



**FOUNDATION INVESTIGATION AND DESIGN REPORT  
HORNEPAYNE PATROL YARD  
HORNEPAYNE, ONTARIO**

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Submitted to

**Ministry of Transportation Ontario Northeast Region**

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Amec Foster Wheeler Project No. **TY163014**

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**Ministry of Transportation Ontario– Northeast Region**  
Foundation Investigation and Design Report  
Proposed Maintenance Structure – Hornepayne Patrol Yard  
Hornepayne, Ontario  
March 2014



## **PART A**

### **FOUNDATION INVESTIGATION REPORT HORNEPAYNE PATROL YARD HORNEPAYNE, ONTARIO**

## 1.0 INTRODUCTION

### 1.1 Background

Amec Foster Wheeler Environment & Infrastructure (Amec Foster Wheeler) has been retained by The Minister of Transportation Ontario, Northeast Region (MTO) for provision of foundation engineering services at Ornpene Patrol Yard as part of the Assignment No. 01E006.

This report addresses the results of the subsurface investigation carried out by Amec Foster Wheeler at the MTO Ornpene Patrol Yard, located on the west side of Roundhouse Road., approximately 100 m south of Highway 631, 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 that MTO plans to construct a new sand/salt storage building at the Ornpene 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. This structure is to have an approximate area of 100 m<sup>2</sup> (10 m by 20 m), as shown on Drawing 1, and on Drawing 2 which was provided to Amec Foster Wheeler by the MTO.

### 1.2 Site Description

The patrol yard is located in Ornpene, Ontario, in the Township of Ornpene, District of Algoma. The entrance to the site is located approximately 100 m south of Highway 631 on the west side of Roundhouse Road. The latitude and longitude coordinates for the site are Latitude 44°22'33" and Longitude 80°00'26".

At the time of the investigation, one large salt/sand storage dome was located in the southeast portion of the patrol yard and one smaller salt storage building was located just to the north of the salt/sand dome. One office/garage building was located to the northwest of the salt/sand dome, adjacent to the site entrance and Roundhouse Road. The remaining areas of the yard were generally vacant land, stockpile areas, and vehicle parking areas. A shallow north to south oriented swale was present in the western portion on the patrol yard and intersected the proposed storage building footprint. Photographs of the site are included in Appendix A.

The new proposed structure will be constructed west of the existing sand/salt dome, in a vacant portion of the property, 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 and till predominantly a sand to silt sand matrix, high content of clasts, and often low carbonate content. This data is 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 Mesoproterozoic Metasedimentary rocks (Paragneiss and migmatites) MNDM “Geology Survey August 2003, 1:250,000 Bedrock Geology of Ontario” map indicates. The site is located in the Superior Province.

## 2.0 INVESTIGATION PROGRAM

### 2.1 Soil Drilling Investigation

The fieldwork at the site was carried out on October 1, 1, and 20, 2016, when five boreholes (H016-01 to H016-05) were advanced within the proposed sand/salt storage structure footprint to depths between 10.0 m and 12.0 m below the existing ground surface.

The borehole locations referenced to the MTM NAD83 Zone 13 northing and easting coordinate system, the ground surface elevations referenced to Geodetic datum and the drilled depths are summarized below and are shown on Drawing 1. The borehole locations were relocated slightly from the originally planned locations to avoid uneven ground due to the swale in the vicinity of the building footprint.

**Table 1: Hornepayne Borehole Summary**

Foundation Element <sup>1</sup>	Borehole Designation	Location (MTM NAD83 Zone 13)		Ground Surface Elevation (m)	Borehole Depth <sup>2</sup> (m)
		Northing (m)	Easting (m)		
Northeast Corner	H016-01	4,444,341	244,404	324.0	12.0
Southeast Corner	H016-02	4,444,344	244,412	324.4	12.2
Southwest Corner	H016-03	4,444,344	244,444	324.3	11.6
Northwest Corner	H016-04	4,444,364	244,443	324.4	10.0
Centre	H016-05	4,444,360	244,444	324.4	12.0

1 – All foundation elements refer to location in the footprint of the proposed development.

2 – Depth includes depth of coring.

The ground surface elevations at the borehole locations were surveyed by Amec Foster Wheeler personnel. The top of a rock plug set in concrete with a known elevation of 32.03 m was used as a local benchmark. The borehole locations were also georeferenced to MTM coordinates using a handheld Global Positioning System (GPS) unit. The elevations and GPS coordinates can also be found on the Record of Borehole sheets.

The boreholes were advanced using 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 D1586) 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 Terms of Reference (TOR) and Amec Foster Wheeler's proposal for this investigation, the following laboratory tests were conducted:

- Natural water content (SS)
- Grain size distribution – sieve only (SS)
- Grain size distribution (sieve and hydrometer) (SS)
- Atterberg Limits (3)
- pH, chlorides, sulphates, resistivity (1)

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

## 3.0 SUB-SURFACE CONDITIONS

In general, the subsurface conditions at the site consists of surficial fill underlain by sequential silt and sand deposits overlying clayey silt till. A summary of the subsurface conditions encountered in the boreholes is presented below and the Record of Borehole sheets are included in Appendix B.

### 3.1 Sand/Gravelly Sand Fill

Sand fill was encountered at the ground surface in boreholes 16-01 to 16-03, and gravelly sand fill was encountered at the ground surface in boreholes 16-04 and 16-05 advanced



at the site. The thickness of the fill ranged between 0.3 m and 1.0 m at the borehole locations. The measured SPT 'N' values ranged between 13 blows and 31 blows per 0.3 m of penetration indicating a compact to dense state.

The completed lab testing on selected fill samples measured water contents ranging from 10% to 15% of the materials dry weight.

Three grain size distributions were completed on selected split spoon samples of the fill material. The results are as follows:

- Gravel 0% to 30%
- Sand 61% to 65%
- Silt and Clay 5% to 15%

The grain size distribution curves are presented in Appendix C.

### 3.2 Silt

A layer of brown to grey silt was encountered below the fill material at all of the borehole locations. The silt deposit was contacted at depths between 0.3 m and 1.0 m below ground surface (Elevations 326.0 m and 326.1 m), and the deposit ranged in thickness from 0.3 m to 0.6 m. The deposit was comprised of silt, trace to some clay and trace to some sand and gravel.

The measured SPT 'N' values ranged between 6 blows and 10 blows per 0.3 m of penetration indicating a loose to dense state of compactness with the exception of a 1.1 m to 2.0 m thick layer of loose silt which was encountered in all boreholes with the exception of borehole 16-03. The natural moisture content, as measured in collected split spoon samples from all boreholes ranged from 30% to 40%.

Three grain size distributions were conducted on selected split spoon samples of the silt deposit. The results are as follows:

- Gravel 0%
- Sand 0% to 2%
- Silt 80% to 90%
- Clay 10% to 10%

The grain size distribution curves are presented in Appendix C.

### 3.3 Sand

Sand, some silt and clay and trace was encountered below the silt in boreholes 16-01 and 16-02. The sand was encountered at depths of 6.6 m and 6.0 m (Elevations 321.0 m and 320.0 m, respectively). The thickness of the sand deposit was 2.0 m and 1.0 m at the two



boreholes, respectively. The measured SPT 'N' values ranged from 3 blows to 11 blows per 0.3 m of penetration, indicating a dense state for full sand samples where the sample interval did not encounter a transition in soil strata.

The natural moisture content, as measured in collected split spoon samples of the sand ranged from 10% to 14%.

One grain size distribution was completed on the split spoon sample collected of the silt/sand, the results are as follows:

- Gravel 0%
- Sand 100%
- Silt/Clay 0%

The grain size distribution curve is presented in Appendix C.

### 3.4 Gravelly Sand

Gravelly sand with trace silt and clay was encountered below the silt in borehole 16-03. The gravelly sand was encountered at a depth of 1.6 m (Elevation 321.4 m). The thickness of the gravelly sand deposit was 2.0 m at the borehole location. The measured SPT 'N' values ranged from 3 blows to greater than 100 blows per 0.3 m of penetration indicating a dense to very dense state.

The natural moisture content, as measured in collected split spoon samples of the sand ranged from 10% to 14%.

One grain size distribution was completed on a split spoon sample collected of the gravelly sand, the results are as follows:

- Gravel 2%
- Sand 66%
- Silt/Clay 32%

The grain size distribution curve is presented in Appendix C.

### 3.5 Cobbles and Boulders

A nest of cobbles and boulders, with sand and gravel was encountered below the silt in borehole 16-04. The cobble and boulder nest extended from 6.3 m to 1.6 m below ground surface (321.4 m to 311.3 m). The cobble and boulder nest could not be penetrated by augers and coring was necessary to advance the borehole through this zone. The soil matrix was removed by the coring process and therefore cannot be identified.

### 3.6 Clayey Silt

Clayey silt with some sand and trace gravel was encountered below the silt layer in borehole 16-01. The clayey silt was 2.2 m in thickness and extended to Elevation 314.6 m. One measured SPT 'N' value within the clayey silt was 6 blows per 0.3 m of penetration indicating a hard consistency.

Atterberg limit testing conducted on split spoon sample from borehole 16-01, yielded a liquid limit of 21%, a plastic limit of 16% and a plasticity index of 13, indicating the clayey silt is low plasticity.

A plasticity chart is presented in Appendix C.

### 3.7 Clayey Silt (Till)

A layer of clayey silt till was encountered below the sand, cobbles and boulders and clayey silt deposits at all borehole locations. All of the boreholes were terminated in the clayey silt till deposit at depths between 10.0 m and 12.0 m.

Measured SPT testing 'N' values within the till were greater than 100 blows per 0.3 m of penetration indicating a hard consistency. The clayey silt till was difficult to penetrate with the soil augers and rotary coring using a N° sized core barrel was used to advance the boreholes in the cohesive till, which precluded standard penetration testing.

Atterberg limit testing conducted on split spoon samples from boreholes 16-01 and 16-02 resulted liquid limits of 21% and 26%, plastic limits of 11% and 12%, and plasticity indices of 10% and 14% indicating a clayey silt till of low plasticity. A plasticity chart is presented in Appendix C.

### 3.8 Groundwater Conditions

At the completion of drilling, groundwater was encountered in borehole 16-01 at a depth of 3.2 m below ground surface. The remaining boreholes were dry upon completion. The field schedule permitted the measurement of the groundwater levels the day following the drilling with the exception of borehole 16-02, because the drilling crew demobilized after that borehole was completed. The groundwater measurements are shown on the Record of borehole sheets and are summarized below.

**Table 2: Hornepayne Groundwater Measurements**

Foundation Element	Borehole Designation	Ground Surface Elevation (m)	Water Level Depth Below Ground Surface (m)	
			Upon Completion of Drilling	Following Day of Drilling <sup>1</sup>
Northeast Corner	BH16-01	324.0	3.2	1.3
Southeast Corner	BH16-02	324.4	Drill	Not Measured
Southwest Corner	BH16-03	324.3	Drill	1.4
Northwest Corner	BH16-04	324.4	Drill	1.2
Centre	BH16-05	324.4	Drill	2.4

*1 – Water level measurements were taken twice in BH16-01 and BH16-03, BH16-04, and BH16-05 (upon borehole completion and again the following day).*

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.

## 4.0 CLOSURE

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

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## **PART B**

### **FOUNDATION DESIGN REPORT HORNEPAYNE PATROL YARD HORNEPAYNE, ONTARIO**

## 5.0 DISCUSSION AND RECOMMENDATIONS

### 5.1 General

This section of the report provides foundation design recommendations for the proposed MTO patrol yard structure in Cornepane and is based on interpretation of the factual data obtained from the boreholes advanced during the subsurface investigations at this site. The discussion and recommendations presented are intended to provide the designers with sufficient information to assess/evaluate the design of the existing structure foundations.

