GEOTECHNICAL INVESTIGATION REPORT
MOUNTBATTEN EXTENSION PHASE 2
NEW STORM AND SANITARY SEWERS AND RESIDENTIAL DEVELOPMENT
WINDSOR, ONTARIO

Submitted to:
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1.0 INTRODUCTION

1.1 Background

Amec Foster Wheeler Environment & Infrastructure, a Division of Amec Foster Wheeler Americas Limited ("Amec Foster Wheeler") has been retained by the Corporation of the City of Windsor (the "City") to provide geotechnical services for proposed redevelopment of the former Tecumseh Water Treatment Plant located at the corner of Riverside Drive East and Martinique Avenue in the City of Windsor, Ontario. As part of this project, a geotechnical investigation was carried out to support the design for new sewers and foundations for the proposed residential structures. A Key Plan showing the general location of the site is provided on Figure 1, included at the end of the text.

This report is prepared based on the geotechnical investigation carried out at the site and includes information on soil and groundwater conditions obtained from the geotechnical investigation.

The purpose of the geotechnical investigation was to determine the subsurface soil and groundwater conditions and associated geotechnical parameters and to prepare an engineering report with recommendations for the geotechnical aspects of the design of the proposed new storm and sanitary sewers, and residential development.

The construction conditions discussed in this report are intended primarily to assist in the design decisions. Contractors should be aware that the data and their interpretations presented in this report may not be sufficient to assess all factors that may have an impact on the construction process.

This report is prepared with the assumption that the design and construction will be in accordance with all applicable standards, codes, regulations of authorities having jurisdiction and with good engineering practice. Further, the recommendations and opinions in this report are applicable only to the subject project described above.

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

The scope of this project is strictly limited to the geotechnical aspects of the proposed development. Any potential environmental concerns either already existing or arising from development at this site are beyond the scope of this investigation.

1.2 Project Description

The site is approximately 3 hectares in area and it is planned to redevelop the site with new storm and sanitary sewers, 19 single family homes and 5 blocks of town homes. The inverts of the new sewers will be approximately between elevation 172.25 m and 173.40 m. A new sanitary sewer will be installed along Martinique Avenue to service the new townhomes. The new residential
homes will incorporate basements. The redevelopment will also incorporate the construction of new asphaltic pavement.

It was also requested that the existing fill left on site from the demolition of the former treatment plant be assessed to determine if it is suitable to support the new foundations for the residential structures. In addition, the composition of the fill placed in the southeastern portion of the site sometime in the past is to be determined.
2.0 INVESTIGATION PROGRAM

2.1 Field Work

The scope of work included the advancement of nine (9) sampled boreholes designated as BH1 to BH9, inclusive, and six (6) test pits designated as TP1 to TP6, inclusive. The boreholes were drilled to depths ranging from 5.0 m to 8.4 m below the existing ground surface. The test pits were advanced to depths of 3.2 m to 4.8 m below the ground surface.

The locations of the boreholes and test pits are shown on Figure 2. The figure was prepared from a plan provided by the City. The coordinates of the borehole and test pit locations were determined in the field using a hand-held GPS with an accuracy of ±3 m. The coordinates of the boreholes and test pits are shown on the borehole and test pit logs attached in Appendix A.

The borehole drilling and test pitting program for the investigation was carried out between September 1 and 8, 2015. The boreholes were advanced using a self-propelled drilling machine equipped with hollow stem augers and conventional soil sampling tools. Soil samples were taken at frequent intervals of depth using a 50 mm diameter split spoon sampler following the Standard Penetration Test (ASTM D1586) procedure. The open excavation test pits were advanced using an excavator.

The drilling and test pitting were conducted under the full-time supervision of Amec Foster Wheeler’s engineering staff who directed the drilling/test pitting and sampling operation, and logged the boreholes and test pits.

After completion of each borehole, the augers were extracted, the borehole was inspected for groundwater and caving, and backfilled using bentonite grout. The test pits were backfilled using the excavated soil generated by the test pit operation.

All samples were field logged, placed in airtight containers, and transported to Amec Foster Wheeler’s Tecumseh laboratory for further examination and testing.

Ground surface elevations are referenced to the top elevations of the existing catch basins on the roadway. The top elevations of the catch basins were taken from the cut and fill layout plan provided by the City. Borehole BH1 was referenced to the top elevation of the catch basin at the north end of Mountbatten Crescent near the southwest corner of Lot 9, with a given elevation (El.) of 176.183 m. All other test holes were referenced to the top elevation of the catch basin on Martinique Avenue east of Block 2, with a given elevation of 175.579 m. It is understood that the elevations are referenced to geodetic datum. The elevations used in this report were obtained strictly for use by this office in the geotechnical design of the project. They should not be used by any other party for any other purpose.
2.2 Laboratory Testing

Natural moisture content tests were carried out on all of the recovered soil samples in accordance with ASTM D2216. Grain size distribution tests were completed on two (2) selected soil samples in accordance with ASTM D422 and Atterberg limit tests were carried out on two (2) samples in accordance with ASTM D4318. The test results are included in Appendix B.

Soil sample collected from two boreholes was sent to Paracel Laboratories Ltd. in Ottawa, Ontario to determine the pH, resistivity etc. to assess corrosion potential. The results of the analytical testing are attached in Appendix B and summarized in Table 2.
3.0 SITE DESCRIPTION AND GEOLOGICAL BACKGROUND

3.1 Site Description

The site for the proposed redevelopment of the former Tecumseh Water Treatment Plant is located at the corner of Riverside Drive East and Martinique Avenue in the City of Windsor, Ontario. The location of the site is shown on Key Plan, Figure 1. The site is approximately 3 hectares in area and it is planned to redevelop the site with new storm and sanitary sewers, 19 single family homes and 5 blocks of town homes. A new sanitary sewer will be installed along Martinique Avenue to service the new townhomes. The topography of the land in the vicinity of the proposed site is generally variable as a result of previous development and the site is currently covered with grass.

3.2 Geological Background

The site is located within a geological feature known as Essex Clay Plain, which is an extensive clay plain with little relief and poor natural drainage. The plain is underlain by a relatively thick (30 m to 40 m) deposit of glaciolacustrine silty clay till. Occasional embedded pockets and lenses of sand and silt are present as well as occasional cobbles and / or boulders. The clay deposit is supported by limestone bedrock.

Along the Detroit River shoreline, it is common to encounter significant amounts of man-placed fill materials and buried abandoned structures.

The generally low permeability characteristics of the clay deposit render this deposit as an “aquitard” where the groundwater is stored in the soil pores and moves extremely slowly. Local sizeable fluctuations in the groundwater elevations can occur depending on the prevalent weather and precipitation conditions.
4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Soil Conditions

The soil descriptions presented here are based on visual and tactile examinations, augmented with field tests and select laboratory tests. Details of the subsurface soil conditions at the borehole and test pit locations are given on the Record of Borehole logs and Test Pit logs, respectively, attached in Appendix A. The results of laboratory testing carried out on recovered soil samples are also shown on the borehole and test pit log sheets. The stratigraphic boundaries shown on the borehole and test pit logs are inferred from non-continuous samples and observations during drilling/test pitting, and therefore should be considered as approximate and not as precise planes of geologic change. The soil conditions may vary between and beyond the boreholes/test pits.

The subsurface soil conditions encountered in the boreholes and test pits at the site generally consisted of the topsoil, asphaltic pavement, fill materials and cohesive silty clay. The following descriptions are presented as a summary only.

**Topsoil and Asphaltic Pavement**

Test holes BH2, BH3, BH4, BH5, TP1, TP3, TP4 and TP6 were advanced through a layer of organic topsoil. The thickness of the topsoil layer was about 127 mm to 508 mm at the test hole locations. It should be noted that the thickness of the topsoil may vary over the site from that encountered at the test hole locations. It is therefore recommended that an allowance be made for possible variations in topsoil thickness when making construction estimates.

Borehole BH1 encountered pavement consisting of 127 mm of asphaltic concrete pavement with about 300 mm of crushed granular base materials.

**Fill Materials**

Boreholes BH4, BH5, BH6, BH7, BH8, BH9 and all test pits encountered fill materials at the ground surface or below the topsoil. The fill generally consisted of silty clay, mixed with organics and debris, to silty sand or sandy silt. The thickness of the fill was about 1.0 m to 4.9 m at the test locations. The measured “N” values from Standard Penetration Test obtained in the fill materials ranged from 3 blows to 12 blows per 0.3 m penetration. The moisture content of the tested fill samples varied from 9 percent to 25 percent.

A grain size distribution analysis and Atterberg limits tests were carried out on a recovered silty clay fill sample obtained from borehole BH8. The results of these tests are included on the borehole log sheet and plotted on the laboratory figures attached in Appendix B.

It should be noted that the thickness of the pavement and fill materials may vary between and beyond the test holes from that encountered at the test hole locations.

**Silty Clay**

Cohesive silty clay stratum was encountered directly underlying the topsoil or fill materials in all test holes advanced at the site. The silty clay was mottled brown and grey to grey in colouration.
All boreholes advanced at the site were terminated in grey silty clay. The measured "N" values from Standard Penetration Tests in the silty clay ranged from 2 blows to 36 blows per 0.3 m penetration. A field vane test carried out in the grey silty clay yielded peak undrained shear strengths between 49 kPa and 70 kPa. Based on the "N" values and undrained shear strength obtained from the clay stratum, the cohesive silty clay can be considered to have a soft to hard consistency. The moisture content of the tested silty clay samples varied from 11 percent to 23 percent.

