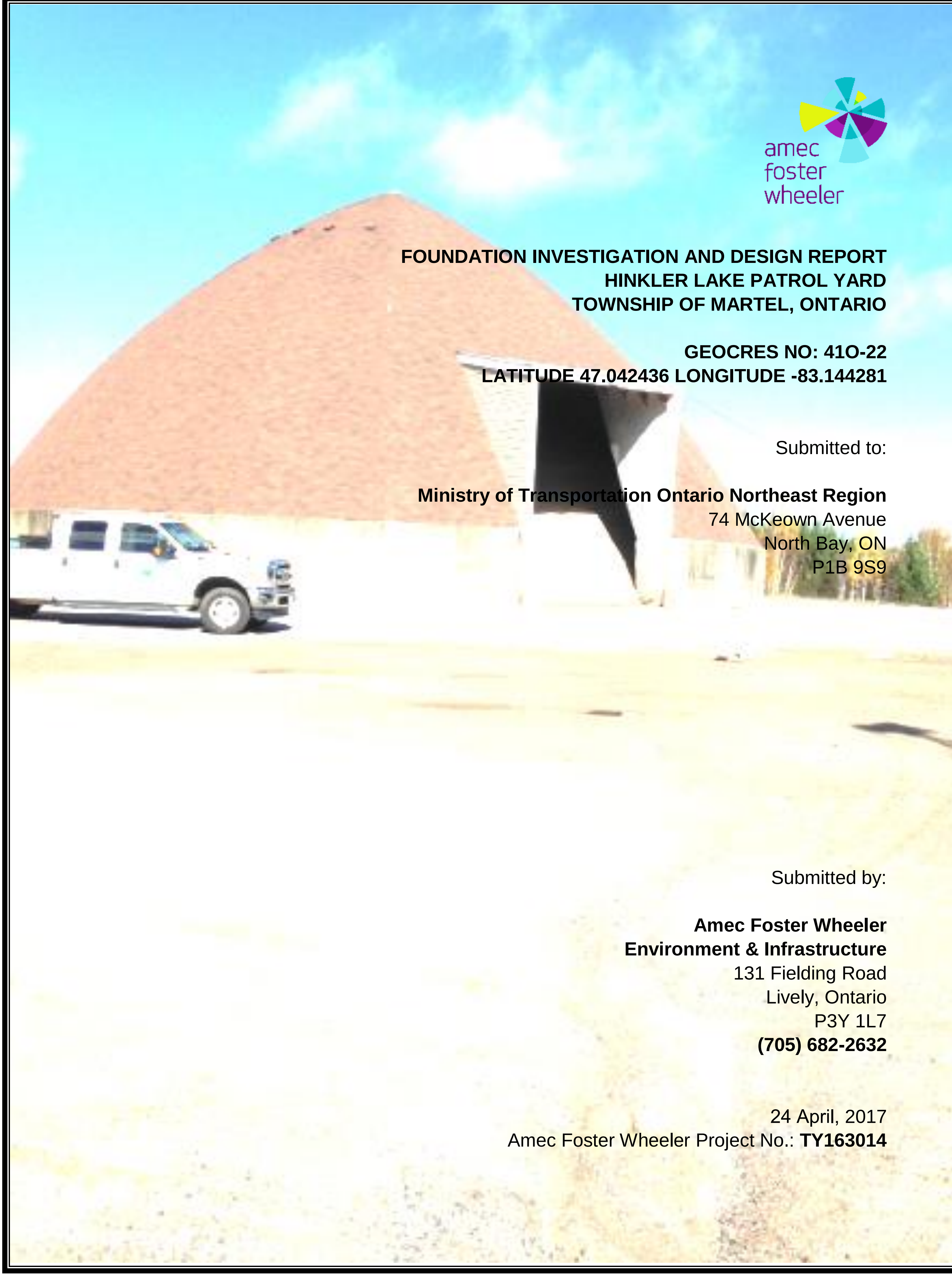


FOUNDATION INVESTIGATION AND DESIGN REPORT
HINKLER LAKE PATROL YARD
TOWNSHIP OF MARTEL, ONTARIO

GEOCRES NO: 41O-22
LATITUDE 47.042436 LONGITUDE -83.144281

Submitted to:

Ministry of Transportation Ontario Northeast Region
74 McKeown Avenue
North Bay, ON
P1B 9S9

Submitted by:

Amec Foster Wheeler
Environment & Infrastructure
131 Fielding Road
Lively, Ontario
P3Y 1L7
(705) 682-2632

24 April, 2017
Amec Foster Wheeler Project No.: **TY163014**

TABLE OF CONTENTS

Section **Page**

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

PART A

FOUNDATION INVESTIGATION REPORT
HINKLER LAKE PATROL YARD
TOWNSHIP OF MARTEL, ONTARIO

1.0 INTRODUCTION

1.1 Background

Amec Foster Wheeler Environment & Infrastructure (Amec Foster Wheeler) has been retained by The Ministry of Transportation Ontario, Northeast Region (MTO), for provision of foundation engineering services at six Patrol Yards as part of the Assignment No. 5015-E-0064.

This report addresses the results of the subsurface investigation carried out by Amec Foster Wheeler at the MTO Hinkler Lake Patrol Yard, located on Highway 129, approximately 82 km north of the MTO Axe Lake Patrol Yard in the Township of Martel, Ontario as shown on Drawing 1.

The terms of reference and scope of work for the foundation engineering services are outlined in MTO's Request for Quotation (RFQ), and associated Addendum and clarification responses for the Assignment.

Amec Foster Wheeler understands the MTO plans to construct a new sand/salt storage building structure at the Hinkler Lake Patrol Yard. The purpose of this investigation was to determine the subsurface conditions and relevant soil properties within the subject site in order to provide recommendations for the foundation design aspects of the proposed development at the yard. The proposed structure is to have an approximate area of 432 m^2 (18 m by 24 m), as shown on Drawing 1, and on the preliminary site plan provided to Amec Foster Wheeler by the MTO.

1.2 Site Description

The patrol yard is located in the Township of Martel, District of Algoma. The entrance to the site is approximately 25.5 km north of the intersection of Highway 556 and Highway 129. The latitude and longitude coordinates for the site are Latitude 47.042436 and Longitude -83.144281.

At the time of the investigation, a salt/sand storage dome was located in the central portion of the Patrol Yard. An office building was located to the north of the salt/sand dome, adjacent to the site entrance. There was also a garage/fueling station to the east of the salt/sand dome. The remaining areas of the yard were generally vacant land, stockpile areas, and vehicle parking areas. Site photographs are included in Appendix A.

The proposed new structure will be located south of the existing sand/salt dome as shown on Drawing 1.

1.3 Site Geology

The general surficial geology in the area of the site, can be characterized as Glaciofluvial outwash deposits which are comprised of gravel and sand, with some deltaic deposits, according to Ministry of Northern Development and Mines (MNDM) interactive "Quaternary Geology" map.

The bedrock in the area of the site can be described as Neo-to Mesoarchean massive to foliated grandiorite to granite. It is located in the Superior Province according to MNDM "Geology Survey August 2003, 1:250,000 Bedrock Geology of Ontario" map.

2.0 INVESTIGATION PROGRAM

2.1 Soil Drilling Investigation

The fieldwork at the site was carried out on October 12 and 13, 2016, when five boreholes (BH16-01 to BH16-05) were advanced within or near the proposed maintenance structure footprint all to a depth of 15.9 m below the existing ground surface. Borehole BH16-02 was offset from the proposed building footprint due to access limitations at the original borehole location.

The borehole locations (referenced to the MTM NAD83 Zone 13 northing and easting co-ordinate system), the ground surface elevations (referenced to Geodetic datum) and the drilled depths are summarized below and are shown on Drawing 1.

Table 1: Hinkler Lake Borehole Summary

Approximate Area	Borehole Designation	Location (MTM NAD83 Zone 13)		Ground Surface Elevation (m)	Borehole Termination Depth (m)
		Northing (m)	Easting (m)		
Southwest Corner	BH16-01	5,211,721	369,840	414.1	15.9
Northwest Corner	BH16-02	5,211,747	369,815	413.9	15.9
Northeast Corner	BH16-03	5,211,748	369,857	414.0	15.9
Southeast Corner	BH16-04	5,211,721	369,861	413.7	15.9
Centre	BH16-05	5,211,738	369,851	413.8	15.9

The ground surface elevation at the borehole locations were surveyed by Amec Foster Wheeler's personnel. A local benchmark with a known elevation of 414.740 m was used as a reference. The borehole locations were geo-referenced to MTM co-ordinates using a hand-held Global Positioning System (GPS) unit. The ground surface elevations and GPS co-ordinates at the borehole locations are also presented on the Record of Borehole sheets, attached in Appendix B.

The boreholes were advanced using 108 mm inside diameter hollow stem augers and conventional soil sampling methods under the supervision of an Amec Foster Wheeler technician, providing soils information along with relative soil density under the direction of the Amec Foster Wheeler project manager. Soil samples were collected at predetermined depth intervals in accordance with Standard Penetration Testing (SPT) procedures (ASTM D-1586) utilizing a mechanical hammer. Test results are recorded on the Record of Borehole sheets as 'N'-values. These values provide an indication of the various soil strata's condition with respect to compactness or consistency. The samples were placed in plastic bags and delivered to Amec Foster Wheeler's geotechnical laboratory in Sudbury for further examination and testing. One soil sample was submitted to AGAT Laboratories in Mississauga, Ontario, for analytical testing for pH, chlorides, sulphates and resistivity.

2.2 Laboratory Testing

In accordance with the TOR and Amec Foster Wheeler's proposal for this investigation, the following laboratory tests were conducted:

- Natural water content (63)
- Grain size distribution (15)
- Hydrometer (3)
- pH, chlorides, sulphates, resistivity (1)

The results of in-situ and laboratory tests are presented on the Record of Boreholes in Appendix B. The grain size distribution curves are shown in Appendix C, and the results of soil corrosivity tests are shown in Appendix D

3.0 SUBSURFACE CONDITIONS

In general, the subsurface condition encountered at the site consists of sand to sand and gravel fill underlain by native sand extending to the borehole termination depths. A summary of the subsurface conditions encountered in the boreholes is presented below and on the Record of Borehole sheets included in Appendix B.

3.1 Sand Fill/Gravelly Sand Fill/Sand and Gravel Fill

Non-cohesive fills were present at the ground surface in Boreholes BH16-01 to BH16-05. The thickness of the fill was between 0.7 m and 1.5 m. The fill layer consisted of brown gravelly sand or sand and gravel at Boreholes BH16-01, and BH16-03 to BH16-05, and sand with trace fines (silt and clay) at Borehole BH16-02. The measured SPT 'N' values within the fill ranged between 9 blows and 35 blows per 0.3 m of penetration, indicating a loose to dense, predominantly compact state of compactness.

The laboratory testing on selected fill samples resulted water contents ranging from 3% to 9% of the materials' dry weight.

Four grain size distribution tests were completed on selected samples of the fill layer, the results are as follows:

- Gravel (%): 21 to 39
- Sand (%): 57 to 68
- Silt & Clay Size (%): 4 to 13

The grain size distribution graphs are presented in Appendix C and the grain size distribution test results are shown on the Record of Borehole sheets.

3.2 Sand

A layer of sand was encountered below the fill in all boreholes. The sand extending to the borehole termination depth of 15.9 m at each borehole location. The sand consists of some to trace gravel, silt, and clay. A coarser gravelly sand layer was present interlayered within the sand deposit from approximately 3.0 m to 4.1 m below existing ground surface in Borehole BH16-04. A finer sand layer with no gravel and trace silt and clay was present near the bottom of Boreholes BH16-01, 03, and 05.

Measured SPT 'N' values within the sand ranged between 5 blows to 76 blows per 0.3 m of penetration indicating a loose to very dense state of compactness. The SPT Values also indicate that the sand layer is predominantly compact to dense with the exception of 1.5 m to 3.1 m thick layer of loose sand as encountered in all boreholes with the exception of Borehole BH16-02. The natural moisture content, as measured in selected samples from the boreholes ranged from 2% to 23%.

Fourteen grain size distributions were completed on selected split spoon samples of the sand layer, including the gravelly sand interlayer in Borehole BH16-04, the results summarized are as follows:

- Gravel (%): 0 to 29
- Sand (%): 67 to 94
- Silt & Clay Size (%) 1 to 13

The grain size distribution curves are presented in Appendix C and the grain size distribution test results are shown on the Record of Borehole sheets.

3.3 Groundwater Conditions

Upon the completion of drilling, groundwater was measured at depths ranging from 9.9 m to 10.9 m below ground surface, except for Borehole BH16-01 in which no groundwater measurement was conducted on completion. The groundwater measurements are shown on the Record of Borehole sheets and are summarized below.

The groundwater at the site is expected to fluctuate seasonally and can be expected to be somewhat higher during the spring months and in response to major weather events.

Table 2: Hinkler Lake Groundwater Measurements

Foundation Element 1	Borehole Designation	Location (MTM NAD83 Zone 13)		Ground Surface Elevation (m)	Water Level Depth Below Ground Surface (m)
		Northing (m)	Easting (m)		
Southwest Corner	BH16-01	5,211,721	369,840	414.1	Not measured
Northwest Corner	BH16-02	5,211,747	369,815	413.9	10.1
Northeast Corner	BH16-03	5,211,748	369,857	414.0	10.9
Southeast Corner	BH16-04	5,211,721	369,861	413.7	10.1
Centre	BH16-05	5,211,738	369,851	413.8	9.9

3.4 Analytical Results

Split spoon sample number 4 from BH16-05 was sent to an independent laboratory for analytical testing comprising pH, sulphate, resistivity and chloride determination and the test results are presented in Appendix D.

4.0 CLOSURE

This Foundation Investigation Report was prepared by Nicholas Kicz, EIT, and reviewed by Mr. Mehdi Mostakhdemi, M.Sc., P.Eng. Mr. Ty Garde, M.Eng, P.Eng., a Designated MTO Foundations Contact for Amec Foster Wheeler, conducted an independent review of this report.

Respectfully submitted,

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

Prepared by:

Nicholas Kicz
Geotechnical Engineer in Training

Mehdi Mostakhdemi, M.Sc., P. Eng.
Geotechnical Engineer

Ty Garde, M. Eng., M. Eng., P. Eng.,
Designated MTO Foundations Contact

PART B

FOUNDATION DESIGN REPORT
HINKLER PATROL YARD
TOWNSHIP OF MARTEL, ONTARIO

5.0 DISCUSSION AND RECOMMENDATIONS

5.1 General

This section of the report provides foundation design recommendations for the proposed MTO Hinkler Lake Patrol Yard sand/salt storage structure and is based on interpretation of the factual data obtained from the boreholes advanced during the subsurface investigation at this site. The discussion and recommendations presented are intended to provide the designers with sufficient information to assess/evaluate the design of the proposed structure's foundations.