It is understood that a new salt storage maintenance structure is proposed for the site. The proposed structure is about 10 m wide and 20 m in long, with a concrete foundation wall, timber side walls, steel roof, and finished with an interior 10 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 Reports (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 building should be stripped and cleared of surface vegetation, topsoil, loose/soft soil and/or construction debris prior to construction. These materials are not suitable for the subgrade of building foundations, floor slabs, or engineered fills and should be excavated and backfilled with engineered fill comprised Granular A or Granular Type II placed and compacted in accordance with Ontario Provincial Standard Specification (OPSS.PROV 01 Construction Specification for Compacting, and SP 10/S21 Amendment to OPSS.PROV 01 Quality Control for Compaction, Method 1.

Following stripping of these unsuitable surficial soils, the prepared subgrade should be heavily proofrolled. The required extent of stripping of any loose granular soils including the sand to gravel/sand fill present within the building envelope, or softened, upper portions of the native deposits will need to be determined based on the results of the proofrolling and inspection. Soils

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

Following proofrolling and approval of the subgrade, engineered fill should be placed in maximum 300 mm thick loose lifts and uniformly compacted to at least 100% of the fill materials Standard Proctor Maximum Dry Density (SPMDD). The final lift of engineered fill beneath conventional loaded floor slabs should consist of a minimum thickness of 100 mm of OPSS PROV 1010 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 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 pads, 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 0.1 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 reuse as foundation wall backfill provided that these materials are free of organics, any boulders or cobbles greater than 100 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 percent of the materials' SPMDD inside the building and 98 percent SPMDD on the outside of the building.

### 5.3 Building and Perimeter Retaining Wall Foundation

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 dense silts, dense sands and very dense tills. 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 dense silts at shallow depths at the site and are further discussed in the report.
- **Deep Foundations - Steel H-piles driven to found in overburden, Steel H-piles and Caissons founded on/in bedrock:** Driven steel H-piles could be founded in the hard clay silt till overburden at an approximate depth of 1.1 m below ground surface. However, it is expected that it would be difficult to drive the piles through the gravel sand, and cobbles and boulders strata present above the clay silt till. Driven steel H-piles may not be feasible for support of building foundations and perimeter wall foundations as the depth of the bedrock is not known at this site. Similarly, caissons founded in the bedrock may not be feasible for support of building foundations and perimeter wall foundations 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. Further it is expected the cost to mobilize pile driving equipment for the foundation construction would be high for the relatively small structure. Due to the expected high construction costs, steel H-piles and caissons are not the preferred foundation alternative for this project. These options are not discussed further in this report.

The following sections provide recommendations for the foundation design for 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

For support of the new foundations, strip or spread footings should be founded below an fill and an loose near surface soils, on the native, undisturbed compact silt. 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 (m)
16-01	32.6	2.0
16-02	32.3	2.0
16-03	32.0	2.0
16-04	32.0	2.0
16-05	32.3	2.0

The founding elevations given above will require excavation to a depth of 2.0 m below the existing grades to provide sufficient earth cover for frost protection. Refer to Section 6 for further comments related to frost protection.

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,  $\phi_{gu}$  and  $\phi_{gs}$ , 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 (CIBC 2014).

**Table 4: Factored Geotechnical Resistances/Reactions**

Founding Stratum	Footing Width (m)	Factored Geotechnical Resistance at ULS	Geotechnical Reaction at SLS <sup>1</sup>
Compact Silt	1 to 2	320 kPa	200 kPa

<sup>1</sup> 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 CIBC 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 forces (sliding resistance between the base slab or concrete footings for the proposed structure and the subgrade should be calculated in accordance with Section 6.10.4 of the CIBC 2014. A coefficient of friction ( $\tan \phi'$ ) of 0.5 may be used in the sliding assessment between spread footings founded on compact sand. The above coefficient of friction is unfactored and a resistance factor of 0.9 should be applied in accordance with Table 6.2 of CIBC 2014 based on the available subsurface conditions.

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

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

Where:

$A'$  Effective contact area (m<sup>2</sup>)

$C'$  Nil

$\tan \phi'$  Coefficient of internal friction for soil close to the underside of the spread/strip footing

$V$  Unfactored vertical force (kN)

$R_r$  Unfactored horizontal load (kN)

$\psi$  Consequence factor (1.0)

$\phi_{gu}$  Geotechnical resistance factor (0.9)

### 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 proofrolled prior to placing under floor fill. If contaminated or soft spongy areas are intercepted, they should be subexcavated 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. It is anticipated that the existing sand/gravel/sand fill will be subexcavated and replaced with approved engineered fill material as discussed in Section 4.2, above. If the existing sand/gravel/sand fill is evaluated by the Quality Verification Engineer following proofrolling and determined to be suitable to remain in place below the slab on grade floor subexcavation of the existing fills may not be necessary.

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<sup>2</sup> plate (300 mm by 300 mm). For foundations on granular noncohesive, the modulus of vertical subgrade reaction can be estimated from the equations given below (CFEM, 2006).

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

$k_{vb}$  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 30 MPa/m may be used for a 1 ft<sup>2</sup> 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 subdrainage system is not required, assuming there are no depressed sections in the building and the surface of the asphalt or concrete floor 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 30-0.100, Foundation Frost Penetration Depths for Northern Ontario. Therefore, all foundations exposed to seasonal freeze and thaw (external foundations and foundations in unheated areas) should be provided with a minimum of 2.0 m of soil cover or equivalent thermal insulation for frost protection purposes. In addition, an bearing soil and fresh concrete should be protected from freezing during cold weather construction.

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 subdrainage

system is not required, assuming there are no depressed sections in the building and the asphalt surface will be above the exterior grade.

## 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 (OHS) for Construction Activities. Based on the OHS classification system, the soils to be excavated on site would be classified as follows:

Fill Materials	Type 3
Silt and Sand above water Table	Type 3
Silt and Sand below water Table	Type 1

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 1:1V. 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 1, unless the soils are dewatered by positive methods. For Type 1 soils an excavation slope of 3:1V, or flatter, is required from the base for excavations, in accordance with the OHS.

## 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 1:1 horizontal to 1 vertical (1:1V) extending up and back from the rear face of the footing (Case II).

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

**Table 5: Un-Factored Parameters**

Material Type	$K_a$	$K_0$	$K_p$
Native Sand/Silt– Case I	0.31	0.00	3.20
Compacted Granular A or Granular B, Type II – Case II	0.20	0.00	3.03
Compacted Granular B, Type I – Case II	0.31	0.00	3.20

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 wall 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 0.01 times the height of the wall for passive earth pressure or
- a combination of both.

## 5.9 Seismic Considerations

The CIBC 2014 contains updated seismic analysis and design methodology. The CIBC 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  $F_a$  (PGA) and  $F_v$  (PGV), respectively, for the effects of site-specific soil conditions in design. The new approach of the CIBC 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 4.3.2 of CIBC 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 0.2, 0.5, and 2.0 second return periods in accordance with Section 4.3.1 of the CIBC 2014.

The corresponding acceleration coefficients associated with return periods of 100 years, 1000 years and 2000 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	Coefficient of PGV	5% Damped Spectral Response Acceleration for a Period of 0.2 s, $S_a(0.2)$
100	10% in 100 years	0.012	0.011	0.020
1000	1% in 1000 years	0.020	0.019	0.030
2000	2% in 1000 years	0.030	0.032	0.063

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 (2000) 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 0.01, a site coefficient,  $FPGA$ , of 1.2, 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 2,000 probabilities per annum. The  $\overline{M}_w$  and  $\overline{D}$  were assumed to be 6.13 and 10 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 6.6 and C6.6 of the CIBC 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 1:1 horizontal to 1 vertical (1:1V) 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 2,000 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	0.30	0.20	0.30
Non-Yielding Walls	0.30	0.30	0.33
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	1.0	1.0	1.0
Non-Yielding Walls	1.0	6.2	1.3

## 5.10 Stability Assessment and Settlement Assessment in Sand/Salt Area

### 5.10.1 Stability Assessment

Factors of safety of 1.3 for temporary and 1.0 for permanent conditions (equivalent geotechnical resistance factors of 0.75 and 0.60 for a typical degree of understanding) are considered to be applicable to the project. To assess the global stability of the storage structure and to check that minimum factors of safety of 1.3 and 1.0 for temporary and permanent conditions are achievable for the maximum height of the sand stockpile, slope stability analyses were performed by modelling three scenarios: existing conditions, excavation and replacement of 2 m of fill and excavation and replacement of 3 m of fill.

The SLOPEW computer program developed by GeoSlope international was employed for computation of the factor of safety, using the Morgenstern-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 3.0 m from ground surface upwards, with a 1.0 m high peak above the wall, providing an approximate angle of repose of 30 degrees.

The stratigraphic 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, and modified by including a layer of engineered fill, 2 m and 3 m thick, to replace the existing fill below the storage building foot print (refer to the stability model in Appendix E).

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 <sup>3</sup> )	Effective Cohesion (kPa)	Friction Angle, Phi (°)
Sand Pile	10	0	30
Compact sand/gravel sand FILL	20	0	32

Material Type	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Friction Angle, Phi (°)
Compact silt	18	0	30
Loose Silt	18	0	28
Compact to Dense Sand to Gravelly Sand	20	0	33
Hard Clayey Silt / TILL	21	0	32
Engineered Fill	22	0	30

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 for the existing conditions, with no engineered fill is 1.2. The factors of safety for the scenarios with engineered fill are 1.4 for 2 m of engineered fill and 1.4 for 3 m of engineered fill. Subexcavation of the existing fill and replacement with engineered fill is therefore recommended to achieve the required factor of safety for slope stability of the sand/salt pile.

### 5.10.2 Settlement Assessment

Based on available information from the MTO the sand pile will be placed directly on the storage building floor. For the purposes of this settlement analysis, three scenarios have been assumed that the existing compact sand and gravelly sand fills below the foot print of the storage building will remain in place that the fills will be replaced with 2 m of engineered fill, and that the fills will be replaced with 3 m of engineered fill to support the new building floor. Based on the results of the geotechnical investigation, the engineered fill will overlie native silt.

The ground surface displacements (settlement) as a result of the placement of the sand stockpiles have been estimated using the commercially available computer program Settle3D from Rocscience.

The contact pressure at the edge of the slab, based on a 3.0 m high wall is about 10 kPa. The contact pressure in the centre of the slab is about 200 kPa. The average contact pressure is about 130 kPa has been assumed in the settlement analysis to include the weight of the full sand stockpile. This analysis assumes a sand volume of 3,200 m<sup>3</sup>, a unit weight of 18 kN/m<sup>3</sup> for the sand, and a floor area of 32 m<sup>2</sup>.

Table 5.10.2 below provides the soil parameters used as part of the settlement analysis.

**Table 9: Material Properties for Stability Model**

Material Type	Unit Weight (kN/m <sup>3</sup> )	Elastic Moduli, E (MPa)
Engineered Fill	22	100
Compact silt	18	20
Loose Silt	18	10
Compact to Dense Sand to Gravelly Sand	20	100
Hard Clayey Silt / TILL	21	100

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 10: Settlement at Centre/Edge of Proposed Structure**

Scenario	Settlement at Centre of Proposed Structure	Settlement at Edge of Proposed Structure
	Immediate (mm)	Immediate (mm)
Existing Fill Remains	10	20
2 m of Engineered Fill	10	22
3 m of Engineered Fill	30	10

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 one half and one third of the values presented above.

