% SPMDD. To create a stable working surface and to distribute loadings, compacted OPSS Granular A or equivalent should be placed over the Granular B materials, below all floor slabs. The compacted OPSS Granular A or equivalent should be 200 mm thick at minimum, compacted to 100% SPMDD.

Floor slabs below unheated buildings or equipment should be provided with adequate insulation to prevent cracking from potential frost heave unless the compacted Granular A base is placed on clean limestone bedrock. A 100 mm thickness of high-density Styrofoam insulation, extending horizontally 1.8 m beyond the building/slab footprint, should be adequate to prevent frost heave where necessary.

For preliminary design, the module of vertical subgrade reaction (K_s) for granular material over the encountered subgrade materials is approximated to be $20\ MN/m^3$. This value should be modified by appropriate shape and depth factors to determine the vertical sub grade modulus (K_s) for slabs and bases.

7.4 Earthquake Design Parameters

The parameters for determination of the Site Classification for Seismic Site Response are set out in Table 4.1.8.4.A of the 2012 Ontario Building Code (OBC). The classification is based on the determination of the average shear wave velocity in the top 30 metres of the site stratigraphy, where shear wave velocity (V_s) measurements have been taken. In the absence of such measurements, the classification is estimated on the basis of empirical analysis of un-drained shear strength or penetration resistance. The applicable penetration resistance is that which has been corrected to a rod energy efficiency of 60% of the theoretical maximum or the (N_{60}) value.

Based on the SPT-N values from borehole information, the subsurface stratigraphy generally comprises of stiff soil. On this basis, the site designation for seismic analysis is Class D according to Table 4.1.8.4.A from the quoted code.

7.5 Lateral Earth Pressure on Walls

The structures should be designed to withstand lateral earth pressure using the following equation:

$$p = k(\gamma h + q)$$

Where p is lateral earth pressure, K is coefficient of lateral earth pressure assumed to be 0.5 for at-rest condition, γ is backfill unit weight assumed to be 20 kN/m^3, h is depth from the ground surface and q is surcharge at ground surface adjacent to the wall. The above expression assumes that backfill consisting of free-draining granular material with a drainage system to prevent the build-up of hydrostatic pressure behind the wall. The granular backfill should be compacted to at least 98% SPMDD, placed in maximum 200 mm lifts.

7.6 Groundwater Control

For foundation excavations extending below the groundwater level, it will be necessary to lower and maintain the groundwater level below the excavation base. As described in the section 6.5, the water levels would be located between approximately 1.3 to 5.4 mbgl. Therefore, the excavation area and foundation zone maybe be in a wet area depending on the seasonal conditions. Suitable dewatering technique should be employed to make the construction area dry. As the groundwater at the site may fluctuate seasonally it can be expected to be even higher in response to major precipitation events, no impact to the development is expected.

7.7 Site Grading and Engineered Fill Construction

Site grading operations involving "cut and fill" procedures in the order of ± 2 m are expected through the site. It is recommended to construct engineered fill in areas to be raised in order to suitably support the future roadway, infrastructure servicing and lightly loaded building structures.

It is noted that topsoil stripping operations should be conducted when the ground is not wet and will support large scale construction equipment. Over-stripping can result when the ground conditions are wet and unstable.

Inorganic onsite native soil deposits from potential "cut" areas may potentially be reused to construct engineered fill capable of supporting building structures, infrastructure servicing and future roadways. The natural moisture content of the "cut" soils to be used as engineered fill should be within 2% below their optimum moisture contents to achieve the specified degree of compaction.

Any shortfall of fill material required for site grading operations may be made with similarly graded imported soils for the various purposes described above. It is recommended that any proposed imported source materials be tested prior to importing, in order to ensure that the environmental quality of the imported fill meets all environmental approval criteria and to ensure that the natural moisture content of the fill is suitable for compaction.

It is recommended that engineered fill construction be conducted during the summer and early fall months when drier warmer weather conditions typically exist as the onsite soils are sensitive to moisture and will become difficult to handle and compact to the specified degree of compaction when wet.

The onsite deposits are frost-susceptible. Constructing engineered fill, backfilling footings, foundation walls and service trenches using these finer grained soils during the winter months is not advisable, unless suitable weather conditions prevail, the soils are at suitable moisture content, and strict procedures are followed and monitored on a full-time basis by the geotechnical engineer.

The onsite soils are susceptible to softening and deformation when exposed to excessive moisture and construction traffic. As a result, it is imperative that the grading/filling operations are planned and maintained to direct surface water run-off to low points and then be positively drained by suitable means. During periods of wet weather, construction traffic should be directed along the designated construction routes so as not to disturb and rut the exposed subgrade soil.

Temporary construction roads consisting of clear crushed material (such as crushed stone or recycled concrete) may be required during poor weather conditions such as a wet spring or fall.

7.8 Site Servicing

7.8.1 Excavation Conditions

It is anticipated that municipal water-main and sewer servicing will generally be in the range of 2 to 4 m below final design grades. Excavation side slopes should comply with the current "Regulations for Construction Projects under the Ontario Occupational Health and Safety Act". The native or re-compacted fill soils can be generally classified as Type 3 soils. Excavation in the Type 3 soils may be sloped not steeper than 1 vertical to 1 horizontal throughout. The excavation side slopes should be suitably protected from erosion processes. For the conventional excavation depth, it is not anticipated to encounter major water flow into the excavation. Should unstable and/or wet conditions be encountered, side slopes are to be flattened to a stable configuration. The geotechnical engineer should be retained to examine and inspect cut slopes to ensure construction safety.

7.8.2 Pipe Bedding

The native and re-compacted fill soil will generally provide suitable subgrade support to sewer and watermain servicing provided that the integrity of the base of the trench excavations can be maintained during construction. Any unsuitable soils exposed at the pipe subgrade should be sub-excavated and replaced with a minimum 150 mm bedding thickness of OPSS Granular A, compacted to at least 98% SPMDD. The bedding requirements for the services should be in accordance with Ontario Provincial Standard Drawings (OPSD) standards and the local town’s Standards. Granular "A" should be used to backfill around the pipe to at least 150 mm above the top of the pipe. From the springline to 300 mm above the obvert of the pipe, sand cover shall be used. Particular attention should be given to ensure material placed beneath the haunches of the pipe is adequately compacted.

7.8.3 Trench Backfill

Excavated inorganic materials are considered suitable for reuse as trench backfill. If necessary, potential mixing of drier and wetter excavated soils in proper ratios can be done to produce a suitable mixture at or near the optimum water content for compaction in order to achieve the required compaction specification. Conversely, judicious addition of water may be required if the soils are significantly drier than their optimum moisture content in order to facilitate suitable compaction.

Backfilling of service trenches under proposed pavement areas shall be carried out using approved imported soils or imported OPSS approved Granular B materials provided it can be placed in maximum 300 mm lifts and compacted to a minimum of 98% SPMDD. The onsite fill materials may not meet compaction requirements or may contain substantial amounts of silt or clay and therefore, are not considered suitable to be used as backfill. It is expected that most material will have to be imported. Materials such as organic soils, overly wet soils, boulders and frozen materials (if work is carried out in the winter months) should not be used for backfilling. Backfilling operations should follow closely after excavation so that only a minimal length of trench slope is exposed at any one time to minimize potential problems. This will potentially minimize over-wetting of the subgrade material. Particular attention should be given to make sure frozen material is not used as backfill should construction extend into the winter season.

Proctor compaction tests must show that the soil is capable of being compacted to a satisfactory density; results submitted to A&A for approval and then be delivered on site within 2% of its optimum moisture content. Materials that have been imported and approved for use that are stored onsite should be maintained within 2% of their optimum moisture content. They should also be protected from the weather with tarps.

7.8.4 Pavement Structures (Parking Areas and Access Roads)

It is our understanding from the proposed development that new driveways and parking areas will be constructed for this project. The subgrade for pavement structures is generally expected to consist of silty clay and potentially engineered fill. The recommended pavement structure is outlined in Table 7, based on the anticipated traffic volume and subgrade conditions. No traffic study was available at the time of this report, consequently, the recommended pavement structure should be considered for preliminary design purposes only.

It is assumed that pavement construction will be carried out under dry periods and the subgrade will be stable under the load of construction equipment. If the subgrade is unstable or wet, additional thickness of subbase course material may be required. It should be noted that the recommended pavement structure is not intended to support heavy construction vehicles such as concrete trucks. Consequently, heavy construction traffic should be limited to areas with suitable temporary access roads. The access roads shall consist of a minimum of 450 mm of stony Granular B material placed on a woven geogrid to preclude mixing of the subgrade into the Granular B. A surface coat of recycled asphalt shall be placed on the surface to provide a seal.

Table 7 – Minimum pavement structure requirements

Pavement layer	Thickness (mm)	Material
Surface Course Asphalt	40	OPSS H.L3
Binder Course Asphalt	65	OPSS H.L8
Base Layer	200	OPSS Granular A
Subbase Layer	250	OPSS Granular B

The granular base and sub-base layers should be uniformly compacted to 100% SPMDD. The asphalt materials should be compacted to a minimum of 92% of the Marshal Maximum Relative Density (MRD), as tested by using nuclear density gauge.

Prior to placing the pavement subbase layer, the subgrade should be prepared and heavily proof-rolled under the supervision of the geotechnical engineer. Any weak or soft areas encountered at the original surface must be further sub-excavated and replaced with suitable approved backfill compacted to 98 % SPMDD to provide uniform subgrade support condition. The subgrade should be compacted to 98 % SPMDD for at least the upper 500 mm. Stringent compaction and placement control procedures shall be maintained to ensure uniform subgrade moisture and density conditions are achieved.

It should be noted that even with well-compacted trench backfill, some settlement can be expected after construction. In this regard, surface course asphalt shall be placed at least one year after trench backfill is completed.

The finished pavement surface should be graded to promote runoff to designated surface drainage areas and catch basins. Subdrains should be installed to intercept excess subsurface moisture and prevent subgrade softening. To minimize problems of differential movement between the pavement and catch basins/manholes due to frost action, the backfill around the structures should consist of free draining granular. It is recommended to install longitudinal subdrain with positive drainage outlets at the subgrade level along the edges of the roadway construction. The subdrain stubs should be extended at least ten m from catch basins, along the uphill sides.

7.8.5 Curbs and Sidewalks

The concrete for any new exterior curbs and sidewalks should be proportioned, mixed, placed, and cured in accordance with the requirements of OPSS 353, OPSS 1350 and the municipality. During cold weather, the freshly placed concrete should be covered with insulating blankets to protect against freezing. The subgrade for the sidewalks should consist of undisturbed natural soil or well compacted fill. A minimum 100 mm thick layer of compacted (minimum 98 % SPMDD) Granular A is recommended below sidewalk slabs.

8.0 LIMITATIONS OF REPORT

This report has been prepared for Mr. Bikram Dhillon representing BVD Petroleum (the Client), who retained the services of A&A to conduct a geotechnical investigation for a proposed development of a five-storey hotel building on a property located at 12476 Highway 50, Caledon, Ontario. Further dissemination of this report is not permitted without A&A's prior written approval. A&A has carefully assessed all information provided to them during this investigation but makes no guarantees or warranties as to the accuracy or completeness of this provided information.

The comments given in this report are intended only for the guidance of design engineers and architects. Contractors bidding on or undertaking the work, should in this light, decide that further field investigations, and interpretations of the factual borehole results are necessary to draw their own conclusions as to how the subsurface conditions may affect them. Should soil conditions during excavation for the foundations prove to be different than what have been described in this report, the author of this report should be notified as soon as possible. No liability or claims may be made by owners or third parties against A&A for factors outside (A&A's) control. An independent quality control firm, such as Orbit, must be made available for all concrete and compaction testing associated with construction. All testing results should be made available to the owner, designers, consultant and general contractor.

The site investigation and recommendations follow generally accepted practice for Geotechnical Consultants in Ontario. Materials testing has been completed in accordance with ASTM or CSA Standards or modifications of these standards that have become standard practice.