A grain size distribution analysis and Atterberg limits tests were carried out on a recovered native silty clay sample obtained from borehole BH9. The results of these tests are included on borehole log sheet and plotted on the laboratory figures attached in Appendix B.

4.2 Groundwater Conditions

Groundwater level observations and measurements in the boreholes, and in-situ moisture contents of recovered soil samples are recorded on the borehole logs.

Groundwater was encountered in boreholes BH6 and BH7 at depths of 4.3 m and 1.5 m from the ground surface, respectively. Groundwater seepage was also encountered in test pits TP1 to TP2, inclusive, at depths of 1.1 m to 3.4 m below the ground surface during the field investigation. Groundwater also encountered in test pit TP1 at a depth of about 4.2 m.

Groundwater was not encountered in remaining test holes during the field investigation. These test holes were left open and measured 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, it is inferred that insufficient time had passed to allow stabilization of groundwater levels in the open boreholes.

Typically, the grey colour of the soils noted between approximately 3.6 m and 4.6 m depth below grade is indicative of a permanent saturated condition, and therefore, the fluctuations of the long-term groundwater should be anticipated near this depth levels. However, during and after local precipitation events, groundwater that is ‘perched’ above the long-term levels may accumulate in the fill materials and weathered brown clays above the relatively impermeable clay. In addition, significant amounts of groundwater may be present within the pockets of granular soils known to occur randomly within the overburden soils and within any drainage tiles that may be present. In the absence of an active, engineered drainage system, the design should assume possible temporary groundwater levels rising to the ground surface. Any existing tile drainage system should not be considered “engineered” for the purposes of foundation design unless verified by the competent person.

4.3 Analytical Laboratory Testing

Select soil sample obtained from borehole was sent to Paracel Laboratories Ltd. in Ottawa, Ontario for determination of pH, electrical resistivity, chloride content and sulphate content. The laboratory reports are presented in Appendix B. The results of the test are summarized in Table 1.
The results of the analytical testing are discussed in Section 5.8 of this report.

<table>
<thead>
<tr>
<th>Borehole ID and Sample No.</th>
<th>Sample Depth (m)</th>
<th>pH</th>
<th>Chloride (μg/g)</th>
<th>Sulphate (μg/g)</th>
<th>Electrical Resistivity (Laboratory) (Ω-cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH4, Sample No. 3</td>
<td>2.3 – 2.7</td>
<td>7.53</td>
<td>6</td>
<td>59</td>
<td>5310</td>
</tr>
</tbody>
</table>
5.0 DISCUSSION AND RECOMMENDATIONS

5.1 General

It is understood that it is planned to redevelop the site with new storm and sanitary sewers, 19 single family homes and 5 blocks of town homes. The redevelopment will also include the construction of new asphaltic pavement. At this time, information on the finished elevation, foundation elevation and foundation loads are not available for all of the proposed structures. It is considered for the purpose of preparing this report that there will be no unusual foundation loads or settlement limitations for this residential development. Accordingly, general recommendations for foundations are provided in the following sections.

5.2 Foundations

5.2.1 General

As indicated in Section 4.1, boreholes BH4, BH5, BH6, BH7, BH8, BH9 and all test pits advanced at the site encountered fill materials at the ground surface or below the topsoil. The fill generally consisted of silty clay, mixed with organics and debris, to silty sand or sandy silt. The thickness of the fill was about 1.0 m to 4.9 m at the test locations. Based on the widespread presence of the fill across the site, it is inferred that the majority of the site area contains fill materials, with the exception of the area along Martinique Avenue to north of borehole BH4.

Based on the drawing (Drawing No. S-1625, revision 2 dated April 3, 2003) provided to us, it is understood that the finished floor elevation of the new homes will be at elevation 177.24 m. Therefore, it is estimated that the basement level will be at about elevation of 174.24 m. Based on this assumed basement level, the fill material in the north portion of the site (in the vicinity of boreholes BH6, BH7, BH8 and BH9) is estimated to extend about 1.0 m to 4.0 m below the basement level. The fill material in the south and east portions of the site (in the vicinity of boreholes BH1 to BH5), is expected to terminate above the assumed foundation elevation of 174.24 m.

The fill material and the overlying organic topsoil are not suitable to support residential foundations. Based on the soil conditions encountered in the boreholes, shallow conventional spread and/or strip foundations placed in the undisturbed native stiff/very stiff silty clay can be considered at this site.

Where fill is present below the foundation elevation, it will be necessary to subexcavate the fill and replace it with engineered fill to accommodate conventional strip/spread footing foundation construction. Engineered fill should consist of imported OPSS Granular “A”, or Granular “B” Type I material (OPSS 1010), placed in maximum 150 mm thick lifts and compacted to at least 98 percent of the material’s standard Proctor maximum dry density under full time supervision of qualified geotechnical staff. The engineered fill pad should extend at least 1 m beyond the edge of the footing and should slope downwards at 1 horizontal to 1 vertical, or flatter.

Extensive subexcavation (as much as 4 m below the foundation elevation) may be required at some locations to expose competent native soils. As an alternative to conventional strip/spread
Continued……………….

foundations constructed on native soils or engineered fill, caisson and/or helical pile foundations founded on the native soils below the fill can be considered for the lightly to moderately loaded structures, where the fill materials are present below the basement level. The bearing resistance of the foundation soils at the site will vary with the location and depth of the foundations.

5.2.2 Shallow Foundations for Single Family Homes and Town Homes

The soil bearing resistances have been provided for the structures based on the boreholes advanced as identified in Table 2. The shallow spread/strip foundations constructed in the native undisturbed soils or engineered fill in the vicinity of the associated boreholes may be designed using the corresponding factored bearing resistance at the Ultimate Limit State (ULS) and soil bearing reaction at the Serviceability Limit State (SLS) provided in Table 2. All foundations in the unheated area should have thermal insulation of 1.2 m of soil cover to prevent any frost penetration. The subsurface soil conditions encountered in the boreholes are varied broadly. Therefore, some variations from the given geotechnical resistance of the soils may be considered, subject to interaction between the structural and geotechnical engineers during the detailed design process.

Table 2: Recommended Geotechnical Net Bearing Resistance of the Native Soils for Shallow Spread/Strip Foundations

<table>
<thead>
<tr>
<th>Structure</th>
<th>Boreholes Included</th>
<th>Foundation Elevation (m)</th>
<th>Founding Soils</th>
<th>Net Ultimate Bearing Capacity (kPa)</th>
<th>Factored Bearing Resistance at Ultimate Limit State (ULS)(1) (kPa)</th>
<th>Bearing Reaction at Serviceability Limit State (SLS) (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Family Homes</td>
<td>BH1, BH5 to BH9</td>
<td>Below 174.28</td>
<td>Native Silty Clay or Engineered Fill</td>
<td>230</td>
<td>115</td>
<td>75</td>
</tr>
<tr>
<td>Town Homes</td>
<td>BH2, BH3 and BH4</td>
<td>Below 174.28</td>
<td>Native Silty Clay</td>
<td>200</td>
<td>100</td>
<td>65</td>
</tr>
</tbody>
</table>

(1) A resistance factor of Φ = 0.5 has been applied to the given values.
*Groundwater is anticipated due to presence of sand seams and pockets randomly occurred in the silty clay. Dewatering may be required to lower the groundwater level below the foundation depth.
**Any fill or soft/firm silty clay soils encountered at the foundation depth must be removed before the foundation is built.

Limit states design of foundations, as required by the 2012 Ontario Building Code (OBC), is based on soil-structure interaction. The soil response will vary with the foundation dimensions, depth of embedment, and on the load combinations considered in the design. The bearing resistances recommended above are for vertical loads only (no inclination or no eccentricity). The SLS and ULS values will be less than stated where inclined or eccentric loading conditions exist. The foundation design must consider the actual footing embedment and the load inclinations and eccentricity as per the applicable principles presented in the Canadian Foundation Engineering Manual (CFEM). Amec Foster Wheeler would be pleased to provide detailed assistance in the required geotechnical calculations to satisfy these requirements.
The total and differential settlements should not exceed the conventional limits of 25 mm and 20 mm, respectively for spread/strip foundations designed in accordance with the SLS recommendations provided in this report. If the design requires more stringent settlement limitations or if more accurate values are required, detailed analyses for SLS reaction values and SLS settlements will be required.

The unfactored resistance to horizontal sliding can be calculated as 35% of the acting footing normal load.

The recommended bearing resistances assume native undisturbed soils or approved engineered fill. The soil bearing capacity deteriorates dramatically when the soils are exposed to seepage, weathering and/or construction disturbance. The foundation subgrade soils should be protected from freezing, inundation and equipment traffic at all times. Typical methods to protect the subgrade are discussed later in the report. Prior to placing foundation concrete, the founding subgrade must be cleaned of all deleterious materials such as topsoil, softened, disturbed or caved materials, as well as any standing water.

All excavated foundation bases should be evaluated by the geotechnical engineer to ensure that the founding soils at the excavation base are consistent with the design bearing pressures.

