Geotechnical Investigation Report

Meighen Road Extension & Development
Windsor, Ontario
Project No.: SYW207045

Prepared for:

The Corporation of the City of Windsor
350 City Hall Square West, Room 310, Windsor, Ontario N9A 6S1

11-May-20

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Prepared for:

The Corporation of the City of Windsor
350 City Hall Square West, Room 310, Windsor, Ontario N9A 6S1
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 Introduction

Wood Environment & Infrastructure Solutions, a Division of Wood Canada Limited ("Wood") was retained by The Corporation of the City of Windsor (the "Client") to conduct a geotechnical investigation for the proposed the development of Meighen Road in the area between Chandler Road, Milloy Street and Meldrum Road in City of Windsor, Ontario.

The geotechnical investigation was carried out based on the Wood's Proposal No.: PSY197347, dated December 6, 2019 and subsequent authorization to proceed received from the client.

The project area is shown on the Key Plan, Figure 1. The purpose of this investigation was to provide subsurface soil information at the test locations, and based on this information, to provide geotechnical recommendations pertaining to the reconstruction of the pavement structure and installation of sewers and watermains.

The scope of the fieldwork for this geotechnical investigation included drilling and sampling of a total of eight (8) boreholes within the roadway and field of the former St. Bernard School site.

This report contains the findings of Wood's geotechnical investigation, together with recommendations and comments. The recommendations and comments are based on factual information and intended only for use by design engineers. The number of boreholes may not be sufficient to determine all of the factors that may affect construction methods and costs. Subsurface and groundwater conditions between and beyond the boreholes may differ from those encountered at the borehole locations, and conditions may become apparent during construction that could not be detected or anticipated at the time of the site investigation.

The anticipated construction conditions are also discussed, but only to the extent that they may influence the design decisions. The feasible construction methods, however, express our opinion and are not intended to direct contractors on how they carry out construction. Contractors should also be aware that the data and their interpretation presented in this report may not be sufficient to assess all factors that may have effect upon construction and should conduct the necessary investigation to satisfy themselves with the completeness of the site information.

This report has been prepared with the assumption that the design will be in accordance with good engineering practices, applicable regulations of jurisdictional authorities, and applicable standards and regulations. Further, the recommendations and opinions in this report are applicable only to the proposed project. Hydrogeological and environmental considerations were not included in the scope of work for this geotechnical investigation. The limitations of this report, as discussed in detail in Appendix A, constitute an integral part of this report.

There should be an ongoing liaison with Wood during both the design and construction phases of this project to ensure that the recommendations in this report have been interpreted and implemented. Also, any further clarification and/or elaboration are needed concerning the geotechnical aspects of this project, Wood should be contacted immediately.

2.0 Site Description and Geological Background

2.1 Site Description

The site is situated on the former St. Bernard School Site at 1847 Meldrum Road, and for the development of Meighen Road in the area between Chandler Road, Milloy Street and Meldrum Road in City of Windsor, Ontario. The area is surrounded by both residential and commercial properties, with a majority being residential.

It is understood that the project will include the installation of new storm sewers, sanitary sewers, and watermains for the road extension. From the information provided by the client, the depth of the sewers below existing grade is estimated to be between 2.5 m on Chandler Street to about 5.0 m on Milloy Street.

2.2 Geological Background

The site is located within a geological formation known as Essex Clay Plain (Physiography of Southern Ontario; Ontario Geological Survey, Map P. 2715, 1984), which is an extensive clay plain with little relief and poor natural drainage. The plain is underlain by a relatively thick deposit of glaciolacustrine silty clay to clayey silt till. Occasional embedded pockets and lenses of sand and silt are present within the clay overburden. The clay deposit is underlain by limestone bedrock of the Middle Devonian Dundee Formation (Geological Highway Map Southern Ontario, Ontario Geological Survey, Map P.2441, 1979) at a depth of 35 m to 40 m, based on available drift thickness mapping (Ontario Geological Survey, Preliminary Map P.3255, 1994).

3.0 Investigation Program

3.1 Field Work

The scope of the fieldwork for this geotechnical investigation included five (5) boreholes drilled in the former St. Bernard School site to a depth of 6.6 m below existing grade and three (3) boreholes drilled along the existing roadways (Chandler Road, Miloy Road, and Meldrum Road) to a depth of 8.1 m below existing grade. The location and depth of the boreholes were determined by Wood and the subsequent utility locates were completed by Wood.

The locations of the boreholes from the geotechnical investigation are shown on Figure 2. The UTM coordinates of the boreholes are shown on the Record of Borehole sheets attached in Appendix B. The coordinates at the borehole locations were recorded in the field using a hand-held GPS device with a horizontal accuracy of 3 m.

The borehole drilling program for the investigation was carried out on February 12, and February 20, 2020. The boreholes were advanced using a self-propelled drill equipped with hollow stem augers and conventional soil sampling tools. Soil samples were taken at frequent intervals of depth following the Standard Penetration Test (ASTM D1586) procedure.

The drilling was conducted under the full-time supervision of Wood’s engineering staff who directed the drilling and sampling operation, and logged the boreholes.

After completion of the boreholes the augers were extracted. The open boreholes were examined for groundwater and caving, then backfilled using bentonite pellets and grout slurry in accordance with Ontario Reg. 903. The surface of the pavement at the borehole locations was repaired using “cold patch” asphalt.

All samples were field logged, placed in airtight containers, and transported to Wood’s Windsor laboratory for further examination and testing.

3.2 Laboratory Testing

Natural moisture content tests were carried out in accordance with ASTM D2216 on all the recovered soil samples. One selected native soil sample was tested for the grain size distribution and Atterberg limits in accordance with ASTM D6913, ASTM D7928 and ASTM D4318. The test results are included in Appendix C.

4.0 Subsurface Conditions

4.1 Subsurface Soil Conditions

Boreholes BH1 to BH3 were advanced within the travelled portion of the road, while boreholes BH4 to BH8 were drilled on the former St. Bernard School site. All boreholes were advanced in areas clear of underground utilities. The following is a summary of the subsurface soil conditions encountered in the boreholes. The results of laboratory testing carried out on recovered samples are also shown on the Record of Borehole sheets in Appendix B. The results of the grain size analyses and Atterberg limits can be found in Appendix C.

Pavement Structure and Fill Materials

Based on visual and tactile examination asphalt with underlying granular base fill consisting of crushed granular were encountered at and below the ground surface at boreholes BH1 to BH3. Boreholes BH4 and BH5 encountered topsoil with underlying sand and gravel and silty clay fill respectively. Finally, boreholes BH6 to BH8 encountered topsoil underlain by the native silty clay stratum. The thickness of pavement structure and surficial fills is listed in Table 1 below.

Table 1: Thickness of Existing Pavement Structure & Surficial Fills

Location	Borehole Number	Thickness (mm)					
		Topsoil	Asphalt	Concrete	Granular Base Fill	Sand & Gravel Fill	Silty Clay Fill
Existing Roadways	BH1	-	125	-	330	-	-
	BH2	-	150	-	455	-	-
	BH3	-	150	-	455	-	-
Former School Site	BH4	405	-	-	-	1,425	-
	BH5	175	-	-	-	-	1,195
	BH6	255	-	-	-	-	-
	BH7	305	-	-	-	-	-
	BH8	330	-	-	-	-	-

Silty Clay

Cohesive silty clay was encountered in all boreholes below the above mentioned pavement structures and surficial fills. The cohesive materials were typically encountered at depths greater than 0.3 m to 0.6 m below grade, excluding boreholes BH4 and BH5, where significant sand and gravel (1.4 m thick) and silty clay fills (1.2 m thick) were encountered respectively. From the top down, the silty clay was mottled brown and grey to brown to grey in coloration. All boreholes were terminated in grey silty clay.

The mottled brown and grey portion of silty clay extended to the underside of the fills to depths of typical 0.3 m to 2.2 m below grade. The moisture content of the mottled brown and grey silty clay ranged from 15% to 26%. Measured “N” values from Standard Penetration Test in the mottled brown and grey silty clay generally ranged from 4 blows to 15 blows per 0.3 m penetration, indicating a firm to very stiff consistency.

The top of brown silty clay ranged in depth from 1.3 m to 2.2 m and extended to depths of 2.9 m to 3.7 m. The moisture content of the brown silty clay ranged from 12% to 17%. Measured "N" values from Standard Penetration Test in the brown silty clay generally ranged from 13 blows to 33 blows per 0.3 m penetration, indicating a very stiff to hard consistency.

The top of grey silty clay ranged in depth from 2.9 m to 3.7 m and extended to 6.6 m to 8.1 m (termination depths of boreholes). The moisture content of the grey silty clay ranged from 12% to 18%. The measured "N" values from Standard Penetration Tests ranged from 5 blows to 23 blows per 0.3 m of penetration and generally decreased with depth. Field vane shear testing was completed in the grey silty clay and yielded undrained shear strengths in excess of 70 kPa, indicating a firm to very stiff consistency.

A grain size distribution analysis and Atterberg limits tests were carried out on one grey silty clay sample. The results of these tests are included on the borehole log sheets and attached in Appendix C.

Table 2: Results of Grain Size Analysis and Atterberg Limits Test

Borehole No. / Sample No.	Sample Depth (m)	Grain Size Distribution				Atterberg Limits			USCS Modified Group Symbol
		Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid Limit (W_L)	Plastic Limit (W_P)	Plasticity Index (I_P)	
BH6 / SA5	3.8 to 4.3	1.7	30.9	36.5	30.9	26.0	13.8	12.3	CL
BH7 / SA 7	6.1 to 6.6	3.2	29.9	36.5	30.4	25.7	13.7	12.0	CL

Sandy Silt

Encountered in borehole BH1 was a grey sandy silt layer between 4.4 m and 5.5 m below existing grade. The moisture content of the non-cohesive sandy silt was 18%. Measured "N" values from Standard Penetration Test in the sandy silt was 15 blows per 0.3 m penetration, indicating a compact state.

4.2 Groundwater

The boreholes were left open and remained dry for the relatively brief period between withdrawal of the augers and backfilling of the boreholes. Due to the low permeability of the clayey soil at the site, insufficient time had passed to allow stabilization of groundwater levels in the open boreholes.

Typically, the grey colour of the soils noted at a depth of about 2.9 m to 3.7 m below grade is indicative of a permanent saturated condition, and therefore, fluctuation of the long-term groundwater should be anticipated near this depth level. However, during and after local precipitation events, groundwater that is 'perched' above the long-term level may accumulate in the fills, weathered and fissured clay near the ground surface above the relatively more impervious grey silty clay. In addition, significant amounts of groundwater may be present in any fill materials around existing utilities that may be present.

Perched groundwater may rise to the ground surface following precipitation and snowmelt. In the absence of an active, engineered drainage system, the design should assume possible temporary groundwater levels rising to the ground surface.

5.0 Discussion and Recommendations

5.1 General

It is understood that The Corporation of the City of Windsor is planning to extend Meighen Road from Milloy Street southeast towards the former St. Bernard School site in Windsor, Ontario. In addition, the former school site is anticipated to be redeveloped into twenty-five (25) residential single family lots. Installation of new storm sewers, sanitary sewers and watermain will be carried out as part of the proposed works. From the information provided by the Client, the depth of the sewers is estimated to be approximately 2.5 m to 5.0 m below existing road grade.

The anticipated subsurface conditions in the work area will generally consist of topsoil (former School site), and asphalt (existing roadways) underlain by fill over firm to very stiff silty clay.

It is assumed that the residential lots will have full basements, and shallow foundations has been considered below.