## 5.11 Analytical Results

Split spoon sample number 3 from 1601 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 4.0, chloride content of 0.6 g/g, sulphate content of 2.0 g/g and a resistivity value of 0.3 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 Gravitational Pipe Design Guidelines (GPDG-200), the soils have a severe 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 Pic, EIT, and reviewed by Mr. Mehdi Mostakhdemi, M.Sc., P.Eng. Mr. T. J. 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



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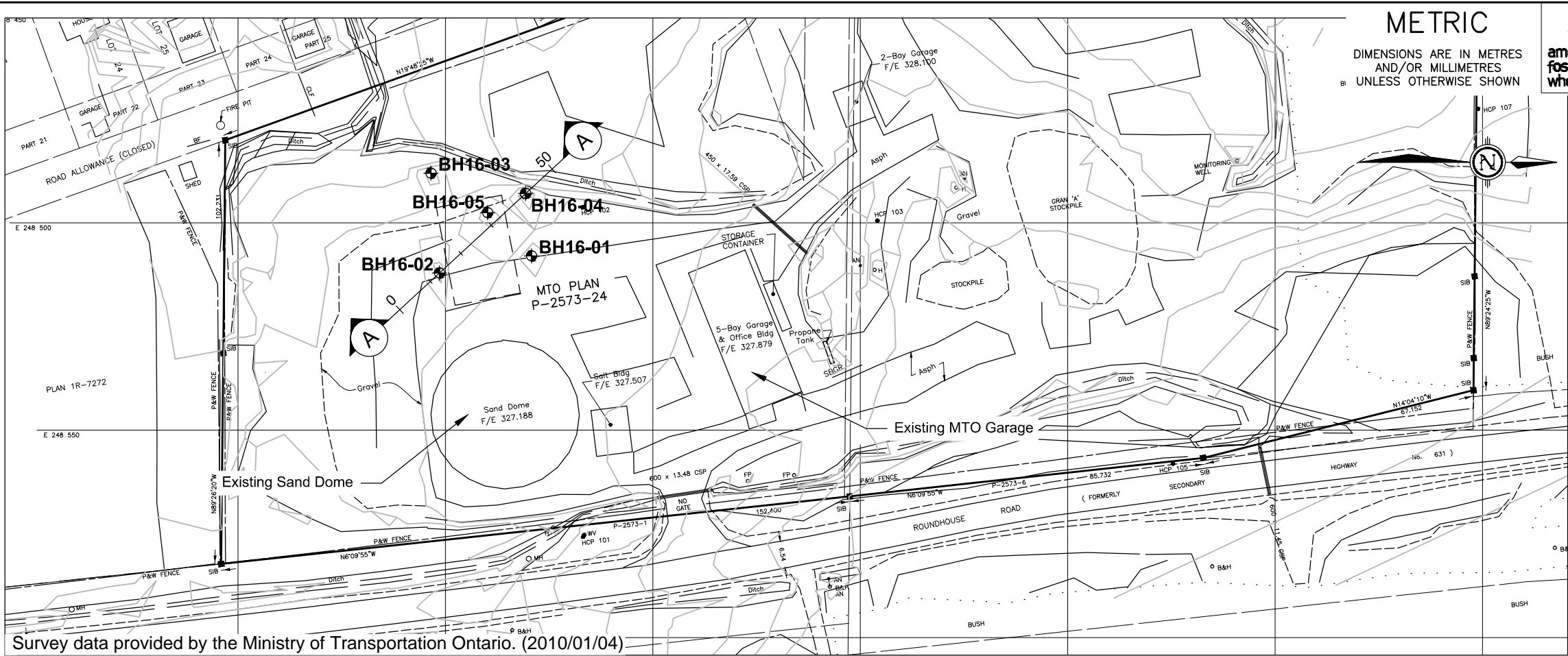


T. J. Garde, M. Eng., M. Eng., P. Eng.,  
Designated MTO Foundations Contact

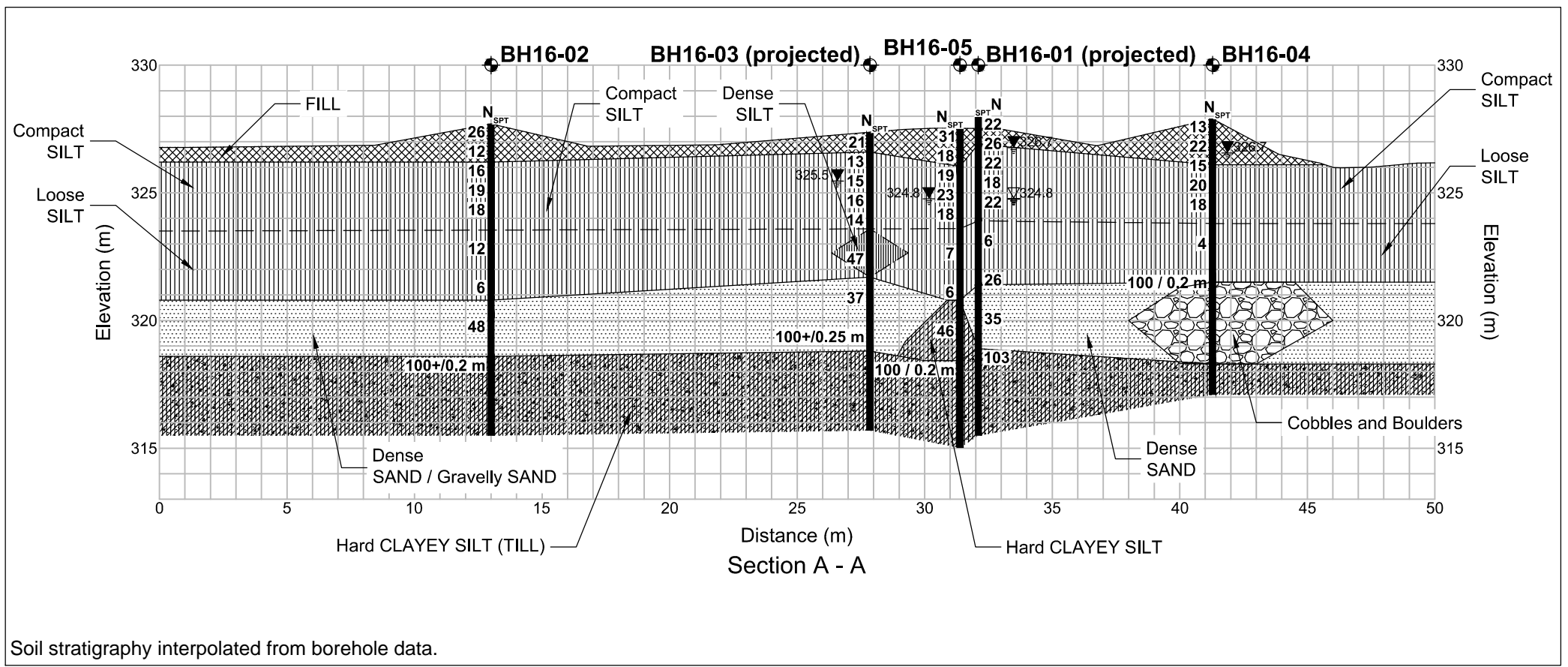




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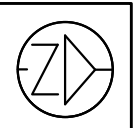
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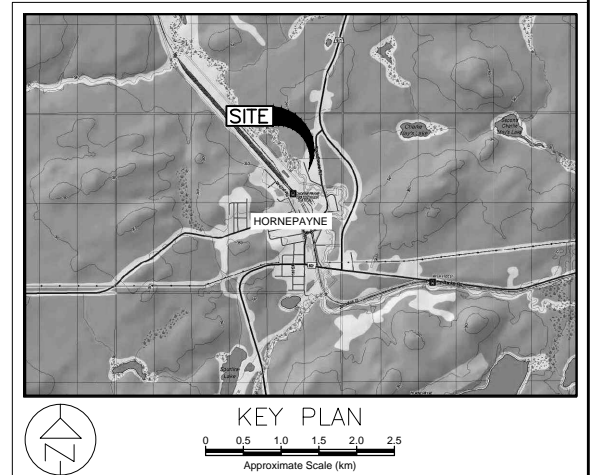


Foundation Investigation  
and Design  
Assignment No. 5015-E-0064  
Hornepayne Patrol Yard  
Hornepayne, Ontario



PROPOSED STORAGE STRUCTURE  
BOREHOLE LOCATION PLAN AND  
SOIL STRATA SECTION

DRAWING  
1

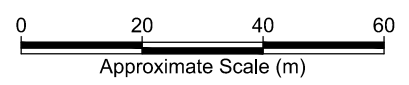


- LEGEND**
- BOREHOLE LOCATION
  - STANDARD PENETRATION TEST VALUE
  - BLOWS/0.3m UNLESS OTHERWISE STATED  
(STD. PEN. TEST, 475 J/BLOW)
  - WATER LEVEL UPON COMPLETION OF DRILLING
  - WATER LEVEL ONE DAY AFTER COMPLETION
  - EXISTING STRUCTURE
  - PROPOSED STRUCTURE

- NOTES**
- THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING FOUNDATION DESIGN REPORT.
  - 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.
  - ELEVATIONS ARE REFERENCED TO GEODETIC DATUM.



NUMBER	ELEVATION	CO-ORDINATES (MTM, NAD 83 ZONE 13)	
		NORTHING	EASTING
TESTHOLES BY OTHERS			
BH16-01	328.0	5454371	0248508
BH16-02	327.7	5454349	0248512
BH16-03	327.3	5454347	0248488
BH16-04	327.9	5454369	0248493
BH16-05	327.7	5454360	0248498
SITE LOCATION LATITUDE/LONGITUDE 49.224773, -84.772648			



REVISIONS	03/05/2017	2	NK	ISSUED TO CLIENT
	01/05/2017	1	NK	REVISED PER MTO COMMENTS
	DATE	REV. BY		DESCRIPTION
DESIGN	NFK	CHK	DMC	CODE
DRAWN	MAT	CHK	NFK	GEOCRES: 42F-51
				DATE: 15-FEB-17



## **APPENDIX A**

### **SITE PHOTOGRAPHS**



**Photo 1**

View of drilling operations facing north. The salt storage structure is shown on the right hand side.

**14 Oct 2016**



**Photo 2**

Swale or creek just to the west of the drilling area. TY1600 was moved south to avoid drilling in it.

**14 Oct 2016**





**Photo 3**

General view of patrol yard showing paved area, MTO garage on left, and salt storage, and dome on right.

**15 Oct 2016**



**Photo 4**

View along backside of site in area of boreholes, the swale/creek is running along the left hand side.

**20 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 stratigraphic encountered within the borehole.

#### ***Description***

This column gives a description of the soil strata, 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*):

<b>Compactness of Cohesionless Soils</b>	<b>SPT N-Value*</b>
Very loose	0 to 5
Loose	5 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	50 to 100

<b>Consistency of Cohesive Soils</b>	<b>Undrained Shear Strength kPa</b>
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., 10/2000 blows for 20 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.	0.2 – 1.0
Very Weak (R1)	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife.	1.0 – 10
Weak (R2)	Can be peeled with a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer.	10 – 20
Medium Strong (R3)	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with a single firm blow of geological hammer.	20 – 40
Strong (R4)	Specimen requires more than one blow of geological hammer to fracture it.	40 – 100
Very Strong (R5)	Specimen requires many blows of geological hammer to fracture it.	100 – 200
Extremely Strong (R6)	Specimen can only be chipped with geological hammer.	200

### 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 – 40	Poor
40 – 60	Fair
60 – 80	Good
80 – 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 10% 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.
Slightly 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 (12.5 mm or 2.1 inches in diameter) and typically 0.5 ft (0.15 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.