5.2.3 Drilled Caisson and Helical Pile Foundations

As indicated, cast-in-place concrete caisson or helical pile foundations can be considered for the proposed structures where extensive fill materials are present below the foundation level. At this time, information on the finished grades, floor elevations and foundation elevations for the proposed structures is only preliminary. It is considered for the purpose of preparing this report that there will be no unusual foundation loads or settlement limitations for the residential structures. Accordingly, general recommendations for deep foundations are provided in the following paragraphs.

Based on the soil conditions encountered in the boreholes, the use of drilled caisson (i.e. cast-in-place) or helical pile foundations placed in native competent soils can be considered to support the residential structures at this site. However, a liner should be used for drilled concrete caissons to prevent caving of the surrounding soil and to control groundwater seepage into the excavation. The bearing resistance of the foundation soils at this site will vary with the depth of the foundation.

The drilled caisson or helical pile foundations placed in the native undisturbed soil in the vicinity of the boreholes identified below may be designed using the corresponding soil bearing reaction at the Serviceability Limit State (SLS) and factored bearing resistance at the Ultimate Limit State (ULS) provided in the Table 3.
### Table 3: Recommended Geotechnical Net Bearing Resistance of the Soils for Drilled Caisson and Helical Pile Foundations

<table>
<thead>
<tr>
<th>Boreholes Included</th>
<th>Approximate Foundation Elevation (m)</th>
<th>Average Design Undrained Shear Strength ($S_u$) (kPa)</th>
<th>Caisson Foundation of Diameter &lt; 1.0 m</th>
<th>Helical Pile with a Single Helix</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH6, BH7, BH8 and BH9</td>
<td>174.28 to 170.50</td>
<td>35</td>
<td>10</td>
<td>Not recommended in the fill</td>
</tr>
<tr>
<td></td>
<td>170.50 to 167.00</td>
<td>50</td>
<td>12</td>
<td>120</td>
</tr>
</tbody>
</table>

Note: (1) Groundwater is anticipated due to presence of sand seams and pockets randomly occurred in the silty clay. Dewatering may be required to lower the groundwater level below the foundation depth.
It is understood that the foundation will be placed below the frost depth, therefore shaft and lateral resistances, and adfreeze uplift due to seasonal saturation and frost effects are not addressed in this report. The foundation design should account for groundwater levels reaching the ground surface periodically throughout the year.

Caisson foundation behaviour under lateral loads is strongly dependent on the foundation structural configuration, on the soils surrounding the caisson, and the type of the lateral loading (shear force vs. overturning moment). Amec Foster Wheeler will be happy to assist with the geotechnical design of the caissons under lateral loads once the foundation concepts and the load combinations are established.

The lateral capacity of a caisson can best be determined by field tests. The stress-deformation behaviour of caisson under lateral loads can be determined using the horizontal subgrade reaction method. In cohesive soils, the coefficient of horizontal subgrade reaction may be estimated by the following equation:

\[
k_s = \frac{67 S_u}{d}
\]

(cohesive soils)

where,

- \(k_s\) = coefficient of horizontal subgrade reaction (kPa/m)
- \(d\) = caisson diameter (m)
- \(S_u\) = undrained shear strength (see Table 3).

In cohesionless soils, the coefficient of horizontal subgrade reaction may be estimated by the following equation:

\[
k_s = \frac{n_h z}{d}
\]

(cohesionless soils)

where,

- \(k_s\) = coefficient of horizontal subgrade reaction (MPa/m)
- \(z\) = depth (m) below finished grade
- \(d\) = caisson diameter (m)
- \(n_h\) = soil coefficient (5 to 10 MPa/m)

Alternatively, the response of a caisson foundation can be analyzed using the nonlinear “p-y” interaction method described in the Canadian Foundation Engineering Manual.

The conventional SLS resistance represents the lateral shear force applied on a free-head caisson that causes a lateral deflection of 10 mm measured at the ground surface. The ULS lateral resistance is defined as the lateral force applied to the caisson shaft causing unstabilized caisson displacements due to soil failure or caisson structural failure.

In the case of deeper caissons where an effective control of the quality of the subgrade at the bottom of the caisson is questionable, it should be noted that the caissons might experience higher than normal settlements under operation loads before the tip resistance will be mobilised.

Typical constructions consideration associated with this type of foundation are discussed in Section 5.12 of this report.
Usually helical piles cannot provide significant lateral resistance (shear resistance) due to the relatively smaller cross section of the pile shaft. Lateral resistance can significantly be improved by the use of battered piles. Where the design relies on the lateral resistance, the design should also consider the cross-sectional properties of the pile shaft. In this case, the lateral resistance should be confirmed by field load tests.

Because the helical piles are proprietary systems, it is recommended that the piles be designed and installed by experienced specialist contractors. The bearing capacity should be confirmed by filed load tests and in writing by the installer.

5.3 Seismic Considerations

The 2012 Ontario Building Code (2012 OBC) contains updated seismic analysis and design methodology. The 2012 OBC uses a site classification system defined by the average soil/bedrock properties in the top 30 metres (100 feet) of the subsurface profile beneath the structure. Based on the limited site investigation and our experience in this area, a “Site Class D – Stiff Soil” designation could be used for design in accordance with the 2012 OBC methodology (Table 4.1.8.4.A).

The four values of the Spectral response acceleration $S_{a}(T)$ for different periods and the Peak Ground Acceleration (PGA) should be obtained from 2012 OBC. The design values of $F_{a}$ and $F_{v}$ for the project site should be calculated in accordance to Table 4.1.8.4 B and C.

5.4 Frost Design Considerations

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 structures 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 permanent soil cover of 1.2 m or equivalent thermal insulation is required for frost protection of foundations.

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

5.5 Excavation and Groundwater Control

All excavations should be carried out in accordance with the current Ontario Occupational Health and Safety Act and Regulations for Construction Projects (Regulation 234). Type 2 conditions are to be considered for the undisturbed, native very stiff or dense soils, and Type 3 conditions are to be considered for the undisturbed, native stiff to firm or compact to loose soils. However, consideration should be given to the possibility of down-rating of the soils if the excavation walls are exposed to weathering for several days without proper protection. Conditions for Type 4 soils
may develop if excavations encounter flowing perched groundwater such as in live and abandoned utility trenches, in soft or very loose soils or are advanced below the groundwater table. The excavations may require flatter slopes if sand or silt seams are encountered, particularly if they are water-filled. Alternatively, a trench liner box could be used for temporary support of excavations. Trench liner boxes should be selected on the basis of the anticipated earth pressures determined according to the recommendations in Section 5.7.

Groundwater inflow into excavations in the clayey soils is expected to be low; however, significant ‘perched’ groundwater may be present within the topsoil and fill materials. This would especially be true during and after local precipitation events. In this case, the inflow into excavations may become significant.

The soils identified are sensitive to disturbance by water. In general, groundwater and surface water run-off can be removed from excavations by means of pumping from strategically placed open sumps. However, special dewatering system may be required at some locations to lower the water level below the foundation depth as identified in Tables 2 and 3.

The caisson excavation bottom should be free of any water. A proper dewatering system may be required to lower the water level below the caisson foundation depth.

Consideration must be given to the potential of ground settlements and/ or undermining induced by excavations and extended dewatering. The construction process should be carefully planned and staged to prevent uncontrolled disturbance of the foundation soils beneath the existing building. Excavations, dewatering and construction vibrations may cause severe damage to the existing structure.

Amec Foster Wheeler should be retained to review the proposed excavation procedures.

A permanent drainage system should be constructed for the basement by placing weeping tiles or drain board connected to gravity outlet or sump.

**5.6 Backfill of Foundations**

Foundations can be backfilled using OPSS Granular “A” and/or Granular “B”, Type I material. This material should be placed in 200 mm thick loose lifts and compacted to 95% of the standard Proctor maximum dry density (SPMDD).

In some cases, the on-site native weathered brown silty clay can also be used as general backfill material providing they are free from any organics and deleterious materials. The existing fill materials are not suitable for general fill and can be used in non-settlement sensitive areas such as landscaped areas. The suitability of the on-site native soil and fill for use as backfill material should be determined in the field after completion of excavation. The backfill material should have the moisture content within 2% of the optimum moisture content at the time of backfilling. Clayey soil may be wetter than the optimum range for compaction purposes. Therefore, upon properly conditioned, the on-site soil should be placed in lifts not thicker than 200 mm in loose state and compacted to at least 95% of the standard Proctor maximum dry density (SPMDD).
5.7 Earth Pressures

A distinction should be made between short-term earth pressures on temporary (during construction) retaining structures, and long-term retaining structures against compacted backfill.

As a preliminary guideline, the temporary shoring structures (if required for deep utility trenches) should be verified for conventional uniform earth pressures of at least 0.3 $P_z$, ($P_z$, in kPa, is the overburden pressure corresponding to the depth ‘z’ of excavation below the ground surface). For the in-situ soils a 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.

For permanent structures, unfactored earth pressure coefficients and associated backfill unit weights are presented in Table 4.