5.2 Shallow Foundations

Details of the loading conditions of the residential lots are not available at this time. However, a moderate loading condition has been assumed for the reporting purposes. Based on the preceding, shallow conventional strip/spread footings may be considered for the proposed single family lots. Any topsoil, fill material or deleterious material encountered and softened or loosened native soils are not suitable to support foundations and should be sub-excavated until suitable material is encountered. Strip/spread footings should be placed on the undisturbed native stiff to very stiff silty clay, or the stiff grey silty clay. Footings within unheated areas should be placed at a depth of at least 1.2 m below ground surface for protection against frost heave. At these depths, spread footings may be designed using the following soil bearing resistances:

Table 3: Soil Bearing Resistances for Shallow Foundations

Depth of Foundation (m)	Net Factored Geotechnical Resistance at ULS (kPa)*	Bearing Reaction at SLS (kPa)	Subgrade Conditions
Surface to 1.2	Frost Zone		
1.2 to 1.8	130	85	Firm to Stiff Mottled Silty Clay
1.8 to 3.0	210	140	Stiff to Very Stiff Brown Silty Clay
Below 3.0 m	150	100	Firm Grey Silty Clay

* A resistance factor of 0.5 was applied

The SLS resistance values are based on a maximum width of footing dimension of not more than 4.0 m. The SLS is based on assumed maximum and differential settlement tolerances of 25 mm and 19 mm, respectively. Wood should be consulted should foundation depths or sizes greater than those described be required.

The ultimate resistance against sliding of the footings can be calculated using a specified (unfactored) friction factor of 0.4, but not greater than 40 kPa multiplied by the contact area of the footing.

As indicated in Section 4.2 above, the long term groundwater table is located between 2.9 m to 3.7 m below grade, and may be above the design depth of anticipated basements for the single family units. Therefore, a drainage system, compliant with Section 9.14 of the Ontario Building Code would be required to lower the groundwater table to reduce hydrostatic pressure acting on the basement walls. Typically this drainage system would include perimeter weeping tiles above the footings, surrounded by free draining material and directed to a frost free outlet, such as a municipal sewer or sump pump. The exterior basement wall should be waterproofed.

The geotechnical pressure values listed above are for vertical loads (no inclination) and no eccentricity. The ULS values could be significantly less than stated if inclined or eccentric loading conditions exist. The foundation design must also consider load inclinations and eccentricity as per the applicable principles presented in the 2006 Canadian Foundation Engineering Manual (CFEM). Wood would be pleased to provide detailed assistance in the required geotechnical calculations to satisfy these requirements.

The footing excavation should be reviewed by a qualified geotechnical consultant to confirm that the bearing soil has adequate bearing capacity.

Loose or disturbed material should be removed from the footing excavation prior to the placement or concrete. Hand cleaning may be required to prepare an acceptable bearing surface. The footing subgrade should be protected at all times from rain, snow, freezing temperatures and the ingress of free water. Concrete should not be placed on frozen soil, nor should the soil beneath the footing be allowed to freeze after construction of the footing. A 50 mm thick lean concrete mix is recommended to be placed over the footing subgrade once it is exposed and approved to avoid deterioration due to construction traffic and forming.

In the event that the design process determines shallow spread footings are not feasible for the complex structure, a raft foundation may be considered. However, additional geotechnical design effort will be required to perform the raft foundation design. Wood will be happy to provide raft foundation design recommendations upon a request.

5.3 Seismic Considerations

The latest Ontario Building Code (OBC) contains updated seismic analysis and design methodology. The OBC uses a site classification system defined by the average soil/bedrock properties in the top 30 m (100 ft) of the subsurface profile beneath the structure. Based on the limited site investigation data and our experience in this area, the project site can be classified as Site Class ‘D – Stiff Soil ’in accordance with OBC criteria in Division B, Part 4, Table 4.1.8.4.A of the OBC.

5.4 Frost Depth

The upper stratigraphy of the soils is considered highly frost susceptible in the presence of water, and as such, frost effects should be considered for foundations or surface structure sensitive to movement.

In accordance with the Ontario Provisional Standard Drawing (OPSD 3090.101) the design frost depth below the ground surface for the general area is estimated to be 1.2 m. Therefore, a minimum permanent soil cover of 1.2 m or equivalent thermal insulation is required for frost protection of shallow foundations.

Where provision of the minimum depths of soil cover outlined above are not practical, rigid high density extruded polystyrene insulation could be used to reduce the required thickness of soil cover. Wood can provide recommended insulation details for specific development conditions upon request.

5.5 Interpreted Soil Design Parameters

Based on the subsurface conditions encountered in the boreholes and the results of the laboratory testing, the following table summarizes the recommended interpreted soil parameters for design. The recommended specified properties were derived based on limited testing and semi-empirical correlations.

Table 4: Interpreted Native Soil Parameter Design Values

Soil	Bulk Unit Weight (kN/m^3)	Buoyant Unit Weight (kN/m^3)	Drained Angle of Internal Friction, Phi (degrees)	Undrained Cohesion, C (kPa)
Undisturbed Firm Silty Clay	19.5 to 20.5	10.5	28	25-50
Undisturbed Stiff to Very Stiff Silty Clay	20.5 to 21.0	11.0	30	50-100

5.6 Earth Pressures

A distinction should be made between short-term earth pressures on temporary excavation support structures, and long-term retaining structures against compacted backfill.

As a preliminary guideline, the temporary shoring structures should be verified for conventional uniform earth pressures of at least 0.35 Pz, (Pz, in kPa, is the total overburden pressure corresponding to the depth 'z' of excavation below the ground surface). For the in-situ soils a conservative unit weight of 22 kN/m^3 should be used. Surcharges at the ground surface should be added in accordance with applicable soil mechanics methods such as described in the Canadian Foundation Engineering Manual (CFEM).

For permanent retaining structures, such as basement walls, unfactored (specified) earth pressure coefficients and associated unit weights are presented in Table 5.

Table 5: Soil Parameters for Earth Pressure Calculations

Backfill Type	Coefficient of Earth Pressure at Active Case	Coefficient of Earth Pressure at Passive Case	Coefficient of Earth Pressure at Rest Case	Design Bulk Unit Weight (kN/m^3)	Effective Friction Angle (degrees)
Select Crushed Limestone (Granular 'A') (*)	0.27 to 0.29	3.4 to 3.7	0.43 to 0.46	22	33 to 35
Well Graded Sand (Granular 'B', Type I) (*)	0.31 to 0.35	2.9 to 3.3	0.47 to 0.52	21.5	29 to 32
Site Generated Silty Clay (**)	0.35 to 0.41	2.5 to 2.9	0.52 to 0.58	20.5	25 to 29

(*) All granular compacted to at least 98% Standard Proctor Maximum Dry Density (SPMDD)
(**) Compacted to at least 95% SPMDD

The design earth pressures in compacted backfill should be augmented with the additional pressures induced by compaction efforts, which typically are taken as a uniform 12 kPa pressure over the entire depth below grade where the calculated earth pressure based on the above earth pressure factors is less than 12 kPa.

Surcharges at the ground surface should be considered in all cases.

Consideration should be given to using the submerged weight plus the hydrostatic pressures where the soil is below the groundwater table unless a permanent dewatering system is installed.

The above coefficients apply to simple cases of retaining structures (wall not higher than typically 4.5 m, horizontal ground surface of the backfill, non-frost susceptible backfill etc.). In case of more complex conditions, appropriate methods should be used as indicated in the Canadian Foundation Engineering Manual (CFEM).

5.7 General Backfilling

All structural fills (fills within settlement sensitive areas) should consist of OPSS Granular 'A' or Granular 'B' Type I (OPSS 1010 specifications) material. This material should be placed in maximum 200 mm thick loose lifts and compacted to minimum 98% of SPMDD.

The on-site native soil can be used as general backfill material providing it is free from any organics and deleterious materials. To expedite compaction the native soils should have a moisture content no less than 3% of the optimum moisture content. Upon proper conditioning, the on-site cohesive soil should be placed in lifts not thicker than 200 mm in loose state and compacted to at least 95% of the SPMDD.

5.8 Slab on Grade

Slabs-on-grade should be constructed on a granular base fully drained at all times and placed over the approved subgrade soil, or engineered fills, consisting of OPSS 1010 Granular ‘A’, with a minimum thickness of 200 mm, compacted to 100% SPMDD. Native subgrade soils for the ground floor will consist of firm to stiff mottled silty clay or stiff to very stiff brown silty clay.

Any organics, unsuitable fills or deleterious materials should be removed prior to placing the granular base. If any soft spots or unsuitable materials are encountered, they should be removed and replaced with OPSS Granular ‘B’ Type I or Type II, placed in thin lifts not exceeding 200 mm in a loose state and compacted to at least 98% SPMDD.

Floor slabs should not be tied to any load-bearing walls or columns unless they have been designed accordingly. Contraction/expansion joints should be provided for the slabs as required by the structural engineer.

In case of outdoor slabs exposed to freeze-thaw cycles it is crucial the subgrade condition is as uniform as possible, properly crowned to promote positive subdrainage, and the granular base is fully drained at all times to minimize differential frost heave. Consideration should be given to increased thickness of the granular base to at least 500 mm, which should be hydraulically connected to a subdrainage system located below the reach of frost penetration.

5.9 General Recommendations for Excavations and Sewer/Watermain Trenching

Excavations can be made with conventional equipment and open cut methods where space requirements permit. If seepage from perched groundwater and runoff flow are prevented, groundwater seepage from native cohesive deposits is expected to be nominal and manageable by conventional dewatering from filtered sumps.

Excavations must be carried out in accordance with Ontario Regulation 213/91 of the Occupational Health and Safety Act (OHSA) as amended. These regulations designate four broad classifications of soils to stipulate appropriate measures for excavation safety. The existing dewatered fills and the native silty clay materials which will be generally encountered within the trenching excavations are classified as Type 3. Saturated granular fills are considered to be Type 4 soils. Excavations may be carried out with unsupported side-slopes no steeper than 1V:1H in Type 3 soils and 1V:3H in Type 4 soils.

Alternatively, a trench liner box could be used for temporary support of vertical excavations providing the natural deposits are properly dewatered where required. It should be noted that additional measures may be necessary to protect the health and safety of the workers even if work is carried out using a trench liner box.

It is understood that an open cut option is desired for the installation of the sanitary and storm sewers as well as the watermain. If other installation methods such as trenchless are to be considered Wood should be notified and further recommendations can be provided.

5.10 Groundwater Control During Construction

Groundwater inflow into excavations in the clayey soils is expected to be low. ‘Perched’ groundwater may be present within the granular fill, intersected utility trenches and weathered materials particularly during and after local precipitation events. In this case, the inflow into excavations may become substantial.

A sandy silt layer was observed in borehole BH1 on Chandler Road between 4.4 m and 5.5 m below existing grade. However, it is understood that utility tie-ins will be near 2.5 m below grade near this location.

The soils identified are sensitive to disturbance by water. Groundwater and surface water run-off should be removed from excavations by means of pumping from strategically placed open sumps located within the excavation bottom but outside the zone of influence of any foundations. Based on the proposed depth of the new storm sewers, groundwater may be encountered near the invert level of trench excavations.

In order to limit the effects of the ground seepage through the fill and surface water run off which may cause sloughing, the trenches should be excavated in short sections (2 to 4 pipe sections in length) and backfilled the same day. The trench length could be adjusted during construction based on soil and groundwater conditions, however, a maximum length of trench of 15 m to be open in advance is recommended on the OPSS 401.07.09. The work area should be graded to direct surface water flows away from the excavations.

If the trench base intersects saturated layers of fine sand and silt, basal instability by piping (boiling) can occur. Where encountered, the condition and extent of the wet layers of sand/silt should be assessed by boreholes and/or test pits before the excavation continues to the design trench base elevation.