The proposed structure will be about 18 m wide and 24 m long, with a concrete foundation wall, timber side walls, steel roof, and finished with an interior 50 mm asphalt floor and/or slab on grade. The proposed building will consist of a conventional building structure for storage of sand and salt, and will allow for inside loading and dumping.

Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project, and for which special provisions may be required in the Contract Documents. Those requiring information on the aspects of construction should make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

It is understood that the Foundation Investigation and Design Report (FIDR) prepared for this assignment will be included in the design-build contract as a reference document. This FIDR is for planning purposes only and the design-build proponent shall satisfy themselves as to the sufficiency of the available information and supplement the information as needed to meet the requirements for detail design. The design-build proponent is solely responsible for selecting the appropriate foundation alternatives for the project and other aspects of the design and construction.

5.2 Site Preparation and Engineered Fill Construction

The areas within the limits of the proposed building should be stripped and cleared of surface vegetation, topsoil, and/or construction debris prior to construction. These materials are not suitable to support the building foundations, floor slabs, and/or any engineered fills and should be excavated and backfilled with engineered fill comprised of Granular A or Granular B Type II placed and compacted in accordance with Ontario Provincial Standard Specification (OPSS) 501 - Construction Specification for Compacting, and SP 105S21 Amendment to OPSS 501 - Quality Control for Compaction, Method B.

Following stripping of these unsuitable surficial soils, the prepared subgrade should be heavily proof-rolled. The required extent of stripping of any loose granular or softened, upper portions of the native non-cohesive deposits will need to be determined based on the proofrolling and inspection. The compact gravelly sand fill within the building envelop may be suitable to remain in place below the floor area if this material performs adequately during proof rolling.

Soils that are more than about 2% above their optimum water content for compaction or contain significant quantities of organics are not considered suitable for use as engineered fill.

Following proof rolling and approval of the subgrade, engineer approved fill should be placed in maximum 300 mm thick loose lifts and uniformly compacted to at least 100% of the fill materials to its Standard Proctor Maximum Dry Density (SPMDD). The final lift of engineered fill beneath conventionally loaded floor slabs should consist of a minimum thickness of 150 mm of OPSS Granular A material, uniformly compacted to at least 100% of its SPMDD.

Care will be required to ensure that the prepared area extends far enough to encompass the limits of the engineered fill. The engineered fill limits are defined such that the fill extends to at least one metre beyond the outside edge of the founding level of any footing/pad or other settlement sensitive area and then downward and outward at a slope of one horizontal to one vertical.

It is emphasized that engineered fill employed during winter months should be carefully placed to ensure that any frozen material is removed prior to placement of additional lifts. Also, construction methods should be reviewed and designed to minimize any disturbance to the top of the approved fill pad(s), otherwise the materials can be disturbed and cause increase settlement of structures.

The final surface of the engineered fill should be protected as necessary from construction and foot traffic, and should be sloped to provide positive drainage for surface water during the construction period. If the engineered fill materials will be left exposed (i.e. uncovered) during periods of freezing weather, consideration should be given to placing an additional temporary soil cover above final subgrade to provide for frost protection.

Special care should be taken to ensure adequate compaction around columns and adjacent to foundation walls.

Where the ground floor slabs for the buildings are established at least 0.15 m above the level of the exterior final grade, no perimeter drainage at the footing level is required and the exterior foundation walls may be backfilled with materials free of existing fill, topsoil, organics and other deleterious materials carefully placed in lifts and compacted. The native soils are considered suitable for re-use as foundation wall backfill provided that these materials are free of organics, any boulders or cobbles greater than 150 mm in size are removed and that these materials are at suitable water content for compaction. Where the backfill against the exterior walls is to support settlement sensitive structures, such as concrete slabs, pavements or sidewalks, it should consist of fill approved by the geotechnical engineer and uniformly compacted to at least 100% of the materials' SPMDD inside the building and 98% SPMDD on the outside of the building.

5.3 Building and Perimeter Retaining Wall Foundations

Based on the subsurface conditions at this site, both shallow and deep foundation options have been considered for support of the building and perimeter retaining wall foundations. No bedrock was encountered as all boreholes were advanced to termination depth in native soils comprised of loose to very dense sands. Therefore, deep foundations may not be practical due to the unknown thickness of the overburden at this site.

A summary of the advantages and disadvantages associated with each option is provided below:

- **Spread footings and/or Slab on grade:** Spread footings are feasible due to presence of loose to very dense at shallow depths at the site and are further discussed in the report.
- **Steel H-piles driven to found in overburden:** Driven steel H-piles could be founded in the sand overburden. However, no extensive zone of very dense soil was identified within the depth of exploration, therefore the H-piles would be designed as friction piles, rather than end bearing piles. Considering the length of pile required for friction piles in the generally compact sand, and the relatively high cost to mobilize pile driving equipment for the foundation construction, friction piles are not the preferred foundation alternative for this project. This option was not further discussed in this report.
- **Steel H-piles driven to found on the bedrock:** Driven steel H-piles may not be feasible for support of building foundations and perimeter wall foundations at this site, as the depth of the bedrock is not known at this site. This option was not further discussed in this report.
- **Caissons founded in the bedrock:** Caissons founded in the bedrock may not be feasible for support of building foundations and perimeter wall foundations at this site, as the depth of the bedrock is not known at this site. Installation of caissons through sands would also require temporary liners to control the instability of the side walls and to control the groundwater seepage into the hole during construction. This option was not further discussed in this report.

The following sections provide recommendations for foundation design of the proposed building and its perimeter walls and slab on grade floor. Based on the subsurface conditions at the site and the above considerations, the preferred foundation design option from a geotechnical/foundations perspective is to support the proposed building and the perimeter retaining walls on shallow foundations (spread footings).

5.4 Shallow Foundations

5.4.1 Founding Elevations

Based on the borehole information, the anticipated loads from the proposed building foundations can utilize conventional spread footings founded on the undisturbed, native, compact to very dense sand. The bearing soils are anticipated to consist mostly of compact sand.

For support of the proposed foundations, strip or spread footings should be founded below any fill and ideally below any loose near-surface soils, on compact to dense sand. The following maximum (highest) founding elevations are recommended for design of shallow foundations

Table 3: Recommended Founding Elevations

Borehole Designation	Maximum (Highest) Founding Elevation (m)	Depth below Existing Grades
BH16-01	412.1	2.0
BH16-02	411.9	2.0
BH16-03	412.0	2.0
BH16-04	411.7	2.0
BH16-05	411.8	2.0

The founding elevations given above will require excavation to a depth of 2.0 m below the existing grades.

The footing subgrade should be inspected by a Quality Verification Engineer following excavation, in accordance with provincial standards to confirm that all existing fill, loosened sand or other unsuitable material have been removed. The founding soils will be susceptible to disturbance. If the concrete for the footings cannot be poured immediately after excavation and inspection, it is recommended that a concrete working slab be placed on the prepared subgrade within four hours of its inspection and approval.

5.4.2 Geotechnical Resistance/Reactions

Strip or spread footings placed on the properly prepared subgrade, at or below the design elevations given in the preceding section, should be designed based on the factored geotechnical resistances at Ultimate Limit States (ULS) and geotechnical reaction at Serviceability Limit States (SLS) given below assuming a "Typical" degree of understanding for both bearing and settlement in accordance with Table 6.2 – Geotechnical Resistance Factors, $Ø_{gu}$ and $Ø_{gs}$, for Ultimate and Serviceability Limit States, Respectively, and for Various Degrees of Site Understanding, from Section 6 – Foundations and Geotechnical Systems, of the Canadian Highway Bridge Design Code (CHBDC) 2014:

Table 4: Factored Geotechnical Resistances/Reactions

Founding Stratum	Footing Width (m)	Factored Geotechnical Resistance at ULS	Geotechnical Reaction at SLS[1]
Compact to very dense sand	1 to 2	400 kPa	250 kPa

1 - For 25 mm of settlement

The geotechnical resistances should be reviewed if the selected footing width or founding elevation differs from those given above. In addition, these geotechnical resistances are provided for loads applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with Section 6.10.4 of the CHBDC 2014.

A geotechnical engineer must inspect/approve the foundation base prior to placement of the granular fill (if required) or the structural concrete. This is necessary to confirm the founding conditions are consistent with the finding of this report, and to review the foundation construction procedures, etc.

5.4.3 Resistance to Lateral Loads / Sliding Resistance

Resistance to lateral loads / sliding resistance between the base slab or concrete footings for the proposed structure and the subgrade should be calculated in accordance with Section 6.10.5 of the CHBDC 2014. A coefficient of friction (tan f') of 0.5 may be used in the sliding assessment between spread footings founded on compact sand. The above coefficient of friction is un-factored and a resistance factor of 0.8 should be applied in accordance with Table 6.2 of CHBDC 2014 based on the available subsurface conditions.

The factored horizontal geotechnical resistance, H_{ri} or H_{rs}, as follows:

$$H_{rs} = \psi \phi_{gu} (0.8 A' c' + 0.8 V \tan\varphi') > H_f$$

Where:

A'	Effective contact area (m^2)
C'	Nil
$\tan\varphi'$	Coefficient of internal friction for soil close to the underside of the spread/strip footing
V	Unfactored vertical force (kN)
H_r	Unfactored horizontal load (kN)
ψ	Consequence factor (1.0)
ϕ_{gu}	Geotechnical resistance factor (0.8)

5.4.4 Slab on Grade

Slab-on-grade construction for a floor slab will be permissible at this site provided that organics, fill materials and all other unsuitable soils be removed from the building envelope. If the existing grade is to be raised, the subgrade should then be proof rolled prior to placing under floor fill. If contaminated or soft spongy areas are intercepted, they should be sub-excavated and replaced with compacted fill. All under floor fill should comprise clean, well graded, sand and gravel, compacted to 95% of the standard Proctor maximum dry density. The existing gravelly sand fill must be evaluated by the Quality Verification Engineer following proof rolling to determine if it is suitable to remain in place below the slab on grade floor, or if it requires sub-excavation and replace with approved engineered fill material.

Slab-on-grade floor systems should be structurally separate from the foundation walls and columns and sawcut control joints should be provided at regular intervals and along column lines to minimize shrinkage cracking and to allow for normal differential settlement of the floor slabs.

The modulus of vertical subgrade reaction (k_{vb}) is not a fundamental soil property, and the value changes with footing size. The current state of practice uses a standard reference vertical subgrade reaction k_{v1} associated with a 1 ft^2 plate (305 mm by 305 mm). For foundations on granular (non-cohesive), the modulus of vertical subgrade reaction can be estimated from the equations given below (CFEM, 2006).

$$k_{vb} = k_{v1}\left[\frac{b+0.3}{2b}\right]^2$$

where
k_{vb} is the modulus of vertical subgrade reaction for actual foundation dimension, b (MPa/m);
k_{v1} is the modulus of vertical subgrade reaction for a 1 ft. x 1ft. plate (MPa/m);
b is the foundation width (m)

Based on the subsurface information a modulus of vertical subgrade reaction of 40 MPa/m maybe used for a 1 ft^2 plate for design purposes.

5.5 Sub-drainage

The effects of rain, snow, freezing temperatures, excessive drying and the ingress of water to the subgrade beneath the slab-on-grade should be prevented as much as possible. A sub-drainage system is not required, assuming there are no depressed sections in the building and the asphalt surface will be above the exterior grade.

5.6 Frost Protection

The frost depth in the project area is about 2.0 m according to Ontario Provincial Standard Drawing (OPSD) 3090.100 – Foundation Frost Penetration Depths for Northern Ontario. Therefore, all foundations exposed to seasonal freeze and thaw (external foundations and foundations in un-heated areas) should be provided with a minimum of 2.0 m of soil cover or equivalent thermal insulation for frost protection purposes. In addition, any bearing soil and fresh concrete should be protected from freezing during cold weather construction.

5.7 Excavation

Where space and construction activities permit the construction of unsupported open-cut excavations, these excavations should be carried out in accordance with the guidelines outlined in the Occupational Health and Safety Act (OHSA) for Construction Activities. Based on the OHSA classification system, the soils to be excavated on site would be classified as follow:

Fill Materials	Type 3
Sand above water Table	Type 3
Sand below water Table	Type 4

Shallow temporary unsupported excavations (i.e. those that are open for a relatively short time period) which are above the water table at the site should be made with side slopes no steeper than 1H:1V. Stockpiles of excavated materials and heavy construction equipment should be kept at least the same horizontal distance from the edge of excavation as the depth of the excavation to prevent local instabilities. Where groundwater is encountered the soil should be considered as Type 4, unless the soils are dewatered by positive methods. For Type 4 soils an excavation slope of 3H:1V, or flatter, is required from the base for excavations, in accordance with the OHSA.

5.8 Lateral Pressure on Perimeter Walls

The perimeter walls of the building and its foundation should be designed against the potential lateral (normal to the walls) loads applied by the sand/salt stockpiles. The lateral pressure above the finished grades will be from the stockpiles only and the lateral earth pressure below the finished grades will be from the surrounding soil as well as the impacts of the stockpiles as a surcharge.

The granular backfill for the perimeter walls may be placed either in a zone with width equal to at least 1.2 m behind the back of the wall stem (Case I) or within the wedge shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical (1.5H:1V) extending up and back from the rear face of the footing (Case II).

The following parameters (un-factored) could be used in the design of the perimeter walls against lateral loads:

Table 5: Unfactored Geotechnical Lateral Pressure Coefficients

Material Type	K_a	K_0	K_p
Native Sand/Silty Sand – Case I	0.31	0.47	3.25
Compacted Granular A or Granular B, Type II – Case II	0.28	0.44	3.53
Compacted Granular B, Type I – Case II	0.31	0.47	3.25

If the wall support and building structure allow lateral movements of the wall (unrestrained), active or passive earth pressures (depending on the direction of the movement) may be used in the design of the wall structure. If the abutment support does not allow lateral movement (restrained), at rest earth pressures should be assumed for geotechnical design. The movement to allow active or passive pressures to develop within the backfill, and thereby assume an unrestrained structure, may be taken as follows:

- rotation (i.e., ratio of wall movement to wall height) of approximately 0.002 about the base of a vertical wall;
- horizontal translation of 0.001 times the height of the wall for active earth pressure and 0.015 times the height of the wall for passive earth pressure; or
- a combination of both.

5.9 Seismic Considerations

The CHBDC 2014 contains updated seismic analysis and design methodology. The CHBDC 2014 method uses a site classification system defined by the average soil/bedrock properties (e.g. shear wave velocity, Standard Penetration Test (SPT) resistance, undrained soil shear strength etc.) in the top 30 metres below the foundation level. There are 6 site classes from A to F, decreasing in ground stiffness from A, hard rock, to E, soft soil; with site class F used to denote other soils (e.g., sites underlain by thick peat deposits, high plastic clays, liquefiable soils, etc.). The site class is then used to obtain acceleration and velocity-based site coefficients F(PGA) and F(PGV), respectively, for the effects of site-specific soil conditions in design. The new approach of the CHBDC is generally in agreement with the Ontario Building Code (OBC) 2012.