### Table 4: Soil Parameters for Earth Pressure Calculations

<table>
<thead>
<tr>
<th>Backfill Type</th>
<th>Active Case</th>
<th>Passive Case</th>
<th>At Rest Case</th>
<th>Design Bulk Unit Weight (kN/m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select Crushed Limestone (Granular &quot;A&quot;) (*)</td>
<td>0.27</td>
<td>3.7</td>
<td>0.42</td>
<td>22</td>
</tr>
<tr>
<td>Well Graded Sand (Granular &quot;B&quot;, Type I) (*)</td>
<td>0.33</td>
<td>3</td>
<td>0.5 to 0.6</td>
<td>21</td>
</tr>
<tr>
<td>Silty Clay Fill (**)</td>
<td>0.45</td>
<td>2.2</td>
<td>0.7 to 0.8</td>
<td>20.5</td>
</tr>
</tbody>
</table>

(*) All granular compacted to at least 98% SPMDD
(**) Compacted to at least 95% SPMDD

The design earth pressures in compacted backfill should be augmented with the dynamic effects of the 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. However, this dynamic effect should be ignored when calculating the passive resistance for thrust blocks, or other instances where the general stability of the structure relies on the passive resistance.

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

For the calculation of the long-term earth pressures, consideration should be given to using the submerged weight where the soil is below the groundwater table unless a permanent dewatering system is installed.

5.8 Corrosion Potential

Analytical testing was carried out on select soil sample obtained from borehole BH4. The results of the testing are summarized in Table 1.
The test results indicate that concrete in contact with the tested soil would have a negligible degree of exposure to sulphate attack based on CSA-A23.1.

Based on the measured resistivity, pH etc., the tested soil samples would be considered noncorrosive to buried metallic elements in accordance with ANSI/AWWA C105/A21.5-05, Appendix A, Table A.1.

The above results and recommendations should be reviewed by a corrosion specialist.

5.9 Sewer Pipe Bedding and Cover

As indicated, it is planned to redevelop the site with new storm and sanitary sewers. The inverts of the new sewers will be approximately between elevations 172.25 m and 173.40 m. A new sanitary sewer will be installed along Martinique Avenue to service the new townhomes. The native-undisturbed silty clay sub-grade is competent to support the bedding for the intended sewer pipes. Once these competent soils are exposed and approved, the pipe bedding should be placed. The pipes should be supported under haunches and sides using the same material as for the bedding. The depth of the bedding should be a minimum of 150 mm; the pipe cover should be completed to at least 300 mm above the pipe crown. Bedding material should consist of Granular “A” compacted to 95% of its Standard Proctor maximum dry density (SPMDD). Cover material should also consist of Granular ‘A’ compacted to 95% of its SPMDD. Alternatively, 19-mm crushed stone (“clear stone”) may be used up to the spring line of the pipe, however, Amec Foster Wheeler recommends that non-woven geotextile be used as for separation between the clear stone and the native soils and backfill. Adjacent sheets of the geotextile should have a minimum overlap of at least 300 mm at the seams. The seams should be stitched where sand or silt lenses are encountered within the bedding and cover zone to prevent separation of the geotextile.

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

Groundwater will tend to accumulate in the trench fill due to infiltration from the surface and leaks in the pipes therefore consideration should be given to the construction of clay (bentonite) collars at strategic locations to reduce the probability of uncontrolled groundwater flow within the pipe bedding.

5.10 Backfilling for Trench

In areas where some settlements may be tolerated, such as landscaping, site-generated native clayey soil compacted in maximum 300 mm loose lifts to at least 95% Standard Proctor Maximum Dry Density (SPMDD) may be used as general trench backfill.

Within pavement areas, trench backfill above the pipe cover material to within 1.0 m of pavement surfaces may be carried out using any approved compactable materials (clean imported granular fill or select site generated fill). The backfill below 1.0 m from the ground surface should be completed in maximum 200 mm loose lifts and compacted to at least 95% SPMDD. Backfill of
trenches in the upper 1.0 m from finished grade should be compacted to a minimum of 98% SPMDD.

5.11 Pavement Design Recommendations

All topsoil and deleterious unsuitable fill materials should be removed to expose competent soils, which should be immediately inspected by the geotechnical consultant. The contractor should be prepared to conduct proof-rolling of the subgrade soils by a heavy roller. Any soft or loose spots revealed by the proof-rolling should be sub-excavated and replaced with imported granular fill meeting the requirements of Granular “B”, Type I or Granular “B”, Type II (OPSS 1010) placed in controlled lifts not exceeding 200 mm and compacted to 98% of its SPMDD. The use of geotextile may be required to provide subgrade support, depending upon conditions at the time of construction.

If raising of the grade is required, select granular fill such as Granular “B”, Type I (OPSS 1010) is recommended. The fill should be placed in controlled lifts not exceeding 200 mm and the material should be compacted to 98% of its SPMDD.

It is anticipated that new roads will be local roads. The following pavement design is recommended as a minimum for use at this site:

![Table 5: Minimum Recommended Pavement Section](image)

All granular base and sub-base materials must meet the corresponding OPSS Form 1010 requirements and be placed in lifts not greater than 200 mm thick, compacted to 100% of the material SPMDD. The asphaltic concrete should be compacted to the specifications of the City of Windsor. The placing and rolling of the asphalt mixtures should conform to OPS requirements. Concrete and concrete construction should conform to current CSA A23.1 requirements.

The above pavement structure table presents recommendations for the minimum thickness of asphalt, concrete, granular base and sub-base only. It does not include a comprehensive pavement design (e.g. asphalt mix design, asphalt cement type). Amec Foster Wheeler would be pleased to assist in the detailed design, if requested by the Client.
It should be noted that the above recommended pavement structures are based on the assumption that the roadway will be used by light trucks and occasional heavy trucks, cars, service and maintenance vehicles. In the areas of heavy truck, turnaround, etc. consideration can be given to using a rigid pavement surface.

5.11.1 Drainage

All granular base and sub-base materials should be fully drained at all times. The serviceability of the asphaltic pavement structure is largely dependent on drainage of the granular base and sub-base materials in order to minimize differential frost movements and variations in subgrade support.

All subgrade should be crowned to promote drainage of the sub-base. Sub-drainage should consist of full-length perforated subdrain pipes of 150 mm diameter to be installed along the perimeter of the paved areas, below the subgrade level, to ensure effective drainage in accordance with OPSD 216.021. The sub-drain pipes should be surrounded by a minimum drainage zone of 19 mm size clear stone of minimum 150 mm thickness and wrapped in suitable non-woven geotextile to provide separation from the surrounding soil. In parking areas, 'stub drains' should be provided at all catch basin locations. Stub drains should be keyed into the subgrade, radiating 3 m outward in four directions from the catch basin, and be constructed similar to the sub-drains described above.

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 the outside edges of the pavement or curb. A minimum slope of 2% should be maintained across the paved sections to ensure proper surface drainage.

5.11.2 Pavement Construction Considerations

The above mentioned pavement design is based on the assumption that construction will take place under dry weather and subgrade conditions. If construction takes place under wet subgrade or weather conditions, the pavement design should be re-evaluated by the geotechnical engineer.

The above pavement designs are not intended to support construction traffic. All construction traffic should travel on temporary haul roads. Where these routes coincide with future pavement or slab-on-grade areas, the haul roads should be provided with a temporary increased thickness of granular material to protect the integrity of the subgrade. The use of geogrid reinforcement below the haul road base layer should be considered to reduce rutting under heavy traffic. A minimum thickness of 300 mm of granular fill should be spread before moderate construction traffic can proceed over this area. This does not include designated haul routes, which require a stronger base of at least 450 mm of crushed granular material of up to 75 mm minus gradation.

5.12 General Construction Considerations

The sub-grade soils identified in this report are extremely sensitive to disturbance from exposure to weathering and/or construction traffic (vehicular and pedestrian). Once the excavations have been completed to design elevations, the sub-grade soils should be immediately inspected by the
geotechnical consultant. Upon approval, the sub-grade soil should be protected from further exposure. The excavation of the foundation and sub-grade soils should be carried out using excavating buckets equipped with a smooth lip (blade) to reduce disturbance of the bearing surfaces.

Vehicular traffic over prepared sub-grade soils, whether or not the granular fill is in place, should be strictly prohibited. Temporary construction routes should be established. If these routes coincide with future paved or slab on grade areas, adequately reinforced hauling roads should be prepared in order to reduce damages to sub-grade soils. The provisions are crucial particularly if the construction is scheduled during wet and/or cold seasons. The use of a separation fabric in conjunction with at least 450 mm of “0 – 50 mm” crushed limestone should be used for haul roads.

In the case of caisson foundations, no person should enter a caisson excavation unless the excavation is completely lined and all appropriate precautions for entry to confined spaces are taken. The depth of excavation must be verified by measurement and inspection performed by a representative of the Geotechnical Consultant. The bottom of the excavation shall be cleaned such that no loose material remains at the bottom of the shaft prior to the placement of caisson. The excavation bottom should be free of any water. A proper dewatering system may be required to lower the water level below the foundation depth. Steel reinforcement and concrete shall be placed immediately following completion of each shaft excavation and inspection. Concrete shall be placed in excavation through a suitable tube or tremie to prevent segregation of all materials. The top 3 meter of concrete shall be mechanically vibrated.

Caisson foundations should be constructed by an experienced contractor and include full-time inspection by the Geotechnical Consultant in order to document material encountered during excavations as well as proper diameter, depth, cleaning and placement and quality of materials. It is good practice to organise pre-construction meetings with the contractors and the Client’s consultants to discuss the detailed approach for the caisson construction.

Winter construction should include provisions to prevent freezing of the foundation subgrade at all times.

Consideration should be given to the potential construction impacts on the adjacent facilities. Among most frequent construction impacts related with the geotechnical setting are the ground settlements during excavations and vibration propagation though the foundation soils. If required, Amec Foster Wheeler can provide further assistance in this regard.
6.0 CLOSURE

The limitations of this report, as discussed in the Report Limitations attached in Appendix C, constitute an integral part of the report.