5.11 Protection of Existing Structures

It is recommended that the alignment and depths of existing utilities be checked relative to the proposed storm sewer and watermain trenches. In general, if movement of existing utilities and other settlement sensitive elements is to be minimized, it will be necessary to carry out sewer construction in properly sheeted and braced excavations. If, however, some movement of the adjacent utilities can be tolerated, sewer installation within a prefabricated support system (trench liner box) is probably acceptable.

Longitudinal open sections of the trenches should be kept to a minimum and backfilling of the trenches should be carried out immediately behind the support system. Any utilities along the proposed route of the trenches should be continuously monitored during construction so that corrective action can be taken if significant ground movement is observed.

A number of existing utility lines will probably cross the proposed alignments. Where existing services are exposed during the excavation, suitable temporary or permanent support of these services should be provided consistent with the requirements of the respective utility company.

5.12 Pipe Bedding, Cover and Backfill

5.12.1 Standard Requirements

The bedding and backfill material should meet the manufacturer's specifications as well as the applicable Ontario Provincial Standard Specifications (OPSS) standards.

Applicable OPSS standards may include:

- OPSS 401 "Construction Specification for Trenching, Backfilling, and Compacting";
- OPSS 402 "Construction Specification for Excavating, Backfilling, and Compacting for Maintenance Holes, Catch Basins, Ditch Inlets, and Valve Chambers"
- OPSS 410 "Construction Specification for Sewer Pipe in Open Cuts";
- OPSS 441 "Construction Specifications for Watermain Installation in Open Cut"
- OPSS 501 " Construction Specifications for Compacting"
- OPSS 517 "Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation"; and

5.12.2 Pipe Bedding and Cover

The depth of the pipe bedding should be a minimum of 150 mm; the pipe cover should be completed to at least 300 mm above the pipe crown. All bedding, clearance and cover materials should consist of Granular 'A' (OPSS 1010) or approved Granular B Type 1 or 2 with 100% passing the 26.5 mm sieve compacted to 95% SPMDD, or unshrinkable fill, in accordance with the OPSS 401 requirements.

In the unlikely case of poor subgrade conditions, a granular clear stone bedding meeting the gradation specifications for sewer stone (equivalent to HL4 coarse aggregate per OPSS 1150) may also be used as bedding and cover material, however a non-woven geotextile should be used as a separation fabric between this material and the native soils. It is further recommended that, where used, the geotextile have a minimum overlap of 300 mm and the seams should be stitched to prevent separation of the geotextile at the seams.

Care should be exercised to avoid compaction methods that may damage the pipe. The placement and thickness of the granular bedding should also meet the pipe manufacturer's specifications.

5.12.3 Buried Structure Bedding & Backfill

Bedding and backfill materials shall be placed in accordance with OPSS 402 on approved subgrade at the bottom of the excavation and around manholes and catch basins, and compacted to 95% SPMDD and in lifts not exceeding 300 mm. Within the thickness of the pavement structures and a distance of 1.0 m from the structure, the backfill should be compacted to 100% SPMDD using hand operated small compactors.

Backfill within the depth of frost penetration should match the adjacent roadway granular materials and should be maintained drained at all times to prevent accumulation of perched groundwater causing frost heave of the pavement abutting the manholes. Filtered stub drains discharging into the manhole should be considered.

5.12.4 Trench Backfilling

The project area is located within a deposit of silty clay. Therefore, the backfill material from 300 mm above the top of pipe to the pavement subgrade level should match, if possible, the existing soils encountered in the trench walls, especially within the depth of frost penetration (about 1.2 m below finished grades). Alternatively, imported Granular 'A' or 'B' Type I, or approved reclaimed well-graded 0-75 mm granular or approved well-graded recycled aggregate placed in lifts not exceeding 200 mm and compacted to 98% of SPMDD may be used.

Consideration could be given to the reuse of the site generated soils from the existing pavement structure as general trench backfill. However, the excavated materials should be carefully sorted and stockpiled by type and any overly wet or deleterious materials should be removed and disposed. Excavated granular material should meet the requirements of select subgrade material in OPSS 1010. Prior to use of these materials, the geotechnical consultant should inspect the stockpiled soil and take samples for testing. Depending upon the test results, the soils may be suitable for use as backfill material.

Anti-seepage barriers (clay/bentonite plugs) should be considered at strategic locations along the utility trenches to control the random flow of the perched groundwater accumulated in the trenches.

As mentioned earlier, in the areas where the trench excavation underlies the roadway, it is good practice to backfill the trench below the road structure with excavated, compactable native inorganic material, at least within the upper frost zone (1.2 m below grade), to provide compatibility with similar native soils. If this technique is not undertaken, then frequent problems could arise with yearly differential frost heaving movements between the trench backfill and the adjacent native soils. Where the trench backfill within the depth of frost penetration differs substantially from the native soils within the trench sides, frost tapers of not less than 10H:1V should be implemented to minimize the risk of differential seasonal movements.

5.12.5 Reaction Blocks

Reaction blocks, if required, should be placed on competent subgrade, or engineered backfill placed on approved subgrade. The active earth pressures and passive resistances can be calculated using the earth pressure coefficients described in Table 5. A reduction factor of at least 2.0 should be applied to the passive resistance. An unfactored friction / adhesion coefficient of 0.4 may be used at the bottom of the reaction block. Buoyancy effects should be accounted for unless the trench backfill is fully drained at all times.

5.13 Pavement Design

It is understood that new pavement construction for the entire width and length of the roadway section will be completed. We understand that Bernard Road is considered a Local Road. During our investigation it was observed the traffic consisted of local residential traffic, occasional utility truck (i.e. Recycling and Refuse Trucks) and city bus traffic.

It is understood that a flexible pavement option is desired for the road reconstruction. Assuming competent subgrade conditions as discussed below. However, for routes with frequent bus stops and turns, a rigid pavement should be considered. If required Wood can provide recommendations for a rigid pavement. The flexible and rigid pavement designs provided in Table 6 and Table 7 below:

Table 6: Recommended Flexible Pavement Design

Layer	Material	Recommended Minimum Thickness (mm)
Asphaltic Concrete	OPSS 1150 HL3 Surface Asphalt	40
	OPSS 1150 HL4 Base Asphalt	65
Granular Base	OPSS 1010 Granular 'A'	450
Granular Subbase	Granular B, Type I or approved equivalent	As Required for Grading

Table 7: Recommended Rigid Pavement Design

Layer	Material	Recommended Minimum Thickness (mm)
Concrete	Portland Cement Concrete	200
Granular Base	OPSS 1010 Granular 'A'	250
Granular Subbase	Granular B, Type I or approved equivalent	As Required for Grading

The concrete pavement as described in Table 7 should be provided with load transfer devices and be doweled to curbs/concrete shoulders at least 0.5 m wide for edge support. The concrete should have a 10-day flexural strength of at least 3.8 MPa and 28-day flexural strength of 4.5 MPa. Panel spacing and jointing patterns should be consistent with current OPSS/OPSD requirements.

It is of critical importance the granular road base be fully drained at all times, especially during the cold seasons to prevent freezing of the porewater within the granular base.

The existing asphalt, concrete and any fill materials should be removed to the design subgrade level. Any existing fill materials encountered at the level of the design subgrade should be subexcavated for at least 300 mm. The exposed surface should be proof rolled using heavy rollers if granular materials are encountered, they should be proof rolled using a heavy rubber-tired roller. If native silty clay materials are encountered, they should be proof rolled using a heavy non-vibratory padfoot steel drum rollers. Any pumping, soft or loose areas of the subgrade should be excavated to a depth of not less than 200 mm below the design subgrade level, and backfilled with approved site generated approved granular or imported granular placed and compacted to 98% SPMDD. Depending on the condition of the exposed subgrade after the subexcavation of the deleterious materials proven by proof-rolling, the use of a separation fabric, or geogrid may be required.

Consideration could be given to the reuse of the granular fill materials from the existing pavement structure as the new pavement base. However, the excavated materials should be carefully sorted and stockpiled by type and any overly wet and deleterious materials should be removed and disposed. Excavated granular material should meet the requirements of select subgrade material in OPSS 1010. Prior to use of these materials, the geotechnical consultant should inspect the stockpiled soil and take samples for testing. Depending upon the test results, the granular soils may be suitable for use as backfill material.

The subgrade material should be sloped so as to promote drainage and prevent the build-up and stagnation of pore water within the granular base. The Contractor should be prepared to conduct proof-rolling of the subgrade soils. For additional recommendation refer to Section 5.12 of this report.

All granular base materials should be compacted to 100% SPMDD. The asphalt base course and surface course should be compacted between 92% and 96.5% of their respective Maximum Relative Densities obtained from the mix design.

If the construction is not carried out during dry weather conditions, it may be necessary to increase the recommended thicknesses of the pavement structure. Further, the proposed granular thickness will not be sufficient to support construction traffic prior to the asphaltic concrete placement, and additional granular material may be required to support this traffic.

Wood notes that the minimum pavement design above is not based on a detailed analysis which would account for future growth of traffic and other specific performance criteria throughout its life cycle. Notwithstanding, the above pavement design is considered typical for the intended road class in Southern Ontario and probably will offer a life cycle without major maintenance of about 15 years. Pavement performance and the ‘life cycle’ is dependent on the traffic load, quality of construction, frost protection, moisture of the base, sub-base and subgrade materials, maintenance of the asphalt during the life cycle, quality of materials etc.

5.14 Drainage

To meet the design requirements for the pavement life, the pavement granular base should be well drained at all times. This can be accomplished by installing perforated subdrain pipes along both sides of the road, below the roadbed level, to ensure effective drainage in accordance with OPSD 216.021. The subdrain pipes should be surrounded by a minimum drainage zone of 20 mm size clear stone of minimum 150 mm thickness and wrapped in suitable non-woven geotextile to provide separation from the surrounding soil.

A minimum slope of 3% should be maintained for the subgrade, and a minimum slope of 2% should be maintained across the surface of the paved sections to ensure proper surface drainage.

5.15 Transition Treatments

At the limits of the project, a butt joint with the existing pavement is recommended. The butt joint between successive lifts of hot mix should be staggered a distance not less than 5 m in accordance with OPSS 313. No joint location should correspond with a joint location in any other layer, along the road.

5.16 Pavement Construction Considerations

The pavement structure maybe placed on a stable subgrade as confirmed by proof-roll inspections by a heavy roller in the presence of the Geotechnical Consultant. As indicated, any soft or loose spots revealed by the proof-rolling should be sub-excavated and replaced with approved site generated granular or imported Granular ‘B’ Type I (OPSS 1010). The sub-grade material should be sloped to promote drainage and prevent the build-up and stagnation of pore water within the granular base.

Where new fill is needed to raise the grade, or replace disturbed portions of the subgrade, imported granular fill conforming to the gradation requirements of OPSS Granular ‘B’ Type I (OPSS 1010) should be placed in thin lifts (maximum 200 mm thick) and compacted to 98% of SPMDD. The long-term performance of the pavement structure is dependent upon the sub-grade support conditions. Stringent construction control procedures must be maintained to ensure that uniform subgrade moisture and density conditions are achieved as much as practically possible where fill is placed and that the subgrade is not disturbed or weakened after it is exposed.

Control of surface water is a significant factor in achieving good pavement life. Grading adjacent to pavement area must be designed so that water is not allowed to pond adjacent to the outside edges of the pavement or curb.

The subgrade soils identified in this report are sensitive to disturbance from excessive exposure to construction traffic (vehicular and pedestrian). Once the excavations have been completed to design elevations, the Geotechnical Consultant should immediately inspect the subgrade soils. Upon approval, the subgrade soil should be protected from further exposure. Disturbance by construction traffic may compromise the bearing resistances of the soils and necessitate further excavation.

If construction is to be completed during the winter months additional care should be given to protecting any subgrade from freezing. No backfill materials shall be placed on frozen subgrade and all backfill shall be free of frozen materials.