Based on the results of this investigation, a Site Class of D for “Stiff Soil” is recommended for seismic design purposes at this site as determined based on Section 4.4.3.2 of CHBDC 2014.

5.9.1 Seismic Analysis Coefficient

The Peak Ground Acceleration Ratio (PGA), Peak Ground Velocity (PGV), and the 5% damped spectral response acceleration values shall be determined for the 475-year, 975-year, and 2475-year return periods in accordance with Section 4.4.3.1of the CHBDC 2014.

The corresponding acceleration coefficients associated with return periods of 475 years, 975 years and 2475 years of ground motion for Site Class C at the project site are estimated and summarized in the following table:

Table 6: Seismic Parameters of Site

Return Period (Years)	Possibility of Exceedance	Coefficient of PGA_{ref}	Coefficient of PGV_{ref}	5% Damped Spectral Response Acceleration for a Period of 0.2 s, $S_a(0.2)_{ref}$
475	10% in 50 years	0.015	0.015	0.029
975	5% in 50 years	0.024	0.025	0.044
2475	2% in 50 years	0.041	0.040	0.071

Note: Values obtained from the site Class C of Earthquakes Canada

5.9.2 Liquefaction Assessment

Liquefaction generally applies to loose, saturated, non-cohesive sediments such as gravel, sand and/or low plasticity silt below the groundwater table. Non-cohesive soils above the groundwater elevation and cohesive soils are generally not considered susceptible to liquefaction. All non-cohesive, coarse grained soils below the groundwater elevation that have a fines content (FC) less than 50%, such as the loose sand below the groundwater table at the site, are assumed to have a sand-like behavior and are considered to be susceptible to liquefaction. A liquefaction triggering assessment following the recommended procedures in Idriss and Boulanger (2004) was completed on the loose sand below groundwater at the site based on the SPT N-values measured within the deposit.

The assessment was conducted with a site specific peak horizontal ground acceleration ratio (PGA_{ref}) of 0.041, a site coefficient, F(PGA), of 1.29, and assuming mean earthquake magnitude and distance ($\overline{M}_w, \overline{D}$) that correspond to the seismic model that results the largest PGA_{ref} for the 1 in 2,475 probabilities per annum. The $\overline{M}_w$ and $\overline{D}$ were assumed to be 6.36 and 178 km as obtained from the seismic hazard deaggregation charts prepared by NRCan on Amec Foster Wheeler's request.

The results of the assessment indicate that the loose sand below water table at the site is not considered liquefiable for the earthquake magnitude outlined above.

5.9.3 Earthquake Induced Lateral Earth Pressures for Perimeter Retaining Walls

In accordance with Section 4.6.5 and C4.6.5 of the CHBDC 2014 and its Commentary (2014), for walls which do not allow lateral yielding, the horizontal seismic coefficient, k_h, used in the calculation of the seismic lateral earth pressure coefficient, is taken as equal to the seismic horizontal acceleration coefficient at zero wall movement. For structures which allow lateral yielding (i.e. the wing walls for this structure), k_h is taken as half of the seismic horizontal acceleration coefficient that corresponds to zero wall movement. The seismic vertical acceleration coefficient k_v in both cases should be ignored.

The granular backfill for the retaining wall may be placed either in a zone with width equal to at least 1.2 m behind the back of the wall stem (Case I) or within the wedge shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical (1.5H:1V) extending up and back from the rear face of the footing (Case II).

The following seismic active pressure coefficients (K_{AE}) and seismic passive pressure coefficients (K_{PE}) for the two backfill cases (Case I to Case II) may be used in design for a return period of 2,475 years; these coefficients reflect the maximum K_{AE} and the minimum K_{PE} obtained using the k_h values as described above. It should be noted that these seismic earth pressure coefficients assume that the back of the wall is vertical; condition of the ground surface behind the wall is assumed to be flat. Where sloping backfill is present above the top of the wall, the lateral earth pressures under seismic loading conditions should be calculated by treating the weight of the backfill located above the top of the wall as a surcharge. Different values of K_{AE} and K_{PE} should be estimated separately for the conditions, if applicable.

Table 7: Lateral Earth Pressures

Seismic Active Pressure Coefficient (K_{AE})			
Wall Type	**Case I** (pressures are based on the existing overburden soil materials)	**Case II** (pressures are based on granular fill)	
		Granular A or Granular B, Type II	**Granular B, Type I**
Yielding Walls	0.34	0.26	0.29
Non-Yielding Walls	0.36	0.28	0.31
Seismic Passive Pressure Coefficient (K_{PE})			
Wall Type	**Case I**	**Case II**	
		Granular A or Granular B, Type II	**Granular B, Type I**
Yielding Walls	4.23	7.21	5.65
Non-Yielding Walls	4.14	6.07	5.54

5.10 Stability Assessment and Settlement Assessment in Sand/Salt Area

5.10.1 Stability Assessment

To assess the global stability of the storage structure and to check that the minimum factor of safety equal to 1.3 (based on a geotechnical resistance factor of 0.75 for temporary global stability and a degree of understanding of 0.75) will be achievable for the maximum height of the sand stockpile, a slope stability analysis was performed by modelling the scenario, which can be found in Appendix E.

The SLOPE/W computer program developed by GeoSlope international was employed for computation of the factor of safety, using the Morgensten-Price method to illustrate the static slope stability analysis, developed on the basis of limit equilibrium.

The stability was modelled both along the length, and the width of the proposed structure. Based on correspondence with the MTO Foundation staff and typical structural drawings provided to Amec Foster Wheeler by the MTO, the foundation walls were inputted as 3.7 m from ground surface upwards, with a 7.5 m high peak above the wall, providing an approximate angle of repose of 32 degrees.

The stratigraphy and groundwater conditions modelled for the stability analysis were based on the existing subsurface conditions identified during the geotechnical borehole investigation completed for the site as presented in Part A of this report.

The MTO has stated that at this time there are no final plans for what the floor of the proposed structure will be, but it is known that it will either be a slab on grade, or asphalt layer. It is expected that the installed base floor will provide additional stability support for the system.

Table 8 below provides the soil parameters inputted into the stability model analysis to provide the given factor of safety. The soil parameters were generally estimated based on standard range values for soil types and the results of the field and laboratory results.

Table 8: Material Properties for Stability Model

Material Type	Unit Weight (kN/m^3)	Cohesion (kPa)	Angle of Internal Friction (°)
Sand Pile	18	0	30
Compact sand to sand and gravel (FILL)	19	0	30
Compact to dense sand	20.5	0	32
Loose sand	20.5	0	32

The results of the slope stability analysis, presented in Appendix E, indicate that the factor of safety against slope failure of the subgrade soils below the sand/salt storage pile is greater than the minimum factor of safety of 1.3.

5.10.2 Settlement Assessment

The existing subsurface conditions have been assumed for the settlement assessment model. Based on available information from the MTO and the results of the geotechnical borehole investigation, the sand pile will be placed on the storage building floor, which in turn will be supported on compact to dense fill overlaying native loose to very dense sand at the site.

The ground surface displacements (settlement) as a result of the placement of the sand stockpiles have been estimated using the commercially available computer program Settle-3D from Rocscience.

The contact pressure at the edge of the slab, based on a 3.7 m high wall is 70 kPa. The contact pressure in the centre of the slab is about 200 kPa. The average contact pressure is about 135 kPa has been assumed in the settlement analysis to include the weight of the full sand stockpile. This analysis assumes a sand volume of 3,240 m^3, a unit weight of 18 kN/m^3 for the sand, and a floor area of 432 m^2.

Based on our understanding of the subsurface conditions at the Site and the assumptions described above, the calculated total settlements of the subsoils under the sand pile are indicated on the following table.

Table 9: Settlement at Centre/Edge of Proposed Structure

Stage	Settlement at Centre of Proposed Structure	Settlement at Edge of Proposed Structure
	Immediate (mm)	Immediate (mm)
After placement of sand pile	40	23

The estimated settlements presented in the above table are considered immediate and are not expected to occur over time as consolidation settlement is not anticipated at the site. We note that the settlement estimates outlined above are approximate only and that some variation in the actual settlements should be expected due to variations in the thickness and compressibility characteristics of the subsurface soils, flexibility/rigidity of the granular pad and uncertainties associated with estimation of soil deformation modulus. The actual settlements are expected to be lower than the values estimated above due to periodic fluctuations in volume (height) of the sand stockpile as well as higher unloading/reloading deformation modulus expected for the subsurface soils at the site. The rebound and settlements after the first loading is anticipated to be between on half and one third of the values presented above.

5.11 Analytical Results

Split spoon sample number 4 from BH16-05 was sent to an independent laboratory for analytical testing comprising pH, sulphate, resistivity and chloride determination and is presented in Appendix D and summarized below.

Laboratory testing results for the sample indicates a pH of 6.7, chloride content of 45 µg/g, sulphate content of 28 µg/g and a resistivity value of 6580 ohm-cm.

The concentration of water soluble sulphate within the soil sample tested does not exceed the limit of 0.1%, above which CSA A.23 recommends the use of sulphate resistant cement. Therefore, sulphate resistant concrete is not required.

Based on Table 3.2 of MTO Gravity Pipe Design Guidelines (GPDG) 2004, the soils have a very low corrosive potential. A more detailed review of these test results should be completed by a corrosion specialist.

6.0 CLOSURE

The Limitations of Report, as presented in Appendix E, forms an integral part of this report.

This Foundation Design Report was prepared by Nicholas Kicz, EIT, and reviewed by Mr. Mehdi Mostakhdemi, M.Sc., P.Eng. Mr. Ty Garde, M.Eng, P.Eng., a Designated MTO Foundations Contact for Amec Foster Wheeler, conducted an independent review of this report.

Respectfully submitted,

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

Prepared by:

Nicholas Kicz
Geotechnical Engineer in Training

Mehdi Mostakhdemi, M.Sc., P. Eng.
Geotechnical Engineer

Ty Garde, M. Eng., M. Eng., P. Eng.,
Designated MTO Foundations Contact

REGISTERED PROFESSIONAL ENGINEER
T. J. GARDE
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
M. MOSTAKHDEMI
100185447
PROVINCE OF ONTARIO

METRIC

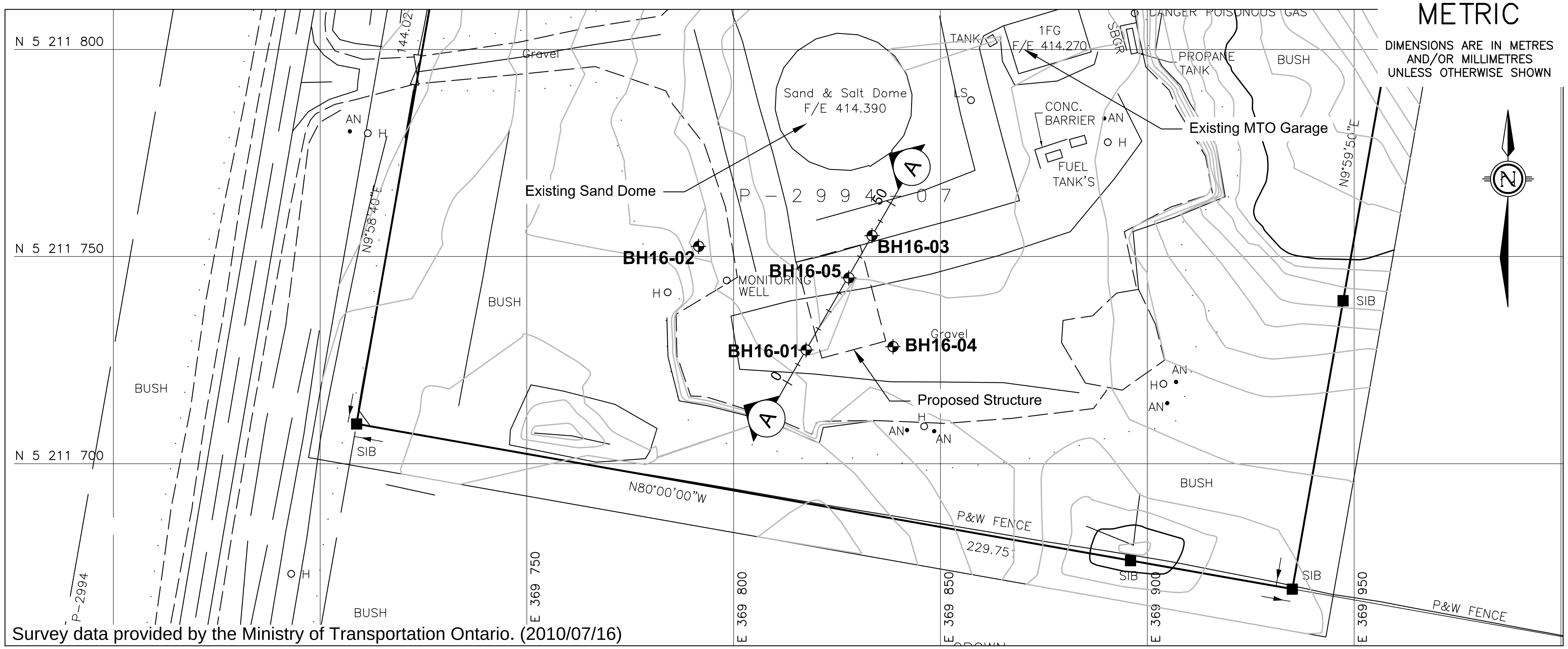
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

amec foster wheeler — Amec Foster Wheeler Environment & Infrastructure, A Division of Amec Foster Wheeler Americas Limited

Foundation Investigation and Design
Assignment No. 5015–E–0064
Hinkler Lake Patrol Yard
Township of Martel, Ontario