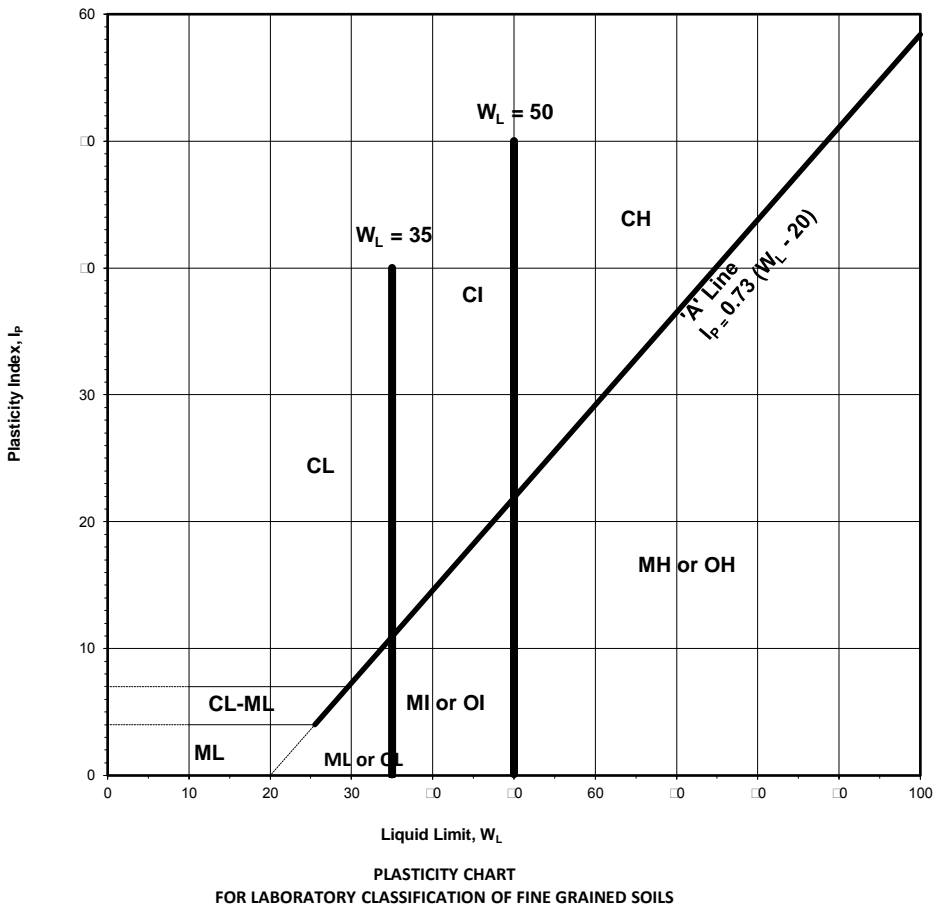


MTC SOIL CLASSIFICATION  
Based on MTC Soil Classification Manual



MAJOR DIVISION					GROUP SYMBOL	TYPICAL DESCRIPTION	INFORMATION REQUIRED FOR DESCRIBING SOILS	LABORATORY CLASSIFICATION CRITERIA			
COARSE GRAINED SOILS (MORE THAN 50% BY WEIGHT LARGER THAN 0.075mm)	GRAVELS (MORE THAN 50% BY WEIGHT LARGER THAN 0.075mm)	CLEAN GRAVELS (LITTLE OR NO FINES)	WIDE RANGE IN GRAIN SIZE (SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZES)		GW	WELL GRADED GRAVELS, GRAVEL SAND MIXTURES, LITTLE OR NO FINES	GIVE TYPE, NAME, IF NECESSARY, INDICATE APPROXIMATE PERCENTAGE OF SAND, GRAVEL, MAJOR GRAIN SIZE, ANGULARITY, SURFACE CONDITION, HARDNESS OF THE COARSE GRAINS, LOCAL OR GEOLOGICAL NAME, OTHER PERTINENT DESCRIPTIVE INFORMATION, AND SYMBOL IN PARENTHESES.  FOR UNDISTURBED SOILS ADD INFORMATION ON STRATIFICATION, DEGREE OF COMPACTNESS, CEMENTATION, MOISTURE CONDITION, DRAINAGE CHARACTERISTICS	C <sub>u</sub> <input type="text"/> D <sub>60</sub> <div><div></div></div> GREATER THAN 6			
			PREDOMINANTLY ONE SIZE OF A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING		GP	POORLY GRADED GRAVELS, GRAVEL SAND MIXTURES, LITTLE OR NO FINES		C <sub>c</sub> <input type="text"/> D <sub>30</sub> <sup>2</sup> <div><div></div></div> BETWEEN 1 AND 3			
		GRAVEL WITH FINES (APPLICABLE AMOUNT OF FINES)	NON PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)		GM	SILTY GRAVELS, POORLY GRADED GRAVEL SAND MIXTURES		NOT MEETING ALL GRADATION REQUIREMENTS FOR GW			
			PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)		GC	CLAYEY GRAVELS, POORLY GRADED GRAVEL SAND MIXTURES		ATTENBERG LIMITS BELOW A LINE OR I <sub>p</sub> LESS THAN 17			
	SANDS (MORE THAN 50% BY WEIGHT SMALLER THAN 0.075mm)	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		FOR UNDISTURBED SOILS ADD INFORMATION ON STRATIFICATION, DEGREE OF COMPACTNESS, CEMENTATION, MOISTURE CONDITION, DRAINAGE CHARACTERISTICS	NOT MEETING ALL GRADATION REQUIREMENTS FOR GW		
			PREDOMINANTLY ONE SIZE OR A RANGE OF SIZES WITH SOME INTERMEDIATE SIZE MISSING		SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES			ATTENBERG LIMITS ABOVE A LINE WITH I <sub>p</sub> GREATER THAN 17		
		SANDS WITH FINES (APPLICABLE AMOUNT OF FINES)	NON PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)		SM	SILTY SANDS, POORLY GRADED SAND SILT MIXTURES			ATTENBERG LIMITS BELOW A LINE OR I <sub>p</sub> LESS THAN 17		
			PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)		SC	CLAYEY SANDS, POORLY GRADED SAND CLAY MIXTURES			ATTENBERG LIMITS ABOVE A LINE WITH I <sub>p</sub> GREATER THAN 17		
FINE GRAINED SOILS (MORE THAN 50% BY WEIGHT SMALLER THAN 0.075mm)	SILT AND CLAYS	IDENTIFICATION PROCEDURE ON FRACTION SMALLER THAN 0.075mm						USE GRAIN SIZE CURVE IN IDENTIFYING THE FACTORS AS GIVEN UNDER FIELD IDENTIFICATION	DETERMINE PERCENTAGE OF GRAVEL AND SAND FROM GRAIN SIZE CURVE. DEPENDING ON PERCENTAGE OF FINES (FRACTION SMALLER THAN 0.075mm) COARSE GRAINED SOILS ARE CLASSIFIED AS FOLLOWS:		
		LIQUID LIMIT LESS THAN 30	DRY STRENGTH (CRUSHING CHARACTERISTICS)	DILATANCY (REACTION TO SQUEEZING)	TOUGHNESS (CONSISTENCY NEAR PLASTIC LIMIT)		LESS THAN 12% GW, GP, SW, SP MORE THAN 12% GM, GC, SM, SC ORDERLINE CASES REQUIRE USE OF DUAL SYMBOL.				
			NONE	SLIGHT	NONE	ML	C <sub>u</sub> <input type="text"/> D <sub>60</sub> <div><div></div></div> GREATER THAN 6				
			MEDIUM TO SLIGHT	NONE TO VERY SLOW	MEDIUM	CL	C <sub>c</sub> <input type="text"/> D <sub>30</sub> <sup>2</sup> <div><div></div></div> BETWEEN 1 AND 3				
		LIQUID LIMIT BETWEEN 30 AND 40	SLIGHT TO MEDIUM	SLOW	SLIGHT	OL	NOT MEETING ALL GRADATION FOR SW				
			NONE TO SLIGHT	SLOW TO SLIGHT	SLIGHT	MI	ATTENBERG LIMITS BELOW A LINE OR I <sub>p</sub> LESS THAN 17				
			SLIGHT	NONE	MEDIUM TO SLIGHT	CI	ATTENBERG LIMITS ABOVE A LINE WITH I <sub>p</sub> GREATER THAN 17				
		LIQUID LIMIT GREATER THAN 40	SLIGHT TO MEDIUM	VERY SLOW	SLIGHT	OI	NOT MEETING ALL GRADATION FOR SW				
			SLIGHT TO MEDIUM	SLOW TO NONE	MEDIUM	ML	ATTENBERG LIMITS BELOW A LINE OR I <sub>p</sub> LESS THAN 17				
			SLIGHT TO VERY SLIGHT	NONE	SLIGHT	CL	ATTENBERG LIMITS ABOVE A LINE WITH I <sub>p</sub> GREATER THAN 17				
	ORGANIC SOILS	LIQUID LIMIT GREATER THAN 40	MEDIUM TO SLIGHT	NONE TO VERY SLOW	SLIGHT TO MEDIUM	OH	NOT MEETING ALL GRADATION FOR SW				
			SLIGHT TO MEDIUM	SLOW TO NONE	MEDIUM	ML	ATTENBERG LIMITS BELOW A LINE OR I <sub>p</sub> LESS THAN 17				
			SLIGHT TO VERY SLIGHT	NONE	SLIGHT	CL	ATTENBERG LIMITS ABOVE A LINE WITH I <sub>p</sub> GREATER THAN 17				
		LIQUID LIMIT BETWEEN 30 AND 40	SLIGHT TO MEDIUM	VERY SLOW	SLIGHT	OI	NOT MEETING ALL GRADATION FOR SW				
			NONE TO SLIGHT	SLOW TO SLIGHT	SLIGHT	MI	ATTENBERG LIMITS BELOW A LINE OR I <sub>p</sub> LESS THAN 17				
			SLIGHT	NONE	MEDIUM TO SLIGHT	CI	ATTENBERG LIMITS ABOVE A LINE WITH I <sub>p</sub> GREATER THAN 17				
		LIQUID LIMIT LESS THAN 30	DRY STRENGTH (CRUSHING CHARACTERISTICS)	DILATANCY (REACTION TO SQUEEZING)	TOUGHNESS (CONSISTENCY NEAR PLASTIC LIMIT)		LESS THAN 12% GW, GP, SW, SP MORE THAN 12% GM, GC, SM, SC ORDERLINE CASES REQUIRE USE OF DUAL SYMBOL.				
			NONE	SLIGHT	NONE	ML	C <sub>u</sub> <input type="text"/> D <sub>60</sub> <div><div></div></div> GREATER THAN 6				
			MEDIUM TO SLIGHT	NONE TO VERY SLOW	SLIGHT TO MEDIUM	OL	C <sub>c</sub> <input type="text"/> D <sub>30</sub> <sup>2</sup> <div><div></div></div> BETWEEN 1 AND 3				
READILY IDENTIFIED BY COLOUR, ODOUR, SPONGY FEEL OR FREQUENTLY BY FIBROUS TEXTURE					Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS	NOT MEETING ALL GRADATION FOR SW				