LICENSED PROFESSIONAL ENGINEER
M.M.HEIDARI SARVESTANI
100521871
PROVINCE OF ONTARIO

March 6, 2020
Mehdi Heidari, Ph.D., P.Eng.

9.0 REFERENCES

Bowles, & E., J. (1996). *Foundation Analysis and Design.* McGraw Hill Inc.

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Sowers, G. (1979). *Introductory Soil Mechanics and Foundations: Geotechnical Engineering.* New York: MacMillan.

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APPENDIX A – Site Drawings

Figure 1 – Site Location Map for The Subject Site at 12476 Highway 50, Caledon, Ontario.

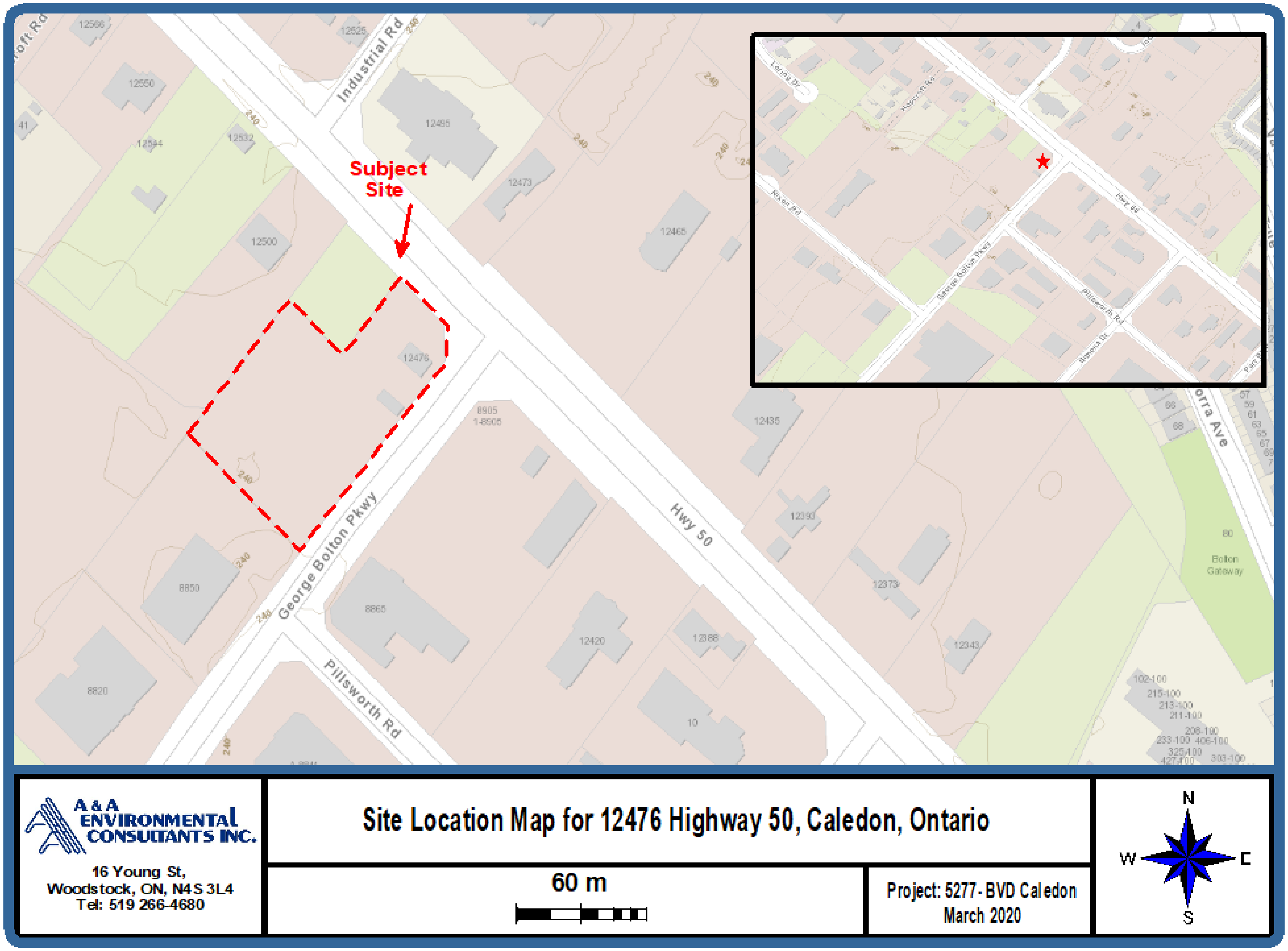
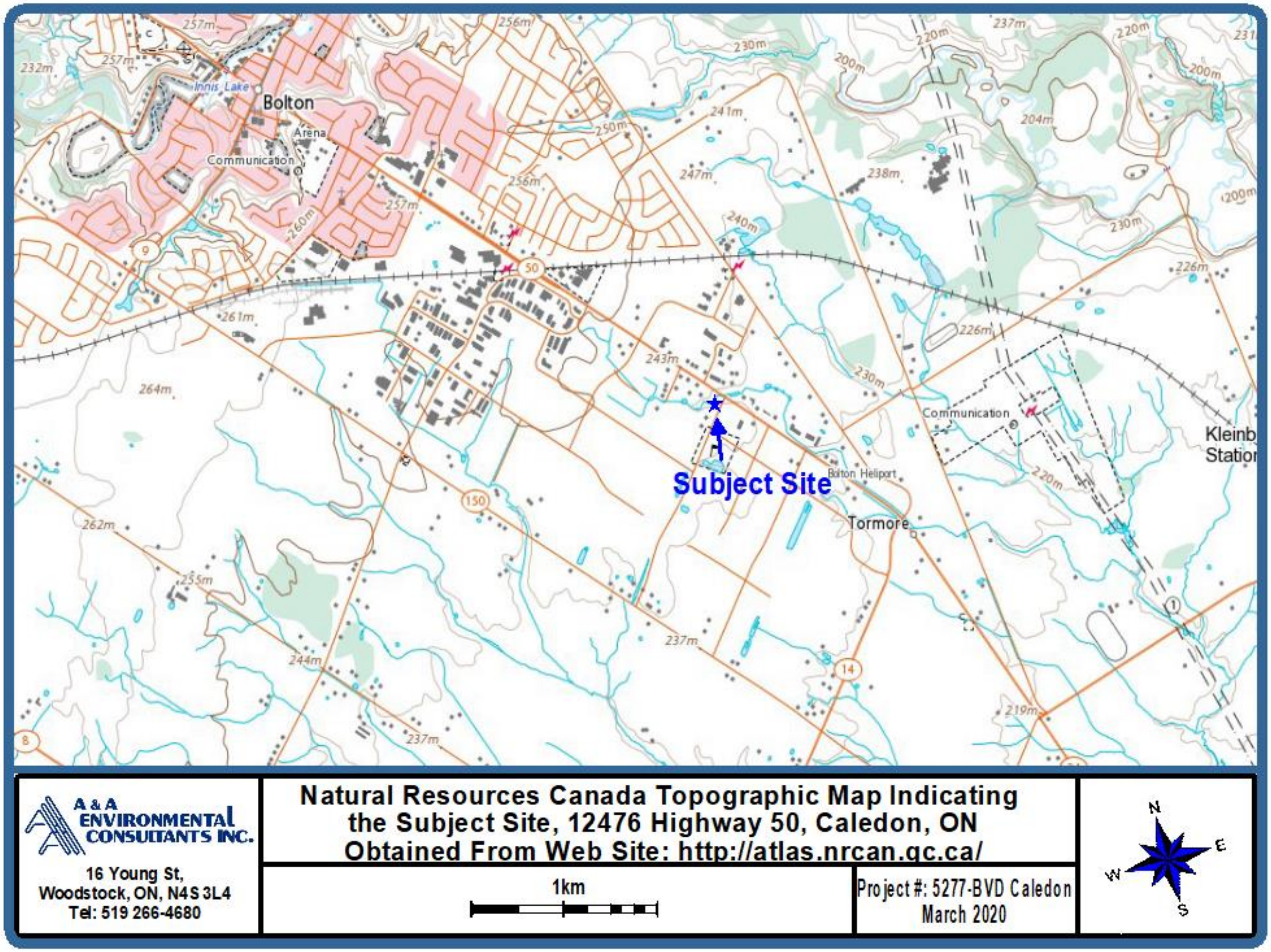


Figure 2 – Topographic Map of Subject Study Area



A & A ENVIRONMENTAL CONSULTANTS INC.

16 Young St,
Woodstock, ON, N4S 3L4
Tel: 519 266-4680

Natural Resources Canada Topographic Map Indicating the Subject Site, 12476 Highway 50, Caledon, ON
Obtained From Web Site: http://atlas.nrcan.gc.ca/