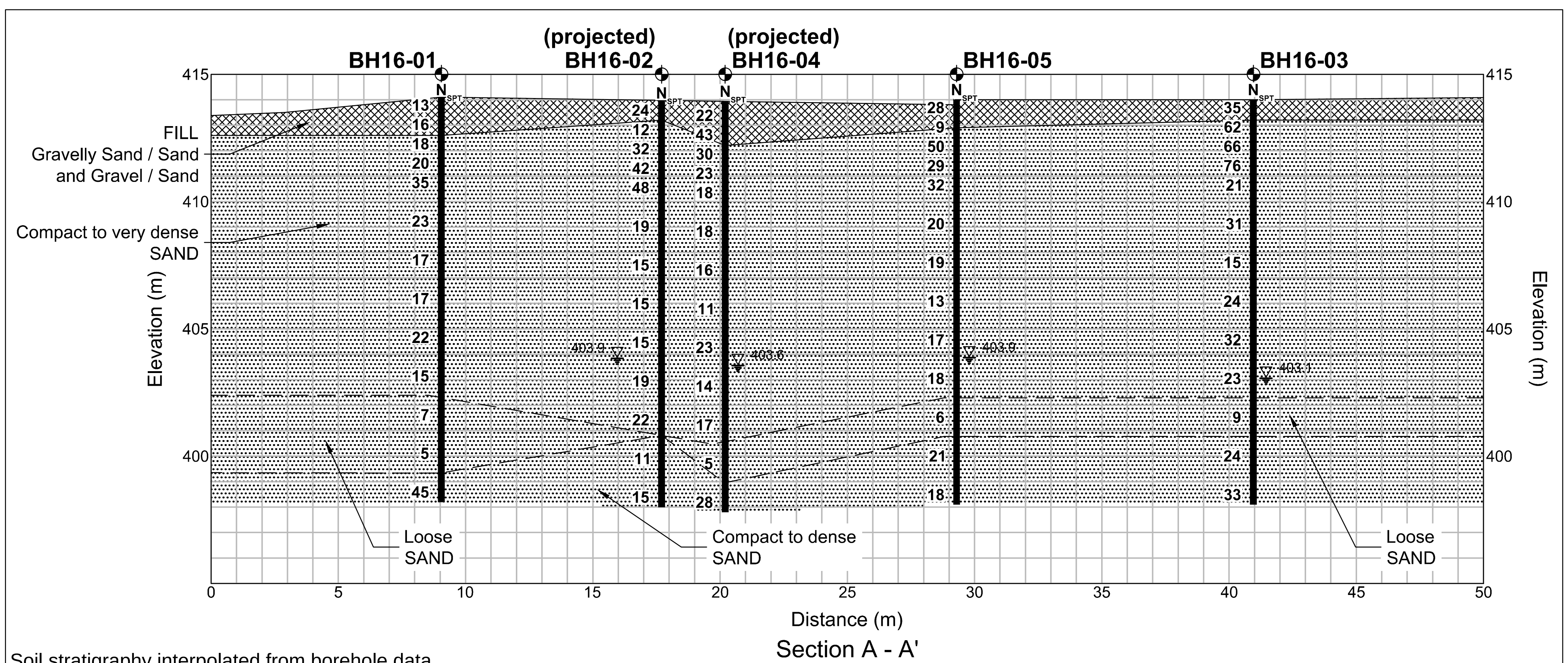
PROPOSED STORAGE STRUCTURE BOREHOLE LOCATION PLAN AND SOIL STRATA SECTION

DRAWING 1



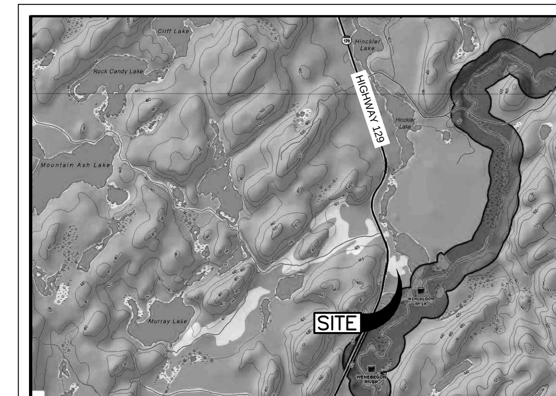
Survey data provided by the Ministry of Transportation Ontario. (2010/07/16)

PLAN



Soil stratigraphy interpolated from borehole data.

CENTERLINE PROFILE



KEY PLAN

Approximate Scale (km)

LEGEND

- BOREHOLE LOCATION – 2016 INVESTIGATION
- N_{SPT} STANDARD PENETRATION TEST VALUE
- 10 BLOWS/0.3m UNLESS OTHERWISE STATED (STD. PEN. TEST, 475 J/BLOW)
- R REFUSAL
- WATER LEVEL UPON COMPLETION OF DRILLING
- EXISTING STRUCTURE
- PROPOSED STRUCTURE

NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING FOUNDATION DESIGN REPORT.
2. THE INTERPRETED STRATIGRAPHY REPRESENTS SIMPLIFIED SUBSURFACE CONDITIONS. THE BOUNDARIES BETWEEN SOIL STRATA HAVE BEEN DEFINED AT BOREHOLE LOCATIONS ONLY. CONDITIONS BETWEEN BOREHOLE LOCATIONS COULD DIFFER FROM ILLUSTRATED CONDITIONS.
3. ELEVATIONS ARE REFERENCED TO GEODETIC DATUM.

NUMBER	ELEVATION (m)	CO–ORDINATES (MTM, NAD 83 ZONE 13) NORTHING (m)	EASTING (m)
TESTHOLES BY OTHERS			
BH16–01	414.1	5211721	0369840
BH16–02	413.9	5211747	0369815
BH16–03	414.0	5211748	0369857
BH16–04	413.7	5211721	0369861
BH16–05	413.8	5211738	0369851

SITE LOCATION
LATITUDE/LONGITUDE 47.042436, –83.144281

REGISTERED PROFESSIONAL ENGINEER — T. J. GARDE — Apr 24/17 — PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER — M. MOSTAKHDEMI — 100185447 — Apr. 24, 2017 — PROVINCE OF ONTARIO

0 20 40 60
Scale (m)

REVISIONS DATE	REV.	BY	DESCRIPTION
04/24/2017	2	NK	REVISED STAMP
02/21/2017	1	NFK	REVISED PER MTO COMMENTS

DESIGN NFK	CHK DMC	CODE	LOAD
DRAWN MAT	CHK NFK	GEOCRES 410–22	DATE 09–FEB–17

DOC: TY163014 – HINCKLER LAKE

DATE PLOTTED: 4/26/2017 3:31:25 PM
FILE LOCATION: P:\projects\2016 Projects\Geotechnical\TY163014 MTO – Patrol Yards Eng\Drawings\TY163014 – Hinckler Lake.dwg

APPENDIX A

SITE PHOTOGRAPHS

Photo 1

Drill rig auguring borehole with view of existing dome, photo taken facing northeast

12 Oct 2016

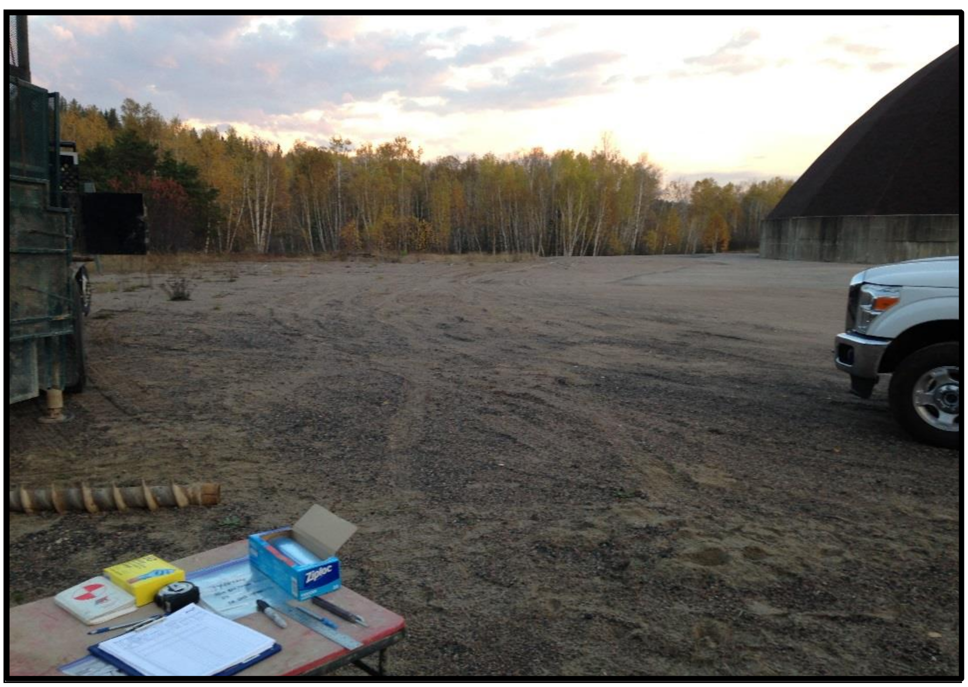


Photo 2

View of drill to the left and part of the dome on the right. View facing northwest of patrol yard landscape

12 Oct 2016

Photo 3

Drillers adjusting steel, with rig set up over borehole. View of flat area of site and west tree line

13 Oct 2016

APPENDIX B

RECORD OF BOREHOLE NO. BH16-01 to BH 16-05

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 *MTC Soil Classification Manual*.

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

Compactness of Cohesionless Soils	SPT N-Value*
Very loose	0 to 5
Loose	5 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	> 50

Consistency of Cohesive Soils	Undrained Shear Strength kPa
Very soft	0 to 12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very stiff	100 to 200
Hard	Over 200

* For penetration of less than 0.3 m, N-values are indicated as the number of blows for the penetration achieved (e.g. 50/25: 50 blows for 25 centimeter penetration).

Soil Sampling

Sample types are abbreviated as follows:

SS Split Spoon	TW Thin Wall Open (Pushed)	RC Rock Core	GS Grab Sample
AU 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.

BEDROCK DESCRIPTION

STRENGTH CLASSIFICATION

Term (Grade)	Field Identification	Approximate Range of Uniaxial Compressive Strength (MPa)
Extremely Weak (R0)	Indented by thumbnail.	0.25 – 1.0
Very Weak (R1)	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife.	1.0 – 5.0
Weak (R2)	Can be peeled with a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer.	5.0 – 25
Medium Strong (R3)	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with a single firm blow of geological hammer.	25 – 50
Strong (R4)	Specimen requires more than one blow of geological hammer to fracture it.	50 – 100
Very Strong (R5)	Specimen requires many blows of geological hammer to fracture it.	100 – 250
Extremely Strong (R6)	Specimen can only be chipped with geological hammer.	>250

JOINT SPACING CLASSIFICATION

Term	Average Joint Spacing (m)
Extremely close	< 0.02
Very close	0.02 – 0.06
Close	0.06 – 0.20
Moderately close	0.20 – 0.6
Wide	0.6 – 2.0
Very wide	2.0 – 6.0
Extremely wide	> 6.0

ROCK QUALITY CLASSIFICATION

Rock Quality Designation, RQD (%)	Description of Rock Quality
0 – 25	Very Poor
25 – 50	Poor
50 – 75	Fair
75 – 90	Good
90 – 100	Excellent

Reference: Deere et al, 1967

WEATHERING CLASSIFICATION

Term (Grade)	Description
Fresh (W1)	No visible sign of rock material weathering; perhaps slight discoloration on major discontinuity surfaces.
Slightly Weathered (W2)	Discoloration indicates weathering of rock material on discontinuity surfaces. Less than 5 % of rock mass altered.
Moderately Weathered (W3)	Less than half of the rock material is decomposed and/or disintegrated into a soil. Fresh or discoloured rock is present either as a continuous framework or as core stones.
Highly Weathered (W4)	More than half of the rock material is decomposed and/or disintegrated into a soil. Fresh or discoloured rock is present either as a discontinuous framework or as core stones.
Completely Weathered (W5)	All rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
Residual Soil (W6)	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume but the soil has not been significantly transported.

Reference: Brown, 1981, "Suggested Methods for Rock Characterization Testing and Monitoring". International Society for Rock Mechanics.

TERMINOLOGY

Rock Quality Designation (RQD) is defined as the percentage of intact core pieces longer than 100 mm (4 inches) to the total length of core. The core should be at least NW size (54.7 mm or 2.15 inches in diameter) and typically 5 ft (nominally 1.5 m) in length.

Solid Core Recovery (SCR) is defined as the percentage of intact cylindrical core pieces to the total length of core.

Total Core Recovery (TCR) is defined as the percentage of intact core pieces to the total length of core.

GROUNDWATER

▽ Groundwater level at completion of drilling.

▼ Groundwater level several hours after completion of drilling.

MTC SOIL CLASSIFICATION
Based on MTC Soil Classification Manual

Ontario

MAJOR DIVISION				GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 75µm)	GRAVELS MORE THAN HALF THE COARSE FRACTION LARGER THAN 4.75mm	CLEAN GRAVELS (LITTLE OR NO FINES)	WIDE RANGE IN GRAIN SIZE & SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICAL SIZE	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
			PREDOMINANTLY ONE SIZE OF A RANGE OF SIZES WITH STONE INTERMEDIATE SIZES MISSING	GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GRAVEL WITH FINES (APPLICABLE AMOUNT OF FINES)	NON PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)	GM	SILTY GRAVELS, POORLY GRADED GRAVEL-SAND- SILT MIXTURES
			PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)	GC	CLAYEY GRAVELS, POORLY GRADED GRAVEL-SAND-CLAY MIXTURES
	SANDS MORE THAN HALF THE COARSE FRACTION SMALLER THAN 4.75mm	CLEAN SANDS (LITTLE OR NO FINES)	WIDE RANGE IN GRAIN SIZE & SUBSTANTIAL AMOUNT OF ALL INTERMEDIATE PARTICLE SIZES	SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			PREDOMINANTLY ONE SIZE OR A RANGE OF SIZES WITH SOME INTERMEDIATE SIZE MISSING	SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		SANDS WITH FINES (APPLICABLE AMOUNT OF FINES)	NON PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)	SM	SILTY SANDS, POORLY GRADED SAND-SILT MIXTURES
			PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)	SC	CLAYEY SANDS, POORLY GRADED SAND-CLAY MIXTURES

IDENTIFICATION PROCEDURE ON FRACTION SMALLER THAN 425µm

MAJOR DIVISION		DRY STRENGTH (CRUSHING CHARACTERISTICS)	DILATANCY (REACTION TO SHAKING)	TOUGHNESS (CONSISTENCY NEAR PLASTIC LIMIT)	GROUP SYMBOL	TYPICAL DESCRIPTION
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT SMALLER THAN 75µm) — SILT AND CLAYS	LIQUID LIMIT LESS THAN 35	NONE	QUICK	NONE	ML	INORGANIC SILTS & SANDY SILTS OR SLIGHTLY PLASTICITY, ROCK FLOUR
		MEDIUM TO HIGH	NONE TO VERY SLOW	MEDIUM	CL	SILTY CLAYS (INORGANIC), GRAVELLY CLAYS, SANDY CLAYS, LEAN CLAYS
		SLIGHT TO MEDIUM	SLOW	SLIGHT	OL	ORGANIC SILT OF LOW PLASTICITY, ORGANIC SANDY SILTS
	LIQUID LIMIT BETWEEN 35 AND 50	NONE TO SLIGHT	SLOW TO QUICK	SLIGHT	MI	INORGANIC COMPRESSIBLE FINE SANDY SILT WITH CLAY OF MEDIUM PLASTICIT, CLAYEY SILTS
		HIGH	NONE	MEDIUM TO HIGH	CI	SILTY CLAYS (INORGANIC) OF MEDIUM PLASTICITY
		SLIGHT TO MEDIUM	VERY SLOW	SLIGHT	OI	ORGANIC SILTY CLAYS OF MEDIUM PLASTICITY
	LIQUID LIMIT GREATER THAN 50	SLIGHT TO MEDIUM	SLOW TO NONE	MEDIUM	MH	INORGANIC SILTS, HIGHLY COMPRESSIBLE MICACEOUS OR DIATOMECACOUS FINE SANDY SILTS, ELASTIC SILTS
		HIGH TO VERY HIGH	NONE	HIGH	CH	CLAYS (INORGANIC) OF HIGH PLASTICITY, FAT CLAYS
		MEDIUM TO HIGH	NONE TO VERY SLOW	SLIGHT TO MEDIUM	OH	ORGANIC CLAYS OF HIGH PLASTICITY
HIGH ORGANIC SOILS		READILY IDENTIFIED BY COLOUR, ODOUR, SPONGY FEEL & FREQUENTLY BY FIBROUS TEXTURE			Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS

INFORMATION REQUIRED FOR DESCRIBING SOILS

Coarse grained soils: GIVE TYPE, NAME, IF NECESSARY, INDICATE APPROX % OF SAND & GRAVEL ; MAX SIZE; ANGULARITY, SURFACE CONDITION, & HARDNESSOF THE COARSE GRAINS, LOCAL OR GEOLOGICAL NAME & OTHER PERTINENT DESCRICTIVE INFORMATION, & SYMBOL IN PARENTHESIS.