The recommendations included in this report, although site specific, have a general nature. Once the intended design details and construction methods are available, it is recommended that the geotechnical consultant be retained to review this information to ensure conformance with the assumptions and limitations considered.

We trust this report is complete within the terms of our reference. However, should there be any questions or if any point requires further clarification kindly contact our office at your convenience.

Sincerely,

Amec Foster Wheeler Environment & Infrastructure
a Division of Amec Foster Wheeler Americas Limited

Prepared By: 

Reviewed by: 

Senior Geotechnical Engineer

Ty Garde, M.Eng., P.Eng.
Geotechnical Group Leader

Ref. No.: SWW157362
FIGURES
APPENDIX A

BOREHOLE AND TEST PIT LOGS
RECORD OF BOREHOLE No. BH1

Project Number: SWW157362
Project Client: The Corporation of the City of Windsor
Project Location: Windsor, Ontario
Drilling Location: N4689880, E341278

Drilling Method: 200 mm Hollow Stem Augers
Drilling Machine: CME 55
Date Started: 1 Sep 15
Date Completed: 1 Sep 15
Logged by: SS
Compiled by: SS
Reviewed by: SM
Revision No.: 0

LITHOLOGY PROFILE

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<thead>
<tr>
<th>DESCRIPTION</th>
<th>SOIL SAMPLING</th>
<th>FIELD TESTING</th>
<th>LAB TESTING</th>
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<td>Sample Type</td>
<td>Sample Number</td>
<td>SPT ‘N’ Value</td>
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COMMENTS

-split spoon hitting rock

Lithology Plot

Geodetic Ground Surface Elevation: 176.4 m

ASPHALT (127 mm thick)

FILL

Crushed granular

SILTY CLAY

Trace sand, trace clay
Weathered
Mottled brown and grey
Firm

Rootlets

Brown Stiff

Very stiff

Grey Firm

END OF BOREHOLE (no refusal)

Penetration Testing

ELEVATION (m)

SPT ‘N’ Value

DEPTH (m)

INSTRUMENTATION INSTALLATION

Geodetic Ground Surface Elevation: 176.4 m

Atterberg Limits

PL Plastic

WP Plastic

LP Liquid

WP Liquid

PASSING 75 um (%)

Moisture Content (%)

LAB TESTING

RECORD OF BOREHOLE No.   BH1

Amec Foster Wheeler
Environment & Infrastructure
11865 County Rd 42
Tecumseh, ON N8N 2M1
Tel: 519-735-2499
Fax: 519-735-9669
www.amecfw.com

Page: 1 of 1

The Corporation of the City of Windsor
Mountbatten Extension Phase 2

Project Number: SWW157362
Project Client: The Corporation of the City of Windsor
Project Location: Windsor, Ontario
Drilling Location: N4689880, E341278

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ELEVATION (m)

SPT ‘N’ Value

DEPTH (m)

INSTRUMENTATION INSTALLATION

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Moisture Content (%)

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Page: 1 of 1
**Lithology Profile**

<table>
<thead>
<tr>
<th>Lithology Type</th>
<th>Description</th>
<th>Sample</th>
<th>Sample Number</th>
<th>Recovery (%)</th>
<th>SPT N' Value</th>
<th>Depth (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topsoil</td>
<td>(508mm thick)</td>
<td>SS</td>
<td>1</td>
<td>78</td>
<td>4</td>
<td>175</td>
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<tr>
<td>Silty Clay</td>
<td>Trace sand, organics</td>
<td>SS</td>
<td>2</td>
<td>39</td>
<td>3</td>
<td>174</td>
</tr>
<tr>
<td></td>
<td>Mottled brown and grey</td>
<td>SS</td>
<td>3</td>
<td>61</td>
<td>8</td>
<td>173</td>
</tr>
<tr>
<td></td>
<td>Firm</td>
<td>SS</td>
<td>4</td>
<td>119</td>
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<tr>
<td></td>
<td>Weathered</td>
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<td>5</td>
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<td>Stiff</td>
<td>SS</td>
<td>6</td>
<td>100</td>
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<tr>
<td></td>
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<td>VT</td>
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<td></td>
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<td>169.4</td>
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<tr>
<td></td>
<td>End of Borehole (no refusal)</td>
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**Soil Sampling**

- Sample Type: SS, VT
- Recovery (%): 78, 39, 61, 119, 100, 100, 100, 100

**Field Testing**

- SPT Penetration Testing
- DCPT Penetration Testing
- Atterberg Limits
- Unit Weight (KN/m³)

**Lab Testing**

- Moisture Content (%)
- Plastic Limit
- Liquid Limit
- Passing 75 um (%)

**Comments**

- No freestanding groundwater observed in open borehole upon completion of drilling.
- Cave in measured at a depth of 4.6 m upon completion of drilling.

---

**Borehole Details**

- No freestanding groundwater observed in open borehole upon completion of drilling.
- Cave in measured at a depth of 4.6 m upon completion of drilling.

---

**Project Information**

- **Project Client:** The Corporation of the City of Windsor
- **Project Number:** SWW157362
- **Project Name:** Mountbatten Extension Phase 2
- **Project Location:** Windsor, Ontario
- **Drilling Location:** N4689152, E341405
- **Drilling Method:** 200 mm Hollow Stem Augers
- **Drilling Machine:** CME 55

---

**NOTES**

- 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'.
**LITHOLOGY PROFILE**

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Sample Number</th>
<th>Recovery (%)</th>
<th>SPT 'N' Value</th>
<th>DEPTH (m)</th>
<th>ELEVATION (m)</th>
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<td>173</td>
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<tr>
<td>VT</td>
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<td></td>
<td></td>
<td>7</td>
<td>168</td>
</tr>
</tbody>
</table>

**SOIL SAMPLING**

- **TOPSOIL (381 mm thick)
- Silty clay
- Trace sand, trace gravel
- Trace organics (rootlets)
- Mottled brown and grey
- Firm

- **Oxidized
- Brown
- Very stiff
- Grey
- Firm

- **END OF BOREHOLE (no refusal)
- 5.3

**FIELD TESTING**

- **Penetration Testing**
  - BPT
  - DCPT

- **LAB TESTING**
  - **Atterberg Limits**
    - Plastic Limit
    - Liquid Limit
  - **Moisture Content (%)**
  - **Unit Weight (KN/m³)**

**COMMENTS**

- **Cave in measured at a depth of 2.3 m upon completion of drilling.**

---

**SPT Penetration Depth**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>SPT Penetration (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

**Drilling Details**

- **Drilling Method:** 200 mm Hollow Stem Augers
- **Drilling Machine:** CME 55
## Lithology Profile

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>Recovery (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.7</td>
<td>TOPSOIL (178mm thick)</td>
<td>94</td>
</tr>
<tr>
<td>2.1</td>
<td>FILL</td>
<td>72</td>
</tr>
<tr>
<td>1.76</td>
<td>SILTY CLAY</td>
<td>67</td>
</tr>
<tr>
<td>1.74</td>
<td>Brown</td>
<td>83</td>
</tr>
<tr>
<td>1.73</td>
<td>Stiff</td>
<td>100</td>
</tr>
<tr>
<td>1.72</td>
<td>Very stiff</td>
<td>100</td>
</tr>
<tr>
<td>1.7</td>
<td>END OF BOREHOLE (no refusal)</td>
<td>100</td>
</tr>
</tbody>
</table>

### Soil Sampling

<table>
<thead>
<tr>
<th>Sample</th>
<th>Recovery (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS 1a</td>
<td>94</td>
</tr>
<tr>
<td>SS 2</td>
<td>72</td>
</tr>
<tr>
<td>SS 3</td>
<td>67</td>
</tr>
<tr>
<td>SS 4</td>
<td>83</td>
</tr>
<tr>
<td>SS 5</td>
<td>100</td>
</tr>
<tr>
<td>SS 6</td>
<td>100</td>
</tr>
</tbody>
</table>

### Penetration Testing

<table>
<thead>
<tr>
<th>Elevation (m)</th>
<th>SPT 'N' Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>1.76</td>
<td>12</td>
</tr>
<tr>
<td>1.74</td>
<td>16</td>
</tr>
<tr>
<td>1.73</td>
<td>13</td>
</tr>
<tr>
<td>1.72</td>
<td>12</td>
</tr>
<tr>
<td>1.7</td>
<td>14</td>
</tr>
</tbody>
</table>

### Lab Testing

- Atterberg Limits
- Moisture Content (%)
- Moisture Unit Weight (KN/m³)
- Undrained Shear Strength (kPa)
- (from P. Penetrometer tests)
- 20 40 60 80

### Comments

- No freestanding groundwater observed in open borehole upon completion of drilling.
- Cave in measured at a depth of 3.9 m upon completion of drilling.
## Lithology Profile