1km

Project #: 5277-BVD Caledon
March 2020

Figure 3 – Geotechnical Boreholes Location, Site Image

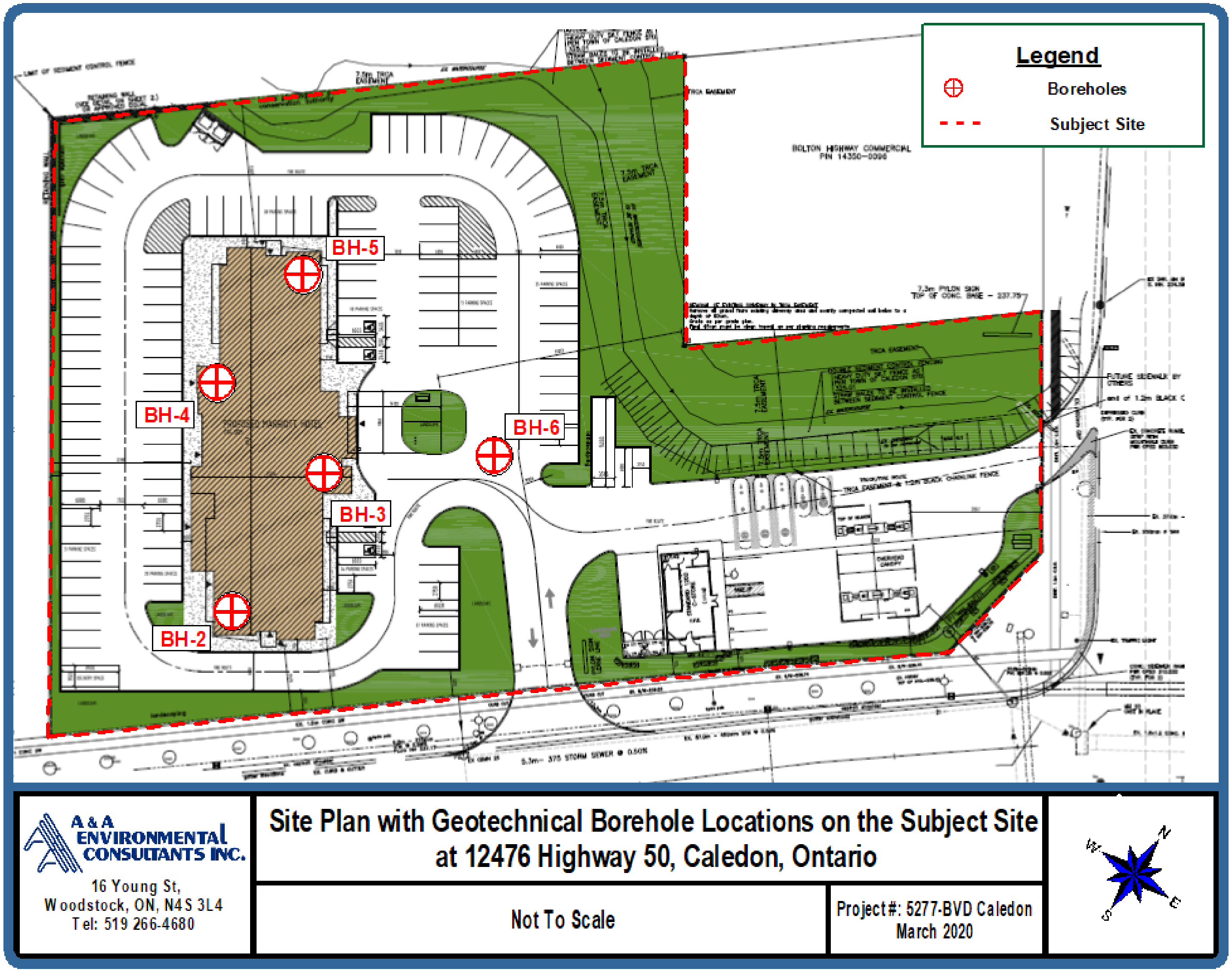


Figure 4 – Geotechnical Boreholes Location, Satellite Image

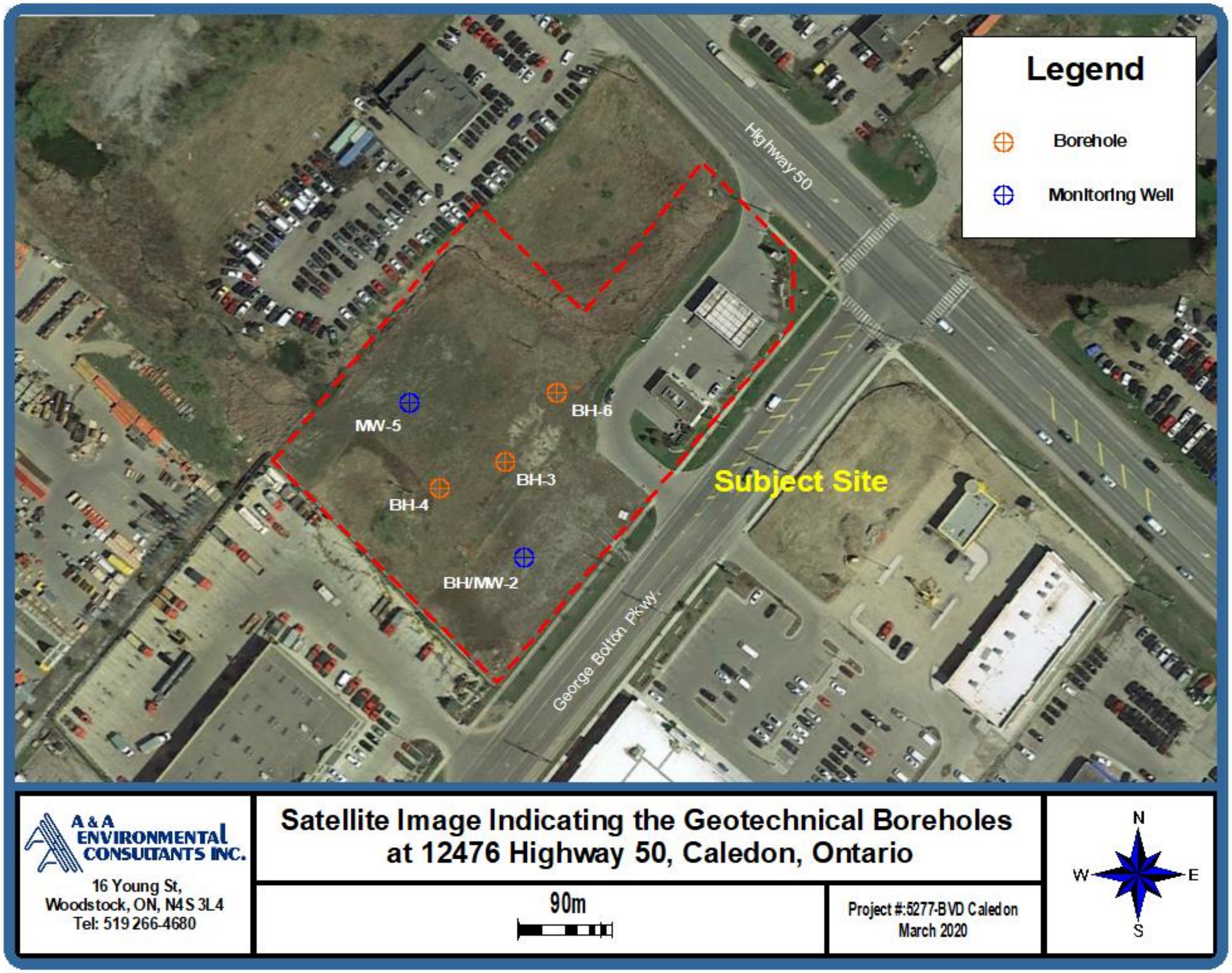
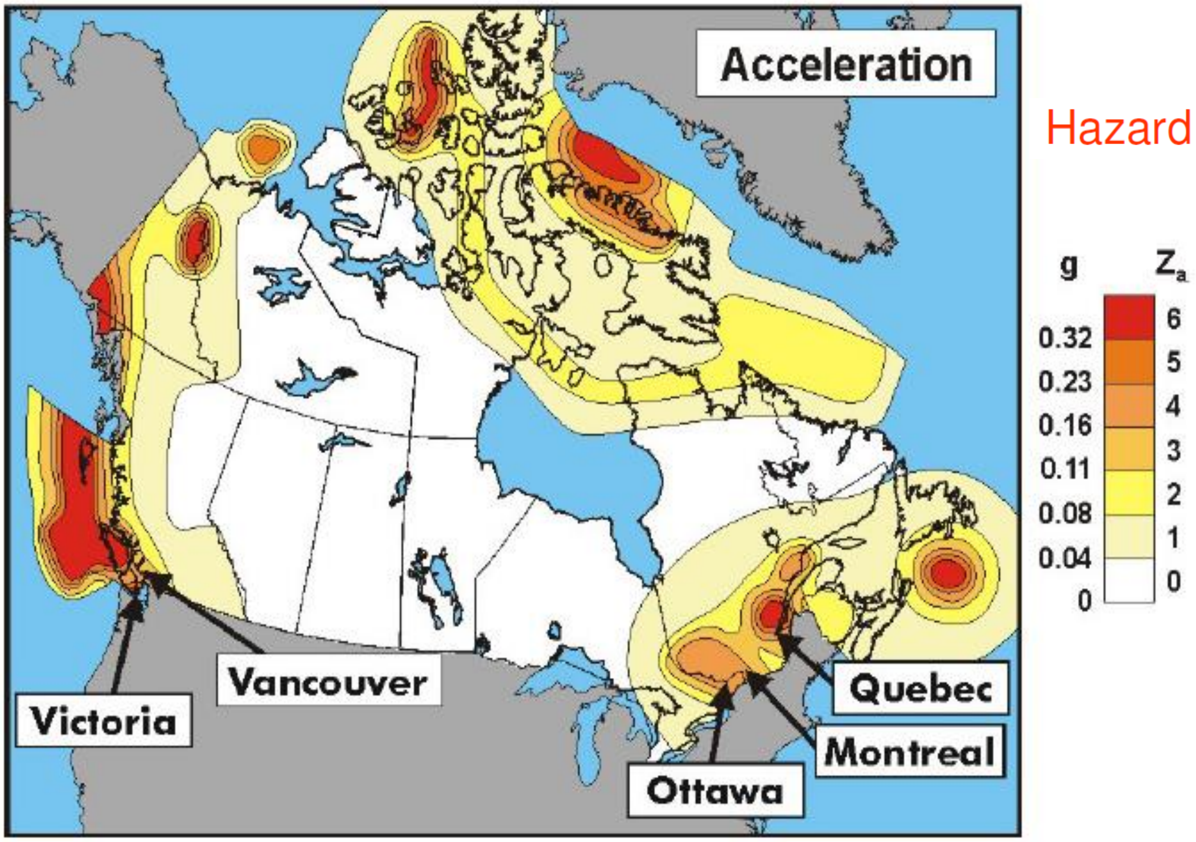


Figure 5 – Earthquake Zoning Hazards

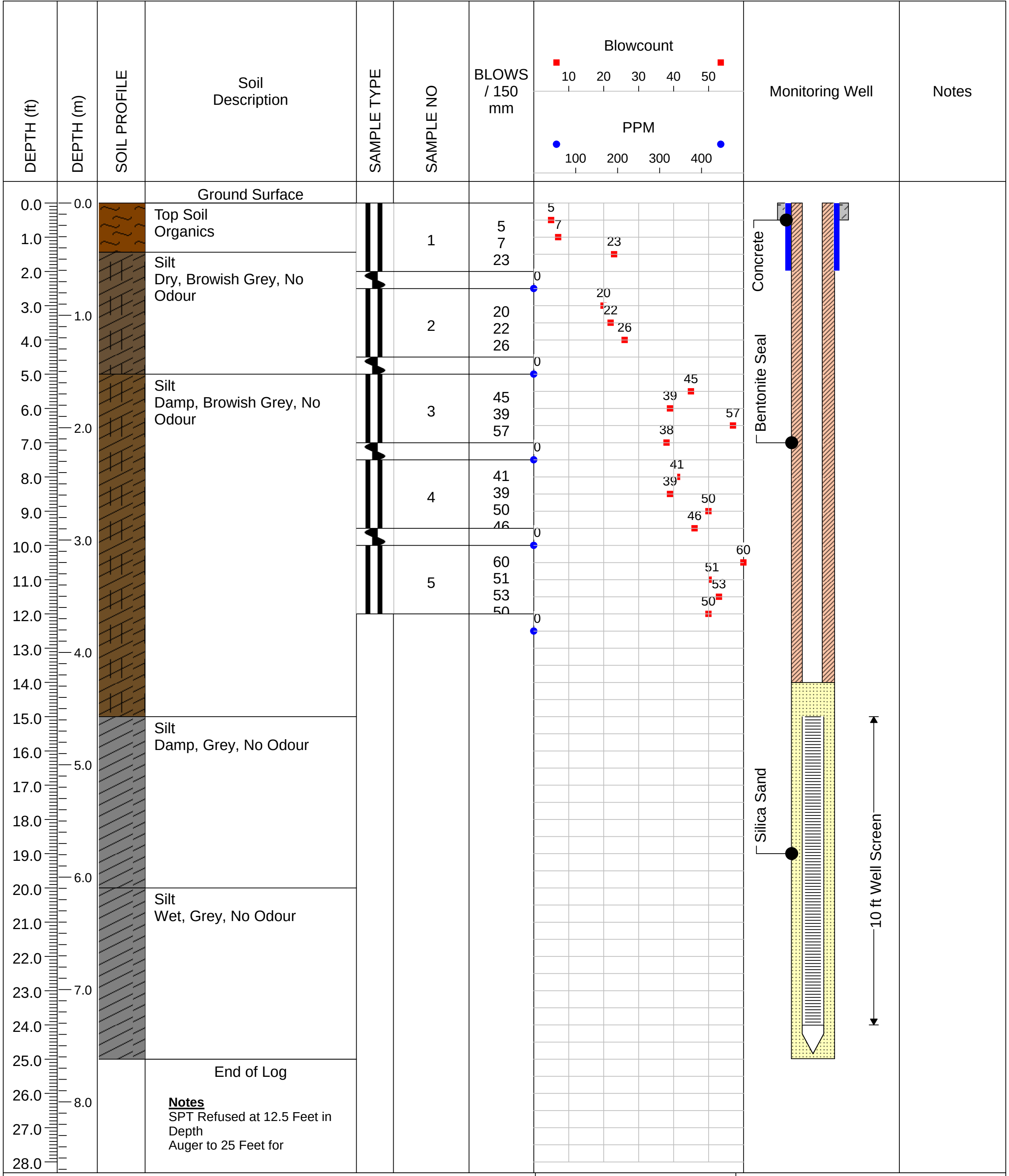


APPENDIX B – Borehole Logs and Explanation of Terms and Symbols

PROJECT: BVD Bolton	**BH LOCATION:** Southwest Corner of Site	**BOREHOLE NO: BH/MW-2**
PROJECT NO: 5276/5277	**LOCATION:** 12476 Highway 50, Bolton, ON	
PROJECT MANAGER: T. Demers	**COMPANY NAME:** A&A Environmental	