FOR UNDISTURBED SOILS ADD INFORMATION ON STRATIFICATION, DEGREE OF COMPACTNESS, CEMENTATION, MOISTURE CONDITION & DRAINAGE CHARACTERISTICS

Fine grained soils: GIVE TYPE, NAME, IF NECESSARY, INDICATE DEGREE AND CHARACTER OF PLASTICITY, AMOUNT AND MAXIMUM SIZE OF COURSE GRAINS, COLOUR IN WET CONDITION, ODOUR, IF ANY, LOCAL OR GEOLOGIC NAME & OTHER PERTINENT DESCRICTIVE INFORMATION & SYMBOL IN PARENTHESIS.

FOR UNDISTURBED SOILS AND INFORMATION ON STRUCTURE, STRATIFICATION, CONSISTANCY IN UNDISTURBED AND REMOLDED STATES, MOISTURE & DRAINAGE CONDITION.

USE GRAIN SIZE CURVE IN IDENTIFYING THE FACTORS AS GIVEN UNDER FIELD IDENTIFICATION

LABORATORY CLASSIFICATION CRITERIA

DETERMINE PERCENTAGE OF GRAVEL & SAND FROM GRAIN SIZE CURVE. DEPENDING ON PERCENTAGE OF FINES (FRACTION SMALLER THAN 75 µm) COARSE GRAINED SOILS ARE CLASSIFIED AS FOLLOWS:

LESS THAN 5% — GW, GP, SW, SP
MORE THAN 12% — GM, GC, SM, SC
5% TO 12% — BORDER LINE CASES REQUIRE USE OF DUAL SYMBOL.

GW: $C_u = \frac{D_{60}}{D_{10}}$ GREATER THAN 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ BETWEEN 1 AND 3

GP: NOT MEETING ALL GRADATION REQUIREMENTS FOR GW

GM: ATTERBERG LIMITS BELOW A-LINE OR Ip LESS THAN 4

GC: ATTERBERG LIMITS ABOVE A- LINE WITH Ip GREATER THAN 7

ABOVE A-LINE WITH Ip BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS

SW: $C_u = \frac{D_{60}}{D_{10}}$ GREATER THAN 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ BETWEEN 1 AND 3

SP: NOT MEETING ALL GRADATION FOR SW

SM: ATTERBERG LIMITS BELOW A- LINE OR Ip LESS THAN 4

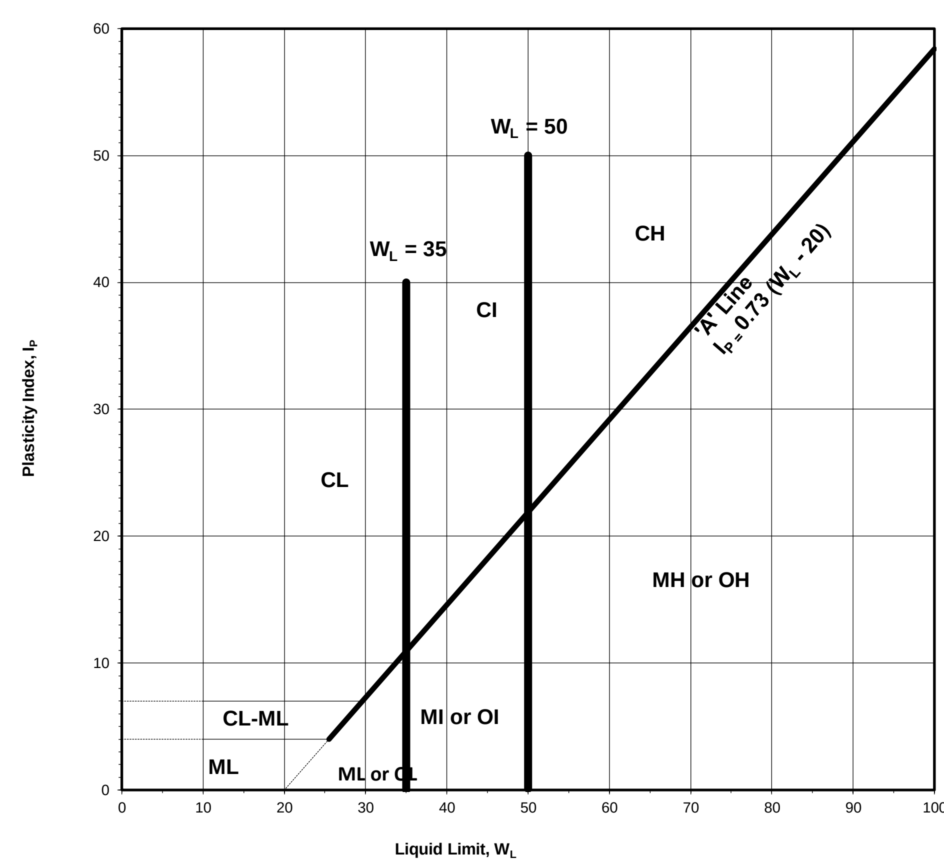
SC: ATTERBERG LIMITS ABOVE A- LINE WITH Ip GREATER THAN 7

ABOVE A-LINE WITH Ip BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS

FRACTION		U.S STANDARD SIEVE SIZE		DEFINING RANGES OF PERCENTAGE BY WEIGHT OF MINOR COMPONENTS	
		PASSING	RETAINED	PERCENT	DESCRIPTOR
GRAVEL	COARSE	75 mm	26.5 mm	Over 30	AND / WITH
	FINE	26.5 mm	4.75 mm	20-30	(ey) or (y)
SAND	COARSE	4.75 mm	2.00 mm	12-20	Some
	MEDIUM	2.00 mm	425 µm	5-12	Trace to some
	FINE	425 µm	75 µm	1-5	Trace
FINES (SILT OR CLAY BASED ON PLASTICITY)		75 µm			

OVERSIZED MATERIAL

ROUNDED OR SUBROUNDED: COBBLES 75 mm TO 200 mm BOULDERS > 200 mm	NOT ROUNDED: ROCK FRAGMENTS > 75 mm ROCKS > 0.76 CUBIC METRE IN VOLUME



PLASTICITY CHART
FOR LABORATORY CLASSIFICATION OF FINE GRAINED SOILS

BOUNDARY CLASSIFICATION: BOUNDARY CLASSIFICATION: SOILS POSSESSING CHARACTERISTICS OF TWO GROUPS ARE DESIGNATED BY COMBINATIONS OF GROUP SYMBOLS FOE EXAMPLE GW-GC WELL GRADED GRAVEL-SAND MIXTURE WITH CLAY BINDER

amec foster wheeler

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

www.amecfw.com

Ontario

amec foster wheeler

RECORD OF BOREHOLE No. BH16-01

G.W.P. 5015-E-0064 LOCATION 0369840 E, 5211721 N ORIGINATED BY PW

DIST ______ HWY 129 BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.) COMPILED BY PW

DATUM MTM NAD 83 Zone 13 DATE 12 October 2016 CHECKED BY TJG

PROJECT Foundation Investigation and Design Report - Hinkler Lake Patrol Yard, Township of Martel, Ontario JOB NO. TY163014

ELEV DEPTH (m)	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH m	ELEVATION m	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
414.1	SE Corner of Proposed Building									
0.0	GRAVELLY SAND trace to some fines compact (FILL)		1	SS	13			414	5	26 68 (6)
			2	SS	16		1	413	4	
412.7 / 1.5	SAND trace fines trace to some gravel compact to dense		3	SS	18		2	412	7	
			4	SS	20				3	
			5	SS	35		3	411	4	
							4	410		
			6	SS	23		5	409	3	
							6	408		
			7	SS	17				3	9 88 (3)

Dynamic cone penetration resistance plot: 20 40 60 80 100. Shear strength kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100. Plastic limit W_P, natural moisture content W, liquid limit W_L; water content (%) 20 40 60. Soil vapour reading COV/TOV (ppm).

Continued Next Page

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Ontario

amec foster wheeler

RECORD OF BOREHOLE No. BH16-01

G.W.P. 5015-E-0064 LOCATION 0369840 E, 5211721 N ORIGINATED BY PW

DIST HWY 129 BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.) COMPILED BY PW

DATUM MTM NAD 83 Zone 13 DATE 12 October 2016 CHECKED BY TJG

PROJECT Foundation Investigation and Design Report - Hinkler Lake Patrol Yard, Township of Martel, Ontario JOB NO. TY163014

ELEV DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	DEPTH m	ELEVATION m	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
						407		
		8	SS	17	8	406	4	
		9	SS	22	9	405	14	
					10	404		
		10	SS	15	11	403	18	
402.4 / 11.7	SAND some silt loose				12	402		
		11	SS	7			20	0 87 13 0
					13	401		

Continued Next Page

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Ontario

amec foster wheeler

RECORD OF BOREHOLE No. BH16-01

G.W.P. 5015-E-0064 LOCATION 0369840 E, 5211721 N ORIGINATED BY PW

DIST HWY 129 BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.) COMPILED BY PW

DATUM MTM NAD 83 Zone 13 DATE 12 October 2016 CHECKED BY TJG

PROJECT Foundation Investigation and Design Report - Hinkler Lake Patrol Yard, Township of Martel, Ontario JOB NO. TY163014

ELEV / DEPTH (m)	DESCRIPTION	NUMBER	TYPE	"N" VALUES	DEPTH (m)	ELEVATION (m)	WATER CONTENT (%)	GR	SA	SI	CL
		12	SS	5		400	23	0	88	12	0
399.4 / 14.8	SAND trace to some silt dense				15	399					
		13	SS	45			19	0	94	6	0
398.3 / 15.9	END OF BOREHOLE										

Notes:

1) Borehole was backfilled with bentonite and auger cuttings on completion.

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 60); SOIL VAPOUR READING COV/TOV (ppm); REMARKS & GRAIN SIZE DISTRIBUTION (%)

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Ontario

amec foster wheeler

RECORD OF BOREHOLE No. BH16-02

G.W.P. 5015-E-0064 LOCATION 0369815 E, 5211747 N ORIGINATED BY PW

DIST HWY 129 BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.) COMPILED BY PW

DATUM MTM NAD 83 Zone 13 DATE 12 October 2016 CHECKED BY TJG

PROJECT Foundation Investigation and Design Report - Hinkler Lake Patrol Yard, Township of Martel, Ontario JOB NO. TY163014

ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	GR	SA	SI	CL
413.9	SW Corner of Proposed Building										
0.0	SAND trace fines some gravel compact (FILL)		1	SS	24		6				
413.2 0.7	SAND trace to some fines trace to some gravel compact to dense		2	SS	12		8	1	87	(12)	
			3	SS	32		2				
			4	SS	42		2				
			5	SS	48		2				
			6	SS	19		2				
			7	SS	15		3	16	81	(3)	

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

ELEVATION (m): 413, 412, 411, 410, 409, 408, 407

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

SOIL VAPOUR READING COV/TOV (ppm)

REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Ontario

amec foster wheeler

RECORD OF BOREHOLE No. BH16-02

G.W.P. 5015-E-0064	LOCATION 0369815 E, 5211747 N		ORIGINATED BY PW
DIST ______ HWY 129	BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.)		COMPILED BY PW
DATUM MTM NAD 83 Zone 13	DATE 12 October 2016		CHECKED BY TJG
PROJECT Foundation Investigation and Design Report - Hinkler Lake Patrol Yard, Township of Martel, Ontario			JOB NO. TY163014

ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH m	ELEVATION m	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND trace to some fines trace to some gravel compact									
			SS	8	15		8	406	3	
			SS	9	15		9	405	2	
						∇	10	404		
			SS	10	19		11	403	13	
			SS	11	22		12	402	19	13 86 (1)
							13	401		
								400		

Chart headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 60); SOIL VAPOUR READING COV/TOV (ppm)

Continued Next Page

+3, ×3: Numbers refer to Sensitivity   ○ 3% STRAIN AT FAILURE

Ontario

amec foster wheeler

RECORD OF BOREHOLE No. BH16-02

G.W.P. 5015-E-0064 LOCATION 0369815 E, 5211747 N ORIGINATED BY PW

DIST ______ HWY 129 BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.) COMPILED BY PW

DATUM MTM NAD 83 Zone 13 DATE 12 October 2016 CHECKED BY TJG

PROJECT Foundation Investigation and Design Report - Hinkler Lake Patrol Yard, Township of Martel, Ontario JOB NO. TY163014

ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH m	ELEVATION m	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	SOIL VAPOUR READING COV/TOV (ppm)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND compact		12	SS	11							
							15	399				
			13	SS	15							
398.1 15.9	END OF BOREHOLE											

Notes:
1) Groundwater was encountered at a depth of 10.1 m at completion.