FRACTION					
U.S. STANDARD SIEVE SIZE			DEFINING RANGES OF PERCENTAGE BY WEIGHT OF MINOR COMPONENTS		
GRAVEL	COARSE	PASSING	RETAINED	PERCENT	DESCRIPTOR
		75 mm	2.0 mm	Over 30	AND WITH
SAND	FINE	2.0 mm	0.075 mm	20-30	less than
	COARSE	0.075 mm	2.0 mm	12-20	Some
	MEDIUM	2.0 mm	0.425 mm	12-20	Trace to some
FINES (SILT OR CLAY BASED ON PLASTICITY)	FINE	0.425 mm	0.075 mm	1-12	Trace
	OVERSIZED MATERIAL				
ROUNDED OR SUBROUNDED COBBLES 20 mm TO 200 mm or CULVERS 200 mm			NOT ROUNDED ROCK FRAGMENTS 20 mm ROCKS 0.06 CU MIC METRE IN VOLUME		



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



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# RECORD OF BOREHOLE No. BH16-01

G.W.P. 5015-E-0064	LOCATION 0248508 E, 5454371 N	1 OF 3	ORIGINATED BY PW
DIST _____ HWY _____	BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.)	COMPILED BY PW	
DATUM MTM NAD 83 ZONE 13	DATE 14 October 2016 - 15 October 2016	CHECKED BY TJG	
PROJECT Foundation Investigation and Design Report - Hornepayne Patrol Yard, Hornepayne, Ontario			JOB NO. TY163014

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE   LIQUID CONTENT   LIMIT			SOIL VAPOUR READING	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa					WATER CONTENT (%)				COV/ TOV (ppm)	GR	SA	SI	CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

# RECORD OF BOREHOLE No. BH16-01

G.W.P. 5015-E-0064	LOCATION 0248508 E, 5454371 N	2 OF 3	ORIGINATED BY PW
DIST _____ HWY _____	BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.)		COMPILED BY PW
DATUM MTM NAD 83 ZONE 13	DATE 14 October 2016 - 15 October 2016		CHECKED BY TJG
PROJECT Foundation Investigation and Design Report - Hornepayne Patrol Yard, Hornepayne, Ontario			JOB NO. TY163014

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			SOIL VAPOUR READING	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa					WATER CONTENT (%)				
									20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
	SAND trace to some silt and clay trace to some gravel dense		8	SS	35		8	320							17			
318.9			9A	SS	103		9	319							13			
9.1	CLAYEY SILT some sand trace gravel hard (TILL)		9B												13			
			10	NQ			10	318							11 21			
							11	317										
			11	NQ											10			
							12	316										
315.5																		
12.5	END OF BOREHOLE																	
	Notes:  1) Groundwater was encountered at a depth of 3.2 m on completion on October 14, 2016.  2) Groundwater was encountered at a depth of 1.3 m on October 15, 2016 in open borehole.  3) Borehole was backfilled with bentonite and auger cuttings on completion.																	

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3 OF 3

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3 OF 3

G.W.P. 5015-E-0064	LOCATION 0248508 E. 5454371 N	3 OF 3	ORIGINATED BY PW
DIST _____ HWY _____	BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.)		COMPILED BY PW
DATUM MTM NAD 83 ZONE 13	DATE 14 October 2016 - 15 October 2016		CHECKED BY TJG
PROJECT Foundation Investigation and Design Report - Hornepayne Patrol Yard, Hornepayne, Ontario			JOB NO. TY163014

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



Ontario

## RECORD OF BOREHOLE No. BH16-02

amec foster wheeler



1 OF 3

G.W.P. 5015-E-0064 LOCATION 0248512 E, 5454349 N ORIGINATED BY PW  
 DIST HWY BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.) COMPILED BY PW  
 DATUM MTM NAD 83 ZONE 13 DATE 15 October 2016 CHECKED BY TJG  
 PROJECT Foundation Investigation and Design Report - Hornepayne Patrol Yard, Hornepayne, Ontario JOB NO. TY163014

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	SOIL VAPOUR READING COV/ TOV (ppm)	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa									WATER CONTENT (%)			GR	SA	SI	CL
									○ UNCONFINED	● QUICK TRIAXIAL	+ FIELD VANE	× LAB VANE	20					40	60	80				
327.7	SE Corner of Proposed Building																							
0.0	SAND trace gravel compact (FILL)		1	SS	26									7 <sub>○</sub>										
								327																
			2	SS	12		1							6 <sub>○</sub>										
326.3																								
1.5	SILT trace to some clay trace sand compact		3	SS	16			326						17 <sub>○</sub>										
							2																	
			4	SS	19									22 <sub>○</sub>										
							3	325																
			5	SS	18									24 <sub>○</sub>										
							4	324																
			6	SS	12		5	323						21 <sub>○</sub>										
322.1																								
5.7	SILT trace to some clay trace sand loose						6	322																
			7	SS	6									24 <sub>○</sub>				0 2 92 6						
320.8								321																
6.9																								

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+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE



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2 OF 3

G.W.P. 5015-E-0064	LOCATION 0248512 E, 5454349 N	2 OF 3	ORIGINATED BY PW
DIST _____ HWY _____	BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.)		COMPILED BY PW
DATUM MTM NAD 83 ZONE 13	DATE 15 October 2016		CHECKED BY TJG
PROJECT Foundation Investigation and Design Report - Hornepayne Patrol Yard, Hornepayne, Ontario		JOB NO.	TY163014

[illegible]

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



# RECORD OF BOREHOLE No. BH16-02

3 OF 3

G.W.P. 5015-E-0064	LOCATION 0248512 E. 5454349 N	3 OF 3	ORIGINATED BY PW
DIST _____ HWY _____	BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.)		COMPILED BY PW
DATUM MTM NAD 83 ZONE 13	DATE 15 October 2016		CHECKED BY TJG
PROJECT Foundation Investigation and Design Report - Hornepayne Patrol Yard, Hornepayne, Ontario			JOB NO. TY163014

[illegible]

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



Ontario

## RECORD OF BOREHOLE No. BH16-03

amec foster wheeler



1 OF 2

G.W.P. 5015-E-0064 LOCATION 0248488 E, 5454347 N ORIGINATED BY PW  
 DIST HWY BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.) COMPILED BY PW  
 DATUM MTM NAD 83 ZONE 13 DATE 20 October 2016 CHECKED BY TJG  
 PROJECT Foundation Investigation and Design Report - Hornepayne Patrol Yard, Hornepayne, Ontario JOB NO. TY163014

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	SOIL VAPOUR READING COV/ TOV (ppm)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa									
									○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	WATER CONTENT (%)					
327.3	0.0	SW Corner of Proposed Building		1	SS	21												
326.6	0.7	SAND trace silt trace gravel compact (FILL)																
				2	SS	13		1										
								326										
				3	SS	15		2										
				4	SS	16												
								3										
				5	SS	14												
								324										
								4										
								323										
				6	SS	47		5										
								322										
321.7	5.6	GRAVELLY SAND trace to some silt dense						6										
				7	SS	37												
								321										

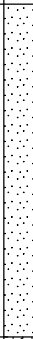

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+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE



# RECORD OF BOREHOLE No. BH16-03

G.W.P. 5015-E-0064	LOCATION 0248488 E, 5454347 N	2 OF 2	ORIGINATED BY PW
DIST _____ HWY _____	BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.)	COMPILED BY PW	
DATUM MTM NAD 83 ZONE 13	DATE 20 October 2016	CHECKED BY TJG	
PROJECT Foundation Investigation and Design Report - Hornepayne Patrol Yard, Hornepayne, Ontario			JOB NO. TY163014

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			SOIL VAPOUR READING	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa					WATER CONTENT (%)							
									○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					W <sub>p</sub> — W — W <sub>L</sub>							
									20	40	60	80	100	20	40	60		GR	SA	SI	CL
	GRAVELLY SAND trace to some silt very dense							320													
			8	SS	100+/ 0.25 m		8								17	○			29	66	(5)
								319													
318.8																					
8.5	CLAYEY SILT some sand to sandy trace gravel very dense (TILL)							9													
			9	NQ				318							11	○					
								10													
								317													
			10	NQ				11													
								316													
315.7	END OF BOREHOLE																				
11.6	Notes:  1) Borehole was dry upon completion on October 20, 2016.  2) Groundwater was encountered at a depth of 1.8 m on October 21, 2016 in open borehole.  3) Borehole was backfilled with bentonite and auger cuttings on completion.  4) Practical auger refusal was reached at 8.5 m depth. Beyond that depth the borehole was advanced using a core barrel to borehole termination.																				

# RECORD OF BOREHOLE No. BH16-04

G.W.P. 5015-E-0064	LOCATION 0248493 E, 5454369 N	1 OF 2	ORIGINATED BY PW
DIST _____ HWY _____	BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.)	COMPILED BY PW	
DATUM MTM NAD 83 ZONE 13	DATE 20 October 2016	CHECKED BY TJG	
PROJECT Foundation Investigation and Design Report - Hornepayne Patrol Yard, Hornepayne, Ontario			JOB NO. TY163014

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			SOIL VAPOUR READING	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa					WATER CONTENT (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
									20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		COV/ TOV (ppm)	GR	SA	SI	CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
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+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE



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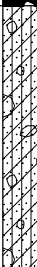
2 OF 2

ORIGINATED BY PW

COMPILED BY PW

CHECKED BY TJG





JOB NO. TY163014

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			SOIL VAPOUR READING	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa					WATER CONTENT (%)				
									○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	20	40	60	80		
	COBBLES/BOULDERS some sand some gravel		9	NQ				320										
			10	NQ				319										
318.3 9.6	CLAYEY SILT some sand to sandy trace gravel hard (TILL)		11	NQ				318										
317.1 10.8	END OF BOREHOLE																	
<p>Notes:</p> <p>1) Borehole dry upon completion on October 20, 2016.</p> <p>2) Groundwater was encountered at a depth of 1.2 m on October 21, 2016 in open borehole.</p> <p>3) Borehole was backfilled with bentonite and auger cuttings on completion.</p> <p>4) Practical auger refusal was reached at 6.4 m depth. Beyond that depth the borehole was advanced using a core barrel to borehole termination.</p>																		

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3</sup>% STRAIN AT FAILURE

# RECORD OF BOREHOLE No. BH16-05

G.W.P. 5015-E-0064	LOCATION 0248498 E, 5454360 N	1 OF 3	ORIGINATED BY PW
DIST _____ HWY _____	BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.)	COMPILED BY PW	
DATUM MTM NAD 83 ZONE 13	DATE 20 October 2016	CHECKED BY TJG	
PROJECT Foundation Investigation and Design Report - Hornepayne Patrol Yard, Hornepayne, Ontario			JOB NO. TY163014

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL LIMIT   MOISTURE   CONTENT   LIQUID LIMIT			SOIL VAPOUR READING	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa					WATER CONTENT (%)						
									○ UNCONFINED   + FIELD VANE ● QUICK TRIAXIAL   × LAB VANE					W <sub>p</sub> —   W   —   W <sub>L</sub>						
327.7 0.0	Centre of Proposed Building		1	SS	31									11	○					
	Gravelly SAND trace to some silt and clay compact to dense (FILL)		2	SS	18										5	○				
326.3 1.5	SILT trace to some clay trace sand loose to compact																			
			3	SS	19											22	○			
			4	SS	23											20	○			
			5	SS	18										25	○				
323.6 4.1	SILT trace to some clay trace sand loose																			
			6	SS	7															
			7	SS	6										20	○				
320.8 6.9																				

Continued Next Page

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





Ontario

## RECORD OF BOREHOLE No. BH16-05

amec foster wheeler

G.W.P. 5015-E-0064	LOCATION 0248498 E, 5454360 N	2 OF 3	ORIGINATED BY PW
DIST _____ HWY _____	BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.)		COMPILED BY PW
DATUM MTM NAD 83 ZONE 13	DATE 20 October 2016		CHECKED BY TJG
PROJECT Foundation Investigation and Design Report - Hornepayne Patrol Yard, Hornepayne, Ontario			JOB NO. TY163014

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			SOIL VAPOUR READING	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa					WATER CONTENT (%)				
									20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
	CLAYEY SILT some sand trace gravel hard																	
			8	SS	46			320						16	29			
								8										
								319										
								9										
318.6																		
9.1	CLAYEY SILT som sand to sandy trace gravel hard (TILL)		9	SS	100+/ 0.25 m									13				
			10	NQ				318										
								10										
			11	NQ				317										
								11										
								316										
			12	NQ				12										
315.2																		
12.5	END OF BOREHOLE																	
	Notes:  1) Borehole dry upon completion on October 20, 2016.  2) Groundwater was encountered at a depth of 2.9 m on October 21, 2016 in open borehole.  3) Borehole was backfilled with bentonite and auger cuttings on completion.																	