<table>
<thead>
<tr>
<th>Lithology</th>
<th>Description</th>
<th>Sample Type</th>
<th>Recovery (%)</th>
<th>SPT 'N' Value</th>
<th>Elevation (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topsoil</td>
<td>(254mm thick)</td>
<td>SS</td>
<td>61</td>
<td>1</td>
<td>175</td>
</tr>
<tr>
<td>Fill</td>
<td>Sandy silt, trace to some clay Brown</td>
<td>SS</td>
<td>72</td>
<td>2</td>
<td>174</td>
</tr>
<tr>
<td>Silty Clay</td>
<td>Trace sand, trace gravel Motbled brown and grey Stiff</td>
<td>SS</td>
<td>72</td>
<td>3</td>
<td>173</td>
</tr>
<tr>
<td>Brown</td>
<td>Weathered, rootlets</td>
<td>SS</td>
<td>89</td>
<td>4</td>
<td>172</td>
</tr>
<tr>
<td>Very stiff</td>
<td></td>
<td>SS</td>
<td>100</td>
<td>5</td>
<td>171</td>
</tr>
<tr>
<td>End of borehole</td>
<td>(no refusal)</td>
<td>SS</td>
<td>100</td>
<td>6</td>
<td>170</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>169</td>
</tr>
</tbody>
</table>

### Field Testing

<table>
<thead>
<tr>
<th>Penetration Testing</th>
<th>MTO Vane*</th>
<th>Nilcon Vane*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Remould</td>
<td>Remould</td>
</tr>
<tr>
<td></td>
<td>175.8</td>
<td>174.6</td>
</tr>
</tbody>
</table>

### Instrumentation Installation

- **Geodetic Ground Surface Elevation:** 176.0 m
- **Drilling Machine:** CME 55
- **Drilling Method:** 200 mm Hollow Stem Augers

### Lab Testing

- **Unit Weight (KN/m³):**
  - Intact
  - Remould
- **Moisture Content (%):**
- **Atterberg Limits:**
  - Plastic %
  - Liquid %
  - Passsing 75 um (%)
  - Ultimate Unit Weight (KN/m³)

### Comments

- Cave in measured at a depth of 3.3 m upon completion of drilling.
- 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. BH6

## Project Details
- **Project Client:** The Corporation of the City of Windsor
- **Project Number:** SWW157362
- **Project Name:** Mountbatten Extension Phase 2
- **Project Location:** Windsor, Ontario
- **Drilling Machine:** CME 55
- **Drilling Location:** N4669057, E341333
- **Date Started:** 1 Sep 15
- **Date Completed:** 1 Sep 15
- **Logged by:** SS
- **Compiled by:** SS
- **Reviewed by:** SM
- **Revision No.:** 0

### Lithology Profile

<table>
<thead>
<tr>
<th>Lithology</th>
<th>Description</th>
<th>Sample 1</th>
<th>Sample 2</th>
<th>Sample 3</th>
<th>Sample 4</th>
<th>Sample 5</th>
<th>Sample 6</th>
<th>Sample 7</th>
<th>Depth (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fill</td>
<td>Silty clay, trace sand, organics</td>
<td>SS 1 54 4</td>
<td>SS 2 62 4</td>
<td>SS 3 25 9</td>
<td>SS 4 62 4</td>
<td>SS 5 29 8</td>
<td>SS 6 33 3</td>
<td>TW 7 51</td>
<td>175</td>
</tr>
<tr>
<td></td>
<td>Dark grey to brown</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pieces of metal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>174</td>
</tr>
<tr>
<td>Steel pieces</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>173</td>
</tr>
<tr>
<td>Wet gravel</td>
<td>Sewage odour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>172</td>
</tr>
<tr>
<td>Silty Clay</td>
<td>Trace sand, trace gravel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>171</td>
</tr>
<tr>
<td></td>
<td>Grey</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>170.4</td>
</tr>
<tr>
<td></td>
<td>Firm</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>169</td>
</tr>
<tr>
<td>END OF BOREHOLE</td>
<td>no refusal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>168.8</td>
</tr>
</tbody>
</table>

## Soil Sampling
- **Sample Type:** SS
- **Sample Number:** 1
- **Recovery (%):** 54
- **SPT 'N' Value:** 4

## Field Testing
- **SPT Penetration Testing:**
  - BPT
  - DCPT
- **SPT 'N' Value:** 175
- **SPT 'N' Value:** 174
- **SPT 'N' Value:** 173
- **SPT 'N' Value:** 172
- **SPT 'N' Value:** 171
- **SPT 'N' Value:** 170
- **SPT 'N' Value:** 169

## Lab Testing
- **Atterberg Limits:**
  - Liquid Limit
  - Plastic Limit

## Instrumentation and Installation

## Comments
- Groundwater measured at a depth of 4.3 m upon completion of drilling.
- Cave in measured at a depth of 5.5 m upon completion of drilling.
**LITHOLOGY PROFILE**

**SOIL SAMPLING**

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Sample Number</th>
<th>Recovery (%)</th>
<th>Depth (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS</td>
<td>1</td>
<td>67</td>
<td>175</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>62</td>
<td>174</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>8</td>
<td>173</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>41</td>
<td>172.8</td>
</tr>
<tr>
<td>SS</td>
<td>5</td>
<td>84</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>79</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>71</td>
<td>9</td>
</tr>
<tr>
<td>TW</td>
<td>8</td>
<td>100</td>
<td>5</td>
</tr>
<tr>
<td>SS</td>
<td>9</td>
<td>100</td>
<td>4</td>
</tr>
<tr>
<td>VT</td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>SS</td>
<td>10</td>
<td>100</td>
<td>6</td>
</tr>
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</table>

**FIELD TESTING**

<table>
<thead>
<tr>
<th>Penetration Testing</th>
<th>SPT 'N' Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTO Vane*</td>
<td>Nilcon Vane*</td>
</tr>
</tbody>
</table>

**LAB TESTING**

- **Atterberg Limits**
- **Unit Weight (KN/m³)**
- **Moisture Content (%)**
- **Cone Penetration Testing**

**INSTRUMENTATION INSTALLATION**

- **Elevation (m)**
- **Liquid Limit (%)**
- **Plastic Limit (%)**

**COMMENTS**

- Groundwater measured at a depth of 1.5 m upon completion of drilling.
- Cave in measured at a depth of 5.4 m upon completion of drilling.
**RECORD OF BOREHOLE No. BH7**

Project Number: SWW157362  
Project Client: The Corporation of the City of Windsor  
Project Name: Mountbatten Extension Phase 2  
Project Location: Windsor, Ontario  
Drilling Method: 200 mm Hollow Stem Augers  
Drilling Machine: CME 55  
Drilling Location: N4689108, E341325

**LITHOLOGY PROFILE**

<table>
<thead>
<tr>
<th>Lithology Plot</th>
<th>DESCRIPTION</th>
<th>Sample Type</th>
<th>Sample Number</th>
<th>Recovery (%)</th>
<th>Sample</th>
<th>SPT 'N' Value</th>
<th>DEPTH (m)</th>
<th>ELEVATION (m)</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SILTY CLAY</td>
<td>Trace sand, trace gravel</td>
<td>SS</td>
<td>11</td>
<td>100</td>
<td>3</td>
<td></td>
<td>8</td>
<td>166.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grey</td>
<td>VT</td>
<td></td>
<td></td>
<td>4</td>
<td></td>
<td>9</td>
<td>166</td>
<td></td>
</tr>
<tr>
<td>END OF BOREHOLE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15</td>
<td></td>
<td>15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SOIL SAMPLING**

- Unit Weight (KN/m^3)
- Intact
- Passing 75 um (%)
- Moisture Content (%)
- Plastic
- Undrained Shear Strength (kPa)
- Remould

**FIELD TESTING**

- SPT Penetration Testing
- DCPT
- MTO Vane
- Nilcon Vane

**LAB TESTING**

- Atterberg Limits
- Remoulded Shear Strength (kPa)
- Moisture Content (%)
- Unit Weight (KN/m^3)

**INSTRUMENTATION INSTALLATION**

- MTO Vane*
- Nilcon Vane*
- DCPT

**COMMENTS**

- Groundwater measured at a depth of 1.5 m upon completion of drilling.
- Cave in measured at a depth of 5.4 m 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'.
Grain Size Distribution:
- Gravel: 0.7%
- Sand: 27.1%
- Silt: 39.1%
- Clay: 33.1%

Spoon hitting rock

Grain Size Distribution:
- Gravel: 0.7%
- Sand: 27.1%
- Silt: 39.1%
- Clay: 33.1%
**Lithology Profile**

**Geodetic Ground Surface Elevation:** 175.3 m

**FILL**
- Silty clay, organics
- Rootlets, trace sand, trace gravel
- Brown and grey

**Silty Clay**
- Trace sand, trace gravel
- Weathered
- Mottled brown and grey
- Stiff
- Brown
- Very Stiff

**SOIL SAMPLING**

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Sample Number</th>
<th>Recovery (%)</th>
<th>SPT ‘N’ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS</td>
<td>1</td>
<td>92</td>
<td>5</td>
</tr>
<tr>
<td>SS</td>
<td>2</td>
<td>75</td>
<td>5</td>
</tr>
<tr>
<td>SS</td>
<td>3</td>
<td>67</td>
<td>4</td>
</tr>
</tbody>
</table>

**FIELD TESTING**

**RECOVERY (%)**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>0</th>
<th>20</th>
<th>40</th>
<th>60</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>175</td>
<td>13</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>174</td>
<td>16</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>173.4</td>
<td>11</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**LAB TESTING**

**Grain Size Distribution:**
- Gravel: 1.2%
- Sand: 28.9%
- Silt: 37.5%
- Clay: 32.4%

**Borehole Details:**
- Cave in measured at a depth of 5.7 m upon completion of drilling.
- No freestanding groundwater observed in open borehole upon completion of drilling.
# TEST PIT STRATIGRAPHY LOG