SAMPLE TYPE SHELBY TUBE CORE SAMPLE SPT SAMPLE GRAB SAMPLE NO RECOVERY

BACKFILL TYPE BENTONITE PEA GRAVEL SLOUGH GROUT DRILL CUTTINGS



Soil Description	SAMPLE NO	BLOWS / 150 mm
Ground Surface		
Top Soil Organics	1	5 7 23
Silt Dry, Browish Grey, No Odour	2	20 22 26
Silt Damp, Browish Grey, No Odour	3	45 39 57
	4	41 39 50 46
	5	60 51 53 50
Silt Damp, Grey, No Odour		
Silt Wet, Grey, No Odour		
End of Log		

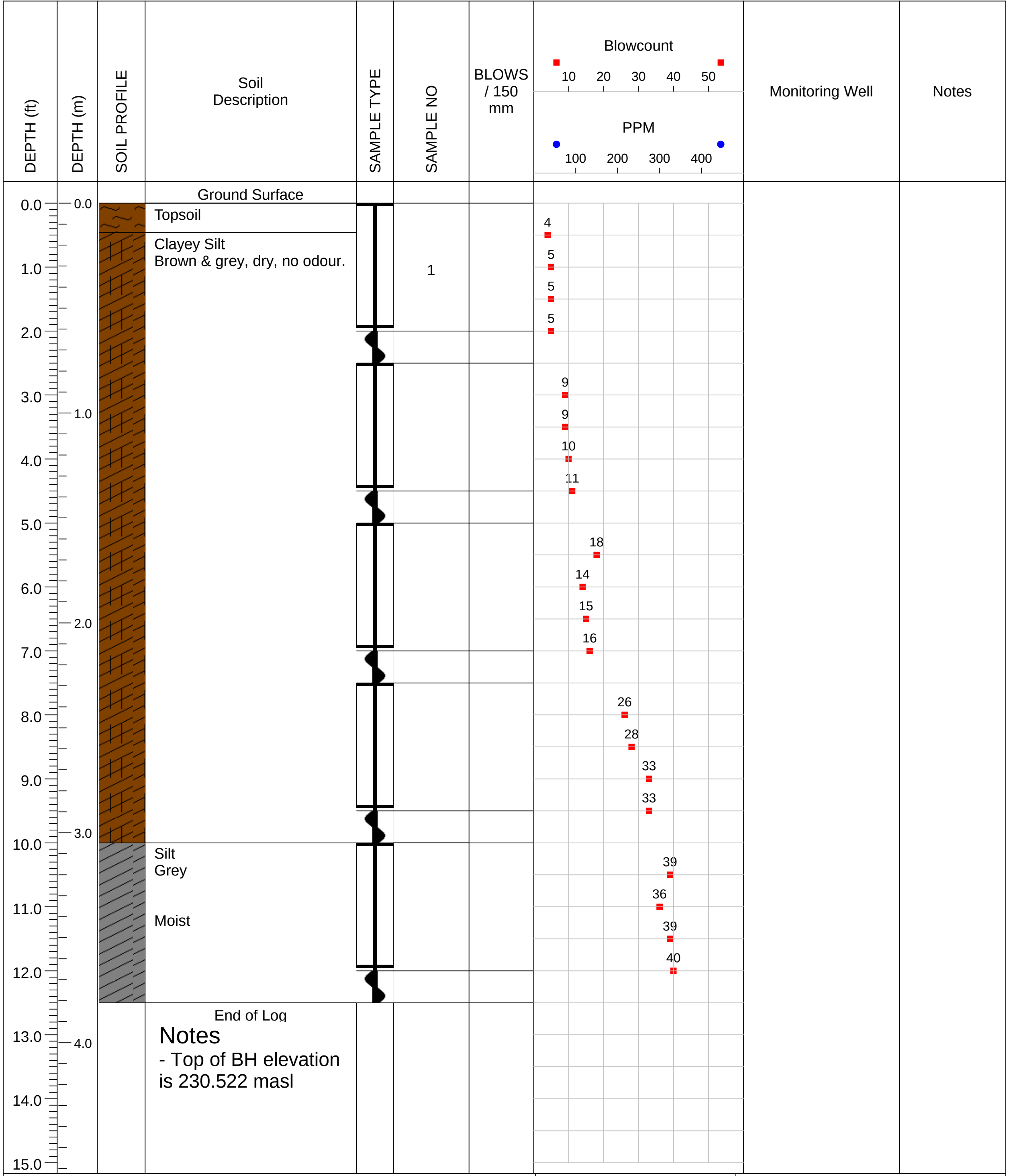
Notes
SPT Refused at 12.5 Feet in Depth
Auger to 25 Feet for

A & A ENVIRONMENTAL CONSULTANTS INC.
16 Young Street Woodstock, ON

LOGGED BY: T. Thornton	**COMPLETION DEPTH:** 25 Feet
REVIEWED BY: A. Rasoul	**DRILL METHOD:** SPT/Auger
DRILL DATE: Feb 11, 2020	**PAGE:** 1 of 1

PROJECT: BVD Bolton	**BH LOCATION:** Central west area of site	**BOREHOLE NO: BH3**
PROJECT NO: 5276/5277	**LOCATION:** 12476 Highway 50, Bolton, ON	
PROJECT MANAGER: T. Demers	**COMPANY NAME:** A&A Environmental	

SAMPLE TYPE	SHELBY TUBE	CORE SAMPLE	SPT SAMPLE	GRAB SAMPLE	NO RECOVERY
BACKFILL TYPE	BENTONITE	PEA GRAVEL	SLOUGH	GROUT	DRILL CUTTINGS



Ground Surface

Topsoil

Clayey Silt
Brown & grey, dry, no odour.

Silt
Grey

Moist

End of Log

Notes

- Top of BH elevation is 230.522 masl

A & A ENVIRONMENTAL CONSULTANTS INC.
16 Young Street Woodstock, ON

LOGGED BY: T. Thornton	**COMPLETION DEPTH:** 12.5 Feet
REVIEWED BY: A. Rasoul	**DRILL METHOD:** SP
DRILL DATE: Feb 11, 2020	**PAGE:** 1 of 1

PROJECT: BVD Bolton

BH LOCATION: Central west boundary of subject site

BOREHOLE NO: BH4

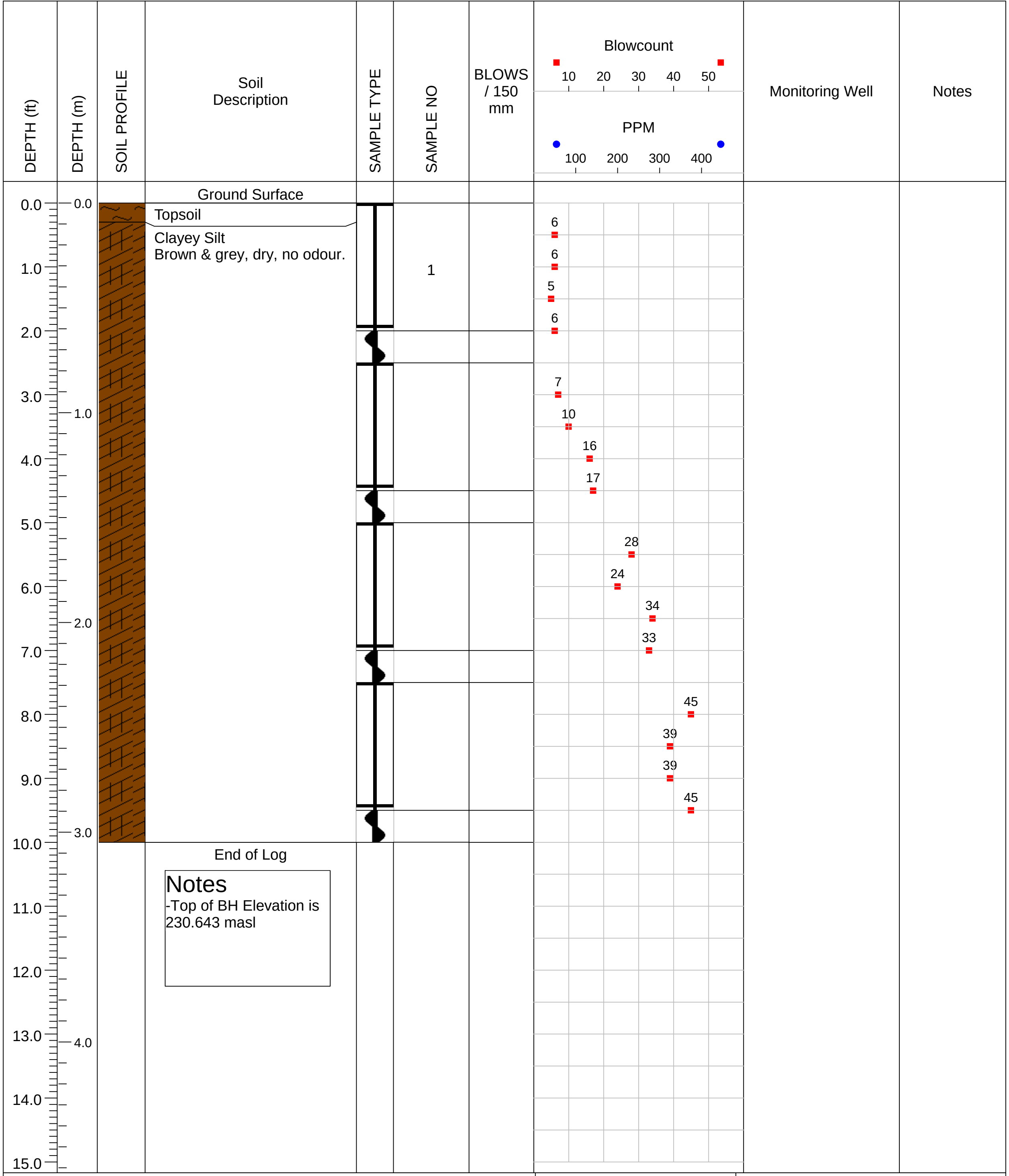
PROJECT NO: 5276/5277

LOCATION: 12476 Highway 50, Bolton, ON

PROJECT MANAGER: T. Demers

COMPANY NAME: A&A Environmental

SAMPLE TYPE	SHELBY TUBE	CORE SAMPLE	SPT SAMPLE	GRAB SAMPLE	NO RECOVERY
BACKFILL TYPE	BENTONITE	PEA GRAVEL	SLOUGH	GROUT	DRILL CUTTINGS



Depth (ft)	Blowcount
0.5	6
1.0	6
1.5	5
2.0	6
3.0	7
3.5	10
4.0	16
4.5	17
5.5	28
6.0	24
6.5	34
7.0	33
8.0	45
8.5	39
9.0	39
9.5	45