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE



Ontario

**RECORD OF BOREHOLE No. BH16-05**

amec foster wheeler



3 OF 3

G.W.P. 5015-E-0064 LOCATION 0248498 E, 5454360 N ORIGINATED BY PW  
 DIST                      HWY                      BOREHOLE TYPE Hollow Stem Augers (108 mm I.D. - 210 mm O.D.) COMPILED BY PW  
 DATUM MTM NAD 83 ZONE 13 DATE 20 October 2016 CHECKED BY TJG  
 PROJECT Foundation Investigation and Design Report - Hornepayne Patrol Yard, Hornepayne, Ontario JOB NO. TY163014

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			SOIL VAPOUR READING	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE				"N" VALUES	SHEAR STRENGTH kPa					W <sub>p</sub>	W		
	4) Practical auger refusal was reached at 9.4 m depth. Beyond that depth the borehole was advanced using a core barrel to borehole termination.																

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

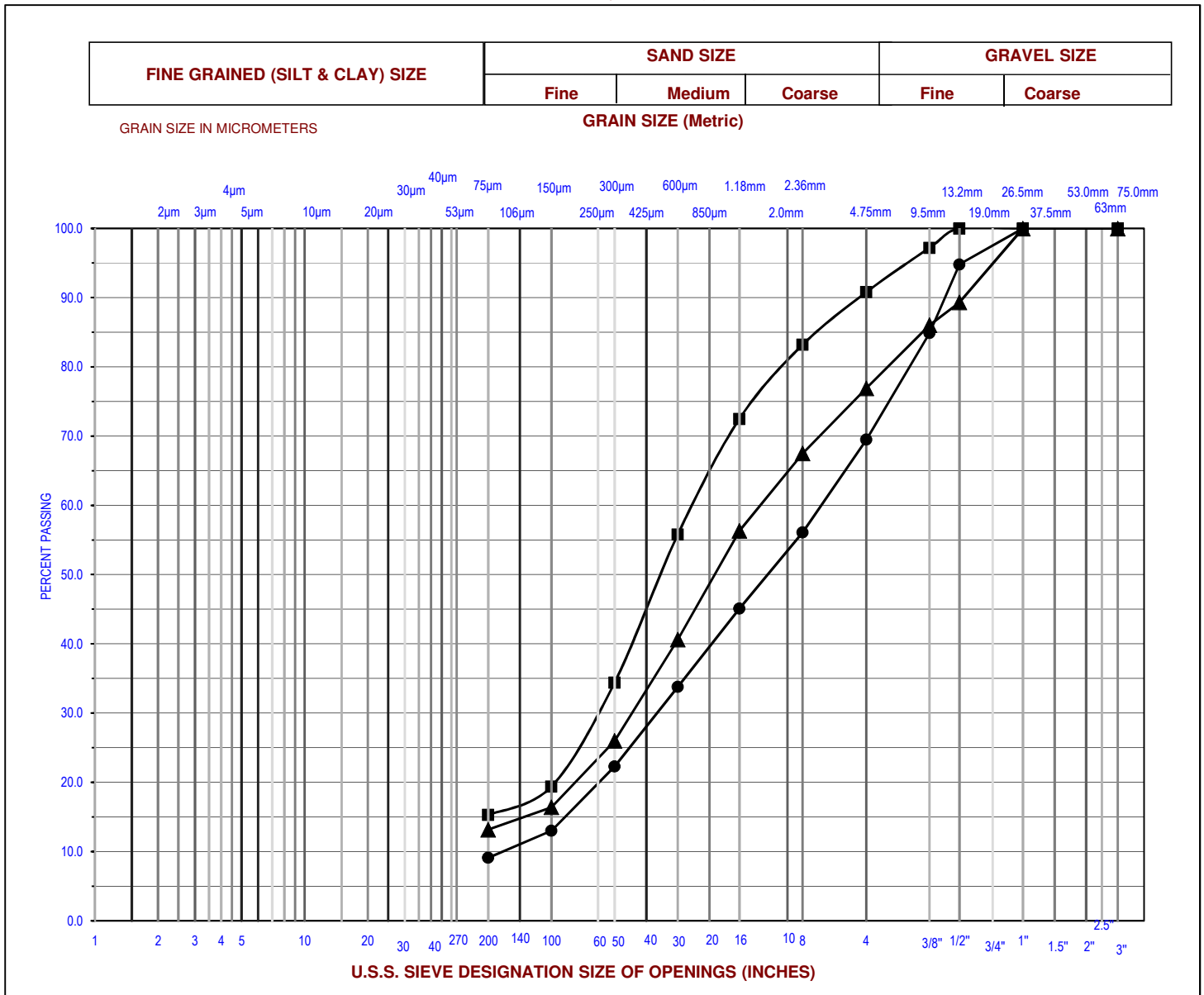
## **APPENDIX C**

### **LABORATORY TESTING RESULTS**

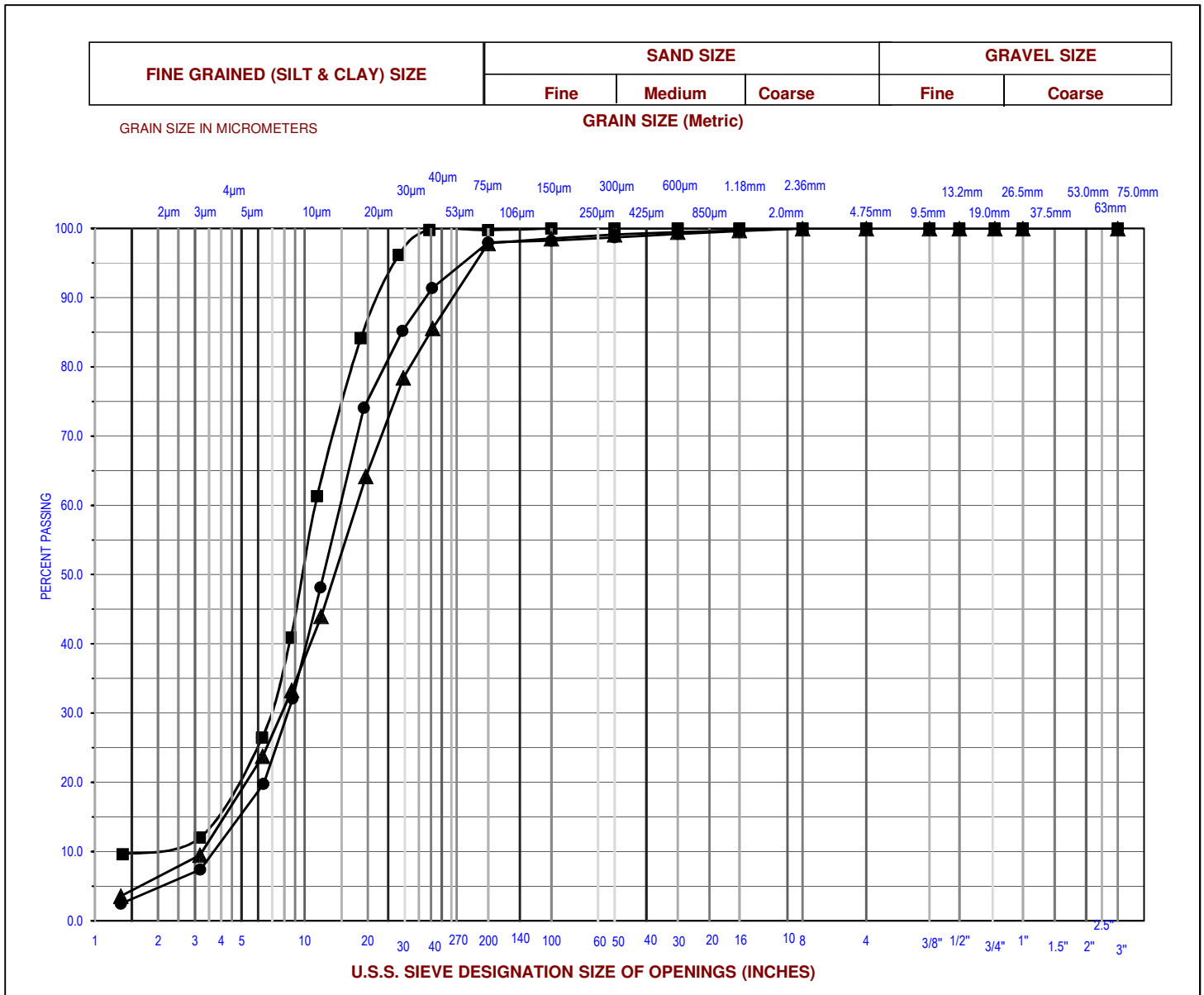


**FIGURE C1 - GRAIN SIZE DISTRIBUTION**

SAND / Gravelly SAND (FILL)


