



## **FINAL REPORT**

### **FOUNDATION INVESTIGATION AND DESIGN REPORT New Storage Structure at Farley's Corner Patrol Yard, Hwy 524, Township of Pringle, North Bay Area**

**Agreement No. 5013-E-0008  
Assignment No. 7  
WO 2015-11006**

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# Ministry of Transportation

## Foundation Investigation and Design Report

Agreement No. 5013-E-0008

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New Storage Structure at Farley's Corner Patrol Yard, Hwy 524, Township of Pringle, North Bay Area

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# 1 FOUNDATION INVESTIGATION REPORT

## 1.1 Introduction

This report presents the results of a geotechnical investigation carried out by **exp** Services Inc. (**exp**) for the proposed new storage structure located at Farley's Corners Patrol Yard, located on Hwy 524 in the Township of Pringle, North Bay area. The work was undertaken under Agreement # 5013-E-0008, Assignment No. 7 (WO 2015-11006). The terms of reference (TOR) were as presented in the Ministry of Transportation (MTO) letter received on March 02, 2015. The TOR noted that the proposed storage structure(s) at this petrol yard involved consideration of two replacement scenarios shown on the site map PLAN PLAN H-1062-524-1 provided by MTO: (i) replacement of existing sand dome storage structure in kind, and (ii) replacement of existing salt shed with a larger structure of 12.2 m x 21.3 m.

The purpose of the investigation is to establish the existing subsurface conditions at the proposed location of the patrol yard structures within the construction limits. The site specific geotechnical investigation consisted of field investigation including visual inspection, drilling, soil sampling, and laboratory testing. Factual results of the investigation and laboratory testing are included in this report. The report has been prepared specifically and solely for the projects described in the report.

## 1.2 Site Description and Geological Setting

### 1.2.1 Site Description

The Farley's Corners Patrol Yard is located on Hwy 524 in the Township of Pringle approximately 0.2 km north of Hwy 522 and Hwy 524 junction (see Key Map on Drawing 1, Appendix B). The terrain at the structure site is relatively flat as shown on photographs included in Appendix A.

In the proposed structure area, there are a sand dome and salt shed. The existing sand dome of about 38 m diameter is located approximately 55 m southeast of the existing MTO benchmark BM 758455 (Elev. 317.558 m) as marked on the site map, PLAN H-1062-524-1, and shown on Drawing 1 in Appendix B. The salt shed is about 9 m wide and 10 m long and is located approximately 5 m northwest of the sand dome.

### 1.2.2 Geological Setting

Map 2544 (Bedrock Geology of Ontario, Southern Sheet, 1991) of the Ministry of Northern Development and Mines indicates that the bedrock formation of the project area is known to be in the Central Gneiss Belt of the Mesoproterozoic Group, mainly of felsic igneous rocks comprised of tonalite, granodiorite and granite. Map 2556 (Quaternary Geology of Ontario, Southern Sheet, 1991) of the Ministry of Northern Development and Mines, indicates that the surface conditions in the vicinity of site consist of glaciofluvial outwash deposits consist of gravel and sand.

## 1.3 Investigation Procedures

### 1.3.1 General

The field investigation was performed during March 23 and March 24, 2015. The field program consisted of drilling four (4) sampled boreholes (BH F15-1, BH F15-2, BH F15-3, and BH F15-4) and one dynamic cone penetration test (DCPT) adjacent to BH F15-3.

The boreholes were strategically located at the patrol yard to provide the subsurface information for the design of replacement of existing sand dome storage structure in kind and replacement of existing salt shed with a larger structure of 12.2 m x 21.3 m. The borehole locations are shown on Drawing 1 in Appendix B.

The borehole locations (referenced to the MTM NAD83 coordinate system) and their ground surface elevations were surveyed by **exp** personnel, with reference to the benchmark at the northwest of the sand dome (MTO BM Elevation 317.56 m), as shown in the site map provided by MTO (PLAN H-1062-524-1).

The boreholes were advanced using a track mounted CME-55 drill rig, equipped with a hollow stem auger/ diamond drilling with NW casing. All borehole drilling/sampling were operated by a specialist drilling contractor, Marathon Drilling Co. Ltd. Boreholes F15-1 and F15-3 were advanced to depths of 3.7 m and 9.8 m respectively until auger/split spoon refusal (BH F15-1) or desired depth. DCPT test performed adjacent to BH F15-3 was advanced until refusal at depth of 10.7 m. Boreholes F15-2 was drilled up to a 6.0 m depth with 3.6 m of bedrock coring, and borehole F15-4 was drilled up to a 9.1 m depth with 2.1 m of bedrock coring.