**Project:** Mountbatten Extension Phase 2  
**Contractor:** Intrepid General Ltd.  
**Test Pit Designation:** TP1

**Project No.:** SWW157362  
**Client:** City of Windsor  
**Surface Elevation (m):** 175.180  
**Date Completed:** 8-9-15

**Location:** Field between Mountbatten and Martinique Ave.  
**Test Pit Method:** Open Excavation  
**Date Started:** 8-9-15  
**Supervisor:** Steve Suurnakki

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Soil Description</th>
<th>Moisture Content</th>
<th>Sample No.</th>
<th>Location: UTM N4689061 E341327</th>
</tr>
</thead>
<tbody>
<tr>
<td>From</td>
<td>At</td>
<td>To</td>
<td></td>
<td>Photos</td>
</tr>
<tr>
<td>0.00</td>
<td>-</td>
<td>0.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.41</td>
<td>-</td>
<td>1.22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.22</td>
<td>-</td>
<td>2.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.03</td>
<td>-</td>
<td>4.75</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **TOPSOIL**

- **FILL** Silty clay, Brown and dark grey

- **FILL**  
  - Silty clay, some bricks & steel, organics, black at depth of 1.27 m
  - Silty clay, organics, brown and dark grey at depth of 1.6 m
  - Silty clay, rebar and steel, brown at depth of 1.98 m
  - Silty clay, bricks, brown at depth of 2.41 m
  - Silty clay, brown at depth 2.92 m
  - Silty clay, debris (brick/pvc), brown at depth of 4.24 m
  - Silty clay, debris (brick/pvc), brown at depth of 4.75 m

Notes:
1. Hand Vane turned at 1 m yielded Su =  100 kPa
2. Groundwater seepage at depth of 2.41 m
3. Groundwater at depth of 4.24 m
## TEST PIT STRATIGRAPHY LOG

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Soil Description</th>
<th>Moisture Content</th>
<th>Sample No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00 - 0.05</td>
<td><strong>FILL</strong> Silty clay, some gravel on surface, brown</td>
<td>12</td>
<td>TP2-1</td>
</tr>
<tr>
<td>0.05 - 1.83</td>
<td><strong>FILL</strong> Silty clay, organics, dark grey and black</td>
<td>18</td>
<td>TP2-2</td>
</tr>
<tr>
<td>1.83 - 3.51</td>
<td><strong>FILL</strong> Silty clay, brown (sample taken at depth of 3.48 m)</td>
<td>25</td>
<td>TP2-3</td>
</tr>
</tbody>
</table>

### Notes:

1. Below depth of 1.83 m, east edge of excavation appears to be a containment pit made of brick and filled with garbage. All other sides appear to be a silty clay fill. Groundwater seepage was originally through containment pit but was observed at depth of 3.05 m from both the west and east sides of the excavation.
## TEST PIT STRATIGRAPHY LOG

**Project:** Mountbatten Extension Phase 2  
**Contractor:** Intrepid General Ltd.  
**Test Pit Designation:** TP3  
**Project No.:** SWW157362  
**Client:** City of Windsor  
**Surface Elevation (m):** 175.371  
**Date Completed:** 8-9-15  
**Location:** Field between Mountbatten and Martinique Ave  
**Test Pit Method:** Open Excavation  
**Supervisor:** Steve Suumakki  
**Location:** UTM N4689106 E341364  
**Date Started:** 8-9-15

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Soil Description</th>
<th>Moisture Content</th>
<th>Sample No.</th>
<th>Photos</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00 - 0.13</td>
<td>Topsoil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.13 - 0.38</td>
<td>FILL Silty clay, brown</td>
<td>11</td>
<td>TP3-1</td>
<td><img src="image1.jpg" alt="Photo" /></td>
</tr>
<tr>
<td>0.38 - 1.12</td>
<td>FILL Silty clay, organics, black</td>
<td>18</td>
<td>TP3-2</td>
<td><img src="image2.jpg" alt="Photo" /></td>
</tr>
<tr>
<td>1.12 - 2.67</td>
<td>SILTY CLAY, trace sand and gravel, mottled brown and grey</td>
<td>16</td>
<td>TP3-3</td>
<td><img src="image3.jpg" alt="Photo" /></td>
</tr>
<tr>
<td>2.67 - 3.23</td>
<td>SILTY CLAY, trace sand and gravel, brown</td>
<td>23</td>
<td>TP3-4</td>
<td><img src="image4.jpg" alt="Photo" /></td>
</tr>
</tbody>
</table>

**Notes:**
1. Groundwater seepage at depth of 1.12 m
### TEST PIT STRATIGRAPHY LOG

**Project:** Mountbatten Extension Phase 2  
**Contractor:** Intrepid General Ltd.  
**Test Pit Designation:** TP4  
**Project No.:** SWW157362  
**Date Started:** 8-9-15  
**Client:** City of Windsor  
**Surface Elevation (m):** 176.921  
**Date Completed:** 8-9-15  
**Location:** Field between Mountbatten and Martinique Ave  
**Test Pit Method:** Open Excavation  
**Supervisor:** Steve Suurnakki

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Soil Description</th>
<th>Moisture Content</th>
<th>Sample No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00 - 0.23</td>
<td><strong>TOPSOIL</strong></td>
<td>17</td>
<td>TP4-1</td>
</tr>
<tr>
<td>0.23 - 0.56</td>
<td><strong>FILL</strong> Silty clay, organics, dark grey</td>
<td></td>
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</tr>
<tr>
<td>0.56 - 1.35</td>
<td><strong>FILL</strong> Silty sand, debris (concrete and steel), brown</td>
<td>13</td>
<td>TP4-2</td>
</tr>
<tr>
<td>1.35 - 1.93</td>
<td><strong>FILL</strong> Silty clay, organics, black</td>
<td>20</td>
<td>TP4-3</td>
</tr>
<tr>
<td>1.93 - 2.44</td>
<td><strong>FILL</strong> Silty clay, organics, dark grey</td>
<td>17</td>
<td>TP4-4</td>
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<tr>
<td>2.44 - 4.27</td>
<td><strong>SILTY CLAY</strong>, trace sand and gravel, mottled brown and grey</td>
<td>17</td>
<td>TP4-5</td>
</tr>
</tbody>
</table>

**Notes:**
1. Groundwater seepage at depth of 2.44 m  
2. Excavation walls started caving in at depth of 2.44 m
# TEST PIT STRATIGRAPHY LOG

**Project:** Mountbatten Extension Phase 2  
**Contractor:** Intrepid General Ltd.  
**Test Pit Designation:** TP5

**Project No.:** SWW157362  
**Date Started:** 8-9-15

**Client:** City of Windsor  
**Surface Elevation (m):** 176.568  
**Date Completed:** 8-9-15

**Location:** Field between Mountbatten and Martinique Ave.  
**Test Pit Method:** Open Excavation  
**Supervisor:** Steve Suurnakki

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Soil Description</th>
<th>Moisture Content</th>
<th>Sample No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00 - 0.56</td>
<td><strong>FILL</strong> Sand, organics, dark brown</td>
<td>7</td>
<td>TP5-1</td>
</tr>
<tr>
<td>0.56 - 1.22</td>
<td><strong>FILL</strong> Silty clay, organics, black</td>
<td>13</td>
<td>TP5-2</td>
</tr>
<tr>
<td>1.22 - 2.13</td>
<td><strong>FILL</strong> Silty clay, sand pockets, brown and dark grey</td>
<td>17</td>
<td>TP5-3</td>
</tr>
<tr>
<td>2.13 - 3.96</td>
<td><strong>SILTY CLAY</strong> Sand, organics, brown and dark grey</td>
<td>19</td>
<td>TP5-4</td>
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</table>

**Notes:**
1. Groundwater seepage at depth of 3.35 m
<table>
<thead>
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<th>Depth (m)</th>
<th>Soil Description</th>
<th>Moisture Content</th>
<th>Sample No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>From</td>
<td>At</td>
<td>To</td>
<td></td>
</tr>
<tr>
<td>0.00</td>
<td>-</td>
<td>0.15</td>
<td>TOPSOIL</td>
</tr>
<tr>
<td>0.15</td>
<td>0.15</td>
<td>0.91</td>
<td>FILL Silty clay, sand seams, brown</td>
</tr>
<tr>
<td>0.91</td>
<td>0.91</td>
<td>1.37</td>
<td>FILL Silty clay, organics, dark grey</td>
</tr>
<tr>
<td>1.37</td>
<td>1.37</td>
<td>2.74</td>
<td>SILTY CLAY, trace sand and gravel, mottled brown and grey</td>
</tr>
<tr>
<td>2.74</td>
<td>2.74</td>
<td>3.35</td>
<td>SILTY CLAY, trace sand and gravel, sand seams, brown</td>
</tr>
</tbody>
</table>
APPENDIX B

GEOTECHNICAL AND ANALYTICAL LABORATORY TESTS RESULTS
**Test Results**

**Sample Location:** BH 8 Sa.4

**Sample Identification:** 534

**Gravel**
- Size: 3" 1.5" 3/4" 3/8" #4 #10 #20 #40 #100 #200

**Sand**
- Size: Coarse 3/8" Medium #80 #100 #200

**Fines**
- Size: Silt and Clay

**Soil Classification:** SILTY CLAY, sand layers/pockets, silt seams

---

**Signed by:**

Justin Palmer, Lab Supervisor, C. Tech.