2) Borehole was backfilled with bentonite and auger cuttings on completion.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No. BH16-03

G.W.P. 5015-E-0064
LOCATION 0369857 E, 5211748 N
ORIGINATED BY PW

DIST ____ HWY 129
BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.)
COMPILED BY PW

DATUM MTM NAD 83 Zone 13
DATE 12 October 2016 - 13 October 2016
CHECKED BY TJG

PROJECT Foundation Investigation and Design Report - Hinkler Lake Patrol Yard, Township of Martel, Ontario
JOB NO. TY163014

ELEV DEPTH (m)	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
414.0	NW Corner of Proposed Building					
0.0	GRAVELLY SAND some fines dense (FILL)	1	SS	35	6	21 66 (13)
413.3 / 0.7	SAND trace to some fines some gravel compact to very dense	2	SS	62	2	
		3	SS	66	3	
		4	SS	76	2	
		5	SS	21	3	
		6	SS	31	3	
		7	SS	15	3	

Depth / Elevation scale (m): 1 / 413; 2 / 412; 3 / 411; 4 / 410; 5 / 409; 6 / 408

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE: 20 40 60 80 100
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%): 20 40 60
SOIL VAPOUR READING COV/TOV (ppm)
GROUND WATER CONDITIONS

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity   ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No. BH16-03

G.W.P. 5015-E-0064 | LOCATION 0369857 E, 5211748 N | ORIGINATED BY PW
DIST | HWY 129 | BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.) | COMPILED BY PW
DATUM MTM NAD 83 Zone 13 | DATE 12 October 2016 - 13 October 2016 | CHECKED BY TJG
PROJECT Foundation Investigation and Design Report - Hinkler Lake Patrol Yard, Township of Martel, Ontario | JOB NO. TY163014

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH (m)	ELEVATION (m)	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND trace to some fines some gravel compact								
		8	SS	24		8	406	3	
						9	405		
		9	SS	32				2	18 79 (3)
						10	404		
		10	SS	23	▽	11	403	10	
402.3 11.7	SAND trace to some fines loose								
						12	402		
		11	SS	9				14	
						13	401		
400.8 13.3	SAND trace fines trace to some gravel compact to dense								

Continued Next Page

+3, ×3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Ontario

amec foster wheeler

RECORD OF BOREHOLE No. BH16-03

G.W.P. 5015-E-0064 | LOCATION 0369857 E, 5211748 N | ORIGINATED BY PW

DIST | HWY 129 | BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.) | COMPILED BY PW

DATUM MTM NAD 83 Zone 13 | DATE 12 October 2016 - 13 October 2016 | CHECKED BY TJG

PROJECT Foundation Investigation and Design Report - Hinkler Lake Patrol Yard, Township of Martel, Ontario | JOB NO. TY163014

ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH m	ELEVATION m	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%) (PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L)	SOIL VAPOUR READING COV/TOV (ppm)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND trace fines trace to some gravel compact to dense		12	SS	24					17		6 91 (3)
							15	399				
			13	SS	33					22		
398.2 15.9	END OF BOREHOLE Notes: 1) Groundwater was encountered at a depth of 10.9 m at completion. 2) Borehole was backfilled with bentonite and auger cuttings on completion.											

Shear strength legend: ○ UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Ontario

amec foster wheeler

RECORD OF BOREHOLE No. BH16-04

G.W.P. 5015-E-0064	LOCATION 0369861 E, 5211721 N	ORIGINATED BY	PW
DIST ____ HWY 129	BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.)	COMPILED BY	PW
DATUM MTM NAD 83 Zone 13	DATE 13 October 2016	CHECKED BY	TJG
PROJECT Foundation Investigation and Design Report - Hinkler Lake Patrol Yard, Township of Martel, Ontario		JOB NO.	TY163014

Column headings: SOIL PROFILE (ELEV / DEPTH (m), DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; DEPTH (m); ELEVATION (m); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 60); SOIL VAPOUR READING COV/TOV (ppm); REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

413.7 NE Corner of Proposed Building

ELEV / DEPTH (m)	DESCRIPTION	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	GR	SA	SI	CL
413.7 / 0.0	SAND & GRAVEL, trace fines, compact to dense (FILL)	1	SS	22	9				
		2	SS	43	3	39	57	(4)	
412.3 / 1.5	SAND, some gravel, trace silt and clay, compact to loose	3	SS	30	4				
		4	SS	23	2				
410.7 / 3.0	GRAVELLY SAND	5	SS	18	3	29	67	(4)	
409.6 / 4.1	SAND, trace fines, trace gravel, compact	6	SS	18	3				
		7	SS	16	4				

Depth scale: 1, 2, 3, 4, 5, 6 m; Elevation scale: 413, 412, 411, 410, 409, 408, 407 m

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No. BH16-04

G.W.P. 5015-E-0064	LOCATION 0369861 E, 5211721 N		ORIGINATED BY PW
DIST	HWY 129	BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.)	COMPILED BY PW
DATUM MTM NAD 83 Zone 13	DATE 13 October 2016		CHECKED BY TJG
PROJECT Foundation Investigation and Design Report - Hinkler Lake Patrol Yard, Township of Martel, Ontario			JOB NO. TY163014

ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH m	ELEVATION m	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND trace fines trace gravel compact									
			8	SS	11		8		3	
			9	SS	23				2	
						∇	10			
			10	SS	14		11		15	4 94 (2)
			11	SS	17				20	
400.5 13.3	SAND trace fines trace gravel loose									

Depth scale: 8, 9, 10, 11, 12, 13 m. Elevation scale: 406, 405, 404, 403, 402, 401, 400 m.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE: 20 40 60 80 100

PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L

WATER CONTENT (%): 20 40 60

SOIL VAPOUR READING COV/TOV (ppm)

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Ontario

amec foster wheeler

RECORD OF BOREHOLE No. BH16-04

G.W.P. 5015-E-0064 | LOCATION 0369861 E, 5211721 N | ORIGINATED BY PW

DIST | HWY 129 | BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.) | COMPILED BY PW

DATUM MTM NAD 83 Zone 13 | DATE 13 October 2016 | CHECKED BY TJG

PROJECT Foundation Investigation and Design Report - Hinkler Lake Patrol Yard, Township of Martel, Ontario | JOB NO. TY163014

ELEV / DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH (m)	ELEVATION (m)	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	SOIL VAPOUR READING COV/TOV (ppm)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			12	SS	5							
399.0 / 14.8	SAND trace fines trace gravel compact						15	399				
			13	SS	28			398				
397.9 / 15.9	END OF BOREHOLE Notes: 1) Groundwater was encountered at a depth of 10.1 m at completion. 2) Borehole was backfilled with bentonite and auger cuttings on completion.											

Plot legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 60)

$+^3$, $\times^3$: Numbers refer to Sensitivity   ○ $^{3\%}$ STRAIN AT FAILURE

Ontario

amec foster wheeler

RECORD OF BOREHOLE No. BH16-05

G.W.P. 5015-E-0064 | LOCATION 0369851 E, 5211738 N | ORIGINATED BY PW

DIST | HWY 129 | BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.) | COMPILED BY PW

DATUM MTM NAD 83 Zone 13 | DATE 13 October 2016 | CHECKED BY TJG

PROJECT Foundation Investigation and Design Report - Hinkler Lake Patrol Yard, Township of Martel, Ontario | JOB NO. TY163014

ELEV DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	NATURAL MOISTURE CONTENT (%)	GR	SA	SI	CL
413.8	Center of Proposed Building								
0.0	GRAVELLY SAND some fines compact (FILL)	1	SS	28	6	26	62	(12)	
		2	SS	9	24				
412.7 1.1	SAND trace to some fines trace to some gravel loose to very dense					13	75	(12)	
		3	SS	50	4				
		4	SS	29	4				
		5	SS	32	3				
		6	SS	20	3				
		7	SS	19	3	6	91	(3)	

Depth scale: 1, 2, 3, 4, 5, 6 m. Elevation scale: 413, 412, 411, 410, 409, 408, 407 m.

Dynamic Cone Penetration Resistance Plot: 20 40 60 80 100. Shear Strength kPa: ○ Unconfined, + Field Vane, ● Quick Triaxial, × Lab Vane: 20 40 60 80 100. Plastic Limit W_P, Natural Moisture Content W, Liquid Limit W_L; Water Content (%) 20 40 60. Soil Vapour Reading COV/TOV (ppm). Remarks & Grain Size Distribution (%).

Continued Next Page

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Ontario

amec foster wheeler

RECORD OF BOREHOLE No. BH16-05

G.W.P. 5015-E-0064 LOCATION 0369851 E, 5211738 N ORIGINATED BY PW

DIST HWY 129 BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.) COMPILED BY PW

DATUM MTM NAD 83 Zone 13 DATE 13 October 2016 CHECKED BY TJG

PROJECT Foundation Investigation and Design Report - Hinkler Lake Patrol Yard, Township of Martel, Ontario JOB NO. TY163014

ELEV DEPTH (m)	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH (m)	ELEVATION (m)	WATER CONTENT (%)
	SAND trace fines trace gravel loose to compact						406	
		8	SS	13		8		3
						9	405	
		9	SS	17				3
					▽	10	404	
		10	SS	18		11	403	13
402.1 / 11.7	SAND trace fines loose					12	402	
		11	SS	6				19
						13	401	
400.5 / 13.3	SAND trace to some fines compact						400	

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; SOIL VAPOUR READING COV/TOV (ppm); REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Ontario

amec foster wheeler

RECORD OF BOREHOLE No. BH16-05

G.W.P. 5015-E-0064 LOCATION 0369851 E, 5211738 N ORIGINATED BY PW

DIST HWY 129 BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.) COMPILED BY PW

DATUM MTM NAD 83 Zone 13 DATE 13 October 2016 CHECKED BY TJG

PROJECT Foundation Investigation and Design Report - Hinkler Lake Patrol Yard, Township of Martel, Ontario JOB NO. TY163014

ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH m	ELEVATION m	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND compact		12	SS	21				21	0 94 (6)
								399		
							15			
			13	SS	18				20	
398.0 15.9	END OF BOREHOLE							398		

Notes:
1) Groundwater was encountered at a depth of 9.9 m at completion.

2) Borehole was backfilled with bentonite and auger cuttings on completion.

Column headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; SOIL VAPOUR READING COV/TOV (ppm)

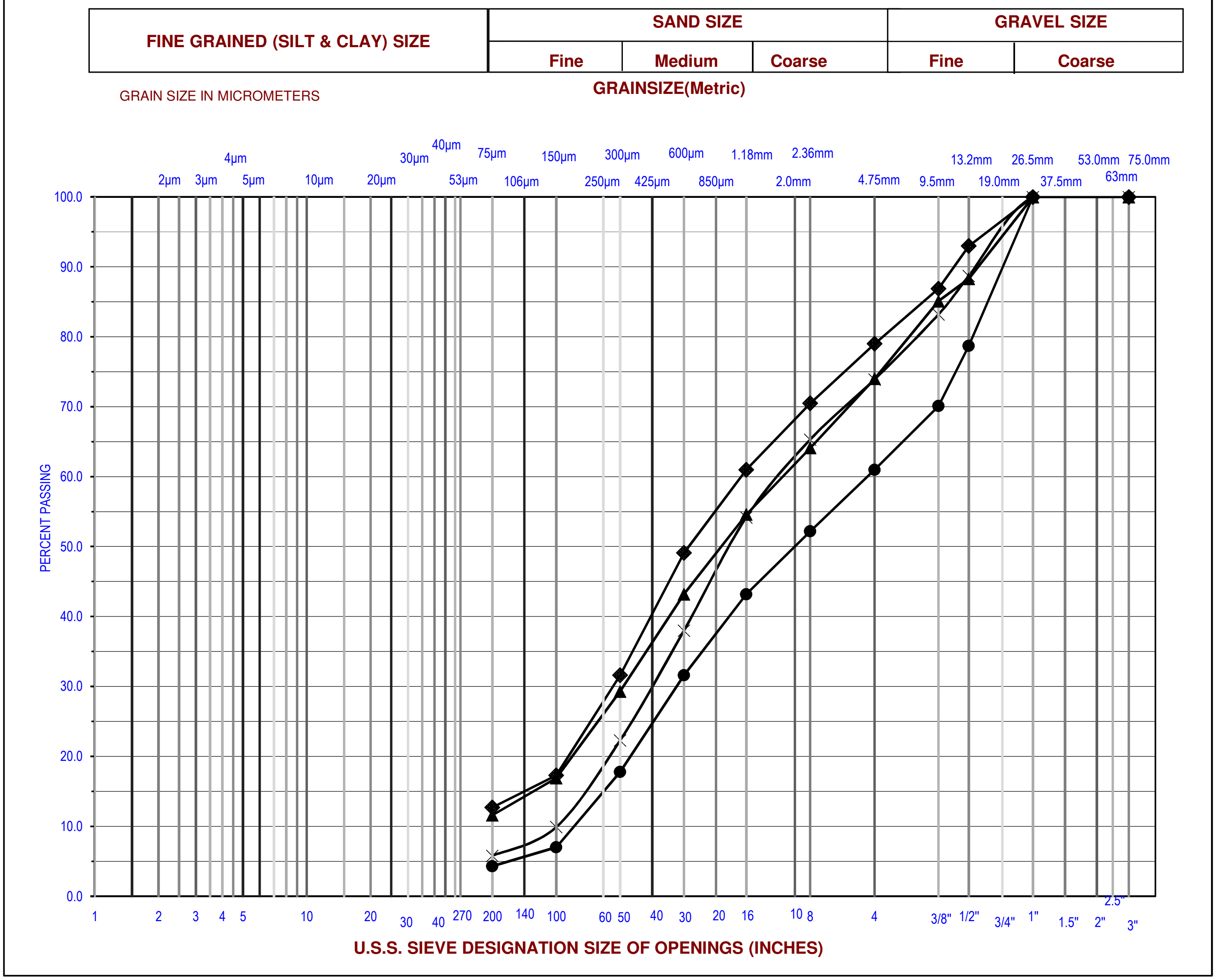
+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

APPENDIX C

LABORATORY TESTING RESULTS

FIGURE C1 - GRAIN SIZE DISTRIBUTION

GRAVELLY SAND / SAND & GRAVEL (FILL)



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)	GRAVEL(%)	SAND (%)	SILT & CLAY (%)
X	16-01	SS1	413.8	26	68	6
◆	16-03	SS1	413.7	21	66	13
●	16-04	SS2	412.6	39	57	4
▲	16-05	SS1	413.5	26	62	12