Notes
-Top of BH Elevation is 230.643 masl

A & A ENVIRONMENTAL CONSULTANTS INC.
16 Young Street Woodstock, ON

LOGGED BY: T. Thornton

COMPLETION DEPTH: 10 Feet

REVIEWED BY: A. Rasoul

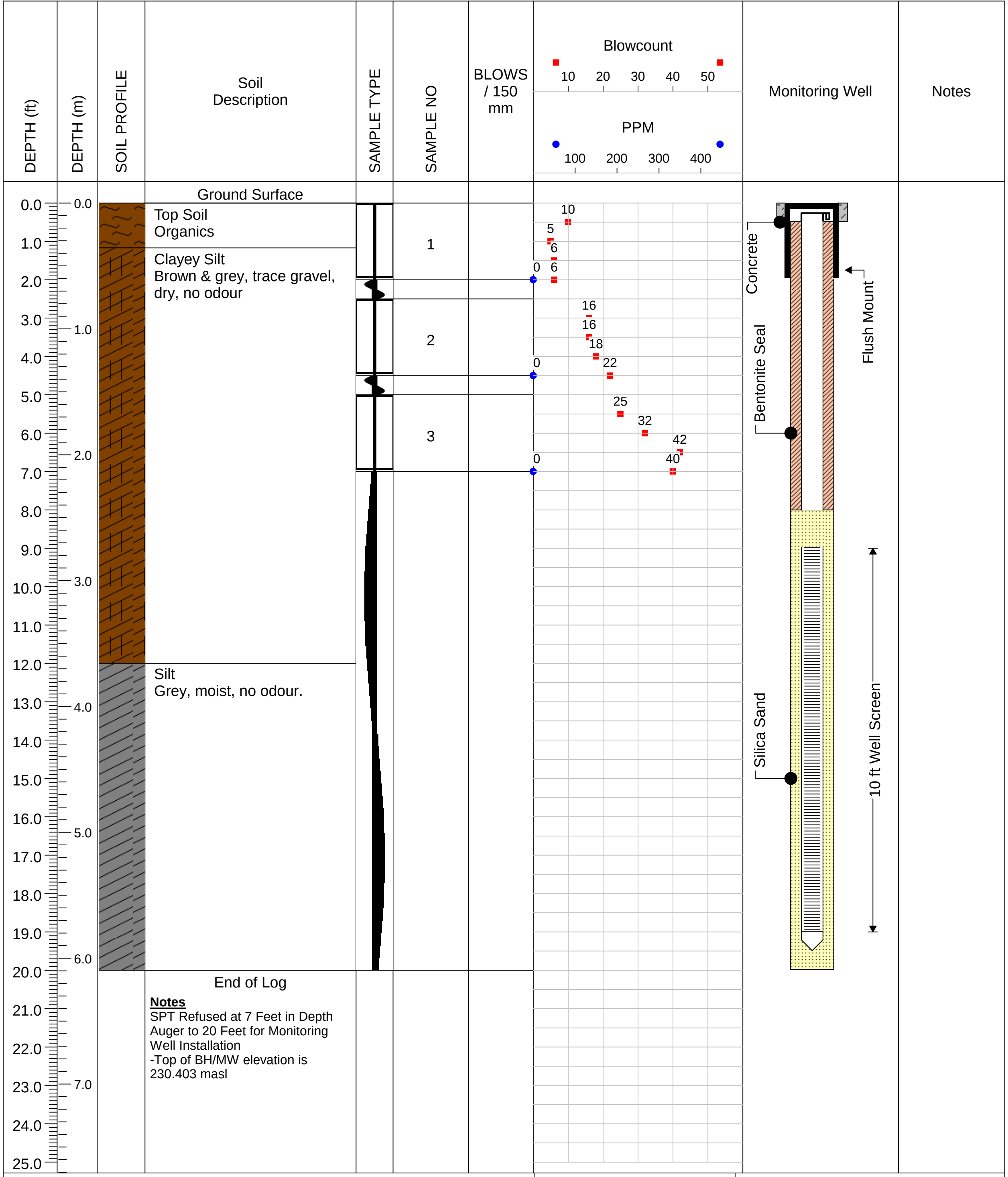
DRILL METHOD: SP

DRILL DATE: Feb 11, 2020

PAGE: 1 of 1

PROJECT: BVD Bolton	**BH LOCATION:** Northwest portion of subject site	**BOREHOLE NO: BH/MW-5**
PROJECT NO: 5276/5277	**LOCATION:** 12476 Highway 50, Bolton, ON	
PROJECT MANAGER: T. Demers	**COMPANY NAME:** A&A Environmental	

SAMPLE TYPE	SHELBY TUBE	CORE SAMPLE	SPT SAMPLE	GRAB SAMPLE	NO RECOVERY
BACKFILL TYPE	BENTONITE	PEA GRAVEL	SLOUGH	GROUT	DRILL CUTTINGS



Soil Description

Ground Surface

Top Soil
Organics

Clayey Silt
Brown & grey, trace gravel, dry, no odour

Silt
Grey, moist, no odour.

End of Log

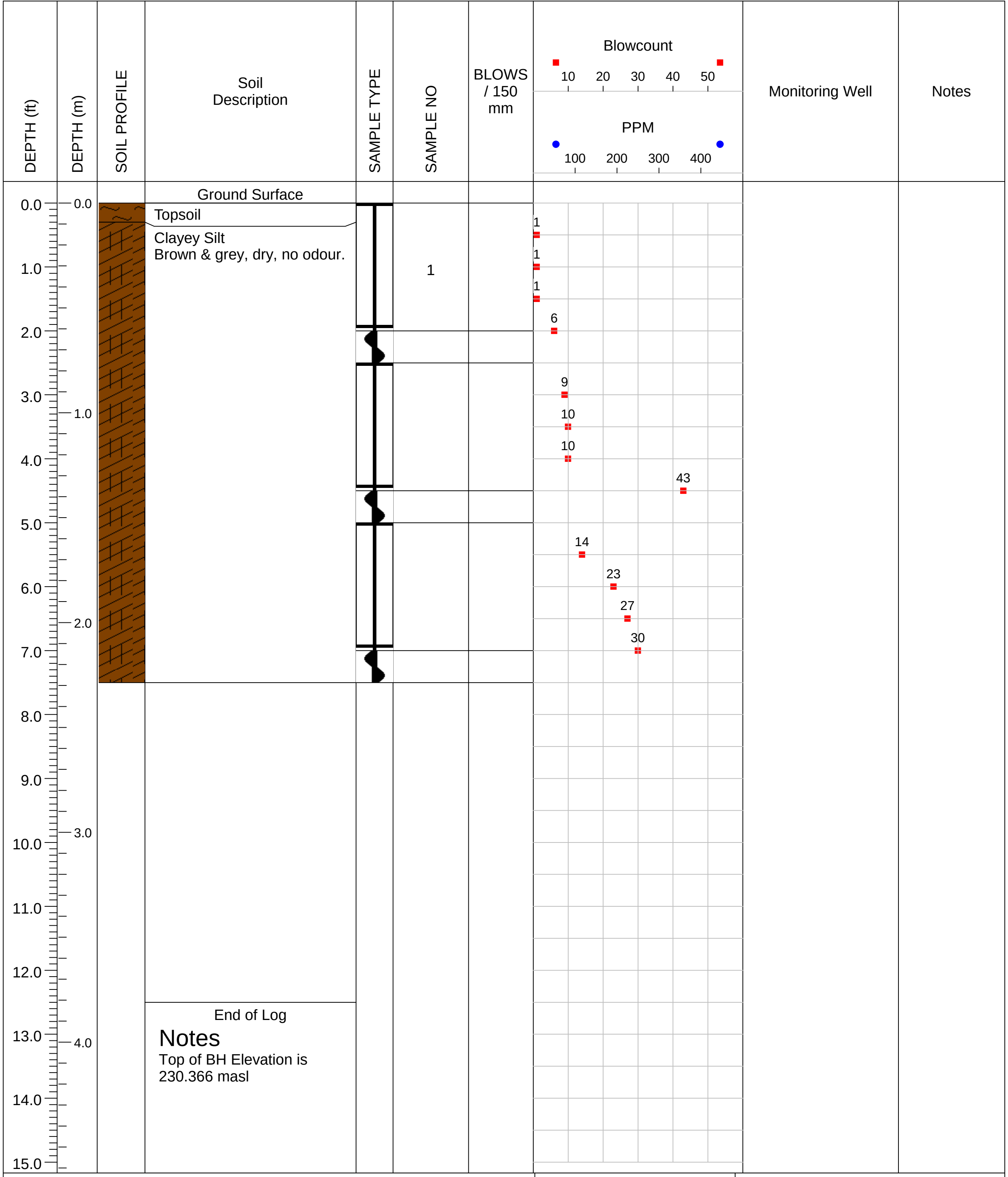
Notes
SPT Refused at 7 Feet in Depth
Auger to 20 Feet for Monitoring Well Installation
-Top of BH/MW elevation is 230.403 masl

A & A ENVIRONMENTAL CONSULTANTS INC.
16 Young Street Woodstock, ON

LOGGED BY: T. Thornton	**COMPLETION DEPTH:** 20 Feet
REVIEWED BY: A. Rasoul	**DRILL METHOD:** SPT/Auger
DRILL DATE: Feb 11, 2020	**PAGE:** 1 of 1

PROJECT: BVD Bolton	**BH LOCATION:** Central portion of subject site	**BOREHOLE NO: BH6**
PROJECT NO: 5276/5277	**LOCATION:** 12476 Highway 50, Bolton, ON	
PROJECT MANAGER: T. Demers	**COMPANY NAME:** A&A Environmental	

SAMPLE TYPE	SHELBY TUBE	CORE SAMPLE	SPT SAMPLE	GRAB SAMPLE	NO RECOVERY
BACKFILL TYPE	BENTONITE	PEA GRAVEL	SLOUGH	GROUT	DRILL CUTTINGS



Ground Surface

Topsoil

Clayey Silt
Brown & grey, dry, no odour.

End of Log

Notes

Top of BH Elevation is 230.366 masl

A & A ENVIRONMENTAL CONSULTANTS INC.
16 Young Street Woodstock, ON

LOGGED BY: T. Thornton	**COMPLETION DEPTH:** 7.5 Feet
REVIEWED BY: A. Rasoul	**DRILL METHOD:** SP
DRILL DATE: Feb 11, 2020	**PAGE:** 1 of 1

Explanation of Terms and Symbols

The terms and symbols used on the borehole logs to summarize the results of field investigation and subsequent laboratory testing are described in these pages.

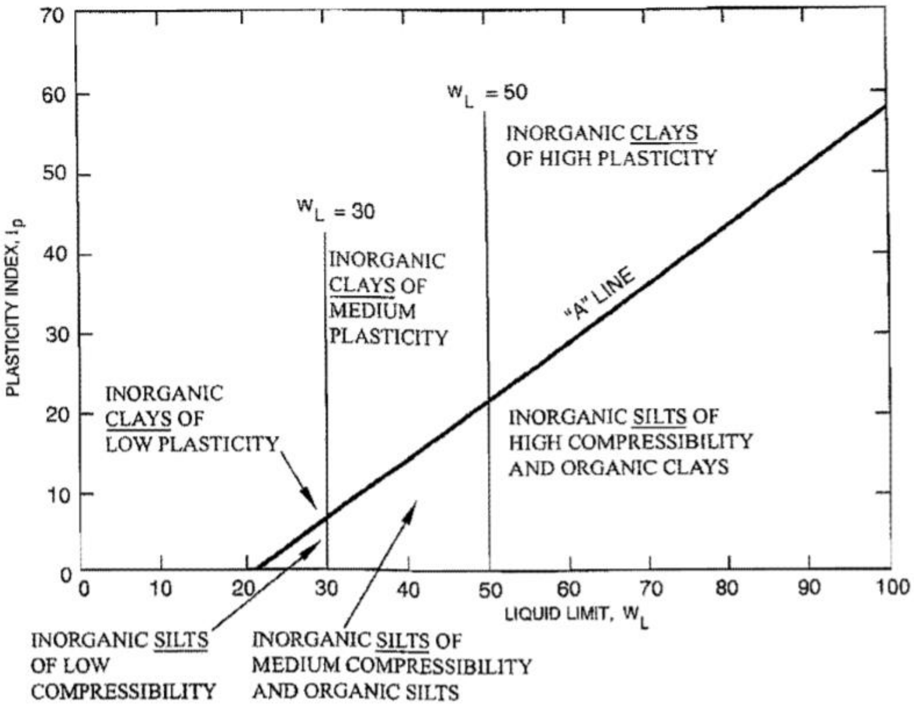
Abbreviations, graphic symbols and relevant test method designations are as follows:

w	Water Content
w_L, LL	Liquid Limit
w_p, PL	Plastic Limit
I_p	Plasticity Index
γ	Soil unit weight
K	Coefficient of Lateral earth pressure
K_s	Module of vertical subgrade reaction
p	Lateral earth pressure
q	Surcharge load
h	Depth from the ground surface
B	Width of rectangular footing
Φ	Geotechnical resistance factor
ϕ	Internal friction angle of soil
c	Cohesion
c_u, S_u	Undrained shear strength
V_s	Shear wave velocity
SPT-N	Penetration resistance
SPMMD	Standard Proctor Maximum Dry Density
MRD	Marshal Maximum Relative Density

Soils are classified and described according to their engineering properties and behaviours.

noun	gravel, sand, silt, clay	**> 35 % and main fraction**
"and"	and gravel, and silt, etc.	**>35 %**
adjective	gravelly, sandy, silty, clayey, etc.	**20 to 35 %**
"some"	some sand, some silt, etc.	**10 to 20%**
"trace"	trace sand, trace silt, etc.	**1 to 10 %**

The plasticity chart (after Casagrande, 1948):



Correlation of soil parameters with uncorrected SPT values for: a) cohesionless soils and b) cohesive soil

Compactness Condition	SPT N-INDEX (blows per 0.3 m)
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	>50

(a)

Consistency	Undrained Shear Strength (kPa)	SPT N-INDEX (blows per 0.3 m)
Very soft	< 12	0 to 2
Soft	12 - 25	2 to 4
Firm	25-50	4 to 8
Stiff	50 - 100	8 to 15
Very stiff	100 - 200	15 to 30
Hard	>200	>30

(b)

- *Standard Penetration Tests (SPT); followed the methods described in ASTM Standard D1586-08a. The number of blows by a 63.5 kg (140 lb) hammer dropped from 760 mm (30 in.) is recorded for a depth of 460 mm (18"). The last two 150 mm distances (total = 300 mm) are used to calculate the SPT-N index.*

APPENDIX C – Grain Size Distribution and Test Results

Orbit Engineering Limited
1900 Clark Boulevard, Unit 9
Brampton, ON, L6T 0E9
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Fax: +1 855 666 3355
www.orbitengineering.ca,
info@orbitengineering.ca

GEOTECHNICAL TESTING REPORT DATA

5277 – BVD BOLTON, ON

Prepared for:

A & A ENVIRONMRNTAL CONSULTINGS INC.