---

**GRAIN SIZE DISTRIBUTION**

MTO LS 702 / ASTM D422

---

**Coarse**: 0.7% 27.1% 39.1% 33.1%

**Fine**: 0% 20% 40% 60% 80% 100%

**Diameter (mm)**: 0.001 0.010 0.100 1.000 10.000 100.000

**Percent Passing %**: 0% 20% 40% 60% 80% 100%
ATTERBERG LIMITS
ASTM D-4318 or LS-703 / 704

Project Number: SWW157362
Sampled on: 1-Sep-2015
Sampled by: SS

Project Client: Windsor, The Corporation of the
Received on: 1-Sep-2015
Received by: JP

Project Name: MountBatten Extension Phase 2
Tested on: 11-Sep-2015
Tested by: JP

Project Location: Windsor, Ontario

Test Results

<table>
<thead>
<tr>
<th>LAB NUMBER</th>
<th>BOREHOLE</th>
<th>SAMPLE</th>
<th>DEPTH (m)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>532</td>
<td>8</td>
<td>1.8</td>
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<table>
<thead>
<tr>
<th>PLASTIC LIMIT</th>
<th>LIQUID LIMIT</th>
<th>PLASTIC INDEX</th>
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</thead>
<tbody>
<tr>
<td>16.0</td>
<td>35.2</td>
<td>19.3</td>
</tr>
</tbody>
</table>

For classification of fine-grained soils and fine-grained fraction of coarse-grained soils:

Equation of "A" Line
Horizontal at PI=4 to LL = 25.5, then PI = 0.73(LL-20)

Equation of "U" Line
Verticle at LL=16 to PI=7 then PI=0.9(LL-8)

Signed by: Justin Palmer, Lab Supervisor, C. Tech.
**Project Number:** SWW157362  
**Sampled on:** 1-Sep-2015  
**Sampled by:** SS  

**Project Client:** Windsor, The Corporation of the City of  
**Received on:** 1-Sep-2015  
**Received by:** SS  

**Project Name:** MountBatten Extension Phase 2  
**Tested on:** 11-Sep-2015  
**Tested by:** SS  

**Sample Location:** BH 9 Sa.7  
**Sample Identification:** 535  

**Soil Classification:**  
- SILTY CLAY, sand layers/pockets, silt seams

**Test Results**

<table>
<thead>
<tr>
<th>GRAVEL</th>
<th>SAND</th>
<th>FINES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>3&quot;</td>
<td>1.5&quot;</td>
<td>3/4&quot;</td>
</tr>
<tr>
<td>100%</td>
<td>80%</td>
<td>60%</td>
</tr>
</tbody>
</table>

**Diameter (mm)**

- 100.000
- 10.000
- 1.000
- 0.100
- 0.010
- 0.001

**Percent Passing %**

- 100%
- 80%
- 60%
- 40%
- 20%
- 0%

Signed by: Justin Palmer, Lab Supervisor, C. Tech.
Test Results

| LAB NUMBER   | 533 |
| BOREHOLE    | 9   |
| SAMPLE      | 7   |
| DEPTH       | 3.65m |

| PLASTIC LIMIT | 13.6 |
| LIQUID LIMIT  | 25.3 |
| PLASTIC INDEX | 11.7 |

For classification of fine-grained soils and fine-grained fraction of coarse-grained soils

Equation of "A"-Line
Horizontal at PI=4 to LL = 25.5, then PI = 0.73(LL-20)

Equation of "U"-Line
Vertex at LL=16 to PI=7 then PI=0.9(LL-8)

Signed by: Justin Palmer, Lab Supervisor, C. Tech.
Certificate of Analysis

Amec Foster Wheeler (Windsor)
11865 County Road 42
Tecumseh, ON N8N 2M1
Attn: Shane MacLeod

Client PO:
Project: SWW157362
Custody: 23673

Report Date: 16-Sep-2015
Order Date: 11-Sep-2015

Order #: 1538007

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

<table>
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<th>Paracel ID</th>
<th>Client ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>1538007-01</td>
<td>SS3 (7.5-9') BH4</td>
</tr>
</tbody>
</table>

Any use of these results implies your agreement that our total liability in connection with this work, however arising, shall be limited to the amount paid by you for this work, and that our employees or agents shall not under any circumstances be liable to you in connection with this work.

Mark Foto, M.Sc.
Lab Supervisor
## Analysis Summary Table

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Method Reference/Description</th>
<th>Extraction Date</th>
<th>Analysis Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anions</td>
<td>EPA 300.1 - IC, water extraction</td>
<td>15-Sep-15</td>
<td>15-Sep-15</td>
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<tr>
<td>pH</td>
<td>EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.</td>
<td>14-Sep-15</td>
<td>14-Sep-15</td>
</tr>
<tr>
<td>Resistivity</td>
<td>EPA 120.1 - probe, water extraction</td>
<td>16-Sep-15</td>
<td>16-Sep-15</td>
</tr>
<tr>
<td>Solids, %</td>
<td>Gravimetric, calculation</td>
<td>15-Sep-15</td>
<td>15-Sep-15</td>
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## Physical Characteristics

<table>
<thead>
<tr>
<th>MDL/Units</th>
<th>Soil</th>
</tr>
</thead>
</table>

| % Solids | 0.1 % by Wt. | 85.0 |

## General Inorganics

| pH | 0.05 pH Units | 7.53 |
| Resistivity | 0.10 Ohm.m | 53.1 |

## Anions

| Chloride | 5 ug/g dry | 6 |
| Sulphate | 5 ug/g dry | 59 |
## Method Quality Control: Blank

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<tr>
<th>Analyte</th>
<th>Result</th>
<th>Reporting Limit</th>
<th>Units</th>
<th>Source</th>
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<th>RPD Limit</th>
<th>Notes</th>
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<td>Sulphate</td>
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<td>5</td>
<td>ug/g</td>
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<td>General Inorganics</td>
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<tr>
<td>Resistivity</td>
<td>ND</td>
<td>0.10</td>
<td>Ohm.m</td>
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<th>Source Result</th>
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<th>Notes</th>
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<td><strong>Anions</strong></td>
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<td>Chloride</td>
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<td>Sulphate</td>
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<td>5</td>
<td>ug/g dry</td>
<td>80.6</td>
<td>1.6</td>
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<td><strong>General Inorganics</strong></td>
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<td><strong>Physical Characteristics</strong></td>
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<tr>
<td>% Solids</td>
<td>89.3</td>
<td>0.1</td>
<td>% by Wt.</td>
<td>89.8</td>
<td>0.6</td>
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### Method Quality Control: Spike

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<tbody>
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<td>Sulphate</td>
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<td>102</td>
<td>78-111</td>
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Certificate of Analysis
Client: Amec Foster Wheeler (Windsor)

Order #: 1538007  Report Date: 16-Sep-2015
Order Date: 11-Sep-2015  Project Description: SWW157362

Qualifier Notes:
None

Sample Data Revisions
None

Work Order Revisions / Comments:
None

Other Report Notes:
n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.
**Client Name:** AMEC FOSTER WHEELER  
**Contact Name:** SHAHEE MACLEOD  
**Address:** 11865 County Road 42 Tecumsehon  
**Telephone:** (519) 775-2400  
**Email Address:** SHAHEE.MACLEOD@AMEC.COM  

**Project Reference:** SWW157362  
**Quote #:** 15-001  
**TAT:** Regular  
**Date Required:**  

**Criteria:**  
- [ ] O, Reg. 153/94 (As Amended), Table [ ]  
- [ ] RSC Filing [ ]  
- [ ] O, Reg. 558/00 [ ]  
- [ ] PROQ [ ]  
- [ ] CMEA [ ]  
- [ ] SUB (Storm) [ ]  
- [ ] SUB (Sanitary) Municipality [ ]  
- [ ] Other [ ]  

**Matrix Type:** S (Soil/Sed) GW (Ground Water) SW (Surface Water) SS (Storm/Sanitary Sewer) P (Paint) A (Air) O (Other)  

**Paracel Order Number:** 1538007  

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<th>Time</th>
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**Refrig. By (Sign):**  
**Refrig. By (Print):** STEVE SMITH  
**Date/Time:** 11-9-15 10:00 AM  
**Temperature:** [ ] °C  

**Method of Delivery:** Pneumatic  
**Verified By:**  
**Date/Time:** Sept 14/15 14:45  
**pH Verified [ ] By:**  

**Chain of Custody (Blank) - Rev 0.3 Oct. 2014**
APPENDIX C

REPORT LIMITATIONS
REPORT LIMITATIONS

The conclusions and recommendations given in this report are based on information determined at the test hole locations. The information contained herein in no way reflects on the environmental aspects of the Project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the test holes may differ from those encountered at the test hole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. It is recommended practice that the Geotechnical Engineer be retained during the construction to confirm that the subsurface conditions across the site do not deviate materially from those encountered in the test holes.

The design recommendations given in this report are applicable only to the project described in the text, and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final design stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

The comments made in this report relating to potential construction problems and possible methods of construction are intended only for the guidance of the designer. The number of test holes may not be sufficient to determine all the factors that may affect construction methods and costs. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices. No other warranty is expressed or implied.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Amec Foster Wheeler Environment & Infrastructure accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.