**LEGEND**

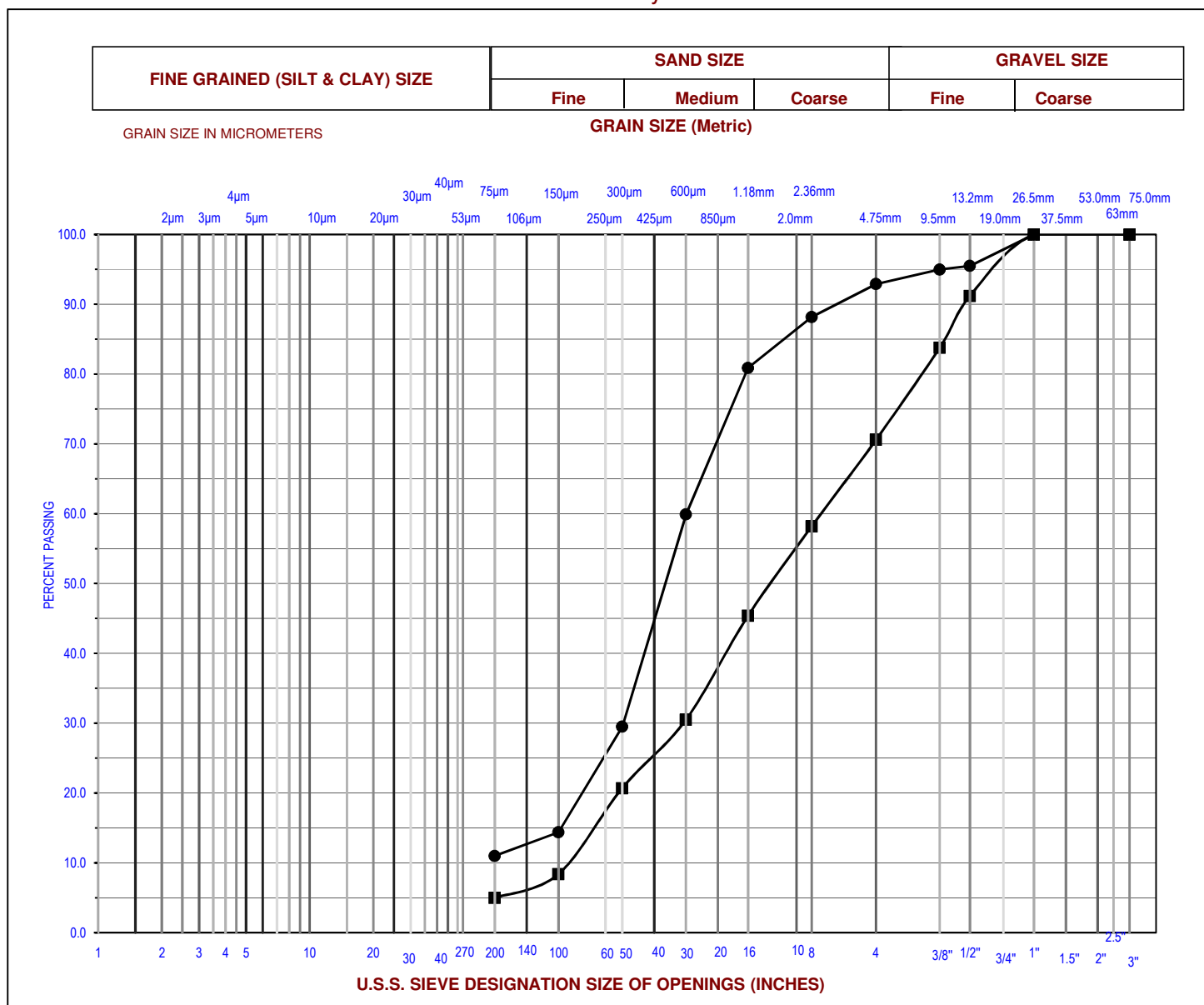
SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)	GRAVEL(%)	SAND (%)	SILT & CLAY (%)
■	BH16-01	SS1	327.7	9	76	15
▲	BH16-04	SS1	327.7	23	64	13
●	BH16-05	SS2	326.6	30	61	9

**FIGURE C2 - SIEVE AND HYDROMETER**
**SILT**

**LEGEND**

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)
■	BH16-01	SS5	324.7	0	0	90	10
▲	BH16-02	SS7	321.3	0	2	92	6
●	BH16-03	SS5	323.9	0	2	94	4

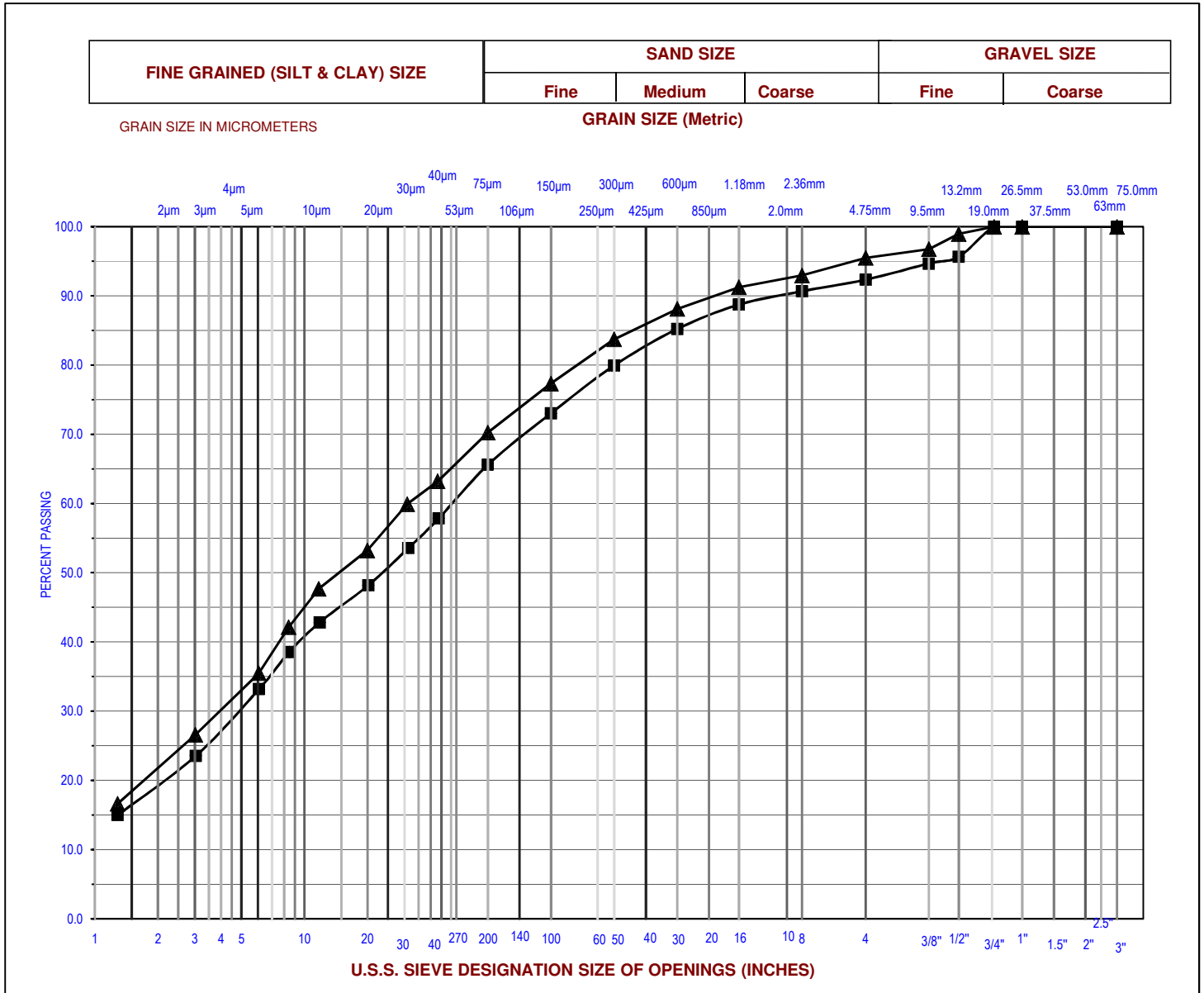
**FIGURE C3 - GRAIN SIZE DISTRIBUTION**

SAND / Gravelly SAND


**LEGEND**

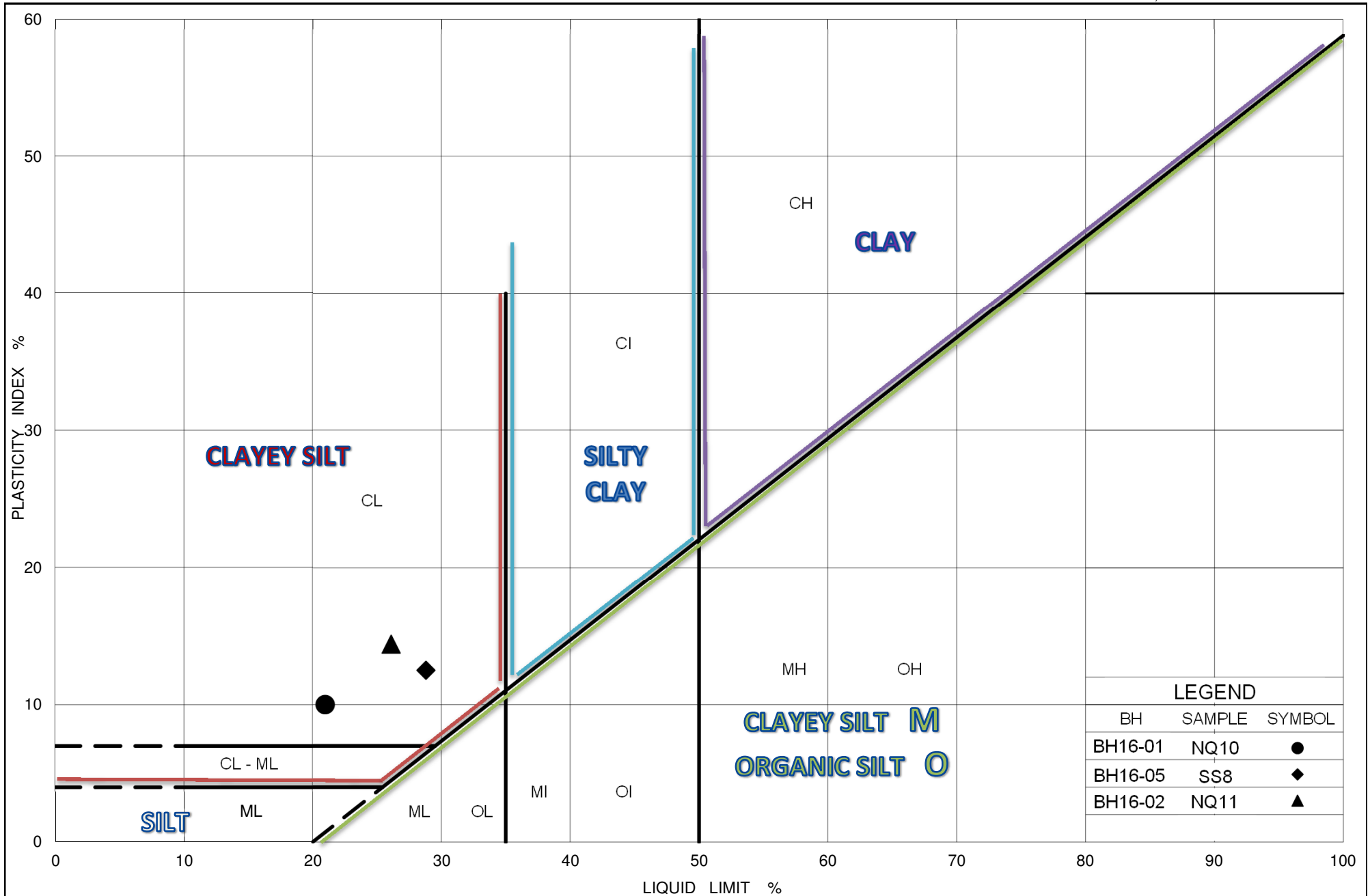
SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)	GRAVEL(%)	SAND (%)	SILT & CLAY (%)
■	BH16-03	SS8	319.5	29	66	5
●	BH16-01	SS8	320.1	7	82	11

**FIGURE C4 - SIEVE AND HYDROMETER**  
**CLAYEY SILT (TILL)**



**LEGEND**

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)	GRAVEL(%)	SAND (%)	SILT (%)	CLAY (%)
■	BH16-01	NQ10	317.8	7	27	47	19
▲	BH16-02	NQ11	316.3	4	26	49	21



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# *PLASTICITY CHART* *CLAYEY SILT & CLAYEY SILT (TILL)*

Figure No. C5

Project No. TY163014 - Hornepayne PY

Checked By: TJG

## **APPENDIX D**

### **ANALYTICAL RESULTS**

**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: 16U160647**

**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

## Certificate of Analysis

AGAT WORK ORDER: 16U160647

PROJECT: TY163014

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

ATTENTION TO: David Brown

SAMPLING SITE:

SAMPLED BY:

### Inorganic Chemistry (Soil)

DATE RECEIVED: 2016-11-16

DATE REPORTED: 2016-11-22

		HOR BH16-01,		
SAMPLE DESCRIPTION:		SS3		
SAMPLE TYPE:		Soil		
DATE SAMPLED:		2016-10-14		
Parameter	Unit	G / S	RDL	8018006
pH, 2:1 CaCl <sub>2</sub> Extraction	pH Units			7.85
Chloride (2:1)	µg/g	4		956
Sulphate (2:1)	µg/g	4		27
Electrical Conductivity (2:1)	mS/cm		0.005	1.84
Resistivity (2:1)	ohm.cm		1	543

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

**8018006** 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 CaCl<sub>2</sub> extract prepared at 2:1 ratio.

Elevated RDL indicates the degree of sample dilution prior to the analysis for Anions in order to keep analytes within the calibration range of the instrument and to reduce matrix interference.