By:

Orbit Engineering Limited

Project No. OE201046AG

February 21, 2020

ORBIT ENGINEERING
Consulting Engineers

Orbit Engineering Limited
1900 Clark Boulevard, Unit 9
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info@orbitengineering.ca

February 21, 2020

A&A Environmental Consultants
16 Young Street
Woodstock, Ontario
N4S 3L4
Email: tdemers@aaenvironmental.ca

Attention: **Mr. Thomas Demers, BASc. (Hons. Env.), EIT - Project Manager**

RE:

LABORATORY TEST RESULTS - Project: 5277 – BVD Bolton, ON

Dear Mr. Thomas,

Orbit Engineering Limited (Orbit) is pleased to provide the Final LABORATORY TESTING REPORT DATA for the above-mentioned project. The report presents the results of laboratory testing carried out on soil samples received at Orbit Laboratory on Feb 18th, 2020.
The laboratory testing included the following:

1. Water Moisture Content - ASTM D2216;
2. Particle Size Analysis (Hydrometer) - ASTM D422 - D2217
3. Atterberg Limits - ASTM 4318.

The results of the testing are summarized in the attached Table 1 and details of testing results are shown in Appendix **A**.

We trust that this information meets your present requirements. If we can be of additional assistance in this regard, please contact this office.

For and on behalf of Orbit Engineering Limited,

Aly Ahmed

Aly Ahmed, Ph D, P.Eng.,
Lab Supervisor

Hafiz Muneeb Ahmad, M.Sc.,P.Eng.,
Principal Engineer
Professional Supervising Engineer

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1900 Clark Boulevard, Unit 9
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Table 1: Summary of Laboratory Testing Results (A & A Project: 5277 – BVD Bolton, ON)

Sample No.	Depth (ft)	Water Content (%)	Atterberg Limits (%)			Soil Compositions (%)				Soil Description
			LL	PL	PI	Gravel	Sand	Silt	Clay	
BH 2	7.5 – 9.5	18.5	21.67	29.29	7.53	--	1	99	--	Silt, trace sand
BH 3	10 -12	16.8	20.69	23.66	2.98	--	1	99	--	Silt, trace sand
BH 4	7.5 - 9.5	14.6	22.44	30.31	7.87	--	--	100	--	Silt
BH 5	5 - 7	15.5	18.18	28.18	10.00	--	1	94	5	Silt, trace clay, trace sand
BH 6	2.5 - 4.5	24.9	27.34	34.10	6.76	--	1	94	5	Silt, trace clay, trace sand

CLOSURE

We trust that this information is satisfactory for your present requirements. Should you have any questions or require additional information, please do not hesitate to contact this office.

For and Behalf of Orbit Engineering Limited,

Majid Touqan, EIT
Lab Operator

Aly Ahmed, Ph D., P.Eng.
Aly Ahmed
Lab Supervisor

Reviewed by:

Hafiz Muneeb Ahmad, M.Sc.,P.Eng.
Principal Engineer
Professional Supervising Engineer

Appendix A

ORBITENGINEERING

NATURAL MOISTURE CONTENT

LABORATORY SERVICES

LS - 703

Project No.: **5277- BVD Bolton**

Operator: Majid Touqan

Borehole No. BH2-BH6

Date 21/02/2020

NATURAL MOISTURE CONTENT				
Sample No.	**Weight of tare (g)**	**Weight of tare + soil (g)**	**Weight of tare + soil (dry) (g)**	**Moisture content (%)**
BH2	24.87	102.56	90.41	18.5
BH3	26.04	119.52	106.05	16.8
BH4	24.38	96.94	87.69	14.6
BH5	23.49	99.97	89.72	15.5
BH6	26.19	116.74	98.7	24.9

Aly Ahmed

Aly Ahmed, Ph D., P Eng
Lab Supervisor

ORBIT ENGINEERING

ATTERBERG LIMITS

(LS-703, 704/D4318)

LABORATORY SERVICES

Project No.: **5277- BVD Bolton**

Borehole No. BH2-BH6

Operator Majid Touqan

Date 21/02/2020

LIQUID LIMIT						
SAMPLE NO.	BH2	BH3	BH4	BH5	BH6	
NO OF BLOWS	25	25	25	25	25	
DISH NO	BH2L	BH3L	BH4L	BH5L	BH6L	
DISH + WET SOIL	15.91	16.61	10.5	11.06	19.41	
DISH + DRY SOIL	12.6	13.69	8.36	8.91	14.81	
MOISTURE	3.31	2.92	2.14	2.15	4.6	
DISH	1.3	1.35	1.3	1.28	1.32	
DRY SOIL	11.3	12.34	7.06	7.63	13.49	
% MOISTURE	29.29	23.66	30.31	28.18	34.10	

PLASTIC LIMIT						
DISH NO	BH2P	BH3P	BH4P	BH5P	BH6P	
DISH + WET SOIL	9.24	13.94	12.7	13.64	19.45	
DISH + DRY SOIL	7.83	11.77	10.62	11.74	15.56	
MOISTURE	1.41	2.17	2.08	1.9	3.89	
DISH	1.35	1.28	1.35	1.29	1.33	
DRY SOIL	6.48	10.49	9.27	10.45	14.23	
% MOISTURE	21.76	20.69	22.44	18.18	27.34	
PLASTIC LIMIT %	21.76	20.69	22.44	18.18	27.34	
LIQUID LIMIT %	29.29	23.66	30.31	28.18	34.10	
PLASTICITY INDEX	7.53	2.98	7.87	10.00	6.76	

Aly Ahmed

Aly Ahmed, Ph D., P Eng
Lab Supervisor

ORBIT ENGINEERING

ATTERBERG LIMITS

LABORATORY SERVICES

(LS-703, 704/D4318)

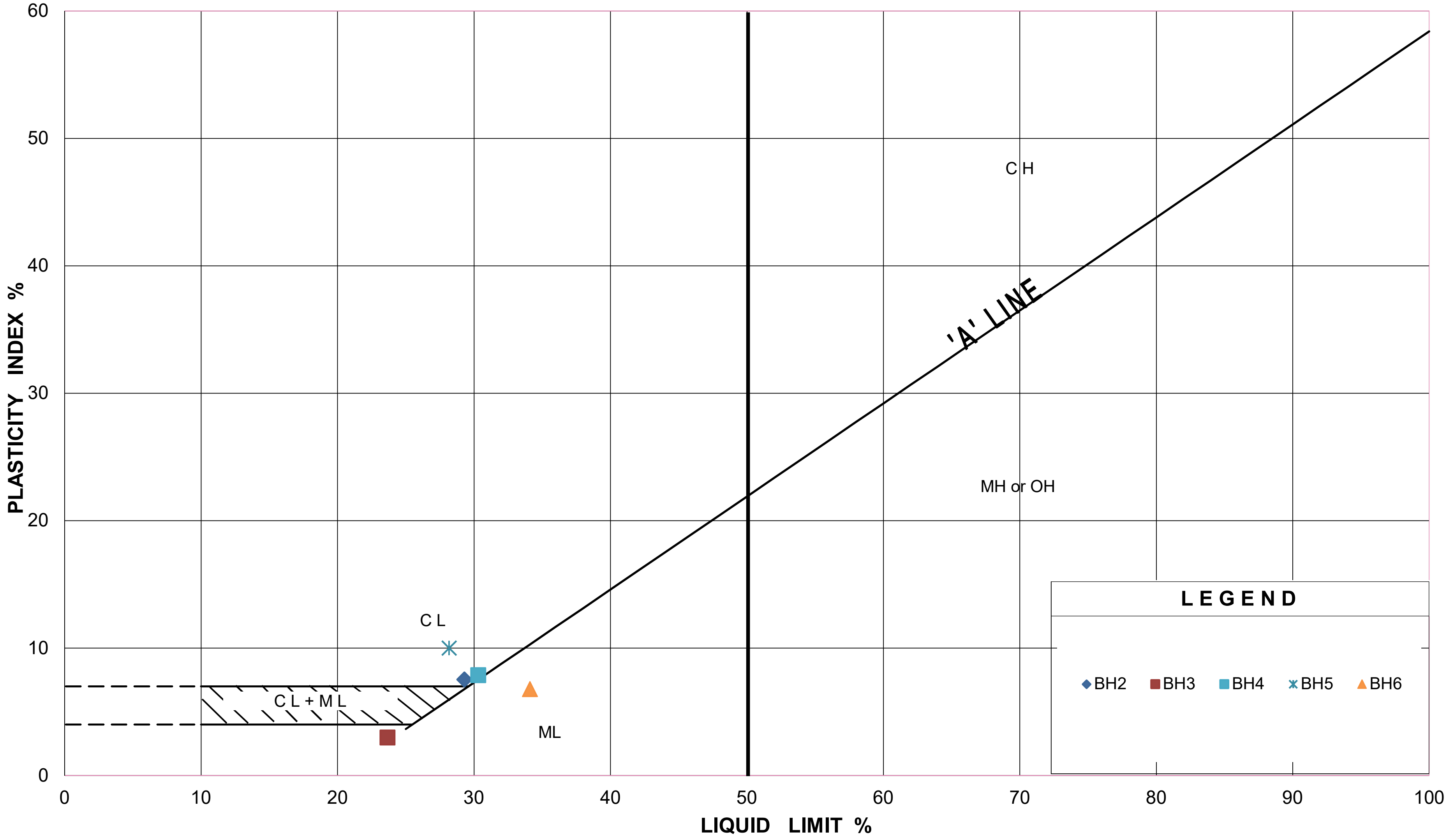
PLASTICITY CHART WORKSHEET

Date :	**Feb. 21, 2020**	**Lab Number :**	**354**
Project Number :	**5277 - BVD Bolton**	**Figure Number :**	**A0**
Drawing Number :			
Soil Description :			

Borehole Number	Sample Type	Sample Number	Natural MC (%)	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Liquidity Index (%)
BH2	CL	BH2	18.5	7.5-9.5	29	22	8	-0.4
BH3	CL	BH3	16.8	10.0-12.0	24	21	3	-1.3
BH4	CL	BH4	14.6	7.5-9.5	30	22	8	-1.0
BH5	CL	BH5	15.5	5.0-7.0	28	18	10	-0.3
BH6	ML	BH6	24.9	2.5-4.5	34	27	7	-0.4