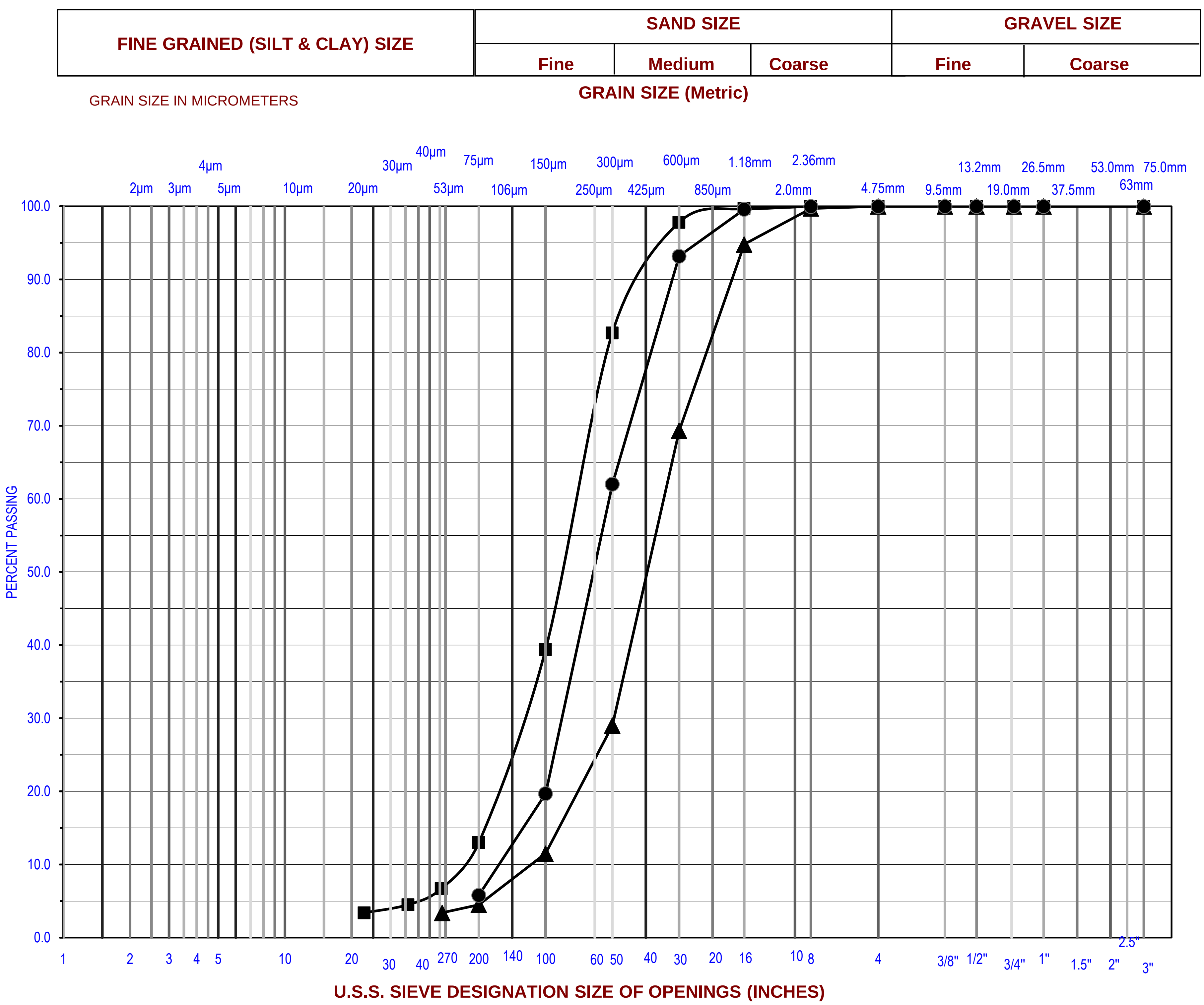
Amec Foster Wheeler Environment & Infrastructure,
a Division of Amec Foster Wheeler Americas Limited
131 Fielding Road, Lively, Ontario
Canada, P3Y1L7
PH: (705) 682-2632, FX: (705) 682-2260
www.amecfw.com

GRAIN SIZE DISTRIBUTION

Project No.:	TY163014
Tested By:	**Reviewed By:**
MMD	TJG

FIGURE C2A - SIEVE AND HYDROMETER

SAND, trace to some silt, trace to some gravel



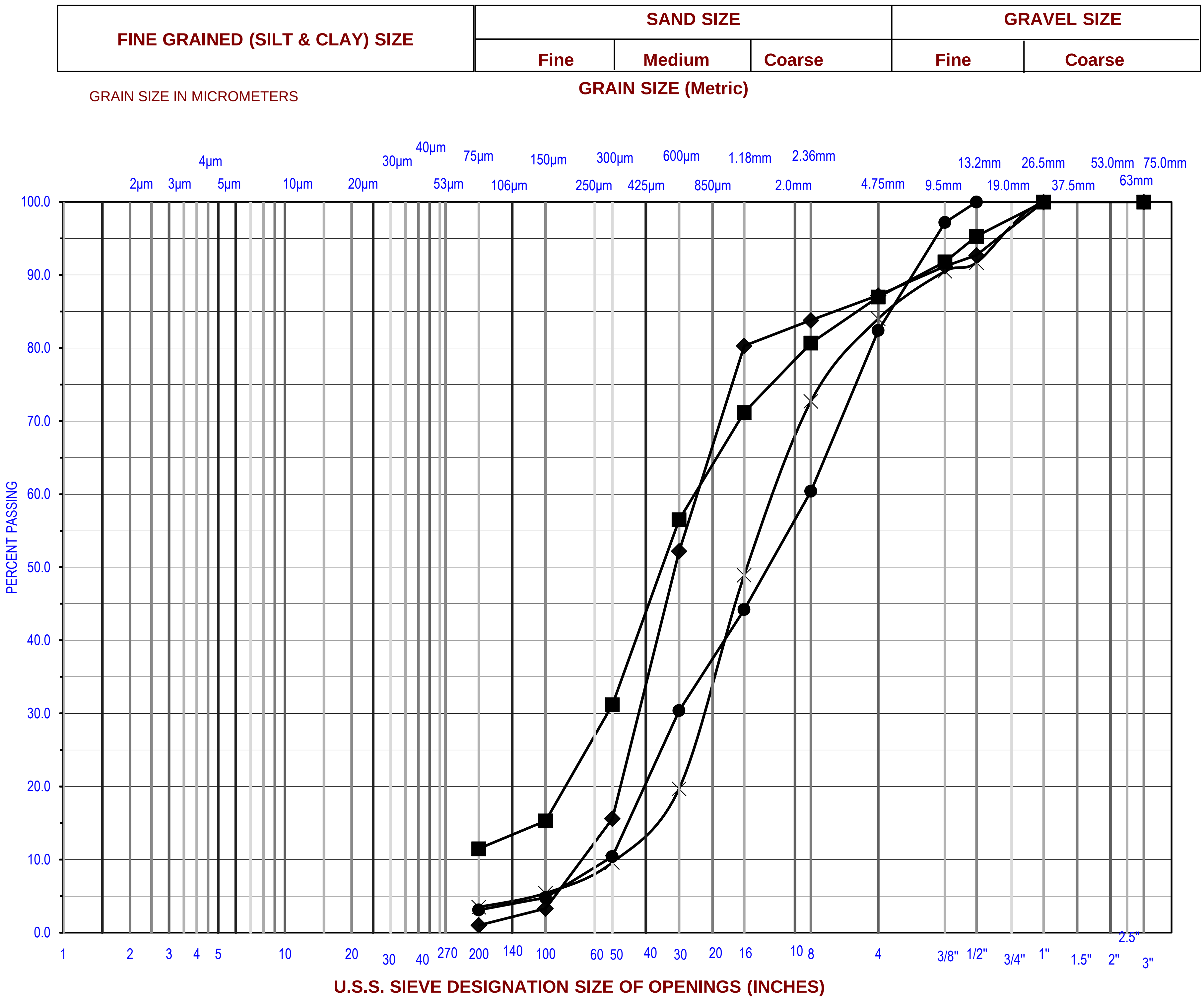
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)	GRAVEL(%)	SAND (%)	SILT (%)	CLAY (%)
■	16-01	SS11	401.6	0	87	13	0
▲	16-01	SS12	400.2	0	88	12	0
●	16-01	SS13	398.6	0	94	6	0

Amec Foster Wheeler Environment & Infrastructure, a Division of Amec Foster Wheeler Americas Limited 131 Fielding Road, Lively, Ontario Canada, P3Y1L7 PH: (705) 682-2632, FX: (705) 682-2260 www.amecfw.com	**SIEVE AND HYDROMETER**	**Project No.:** **TY163014**	
		Tested By:	**Reviewed By:**
		MMD	**TG**

FIGURE C2B - GRAIN SIZE DISTRIBUTION

SAND, trace to some silt, trace to som gravel



LEGEND

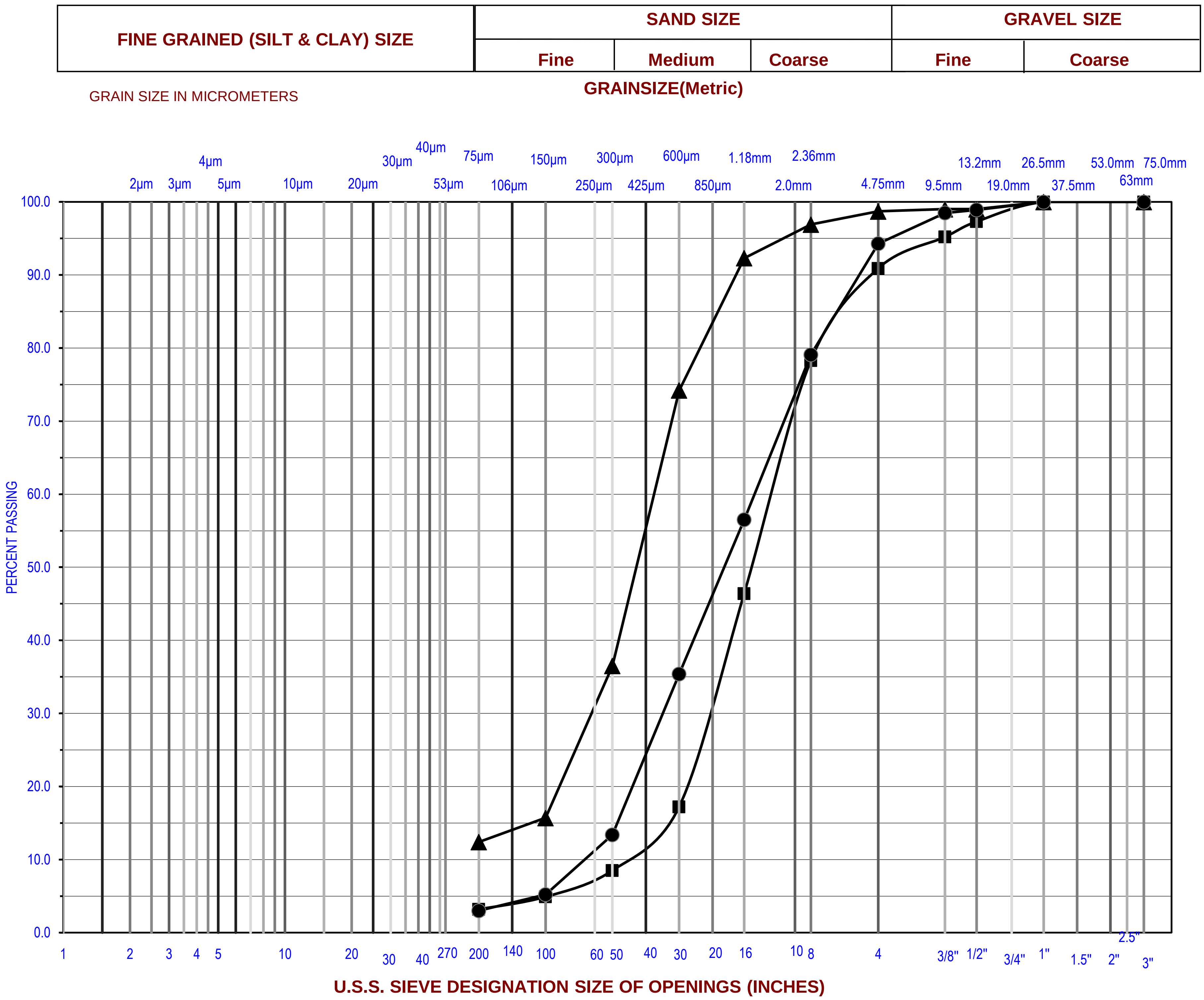
SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)	GRAVEL(%)	SAND (%)	SILT & CLAY (%)
X	16-02	SS7	407.5	16	80	4
◊	16-02	SS11	401.4	13	86	1
●	16-03	SS9	404.6	18	79	3
■	16-05	SS2B	412.7	13	75	12

Amec Foster Wheeler Environment & Infrastructure,
a Division of Amec Foster Wheeler Americas Limited
131 Fielding Road, Lively, Ontario
Canada, P3Y1L7
PH: (705) 682-2632, FX: (705) 682-2260
www.amecfw.com

GRAIN SIZE DISTRIBUTION	Project No.:	TY163014
	Tested By:	Reviewed By:
	MMD	TJG

FIGURE C2C- GRAIN SIZE DISTRIBUTION

SAND, trace to some silt, trace to some gravel



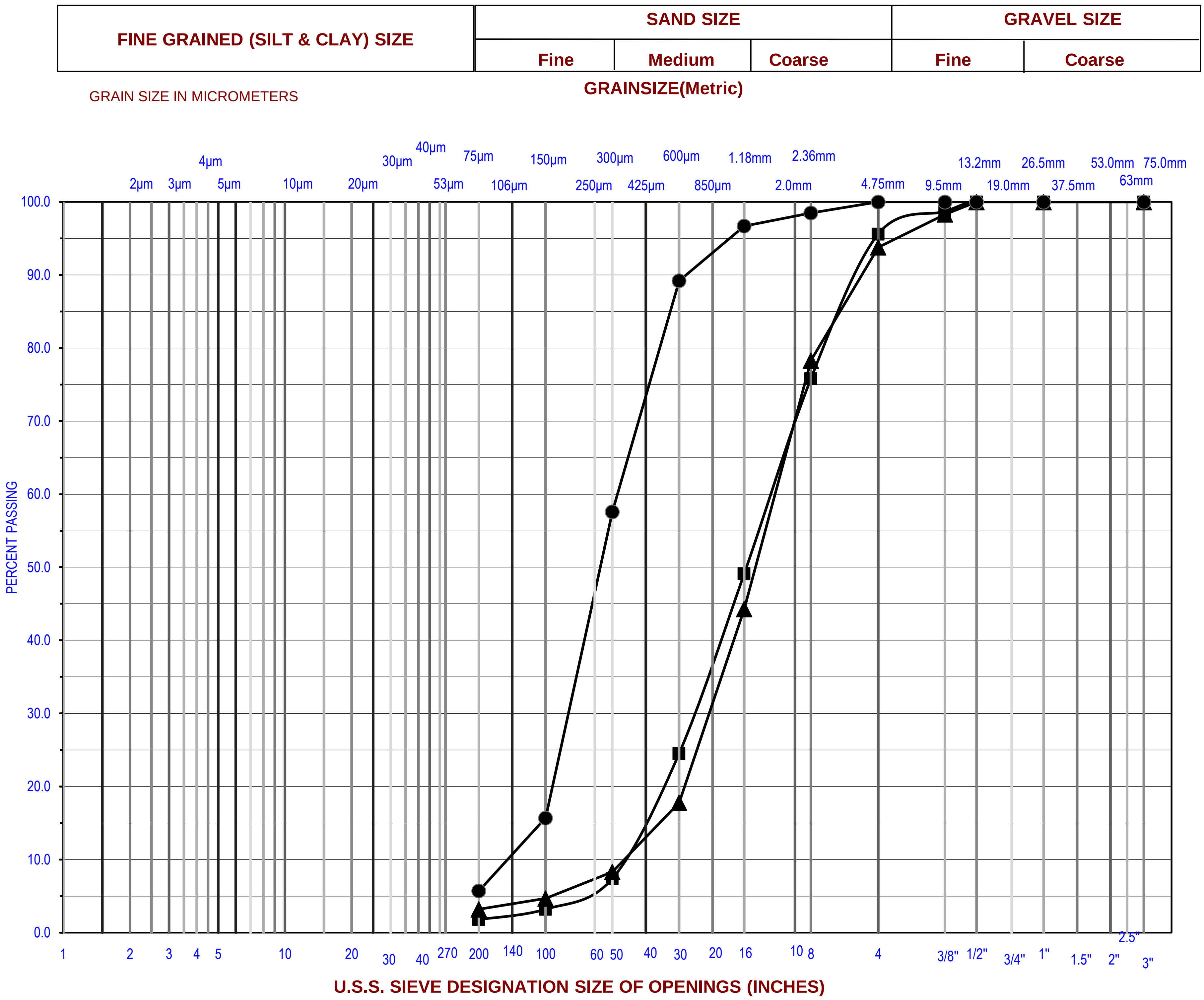
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)	GRAVEL(%)	SAND (%)	SILT (%)
■	16-01	SS7	407.7	9	88	3
▲	16-02	SS2	412.8	1	87	12
●	16-03	SS12	399.9	6	91	3