6.0 Closure

The limitations of this report, as discussed in detail in Appendix A, constitute an integral part of this report. We recommend the Geotechnical Consultant be retained to review drawings and the intended methods of construction (if any) prior to implementation in order to assure conformance with the geotechnical restrictions and assumptions.

We trust this report is complete within the terms of our reference. However, should questions arise concerning this report, do not hesitate to contact us.

Sincerely,

Wood Environment & Infrastructure Solutions,
a Division of Wood Canada Limited

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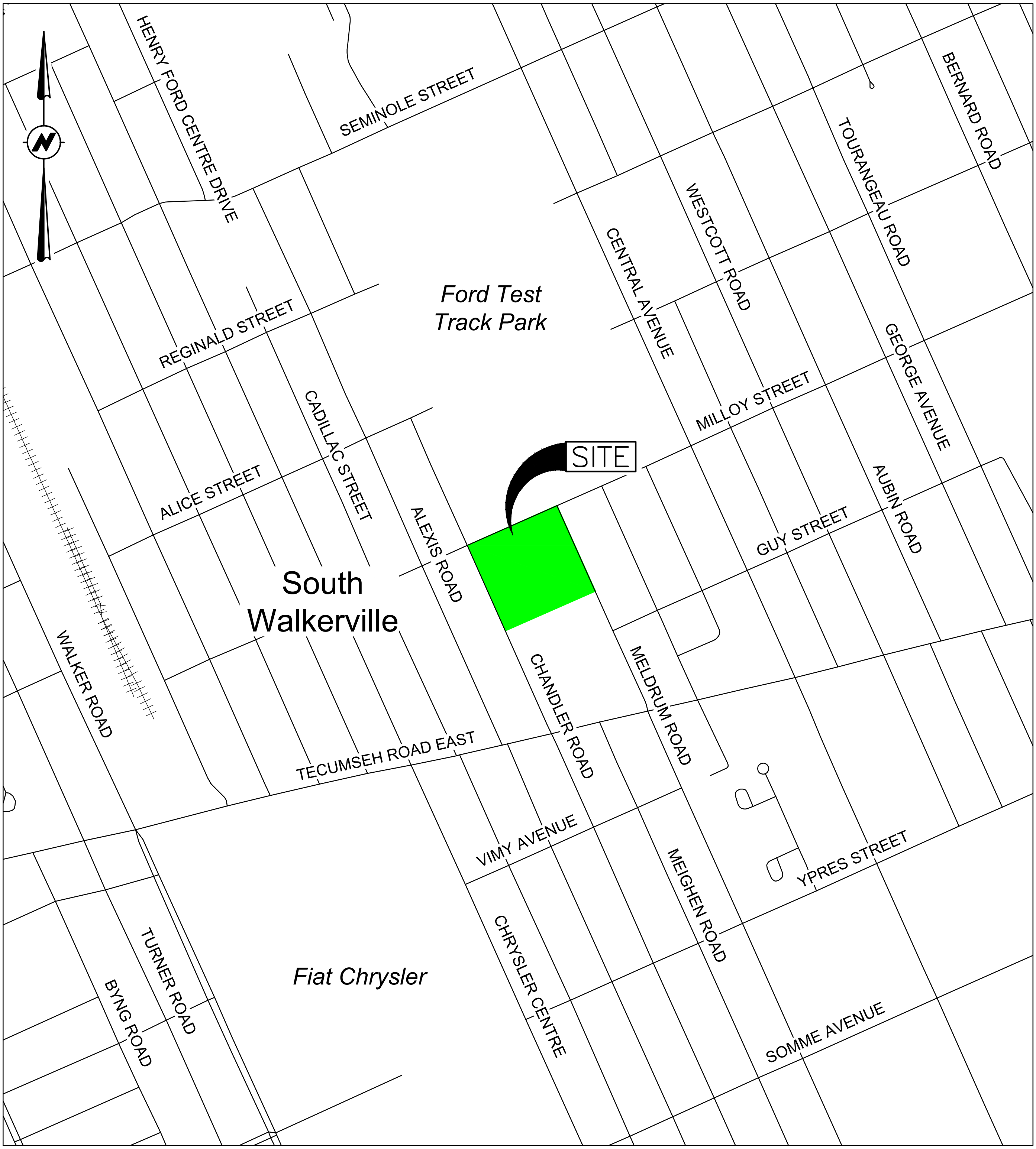
Figures



NOTES:
THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE WOOD ENVIRONMENT & INFRASTRUCTURE SOLUTIONS REPORT No. SYW207045. ALL LOCATIONS ARE APPROXIMATE.

ORIGINAL PAPER SIZE: 8½ x 11.

REFERENCES:
CANMAP STREETFILES V2008.4.

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DWN BY: SJL
CHK'D BY: TA
DATUM: NAD83
PROJECTION: UTM Zone 17
SCALE: 1:10000

PROJECT:
GEOTECHNICAL INVESTIGATION
MEIGHEN ROAD DEVELOPMENT -
FORMER ST. BERNARD SCHOOL SITE
1847 MELDRUM ROAD
WINDSOR, ONTARIO

TITLE:
KEY PLAN

DATE: MAR. 13, 2020
PROJECT No: SYW207045
REV No: 0
FIGURE No: 1

DATE PLOTTED: 3/13/2020 4:50:09 PM
FILE LOCATION: P:\2020\Geotechnical\Projects\SYW207045 – City of Windsor – Meighan Road Extension\08_Drafting\AutoCAD files\SYW207045-R01001.dwg

LEGEND:

⌖ BOREHOLE LOCATION

SCALE 1:2000

NOTES:
THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE WOOD ENVIRONMENT & INFRASTRUCTURE SOLUTIONS REPORT No. SYW207045.

ALL LOCATIONS ARE APPROXIMATE. **ORIGINAL PAPER SIZE: $8\frac{1}{2}$ x 11.**

REFERENCES:
2019 AERIAL PHOTOGRAPHS PROVIDED BY THE COUNTY OF ESSEX; CANMAP STREETFILES V2008.4.

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DWN BY:	SJL
CHK'D BY:	TA
DATUM:	NAD83
PROJECTION:	UTM Zone 17
SCALE:	1:2000

PROJECT:
GEOTECHNICAL INVESTIGATION
MEIGHEN ROAD DEVELOPMENT - FORMER ST. BERNARD SCHOOL SITE
1847 MELDRUM ROAD
WINDSOR, ONTARIO

TITLE:
BORHOLE LOCATION PLAN

DATE:	MAR. 13, 2020
PROJECT No:	SYW207045
REV No:	0
FIGURE No:	2

DATE PLOTTED: 3/13/2020 4:17:08 PM
FILE LOCATION: P:\2020\Geotechnical\Projects\SYW207045 - City of Windsor - Meighan Road Extension\08_Drafting\AutoCAD files\SYW207045-R01002.dwg

Appendix A

Report Limitations

Limitations to Geotechnical Reports

The work performed in the preparation of this report and the conclusions presented herein are subject to the following:

a) The contract between Wood and the Client, including any subsequent written amendment or Change Order dully signed by the parties (hereinafter together referred as the "Contract");

b) Any and all time, budgetary, access and/or site disturbance, risk management preferences, constraints or restrictions as described in the contract, in this report, or in any subsequent communication sent by Wood to the Client in connection to the Contract; and

c) The limitations stated herein.

2. **Standard of care:** Wood has prepared this report in a manner consistent with the level of skill and are ordinarily exercised by reputable members of Wood's profession, practicing in the same or similar locality at the time of performance, and subject to the time limits and physical constraints applicable to the scope of work, and terms and conditions for this assignment. No other warranty, guaranty, or representation, expressed or implied, is made or intended in this report, or in any other communication (oral or written) related to this project. The same are specifically disclaimed, including the implied warranties of merchantability and fitness for a particular purpose.

3. **Limited locations:** The information contained in this report is restricted to the site and structures evaluated by Wood and to the topics specifically discussed in it, and is not applicable to any other aspects, areas or locations.

4. **Information utilized:** The information, conclusions and estimates contained in this report are based exclusively on: i) information available at the time of preparation, ii) the accuracy and completeness of data supplied by the Client or by third parties as instructed by the Client, and iii) the assumptions, conditions and qualifications/limitations set forth in this report.

5. **Accuracy of information:** No attempt has been made to verify the accuracy of any information provided by the Client or third parties, except as specifically stated in this report (hereinafter "Supplied Data"). Wood cannot be held responsible for any loss or damage, of either contractual or extra-contractual nature, resulting from conclusions that are based upon reliance on the Supplied Data.

6. **Report interpretation:** This report must be read and interpreted in its entirety, as some sections could be inaccurately interpreted when taken individually or out-of-context. The contents of this report are based upon the conditions known and information provided as of the date of preparation. The text of the final version of this report supersedes any other previous versions produced by Wood.

7. **No legal representations:** Wood makes no representations whatsoever concerning the legal significance of its findings, or as to other legal matters touched on in this report, including but not limited to, ownership of any property, or the application of any law to the facts set forth herein. With respect to regulatory compliance issues, regulatory statutes are subject to interpretation and change. Such interpretations and regulatory changes should be reviewed with legal counsel.

Appendix B

Explanation of Record of Borehole Sheets and Record of Borehole Sheets BH1 to BH8

GENERAL REPORT NOTES

DEFINITIONS OF PENETRATION RESISTANCE

Standard penetration resistance ‘N’ – The number of blows required to advance a standard split spoon sampler 30 cm into the subsoil, driven by means of a 63.5 kg hammer falling freely a distance of 76 cm.

Dynamic penetration resistance – The number of blows required to advance a 50 mm, 60 degree cone, fitted to the end of drill rods, 30 cm into the subsoil, the driving energy being 474.5 Joules per blow.

SAMPLE TYPE ABBREVIATIONS USED IN BOREHOLE LOGS

S.S.	Split spoon	T.W.	Thinwall open	R.C.	Rock core
A.U.	Auger sample	T.P.	Thinwall piston	W.S.	Washed sample
P.H.	Sample pushed hydraulically			P.M.	Sample pushed manually

SOIL TEST SYMBOLS USED IN BOREHOLE LOGS

○	Standard penetration resistance	▼	Laboratory Vane	□	Unconfined compression
●	Dynamic penetration resistance	▲	Field Vane	■	Undrained shear strength
		X	Penetrometer	S	Sensitivity

NOTE

The soil conditions, profiles, comments, conclusions and recommendations found in this report are based upon the samples recovered during the fieldwork. Soils are heterogeneous materials and, consequently, variations (possibly extreme) may be encountered at site locations away from boreholes. During construction, competent, qualified inspection personnel should verify that no significant variations exist from the conditions described in this report.

EXPLANATION OF BOREHOLE LOG

This form describes some of the information provided on the borehole logs, which is based primarily on examination of the recovered samples, and the results of the field and laboratory tests. Additional description of the soil/rock encountered is given in the accompanying geotechnical report.

GENERAL INFORMATION

Project details, borehole number, location coordinates and type of drilling equipment used are given at the top of the borehole log.

SOIL LITHOLOGY

Elevation and Depth

This column gives the elevation and depth of inferred geologic layers. The elevation is referred to the datum shown in the Description column.

Lithology Plot

This column presents a graphic depiction of the soil and rock stratigraphy encountered within the borehole.