Aly Ahmed

Aly Ahmed, Ph D., P Eng
Lab Supervisor



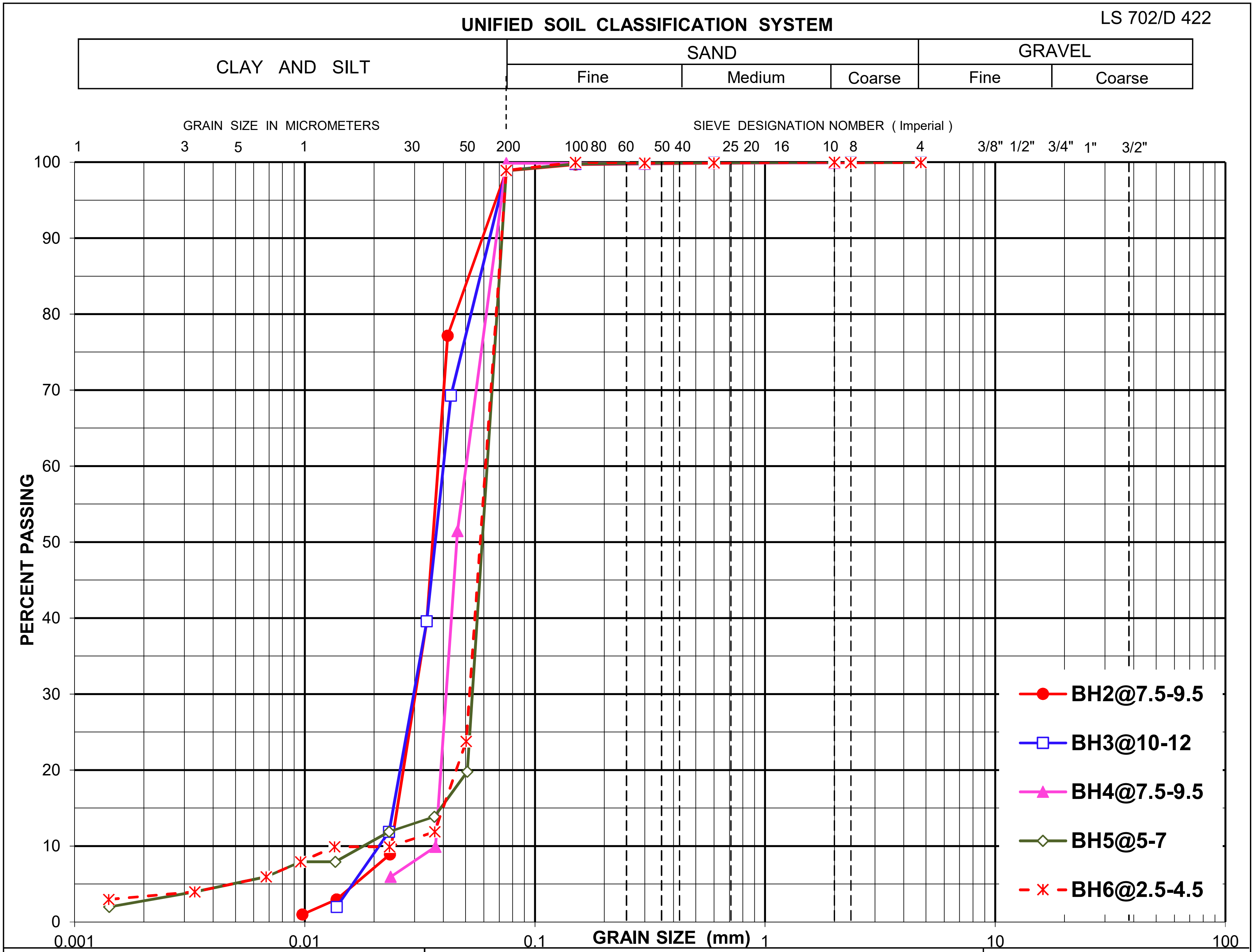
ORBIT ENGINEERING

PLASTICITY CHART

Project No: 5277- BVD Bolton

Drawing No. A1

Date: Feb. 21, 2020



ORBITENGINEERING
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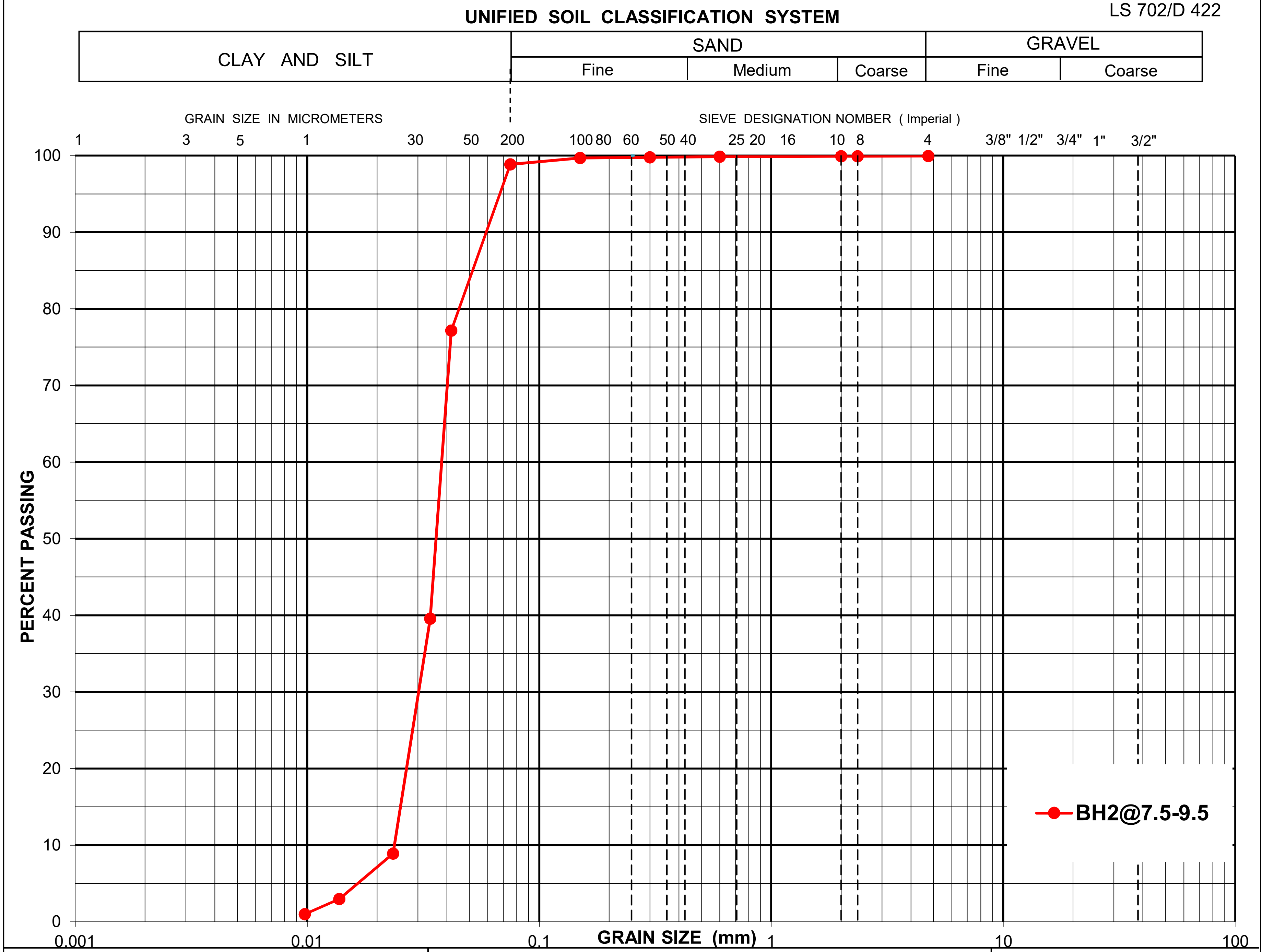
GRAIN SIZE DISTRIBUTION

Figure No.:	**H0**
PROJECT No. :	**5277- BVD Bolton**
DATE :	**Feb. 21, 2020**

LS 702/D 422



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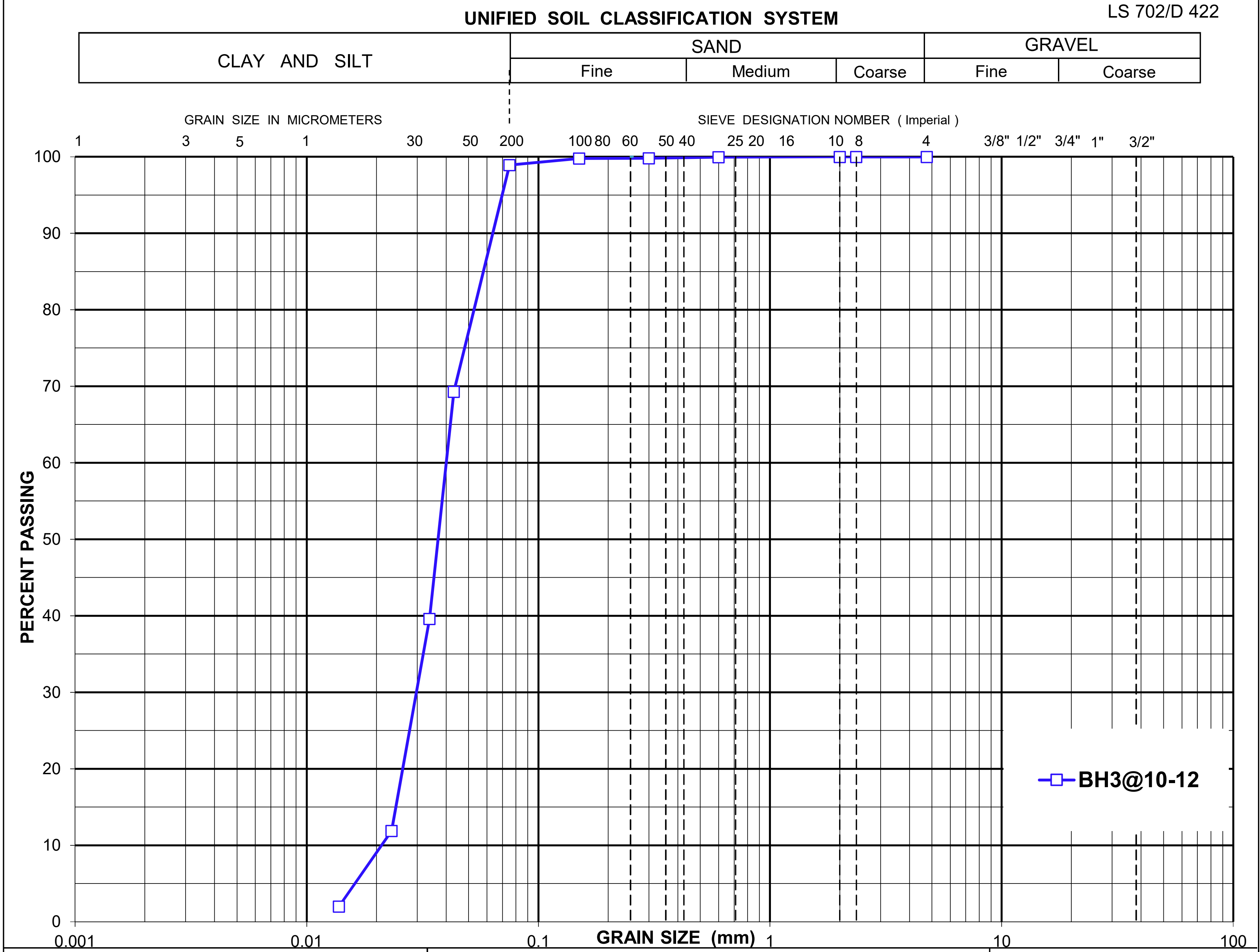
GRAIN SIZE DISTRIBUTION (BH 2)