Amec Foster Wheeler Environment & Infrastructure, a Division of Amec Foster Wheeler Americas Limited 131 Fielding Road, Lively, Ontario Canada, P3Y1L7 PH: (705) 682-2632, FX: (705) 682-2260 www.amecfw.com	**GRAIN SIZE DISTRIBUTION**	**Project No.:**	**TY163014**
		Tested By:	**Reviewed By:**
		MMD	**TJG**

FIGURE C2D - GRAIN SIZE DISTRIBUTION

SAND, trace to some silt, trace to some gravel



LEGEND

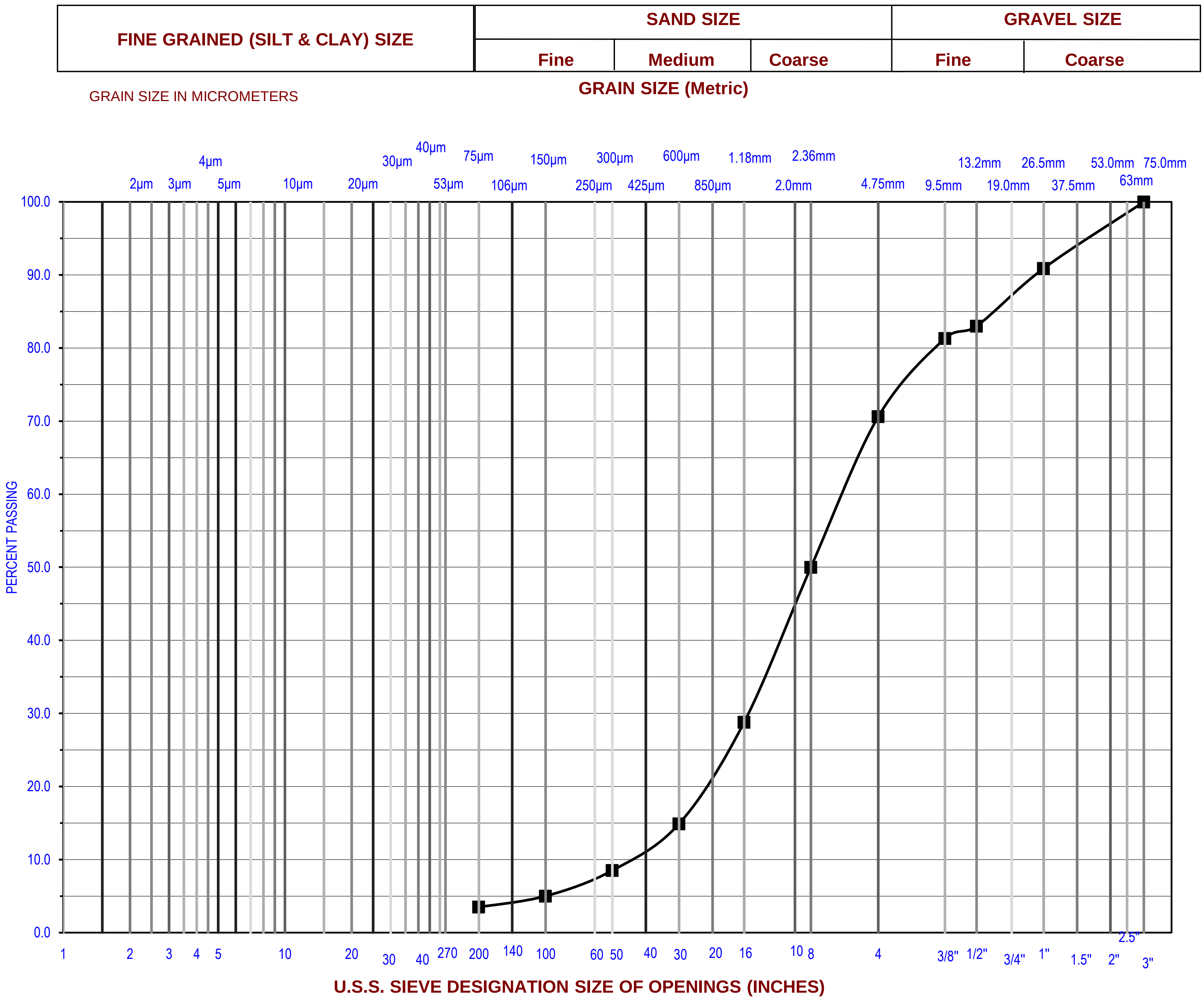
SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)	GRAVEL(%)	SAND (%)	SILT & CLAY (%)
■	16-04	SS10	402.7	4	94	2
▲	16-05	SS7	407.4	6	91	3
●	16-05	SS12	398.8	0	94	6

Amec Foster Wheeler Environment & Infrastructure,
a Division of Amec Foster Wheeler Americas Limited
131 Fielding Road, Lively, Ontario
Canada, P3Y1L7
PH: (705) 682-2632, FX: (705) 682-2260
www.amecfw.com

GRAIN SIZE DISTRIBUTION	Project No.:	TY163014
	Tested By:	Reviewed By:
	MMD	TJG

FIGURE C3 - GRAIN SIZE DISTRIBUTION

GRAVELLY SAND, trace silt



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)	GRAVEL(%)	SAND (%)	SILT & CLAY (%)
■	16-04	SS5	410.4	29	67	4

Amec Foster Wheeler Environment & Infrastructure, a Division of Amec Foster Wheeler Americas Limited 131 Fielding Road, Lively, Ontario Canada, P3Y1L7 PH: (705) 682-2632, FX: (705) 682-2260 www.amecfw.com	**GRAIN SIZE DISTRIBUTION**	**Project No.:**	**TY163014**
		Tested By:	**Reviewed By:**
		MMD	**TJG**

APPENDIX D

ANALYTICAL RESULTS

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: AMEC FOSTER WHEELER ENVIRO&INFRASTR
131 FIELDING ROAD
LIVELY, ON P3Y1L7
(705) 682-2632

ATTENTION TO: David Brown

PROJECT: TY163014

AGAT WORK ORDER: 16U160642

SOIL ANALYSIS REVIEWED BY: Amanjot Bhela, Inorganic Coordinator

DATE REPORTED: Nov 22, 2016

PAGES (INCLUDING COVER): 5

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

AGAT Laboratories
5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 16U160642
PROJECT: TY163014

CLIENT NAME: AMEC FOSTER WHEELER ENVIRO&INFRASTR
ATTENTION TO: David Brown
SAMPLING SITE:
SAMPLED BY:

Inorganic Chemistry (Soil)

DATE RECEIVED: 2016-11-15
DATE REPORTED: 2016-11-22

Parameter	Unit	G / S	RDL	HIN BH16-05
			SAMPLE DESCRIPTION:	SS4
			SAMPLE TYPE:	Soil
			DATE SAMPLED:	2016-10-13
				8017753
pH, 2:1 CaCl2 Extraction	pH Units			6.70
Chloride (2:1)	µg/g		2	45
Sulphate (2:1)	µg/g		2	28
Electrical Conductivity (2:1)	mS/cm		0.005	0.152
Resistivity (2:1)	ohm.cm		1	6580

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

8017753 EC/Resistivity, Chloride and Sulphate were determined on the DI water extract obtained from the 2:1 leaching procedure (2 parts DI water:1 part soil). pH was determined on the 0.01M CaCl2 extract prepared at 2:1 ratio.

Please note that sample was received and analyzed past hold time.

Certified By: Amanjot Bhela

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Quality Assurance

CLIENT NAME: AMEC FOSTER WHEELER ENVIRO&INFRASTR

AGAT WORK ORDER: 16U160642

PROJECT: TY163014

ATTENTION TO: David Brown

SAMPLING SITE:

SAMPLED BY:

Soil Analysis

RPT Date: Nov 22, 2016			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
Inorganic Chemistry (Soil)															
pH, 2:1 CaCl2 Extraction	8017932		7.23	7.18	0.7%	NA	101%	80%	120%	NA			NA		
Chloride (2:1)	8018372		42	43	2.4%	< 2	104%	80%	120%	102%	80%	120%	104%	70%	130%
Sulphate (2:1)	8018372		64	65	1.6%	< 2	94%	80%	120%	100%	80%	120%	102%	70%	130%
Electrical Conductivity (2:1)	8013796		4.59	4.59	0.0%	< 0.005	99%	90%	110%	NA			NA		

Comments: NA signifies Not Applicable.

Certified By: Amanjot Bhela

AGAT Laboratories
5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Method Summary

CLIENT NAME: AMEC FOSTER WHEELER ENVIRO&INFRASTR **AGAT WORK ORDER: 16U160642**

PROJECT: TY163014 **ATTENTION TO: David Brown**

SAMPLING SITE: **SAMPLED BY:**

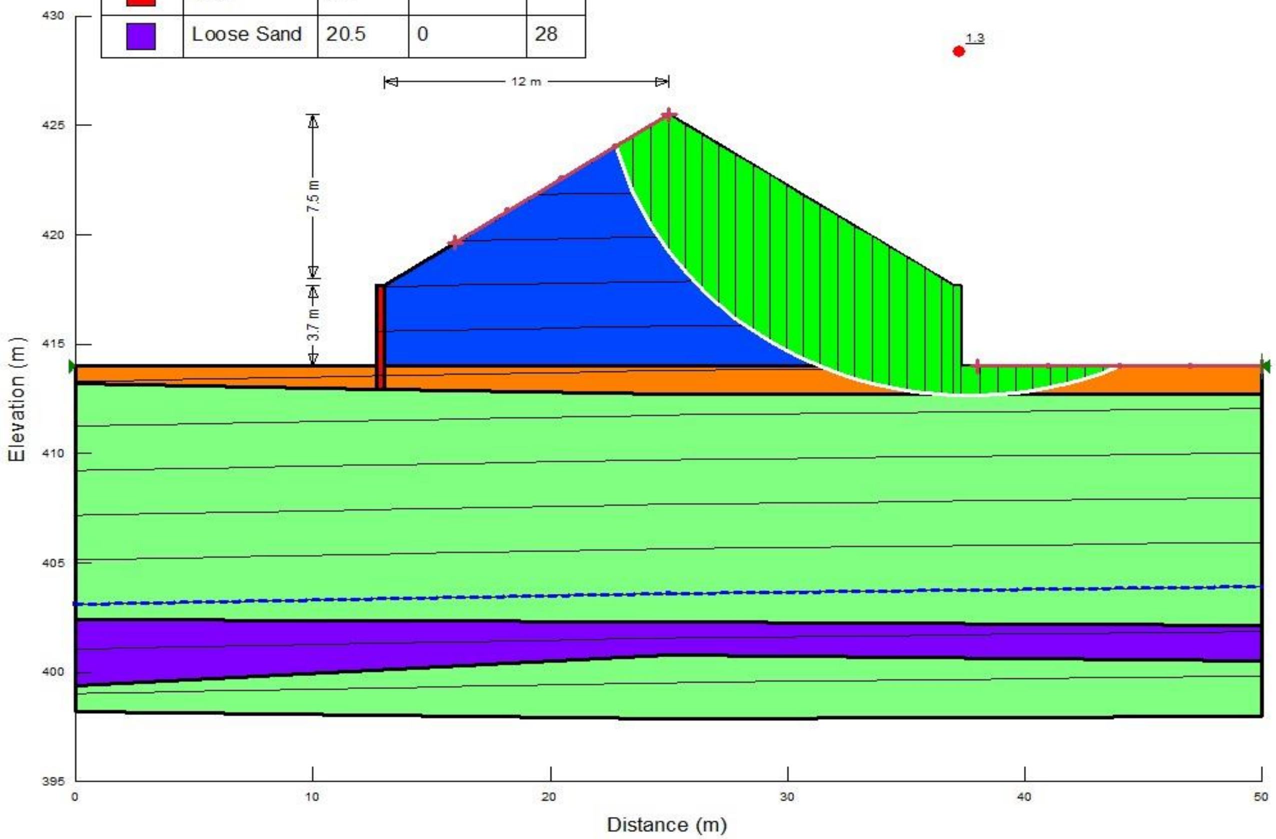
PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
pH, 2:1 CaCl2 Extraction	INOR-93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Resistivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION

APPENDIX E

RESULTS OF STABILITY MODEL

Hinkler Lake Patrol Yard
Sand Pile Static Stability Model

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
Blue	Sand Pile	18	0	30
Orange	Sand, some Gravel (FILL)	19	0	30
Light green	Compact to Dense Sand	20.5	0	32
Red	Wall	24		
Purple	Loose Sand	20.5	0	28



Date: December 2016

Project Number: TY163014

Analysis by: NFK

Reviewed by: MM

APPENDIX F

LIMITATIONS OF REPORT

AMEC FOSTER WHEELER ENVIRONMENT & INFRASTRUCTURE

LIMITATIONS OF REPORT

The conclusions and recommendations given in this report are based on information determined at the borehole 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 construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in 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 on potential construction problems and possible methods are intended only for the guidance of the designer. The number of boreholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. 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 accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.