During the drilling of the boreholes, soil samples were obtained using a 51 mm outside diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D 1586), at intervals shown on the attached borehole logs (Appendix C). The original field (uncorrected) SPT "N" values were recorded on the borehole logs as recommended in the Canadian Foundation Engineering Manual (CFEM. pg. 40), and used to provide an assessment of in-situ consistency of cohesive soils or relative density of non-cohesive soils. At BH F15-4 sand heaving was encountered at depth of 3.0 m, so a wash boring technique was utilized to facilitate taking representative samples at designated elevation with reasonable accuracy. When a hard stratum was reached sampling of rock was performed in two boreholes (BH F15-2 and BH F15-4) by diamond core drilling, using a 1.5 m long NQ double tube wireline core barrel. A dynamic cone penetration test (DCPT) was performed in the vicinity of BH F15-3 to identify a level of a hard stratum in that borehole. The results of the DCPT, recorded SPT "N" values, and relative consistency of the soil layers are shown on the borehole log sheets in Appendix C.

Upon completion of the boreholes, groundwater level measurements were carried out in the open holes. Since wash boring technique was used to advance borehole or to cored bedrock at BH F15-2, the stabilized ground water level could not be established by short term observation in these boreholes. The measured groundwater levels in BH F15 1, BH F15-3 and BH F15-4 were recorded in borehole log sheets in Appendix C. The boreholes were decommissioned by bentonite/cement mixtures in accordance with the Ministry of the Environment Regulation 903, as amended by Regulation 128/03 (the well regulation under the Ontario Water Resources Act).

The fieldwork was supervised by members of **exp's** engineering staff who directed the drilling and sampling operation, logged borehole data in accordance with MTO and/or ASTM standards for soils classification, and retrieved soil samples for subsequent laboratory testing and identification.

All of the recovered soil samples were placed in labelled moisture-proof bags and returned to **exp's** Brampton laboratories for additional visual, textual and olfactory examination, and sampling for lab testing.

### 1.3.2 Laboratory Testing

All samples returned to the laboratory were subjected to visual examination and classification. The laboratory testing program included the determination of natural moisture content and particle size distribution for approximately 25% of the collected soil samples. All of the laboratory tests were carried out in accordance with MTO and/or ASTM standards as appropriate.

The laboratory test results are provided on the attached borehole log sheets in Appendix C. The results of the grain size analyses are presented graphically in Appendix D.

### 1.3.3 Previous Investigation

The foundation report from August 1964 related to this site and named "Foundation Investigation Report for Proposed D.H.O. Patrol Yard, Hwy. # 524, District of Parry Sound, Township of Pringle, Con. 11, Lot 30, District # 13, North Bay (GEOCRE 31E00-047) is provided by MTO. The locations of the historical boreholes drilled in April 1964 are shown on Drawing 1 in Appendix B and the soil stratigraphy assessed during that investigation is shown on the attached drawing in Appendix F.

## 1.4 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil samples, are presented on the borehole log sheets in Appendix C. Laboratory test results are provided in Appendix D. The "Explanation of Terms Used in Report" preceding the borehole logs in Appendix C forms an integral part of and should be read in conjunction with this report.

A borehole location plan and stratigraphic section along the proposed sand storage structure and salt shed are provided in Appendix B. It should be noted that the stratigraphic boundaries indicated on the borehole logs and stratigraphic section are inferred from non-continuous sampling, observations of drilling progress and results of Standard Penetration Tests. These boundaries typically represent transitions from one soil type to another and should not be regarded as exact planes of geological change. Further, subsurface conditions may vary between and beyond the borehole locations.

In general, the stratigraphic sequence at the proposed structure site consists of top sand fill, underlain by native silty sand deposits followed by bedrock. A brief summary of the soil and groundwater conditions encountered in the boreholes is provided below.

### 1.4.1 Fill: Sand

A sand fill layer was encountered below an approximately 25 mm thick layer of asphalt in all boreholes drilled. The thickness of sand fill layer is about 0.6 m extending from Elev. 317.7 m to 316.6 m.

This layer consists of sand with few to little gravel, few to little silt and clay size particles. The material is blackish brown to brown in color, and moist, frozen. Dynamic cone penetration resistance value within this layer is about 80 blows per 300 mm of penetration, suggesting very dense relative density of this layer.