Figure No.:	**H1**
PROJECT No. :	**5277- BVD Bolton**
DATE :	**Feb. 21, 2020**



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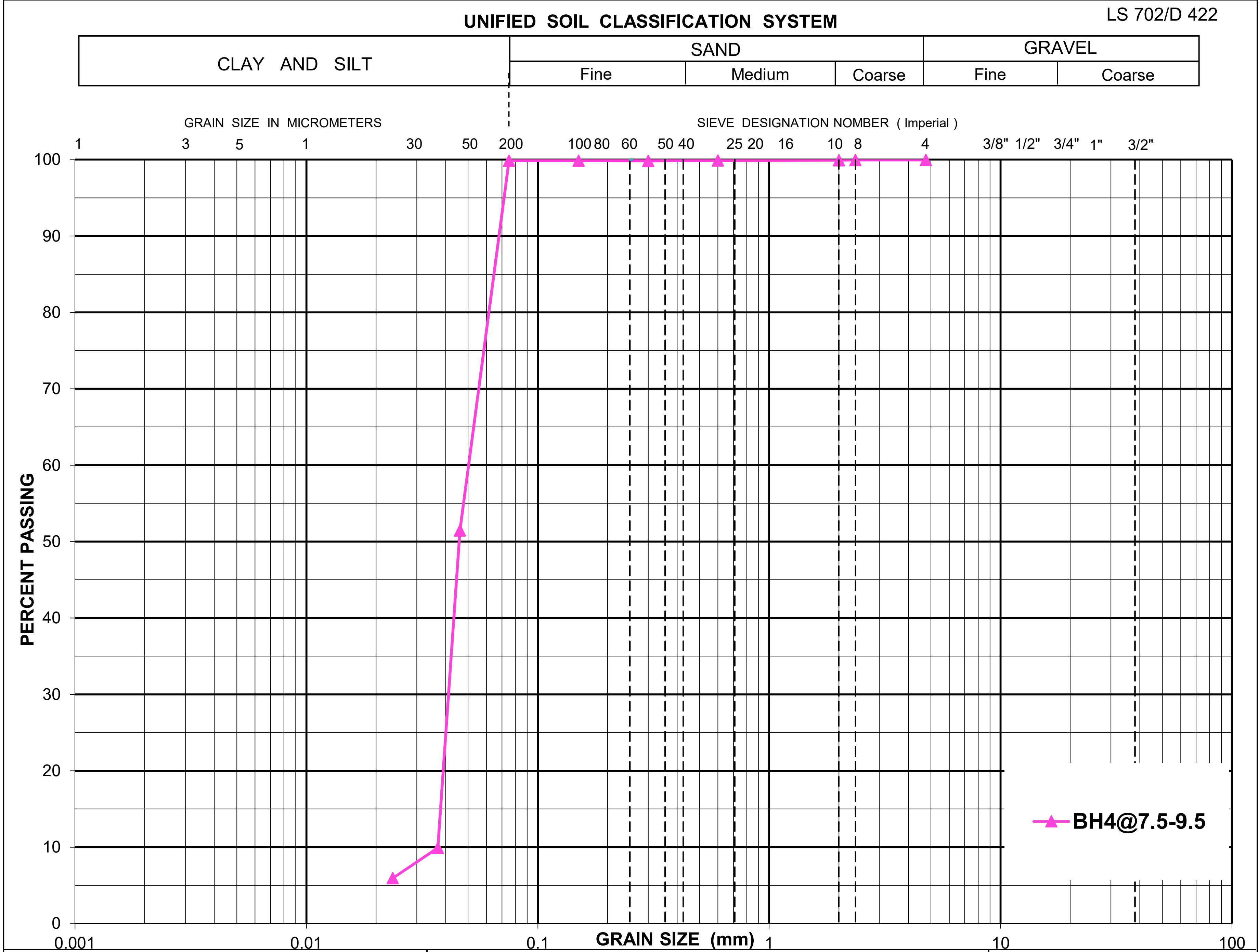
GRAIN SIZE DISTRIBUTION (BH3)

Figure No.: H2

PROJECT No. : 5277- BVD Bolton

DATE : Feb. 21, 2020



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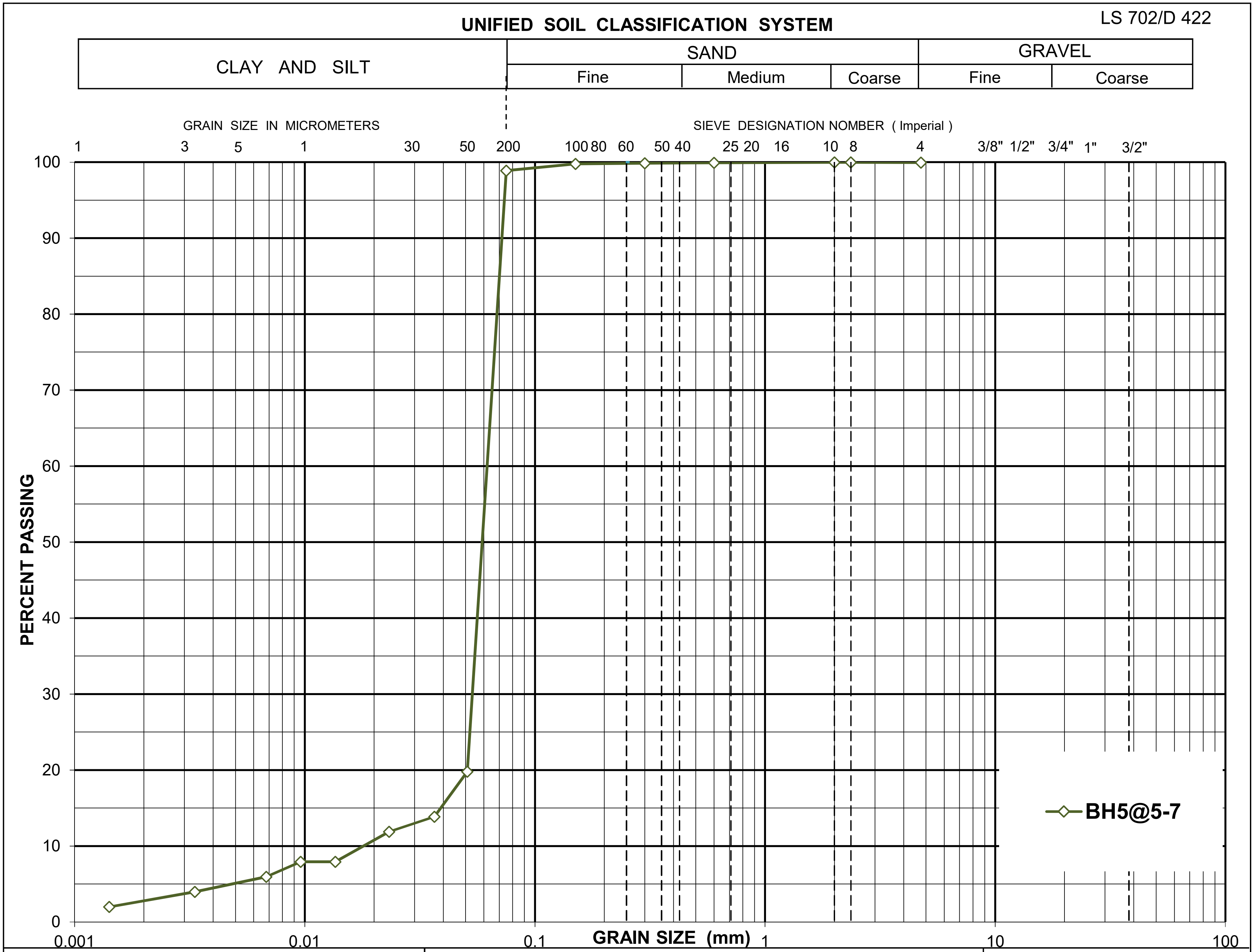
GRAIN SIZE DISTRIBUTION (BH 4)

Figure No.:	**H3**
PROJECT No. :	**5277- BVD Bolton**
DATE :	**Feb. 21, 2020**



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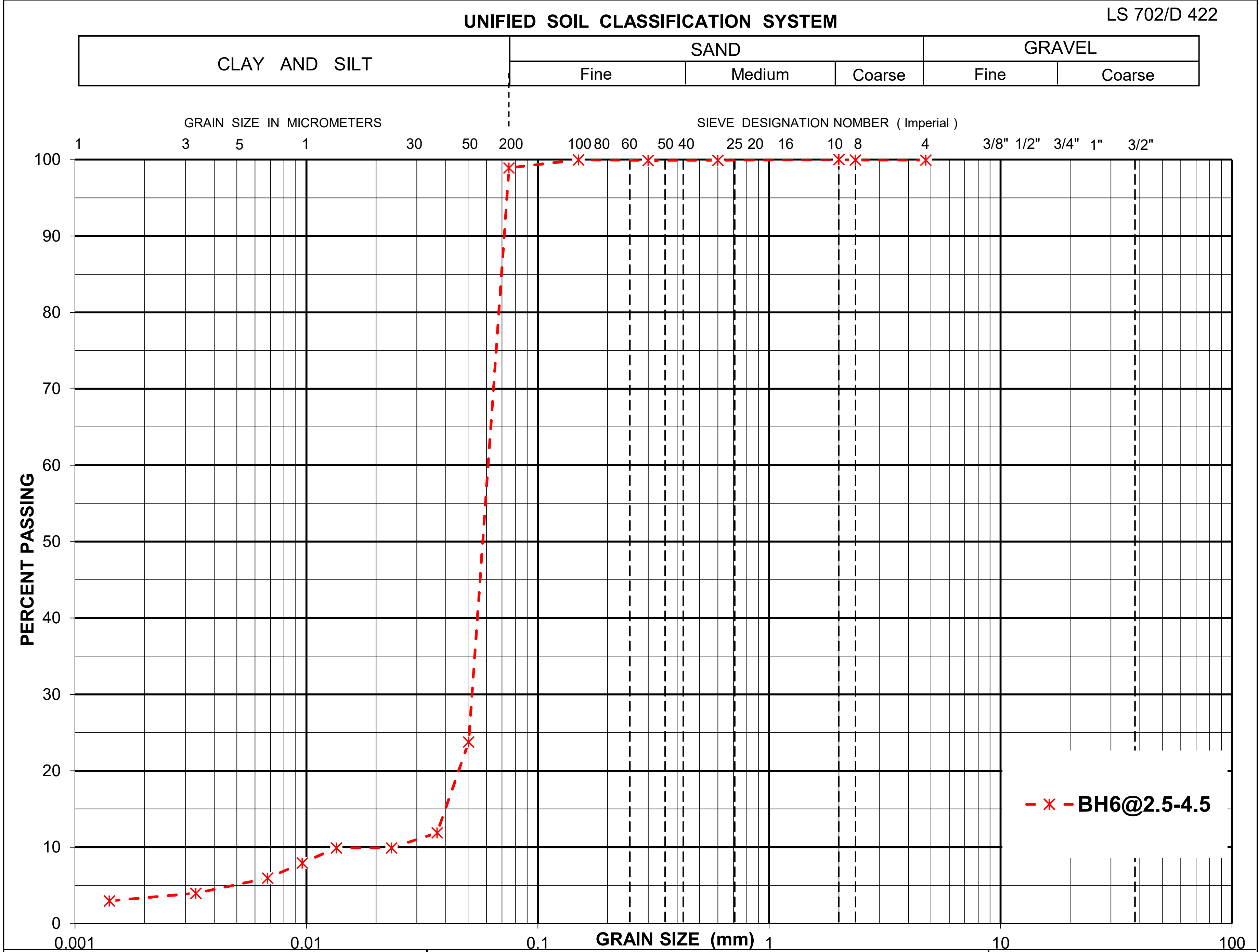
Consulting Engineers

GRAIN SIZE DISTRIBUTION (BH5)

Figure No.: **H4**

PROJECT No. : **5277- BVD Bolton**

DATE : **Feb. 21, 2020**



ORBITENGINEERING
Consulting Engineers

GRAIN SIZE DISTRIBUTION (BH 6)

Figure No.: H5

PROJECT No. : 5277- BVD Bolton

DATE : Feb. 21, 2020