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

Certified By:

*Amanjot Bhela*



## Quality Assurance

CLIENT NAME: AMEC FOSTER WHEELER ENVIRO&INFRASTR

AGAT WORK ORDER: 16U160647

PROJECT: TY163014

ATTENTION TO: David Brown

SAMPLING SITE:

SAMPLED BY:

### Soil Analysis

RPT Date: Nov 22, 2016

DUPLICATE

REFERENCE MATERIAL

METHOD BLANK SPIKE

MATRIX SPIKE

PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

#### Inorganic Chemistry (Soil)

pH, 2:1 CaCl <sub>2</sub> 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*

## Method Summary

CLIENT NAME: AMEC FOSTER WHEELER ENVIRO&amp;INFRASTR

AGAT WORK ORDER: 16U160647

PROJECT: TY163014

ATTENTION TO: David Brown

SAMPLING SITE:

SAMPLED BY:

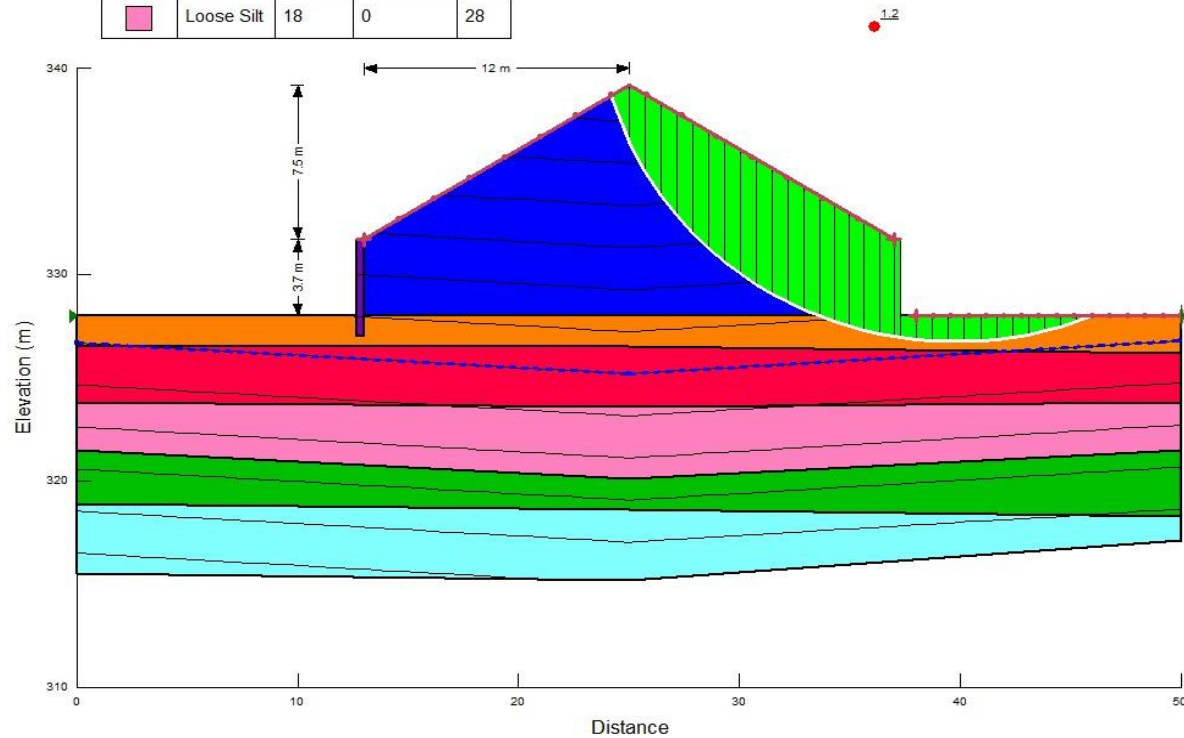
PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
<b>Soil Analysis</b>			
pH, 2:1 CaCl <sub>2</sub> Extraction	INOR-93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION 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**

Ornepahe PY – Existing Conditions  
Sand Pile Static Stability Model

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Cohesion' (kPa)	Phi' (°)
<span style="color: blue;">■</span>	Sand Pile	18	0	30
<span style="color: orange;">■</span>	Sand and Gravel (FILL)	20	0	28
<span style="color: red;">■</span>	Compact Silt	18	0	30
<span style="color: green;">■</span>	Sand	20	0	33
<span style="color: cyan;">■</span>	TILL	21	5	32
<span style="color: purple;">■</span>	Walls	24		
<span style="color: pink;">■</span>	Loose Silt	18	0	28



Date: March 201

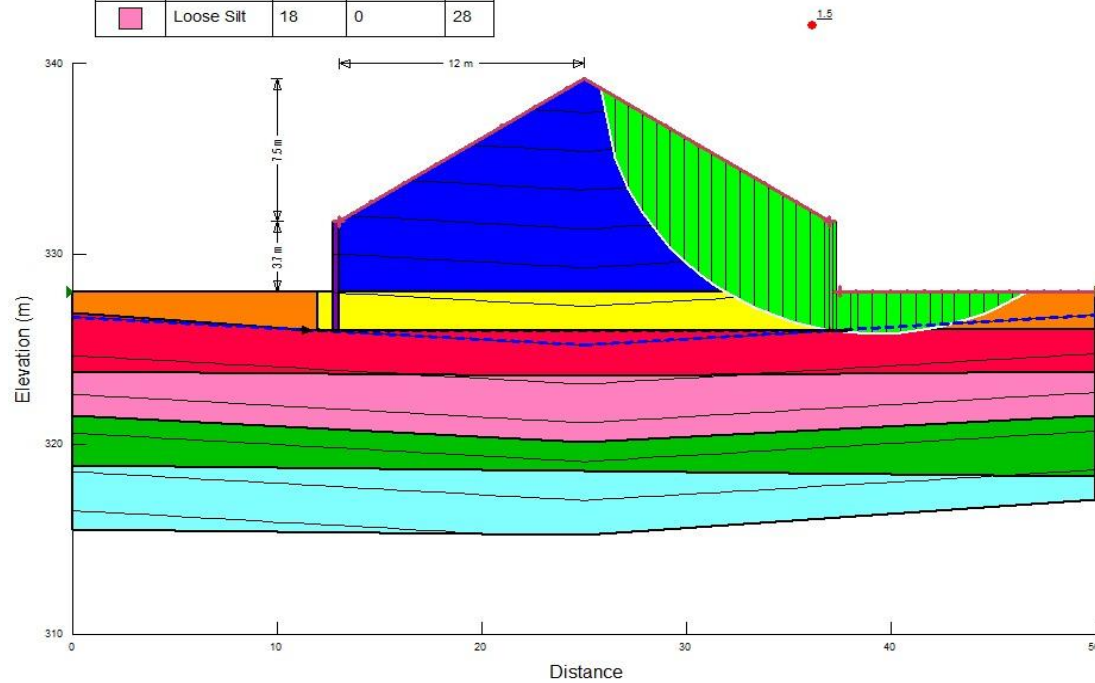
Project Number: TY16301

Analysis by: NF

Reviewed by: MM

Ornepahe PY – 2 m Elevation  
 Sand Pile Static Stability Model

Color	Name	Unit Weight (kN/m³)	Cohesion (kPa)	Phi (°)
Blue	Sand Pile	18	0	30
Orange	Sand and Gravel (FILL)	20	0	28
Red	Compact Silt	18	0	30
Green	Sand	20	0	33
Cyan	TILL	21	5	32
Purple	Walls	24		
Yellow	Engineered Fill	22	0	34
Pink	Loose Silt	18	0	28



Date: March 201

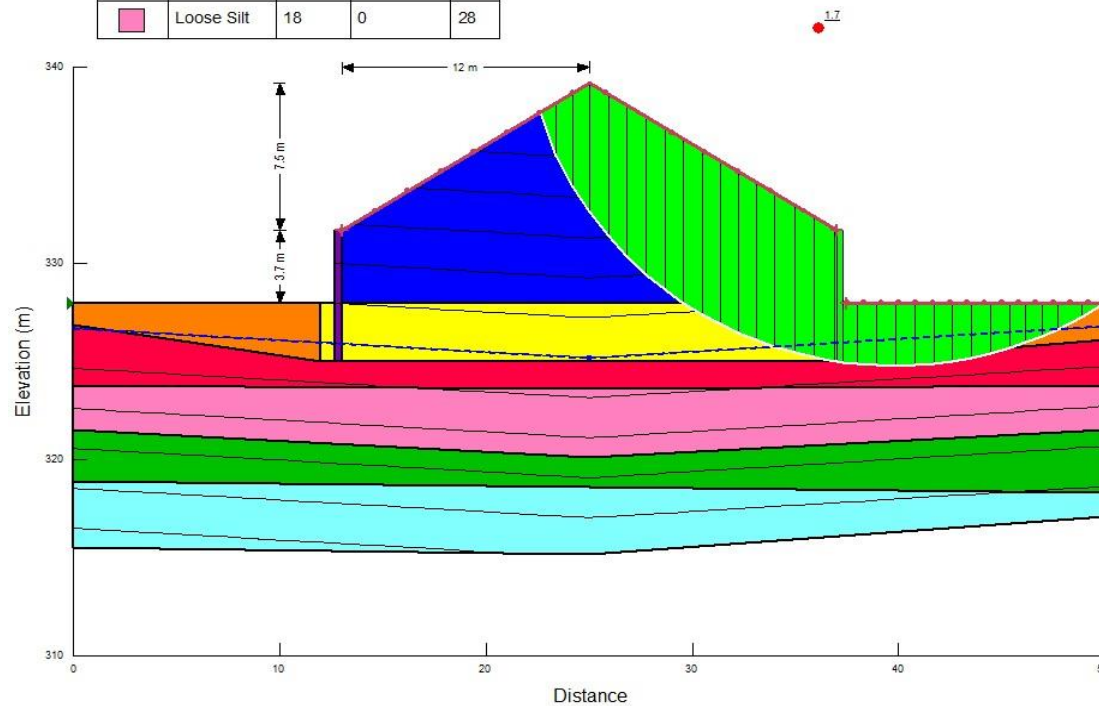
Project Number: TY16301

Analysis by: NF

Reviewed by: MM

Ornepe PY – 3 m Elevation  
Sand Pile Static Stability Model

Color	Name	Unit Weight (kN/m³)	Cohesion (kPa)	Phi (°)
Blue	Sand Pile	18	0	30
Orange	Sand and Gravel (FILL)	20	0	28
Red	Compact Silt	18	0	30
Green	Sand	20	0	33
Cyan	TILL	21	5	32
Purple	Walls	24		
Yellow	Engineered Fill	22	0	34
Pink	Loose Silt	18	0	28



Date: March 201

Project Number: TY16301

Analysis by: NF

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.