Laboratory testing performed on selected samples consisted of moisture content and grain size distribution tests. The test results are as follows:

Moisture Content:

- 2.3% to 9.2 %

Grain Size Distribution:

- 8% to 19% gravel;
- 66% to 82% sand; and
- 10% to 15% silt and clay.

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution tests are also provided on Figure 1 in Appendix D

### 1.4.2 Silty Sand

A layer of silty sand was encountered below the sand fill in all boreholes. The thickness of silty sand layer ranged from 1.8 m to 9.2 m extending from Elev. 317.1 m to 307.4 m. BH F15-1 and BH F15-3 were terminated within this layer upon split spoon refusal or achieving the proposed borehole depth.

This layer consists of sand with few to some silt, trace to little gravel and trace clay. The material is reddish brown to brown in color, and moist to wet. The SPT "N" values within this layer ranged from 3 to above 100 blows per 300 mm penetration, corresponding to very loose to very dense compactness condition, but more typically compact to very dense conditions.

Laboratory testing performed on selected samples consisted of moisture content and grain size distribution tests. The test results are as follows:

Moisture Content:

- 5.3% to 22.2%



#### Grain Size Distribution:

- 0 to 19 % gravel;
- 63% to 89% sand;
- 5% to 25% silt; and
- 1% clay

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution tests are also provided on Figure 2 in Appendix D.

### 1.4.3 Bedrock

The presence of bedrock was found to be approximately between 2.4 m to 10.7 m below the ground surface. The bedrock was inferred from split spoon/DCPT refusal in BH F15-1 and BH F15-3, or confirmed using coring depth of 2.1 m (BH F15-4) to 3.6 m (BH F15-2). The elevation of the inferred or actual bedrock surface below this site ranges from Elev. 314.0 m to 307.4 m. The inferred or actual bedrock surface depth and elevation encountered at these borehole locations are listed in Table 1.1.

Based on the bedrock cores recovered, the bedrock consists of granite gneiss. In general, the bedrock samples are described as light grey/dark grey/pink in colour and have a fine crystalline structure, slightly weathered. The Rock Quality Designation (RQD) measured on the core samples typically ranged from approximately 61% to 100%, indicating a rock mass of fair to excellent quality. Photographs of rock cores are included in Appendix E.

*Table 1.1 Depth and elevation of bedrock or possible bedrock surface*

Borehole	Depth Below Ground Surface (m)	Elevation (m)	Comments
BH F15-1	3.7	314.0	Inferred/ Spoon Refusal
BH F15-2	2.4	315.3	Bedrock Cored
BH F15-3	10.7	307.4	Inferred/ DCPT Refusal
BH F15-4	7.0	310.4	Bedrock Cored

## 1.5 Groundwater Conditions

Information regarding groundwater levels at the site was obtained by measuring the water levels in the open boreholes after completion of drilling. The groundwater levels measured in the boreholes are shown on Table 1.2 and borehole logs. Since wash boring technique was used for drilling BH F15-2, accurate groundwater levels at this borehole could not be measured in the open holes at the time of

drilling operation. Water levels measured in open boreholes might not be stabilized due to short term observation.

Table 1.2 Groundwater levels recorded at the site

Borehole No.	Date of Measuring	Groundwater Level	
		Depth (m)	Elevation (m)
BH-1	03/24/2015	2.1	315.5
BH-3	03/23/2015	3.05	314.15
BH-4	03/24/2015	2.44	314.96

## 2 DISCUSSIONS AND ENGINEERING RECOMMENATIONS

### 2.1 General

This section of the report provides geotechnical design recommendations for the proposed MTO patrol yard structures at Farley's Corners Patrol Yard, located on Hwy 524 in the Township of Pringle, North Bay area. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the current investigation at the site and presented in **Part I-Foundation Investigation Report**. The interpretation and recommendations provided are intended solely to permit designers to assess foundation alternatives, and design the proposed structures. Comments on construction are only provided to highlight issues that could affect the design. Contractors bidding on the works should make their own assessments of the factual data and how it might affect construction means and methods, scheduling and the like.