Description

This column gives a description of the soil stratums, based on visual and tactile examination of the samples augmented with field and laboratory test results. Each stratum is described according to the *Modified Unified Soil Classification System.*

The compactness condition of cohesionless soils (SPT) and the consistency of cohesive soils (undrained shear strength) are defined as follows *(Ref. Canadian Foundation Engineering Manual):*

Compactness of Cohesionless Soils	SPT N-Value
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	> 50

Consistency of Cohesive Soils	Undrained Shear Strength	
	kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1000
Stiff	50 to 100	1000 to 2000
Very stiff	100 to 200	2000 to 4000
Hard	Over 200	Over 4000

Soil Sampling

Sample types are abbreviated as follows:

SS	Split Spoon	TW	Thin Wall Open (Pushed)	RC	Rock Core	GS	Grab Sample
AS	Auger Sample	TP	Thin Wall Piston (Pushed)	WS	Washed Sample	AR	Air Return Sample

Additional information provided in this section includes sample numbering, sample recovery and numerical testing results.

Field and Laboratory Testing

Results of field testing (e.g., SPT, pocket penetrometer, and vane testing) and laboratory testing (e.g., natural moisture content, and limits) executed on the recovered samples are plotted in this section.

Instrumentation Installation

Instrumentation installations (monitoring wells, piezometers, inclinometers, etc.) are plotted in this section. Water levels, if measured during fieldwork, are also plotted. These water levels may or may not be representative of the static groundwater level depending on the nature of soil stratum where the piezometer tips are located, the time elapsed from installation to reading and other applicable factors.

Comments

This column is used to describe non-standard situations or notes of interest.

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MODIFIED * UNIFIED CLASSIFICATION SYSTEM FOR SOILS

*The soil of each stratum is described using the Unified Soil Classification System (Technical Memorandum 36-357 prepared by Waterways Experiment Station, Vicksburg, Mississippi, Corps of Engineers, U.S Army. Vol. 1 March 1953.) modified slightly so that an inorganic clay of "medium plasticity" is recognized.

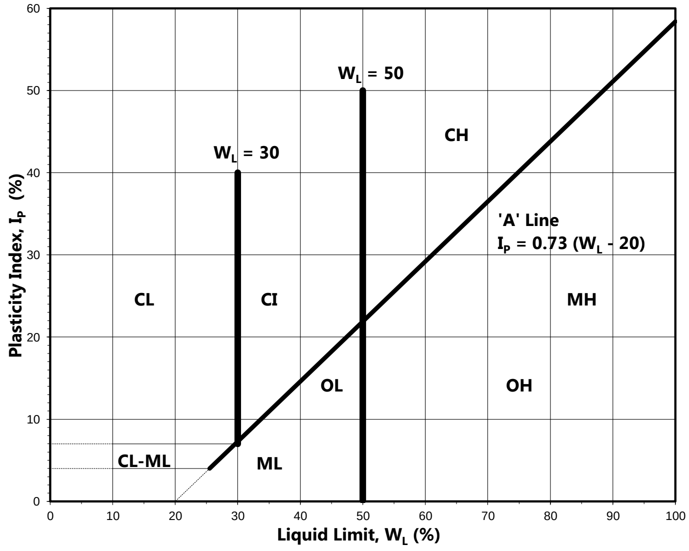
MAJOR DIVISION			GROUP SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA
COARSE GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 75µm)	GRAVELS MORE THAN HALF THE COARSE FRACTION LARGER THAN 4.75mm	CLEAN GRAVELS (TRACE OR NO FINES)	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}} > 4;\ C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$
			GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS
		DIRTY GRAVELS (WITH SOME OR MORE FINES)	GM	SILTY GRAVELS, GRAVEL-SAND- SILT MIXTURES	ATTERBERG LIMITS BELOW "A" LINE OR P.I MORE THAN 4
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES	ATTERBERG LIMITS BELOW "A" LINE OR P.I MORE THAN 7
	SANDS MORE THAN HALF THE COARSE FRACTION SMALLER THAN 4.75mm	CLEAN SANDS (TRACE OR NO FINES)	SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}} > 6;\ C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$
			SP	POORLY GRADED GRAVELS, GRAVEL- SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS
		DIRTY SANDS (WITH SOME OR MORE FINES)	SM	SILTY SANDS, SAND-SILT MIXTURES	ATTERBERG LIMITS BELOW "A" LINE OR P.I MORE THAN 4
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES	ATTERBERG LIMITS BELOW "A" LINE OR P.I MORE THAN 7
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT SMALLER THAN 75µm)	SILTS BELOW "A" LINE NEGLIGIBLE ORGANIC CONTENT	$W_L < 50\%$	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (SEE BELOW)
		$W_L < 50\%$	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS	
	CLAYS ABOVE "A" LINE NEGLIGIBLE ORGANIC CONTENT	$W_L < 30\%$	CL	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY OR SILTY CLAYS, LEAN CLAYS	
		$30\% < W_L < 50\%$	CI	INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS	
		$W_L < 50\%$	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	
	ORGANIC SILTS & CLAYS BELOW "A" LINE	$W_L < 50\%$	OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	WHENEVER THE NATURE OF THE FINES CONTENT HAS NOT BEEN DETERMINED, IT IS DESIGNATED BY THE LETTER "F", E.G SF IS A MIXTURE OF SAND WITH SILT OR CLAY
		$W_L < 50\%$	OH	ORGANIC CLAYS OF HIGH PLASTICITY	
HIGH ORGANIC SOILS			Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOUR OR ODOUR, AND OFTEN FIBROUS TEXTURE

SOIL COMPONENTS

FRACTION	U.S STANDARD SIEVE SIZE		DEFINING RANGES OF PERCENTAGE BY WEIGHT OF MINOR COMPONENTS		
		PASSING	RETAINED	PERCENT	DESCRIPTOR
GRAVEL	COARSE	76 mm	19 mm	35-50	AND
	FINE	19 mm	4.75 mm	20-35 10-20	Y/EY SOME
SAND	COARSE	4.75 mm	2.00 mm	1-10	TRACE
	MEDIUM	2.00 mm	425 µm		
	FINE	425 µm	75 µm		
FINES (SILT OR CLAY BASED ON PLASTICITY)		75 µm			

OVERSIZED MATERIAL	
ROUNDED OR SUBROUNDED: COBBLES 76 mm TO 200 mm BOULDERS > 200 mm	NOT ROUNDED: ROCK FRAGMENTS > 76 mm ROCKS > 0.76 CUBIC METRE IN VOLUME

Plasticity Chart for Soil Passing 425 Micron Sieve



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Note 1: Soils are classified and described according to their engineering properties and behaviour.

Note 2: The modifying adjectives used to define the actual or estimated percentage range by weight of minor components are consistent with the Canadian Foundation Engineering Manual (4th Edition, Canadian Geotechnical Society, 2006.)

RECORD OF BOREHOLE No. BH1

Project Number: **SYW207045**
Project Client: **The Corporation of the City of Windsor**
Project Name: **Meighen Road Extension**
Project Location: **Windsor, Ontario**
Drilling Location: **N4685669, E336245**

Drilling Method: **200 mm O.D. Hollow Stem Augers**
Drilling Machine: **CME55**
Date Started: **12 Feb 2020** Date Completed: **12 Feb 2020**
Logged by: **SKS** Compiled by: **SLS**
Reviewed by: **TA** Revision No.: **0**

LITHOLOGY PROFILE

Local Ground Surface Elevation:

DESCRIPTION	DEPTH (m)
ASPHALT (approx. 125 mm)	
FILL (approx. 330 mm) Crushed granular	0.1
SILTY CLAY Some sand, trace gravel Mottled brown and grey Stiff Brown Very stiff Grey Stiff	0.5
SANDY SILT Trace to some clay Grey Compact	4.4
SILTY CLAY Trace sand, trace gravel Grey Firm	5.5
END OF BOREHOLE (no refusal)	6.6

SOIL SAMPLING / FIELD TESTING / LAB TESTING

Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	Moisture Content (%)
SS	1	100	12	15
SS	2	100	24	12
SS	3	100	23	13
SS	4	78	10	16
SS	5	78	8	13
SS	6	100	15	18
SS	7	100	7	15

DEPTH (m): 1, 2, 3, 4, 5, 6, 7, 8
ELEVATION (m)

FIELD TESTING
PenetrationTesting
○ SPT ● DCPT
MTO Vane* Nilcon Vane*
△ Intact ◇ Intact
▲ Remould ◆ Remould
■ Undrained Shear Strength (kPa)
(from P. Penetrometer tests)
20 40 60 80

LAB TESTING
Atterberg Limits
W_P W W_L
Plastic Liquid
✳ Passing 75 um (%)
○ Moisture Content (%)
★ Unit Weight (KN/m3)
20 40 60 80

INSTRUMENTATION INSTALLATION

COMMENTS & GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

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$\underline{\nabla}$ No freestanding groundwater observed in open borehole upon completion of drilling.

Borehole details, as presented, do not constitute a thorough understanding of all potential conditions present and requires interpretive assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

RECORD OF BOREHOLE No. BH2

Project Number: **SYW207045**
Project Client: **The Corporation of the City of Windsor**
Project Name: **Meighen Road Extension**
Project Location: **Windsor, Ontario**
Drilling Location: **N4685811, E336281**

Drilling Method: **200 mm O.D. Hollow Stem Augers**
Drilling Machine: **CME55**
Date Started: **12 Feb 2020** Date Completed: **12 Feb 2020**
Logged by: **SKS** Compiled by: **SLS**
Reviewed by: **TA** Revision No.: **0**

LITHOLOGY PROFILE — DESCRIPTION — Local Ground Surface Elevation:

SOIL SAMPLING: Sample Type, Sample Number, Recovery (%), SPT 'N' Value — DEPTH (m) — ELEVATION (m)

FIELD TESTING: PenetrationTesting ○ SPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; ■ Undrained Shear Strength (kPa) (from P. Penetrometer tests) 20 40 60 80

LAB TESTING: Atterberg Limits W_P W W_L Plastic Liquid; ✳ Passing 75 um (%) ○ Moisture Content (%) ★ Unit Weight (KN/m3) 20 40 60 80

INSTRUMENTATION INSTALLATION

COMMENTS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

DESCRIPTION	Depth (m)	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	Moisture Content (%)
ASPHALT (approx. 150 mm)						
FILL (approx. 455 mm) Crushed granular	0.2					
SILTY CLAY Some sand, trace gravel Mottled brown and grey Stiff	0.6	SS	1	89	8	20
Brown Very stiff		SS	2	100	23	13
Hard		SS	3	89	33	13
Grey Very stiff		SS	4	100	16	13
Stiff		SS	5	72	11	13
		SS	6	100	10	15
Firm		SS	7	100	7	16
		SS	8	100	5	18
END OF BOREHOLE (no refusal)	8.1					

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∇ No freestanding groundwater observed in open borehole upon completion of drilling.

Borehole details, as presented, do not constitute a thorough understanding of all potential conditions present and requires interpretive assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

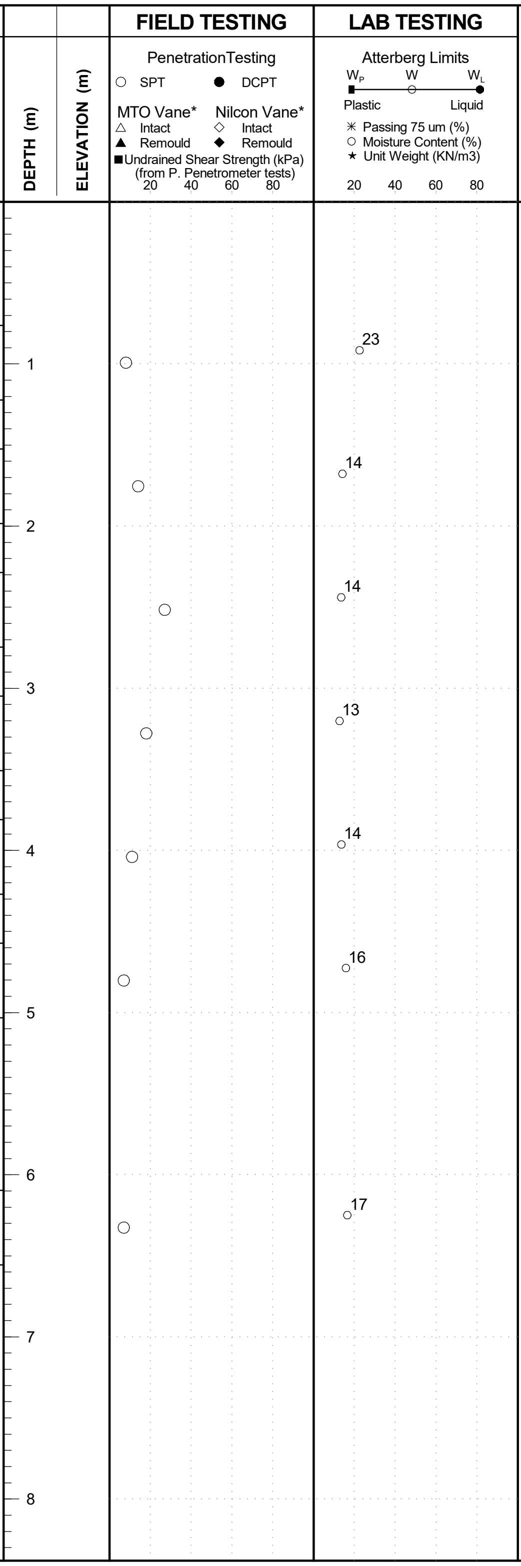
RECORD OF BOREHOLE No. BH3

Project Number: **SYW207045**
Project Client: **The Corporation of the City of Windsor**
Project Name: **Meighen Road Extension**
Project Location: **Windsor, Ontario**
Drilling Location: **N4685726, E336411**

Drilling Method: **200 mm O.D. Hollow Stem Augers**
Drilling Machine: **CME55**
Date Started: **12 Feb 2020** Date Completed: **12 Feb 2020**
Logged by: **SKS** Compiled by: **SLS**
Reviewed by: **TA** Revision No.: **0**

Local Ground Surface Elevation:

LITHOLOGY PROFILE DESCRIPTION	Depth (m)	SOIL SAMPLING Sample Type	Sample Number	Recovery (%)	SPT 'N' Value
ASPHALT (approx. 150 mm)					
FILL (approx. 455 mm) Crushed granular	0.2				
SILTY CLAY Trace sand, trace gravel Mottled brown and grey Stiff	0.6	SS	1	100	8
Brown		SS	2	100	14
Very stiff		SS	3	100	27
Grey with sand seams		SS	4	100	18
Stiff		SS	5	100	11
Firm		SS	6	89	7
		SS	7	100	7
END OF BOREHOLE (no refusal)	6.6				



INSTRUMENTATION INSTALLATION

COMMENTS & GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

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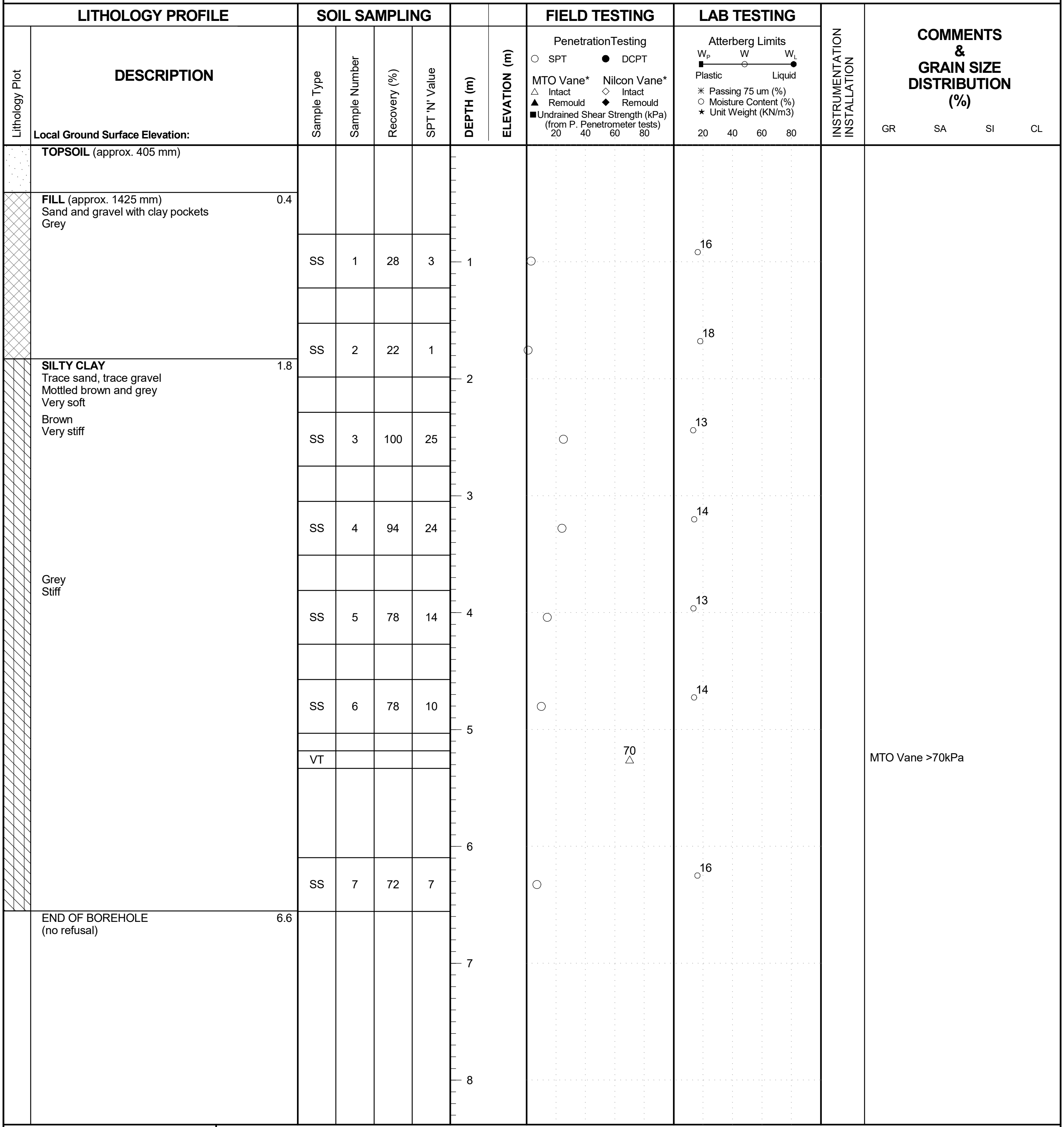
∇ No freestanding groundwater observed in open borehole upon completion of drilling.

Borehole details, as presented, do not constitute a thorough understanding of all potential conditions present and requires interpretive assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

RECORD OF BOREHOLE No. BH4

Project Number: **SYW207045**
Project Client: **The Corporation of the City of Windsor**
Project Name: **Meighen Road Extension**
Project Location: **Windsor, Ontario**
Drilling Location: **N4685703, E336382**

Drilling Method: **200 mm O.D. Hollow Stem Augers**
Drilling Machine: **CME55**
Date Started: **20 Feb 2020** Date Completed: **20 Feb 2020**
Logged by: **MB** Compiled by: **SLS**
Reviewed by: **TA** Revision No.: **0**



DESCRIPTION

Local Ground Surface Elevation:

TOPSOIL (approx. 405 mm)

FILL (approx. 1425 mm) 0.4
Sand and gravel with clay pockets
Grey

SILTY CLAY 1.8
Trace sand, trace gravel
Mottled brown and grey
Very soft
Brown
Very stiff
Grey
Stiff

END OF BOREHOLE 6.6
(no refusal)

Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	Moisture Content (%)	COMMENTS
SS	1	28	3	16	
SS	2	22	1	18	
SS	3	100	25	13	
SS	4	94	24	14	
SS	5	78	14	13	
SS	6	78	10	14	
VT					MTO Vane >70kPa
SS	7	72	7	16	

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▽ No freestanding groundwater observed in open borehole upon completion of drilling.

Borehole details, as presented, do not constitute a thorough understanding of all potential conditions present and requires interpretive assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

RECORD OF BOREHOLE No. BH5

Project Number: **SYW207045**
Project Client: **The Corporation of the City of Windsor**
Project Name: **Meighen Road Extension**
Project Location: **Windsor, Ontario**
Drilling Location: **N4685752, E336368**

Drilling Method: **200 mm O.D. Hollow Stem Augers**
Drilling Machine: **CME55**
Date Started: **20 Feb 2020** Date Completed: **20 Feb 2020**
Logged by: **MB** Compiled by: **SLS**
Reviewed by: **TA** Revision No.: **0**

LITHOLOGY PROFILE | SOIL SAMPLING | FIELD TESTING | LAB TESTING | INSTRUMENTATION INSTALLATION | COMMENTS & GRAIN SIZE DISTRIBUTION (%)

Local Ground Surface Elevation:

Penetration Testing: ○ SPT ● DCPT
MTO Vane*: △ Intact ▲ Remould
Nilcon Vane*: ◇ Intact ◆ Remould
■ Undrained Shear Strength (kPa) (from P. Penetrometer tests) 20 40 60 80

Atterberg Limits: W_P W W_L Plastic Liquid
✳ Passing 75 um (%)
○ Moisture Content (%)
★ Unit Weight (KN/m3)
20 40 60 80

GR SA SI CL

DESCRIPTION	DEPTH (m)
TOPSOIL (approx. 175 mm)	
FILL (approx. 1195 mm) Silty clay, some sand, trace gravel With organics Dark brown	0.2
SILTY CLAY Some sand, trace gravel Mottled brown and grey Stiff	1.4
Brown Very stiff	
Grey Stiff	
Firm	
END OF BOREHOLE (no refusal)	8.1

Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	Moisture Content (%)	MTO Vane	COMMENTS
SS	1	17	1	15		
SS	2	72	11	16		
SS	3	100	16	17		
SS	4	100	23	14		
SS	5	78	14	14		
SS	6	72	10	16		
VT					70	MTO Vane >70kPa
SS	7	83	8	15		
VT					70	MTO Vane >70kPa
SS	8	100	6	17		

DEPTH (m): 1 2 3 4 5 6 7 8

∇ No freestanding groundwater observed in open borehole upon completion of drilling.

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Borehole details, as presented, do not constitute a thorough understanding of all potential conditions present and requires interpretive assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

RECORD OF BOREHOLE No. BH6

Project Number: **SYW207045**
Project Client: **The Corporation of the City of Windsor**
Project Name: **Meighen Road Extension**
Project Location: **Windsor, Ontario**
Drilling Location: **N4685804, E336350**

Drilling Method: **200 mm O.D. Hollow Stem Augers**
Drilling Machine: **CME55**
Date Started: **20 Feb 2020** Date Completed: **20 Feb 2020**
Logged by: **MB** Compiled by: **SLS**
Reviewed by: **TA** Revision No.: **0**

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FIELD TESTING – PenetrationTesting: ○ SPT ● DCPT; MTO Vane*: △ Intact ▲ Remould; Nilcon Vane*: ◇ Intact ◆ Remould; ■ Undrained Shear Strength (kPa) (from P. Penetrometer tests) 20 40 60 80

LAB TESTING – Atterberg Limits: W_P (Plastic) – W – W_L (Liquid); ✳ Passing 75 um (%); ○ Moisture Content (%); ★ Unit Weight (KN/m3); 20 40 60 80

LITHOLOGY PROFILE – DESCRIPTION (Local Ground Surface Elevation:)		Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	DEPTH (m)	ELEVATION (m)	Moisture Content (%)	Atterberg Limits	INSTRUMENTATION INSTALLATION	GR	SA	SI	CL
TOPSOIL (approx. 255 mm)														
SILTY CLAY Some sand, trace gravel With organics Mottled brown and grey Firm	0.3													
		SS	1	43	4	1		17						
		SS	2	89	6			19						
Brown Very stiff						2								
		SS	3	100	29			13						
With oxidized fissures Grey						3								
		SS	4	94	22			13						
Stiff		SS	5	83	14	4		13	14 26		2	31	36	31
		SS	6	78	12	5		14						
Firm						6								
		SS	7	78	7			15						
END OF BOREHOLE (no refusal)	6.6					7								
						8								

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∇ No freestanding groundwater observed in open borehole upon completion of drilling.

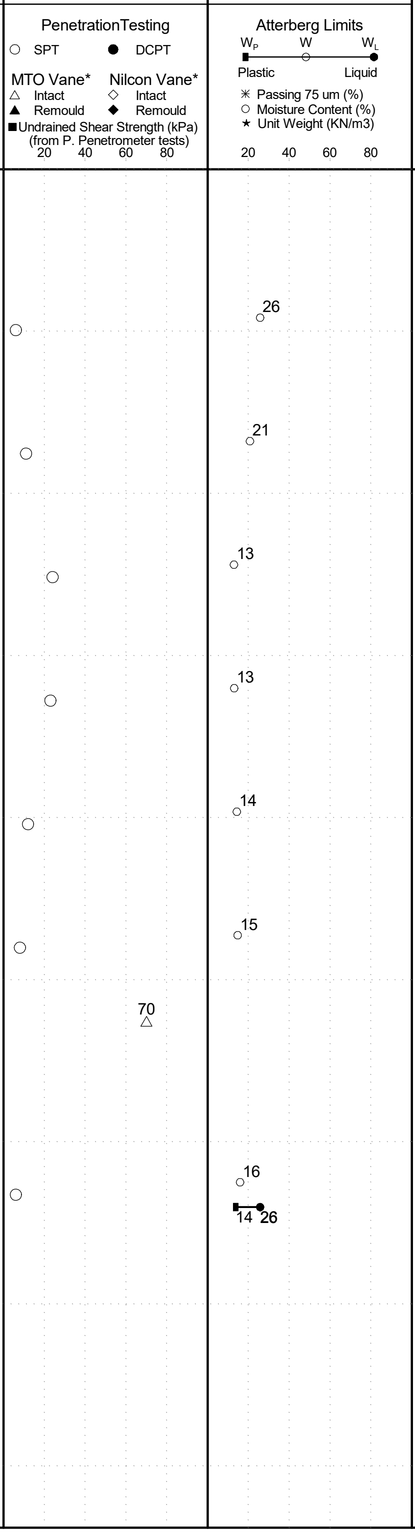
Borehole details, as presented, do not constitute a thorough understanding of all potential conditions present and requires interpretive assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

RECORD OF BOREHOLE No. BH7

Project Number: **SYW207045**
Project Client: **The Corporation of the City of Windsor**
Project Name: **Meighen Road Extension**
Project Location: **Windsor, Ontario**
Drilling Location: **N4685689, E336323**

Drilling Method: **200 mm O.D. Hollow Stem Augers**
Drilling Machine: **CME55**
Date Started: **20 Feb 2020** Date Completed: **20 Feb 2020**
Logged by: **MB** Compiled by: **SLS**
Reviewed by: **TA** Revision No.: **0**

LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%)
DESCRIPTION Local Ground Surface Elevation:		Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	DEPTH (m)	ELEVATION (m)	Penetration Testing	Atterberg Limits / Moisture Content (%)		GR / SA / SI / CL
TOPSOIL (approx. 305 mm)											
SILTY CLAY Some sand, trace gravel Mottled brown and grey Firm	0.3	SS	1	67	6	1		○	26		
Brown Stiff		SS	2	89	11			○	21		
Very stiff		SS	3	89	24	2		○	13		
		SS	4	78	23	3		○	13		
Grey Stiff		SS	5	67	12	4		○	14		
		SS	6	72	8			○	15		
		VT				5		70 △			MTO Vane >70kPa
		SS	7	100	6	6		○	16 14 26		3 30 37 30
END OF BOREHOLE (no refusal)	6.6					7 8					



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▽ No freestanding groundwater observed in open borehole upon completion of drilling.

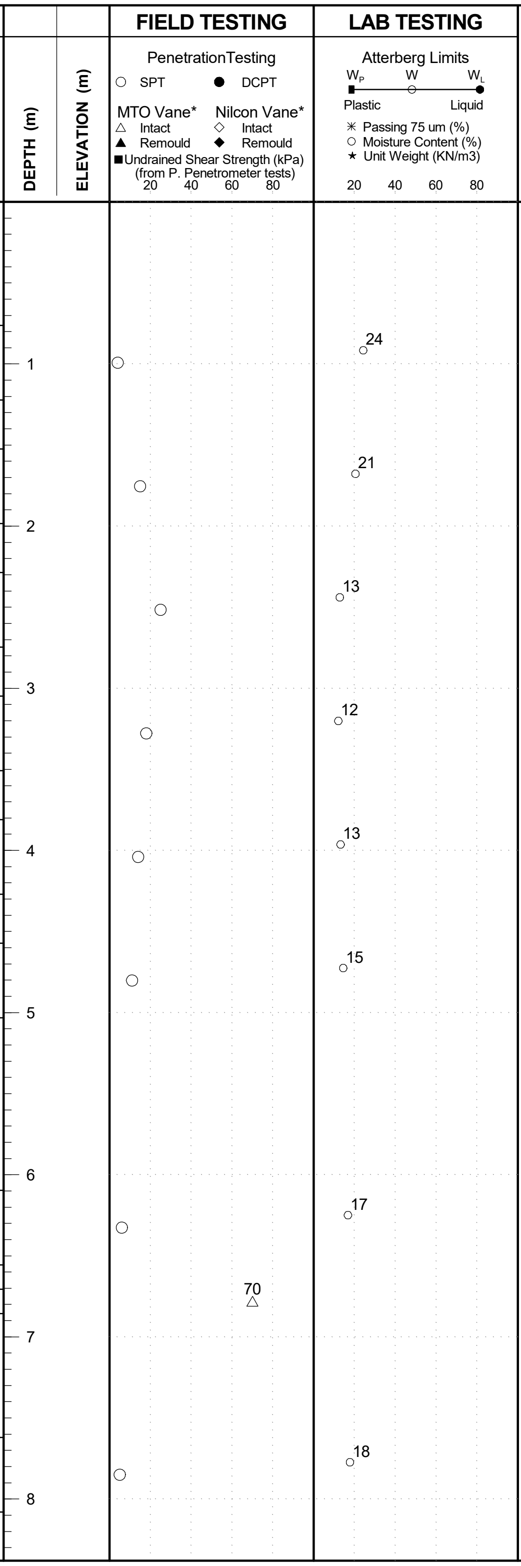
Borehole details, as presented, do not constitute a thorough understanding of all potential conditions present and requires interpretive assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

RECORD OF BOREHOLE No. BH8

Project Number: **SYW207045**
Project Client: **The Corporation of the City of Windsor**
Project Name: **Meighen Road Extension**
Project Location: **Windsor, Ontario**
Drilling Location: **N4685779, E336301**

Drilling Method: **200 mm O.D. Hollow Stem Augers**
Drilling Machine: **CME55**
Date Started: **20 Feb 2020** Date Completed: **20 Feb 2020**
Logged by: **MB** Compiled by: **SLS**
Reviewed by: **TA** Revision No.: **0**

LITHOLOGY PROFILE	SOIL SAMPLING					
DESCRIPTION Local Ground Surface Elevation:	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	LAB TESTING	COMMENTS & GRAIN SIZE DISTRIBUTION (%)
TOPSOIL (approx. 330 mm)						
SILTY CLAY 0.3 Some sand, trace gravel Mottled brown and grey Firm	SS	1	67	4	24	
Very stiff	SS	2	61	15	21	
Brown	SS	3	100	25	13	
Grey With sand pockets	SS	4	83	18	12	
Stiff	SS	5	78	14	13	
	SS	6	94	11	15	
	SS	7	78	6	17	
	VT					MTO Vane >70kPa
Firm	SS	8	100	5	18	
END OF BOREHOLE 8.1 (no refusal)						



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▽ No freestanding groundwater observed in open borehole upon completion of drilling.

Borehole details, as presented, do not constitute a thorough understanding of all potential conditions present and requires interpretive assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

Appendix C

Geotechnical Laboratory Test Results

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ATTERBERG LIMITS
ASTM D-4318 or LS-703 / 704

Project Number: SYW207045
Project Client: City of Windsor
Project Name: Meighen Road Construction
Project Location: Windsor

Sampled by: SS
Tested by: NH

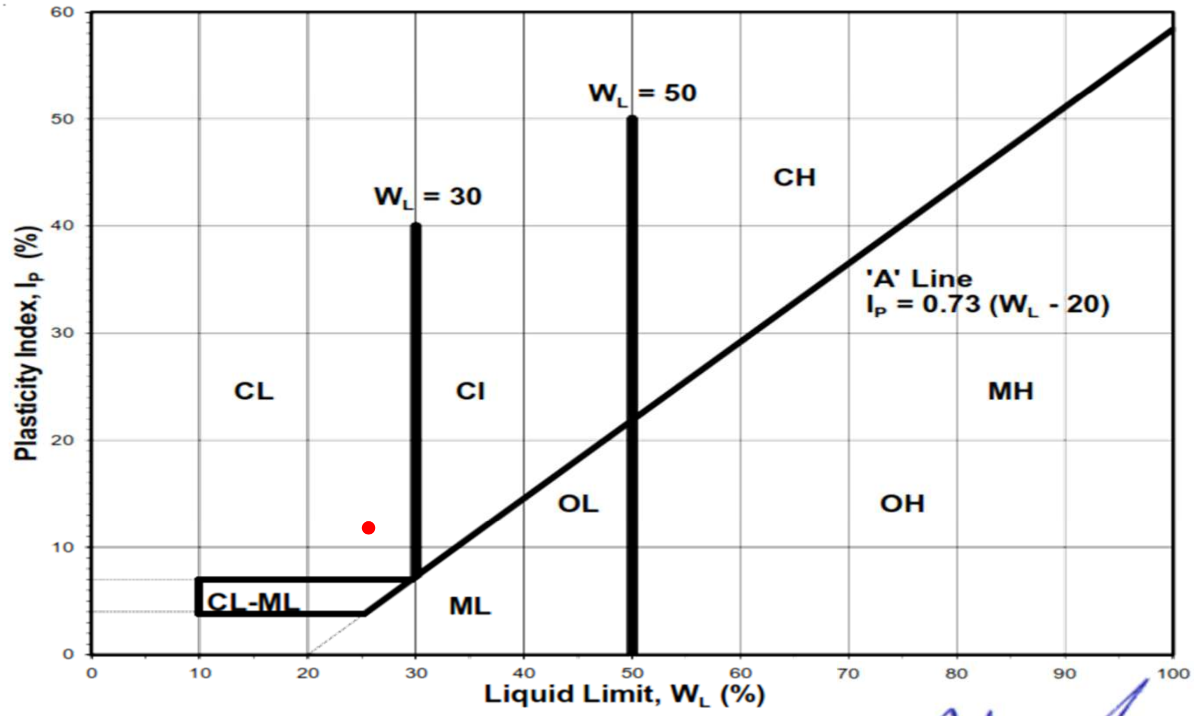
Sampled on: 20-Feb-20
Received on: 20-Feb-20
Tested on: 6-Mar-20

Test Results

LAB NUMBER	232
BOREHOLE	6
SAMPLE	5
DEPTH (m)	3.8-4.3

PLASTIC LIMIT	**13.8**
LIQUID LIMIT	**26.0**
PLASTICITY INDEX	**12.3**

Plasticity Chart for Soil Passing 425 Micron Sieve



Signed by:
Justin Palmer, C. Tech

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GRAIN SIZE DISTRIBUTION
MTO LS 702 / ASTM D7928 / ASTM D6913

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Project Number: SYW207045
Project Client: City of Windsor
Project Name: Meighen Road Construction
Project Location: Windsor

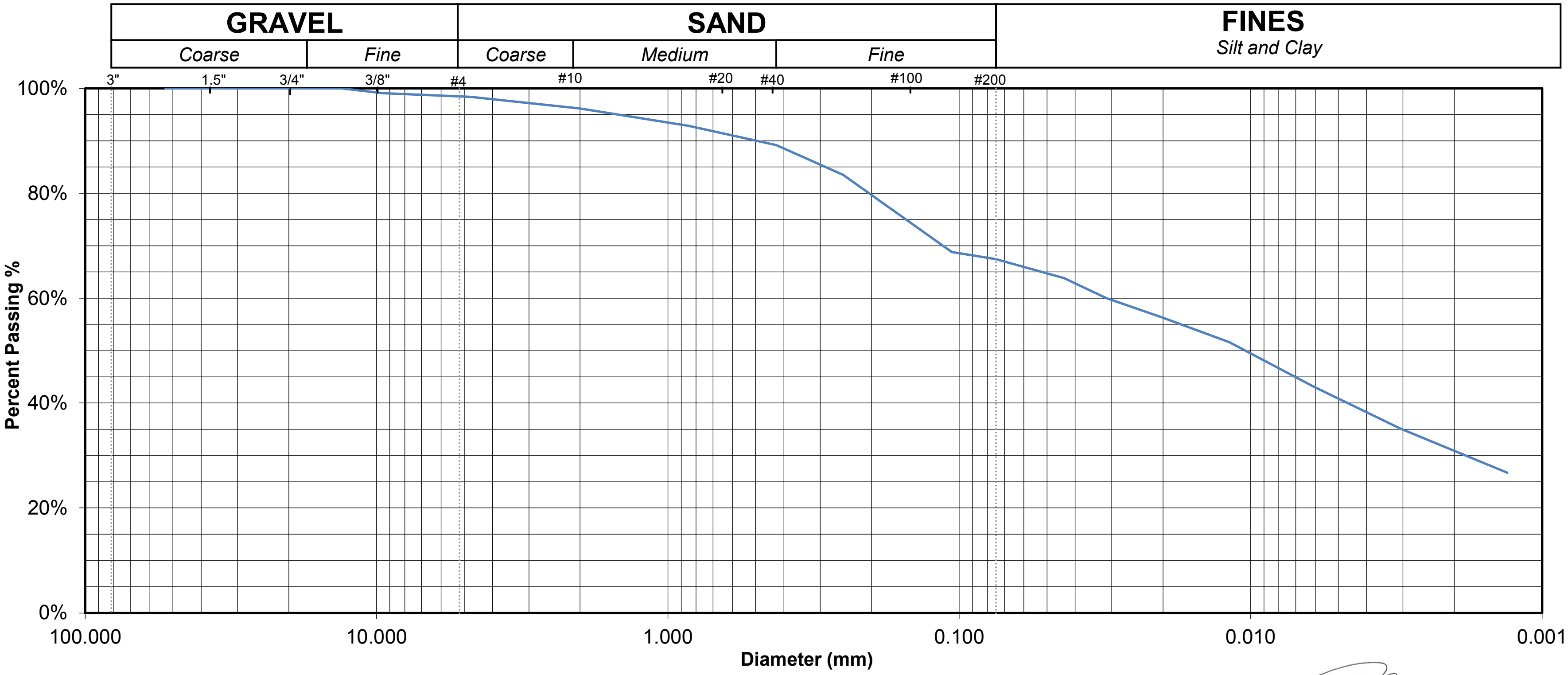
Sampled by: SS
Tested by: JP

Sampled on: 20-Feb-2020
Received on: 20-Feb-2020
Tested on: 2-Mar-2020

Test Results

Sample Location: **BH 6, Sa. 5**
Sample Identification: **233**

Gravel	Sand	Silt	Clay
1.7%	30.9%	36.5%	30.9%



Signed by:
Taner M. Aktas, P.Eng.

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ATTERBERG LIMITS
ASTM D-4318 or LS-703 / 704

Project Number: SYW207045
Project Client: City of Windsor
Project Name: Meighen Road Construction
Project Location: Windsor

Sampled by: SS
Tested by: NH

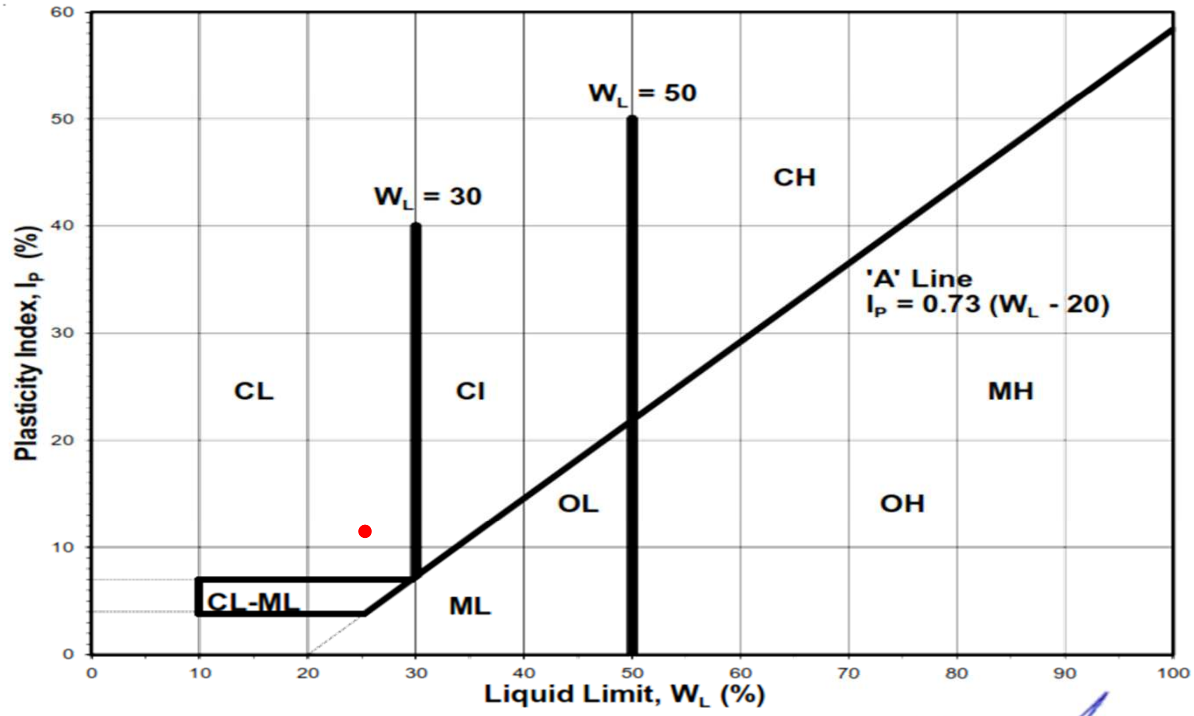
Sampled on: 20-Feb-20
Received on: 20-Feb-20
Tested on: 6-Mar-20

Test Results

LAB NUMBER	234
BOREHOLE	7
SAMPLE	7
DEPTH (m)	6.1-6.6

PLASTIC LIMIT	**13.7**
LIQUID LIMIT	**25.7**
PLASTICITY INDEX	**12.0**

Plasticity Chart for Soil Passing 425 Micron Sieve



Signed by: Justin Palmer, C. Tech

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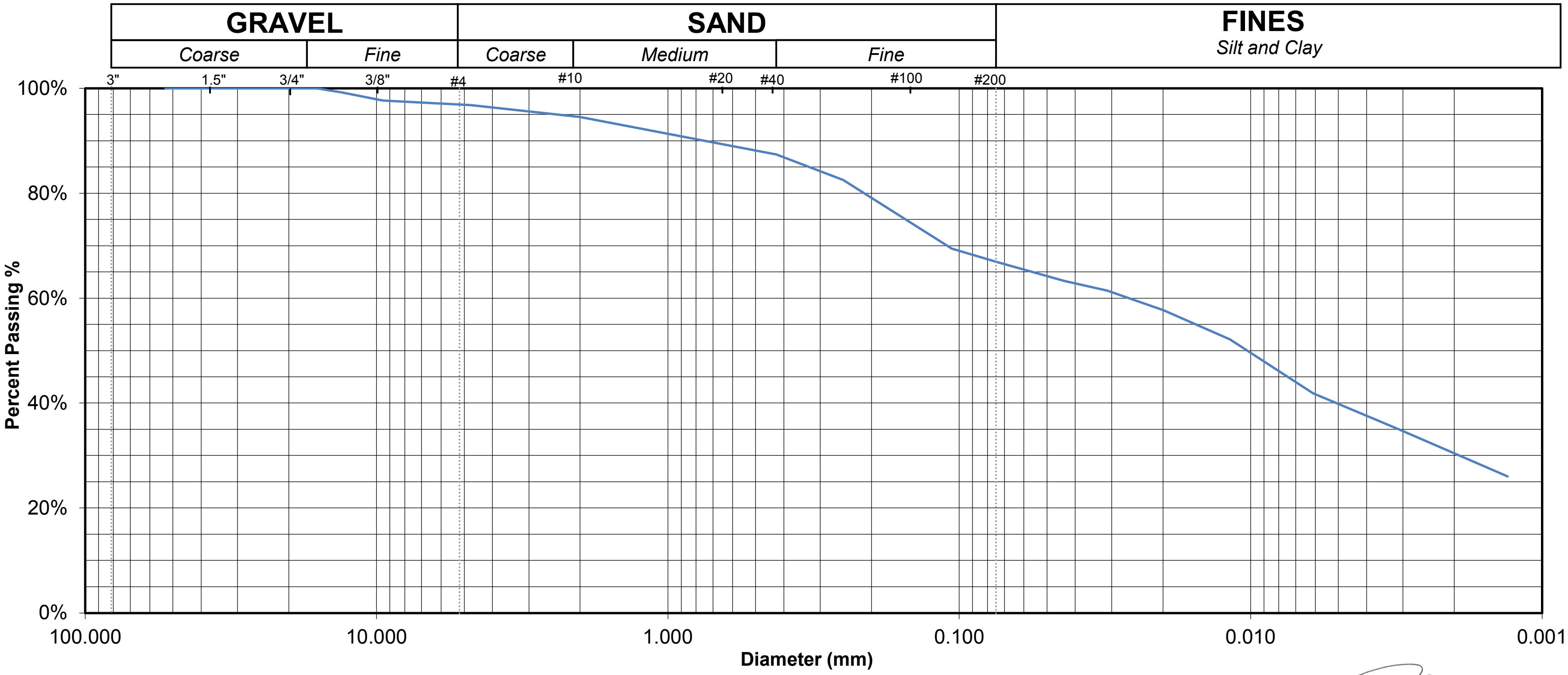
GRAIN SIZE DISTRIBUTION
MTO LS 702 / ASTM D7928 / ASTM D6913

Project Number:	SYW207045	**Sampled by:**	SS	**Sampled on:**	20-Feb-2020
Project Client:	City of Windsor	**Tested by:**	JP	**Received on:**	20-Feb-2020
Project Name:	Meighen Road Construction			**Tested on:**	2-Mar-2020
Project Location:	Windsor				

Test Results

Sample Location: **BH 7, Sa. 7**
Sample Identification: **235**

Gravel	Sand	Silt	Clay
3.2%	29.9%	36.5%	30.4%



Signed by:
Taner M. Aktas, P.Eng.

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