Based on information included in the TOR and correspondence with MTO it is understood that the existing sand dome storage structure (approximately 38 m in diameter) will be replaced by the similar dome storage structure, while the existing salt shed will be replaced with a larger structure which is similar to that at the Cartier Patrol Yard, Cartier Township, in the Sudbury area. The proposed salt shed will have a footprint of about 12.2 m x 21.3 m in plan dimensions. Based on design drawings of the MTO Cartier Patrol Yard (Drawings No. 10-632-1 to 10-632-5 by James Knight & Associates) provided by MTO, it is understood that the proposed salt shed structure will have a maximum height of about 11.0 m to the bottom of the trusses (Drawing No. 10-623-4) and it will be encompassed with a 3.8 m high, cast-in-place concrete walls around the perimeter. Both buildings will have an asphalt floor slab within the plan areas of the storage. The assumed finished top of the asphalt floor will be approximately at Elev. 317.6 m to tie-in to the existing exterior paved areas.

This report addresses the geotechnical design of the foundation for the proposed structures by providing geotechnical design parameters at the Ultimate Limit State (ULS) and Serviceability Limit States (SLS) as well as other geotechnical parameters that may be required in accordance with the latest edition of the *Canadian Highway Bridge Design Code (CHBDC)* (CAN/CSA-S6-14), the *Guideline for Professional Engineers Providing Geotechnical Engineering Service* (1992), the *Canadian Foundation Engineering Manual (CFEM)* (2006), the *provisions in the TOR* and good practice. It also provides discussion about the structure foundation type, stability and settlement analyses, frost protection, construction considerations and dewatering during construction, as requested in the TOR from MTO letter dated March 2, 2015.

As further requested in the TOR, the settlement and stability analyses were completed for a scenario in which the new structures would be loaded to their full allowable capacity. This scenario consists of winter sand and salt stacked to the maximum allowable height of the concrete walls with a stockpile area covering the entire footprint of the buildings.

## 2.2 Geotechnical Design Considerations for Foundations

The geotechnical investigation and its findings pertaining to the subsurface soil characteristics have been covered in **Part I - Foundation Investigation Report** which contains details of the field and laboratory aspects of the investigation.

The overburden soils at the site generally consist of a layer of sand fill underlain by cohesionless deposits of very loose to very dense (typically compact to very dense) silty sand, underlain by bedrock. The total overburden thickness ranged from 2.4 m (BH F15-2) to 10.7 m (BH F15-3) at the tested locations. The overburden soils are underlain by granite gneiss bedrock of fair to excellent quality. The bedrock surface in the area of the structure footprint is variable with elevations ranging from Elev. 315.3 m to Elev. 306.5 m, dipping to the south-east direction. The unstabilized groundwater levels were measured at elevations between Elev. 314.15 m and Elev. 315.5 m (i.e. an approximate depth of between 2.1 m and 3.05 m below ground surface).

### 2.2.1 Evaluation of Foundation Alternatives

The foundation recommendations for the proposed structures in this project were developed based on subsurface conditions encountered in the geotechnical soil borings performed for this study. Considering the findings, shallow strip/spread footings founded on the native compact to very dense silty sand is recommended as the most preferable alternative from geotechnical/foundation perspectives. Considering the depth and sloping nature of the bedrock surface at the site, shallow strip/spread footings founded on bedrock are possible. However, due to the variable nature of the bedrock surface at the proposed building it is possible that in some locations (toward the south-east), strip/spread footings may transition from being founded partially on bedrock and partially on native silty sand soil which may result in a differential settlement. To minimize the risk of differential settlements an engineered fill can be utilized in that alternative.

Deep foundations are considered as not necessary or practical at this site based on the subsurface conditions encountered. Alternatives considered including their advantages, disadvantages, relative cost and risks are summarized in Table 2.1.

Shallow foundations for the sand and salt storage structures should consist of strip/spread footings which typically for this kind of structure have a width of 3 m (i.e. the Cartier Patrol Yard project). The footings founded at shallow depth on/within the native compact to very dense silty sand deposit can likely be constructed using conventional methods as such a founding depth is above the groundwater table as observed in the boreholes during the subsurface investigation.

Table 2.1 Evaluation of foundation alternatives

Options	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
1. Shallow foundation - Strip/Spread footings	1	<ul style="list-style-type: none"> <li>▪ Straightforward construction</li> </ul>	<ul style="list-style-type: none"> <li>▪ Differential settlements a potential issue particularly in areas of shallow bedrock</li> </ul>	<ul style="list-style-type: none"> <li>▪ Lower cost than deep foundation option</li> </ul>	<ul style="list-style-type: none"> <li>▪ Risk of differential settlements due to possible partially founding on shallow bedrock</li> </ul>
2. Deep foundation - Piles	2	<ul style="list-style-type: none"> <li>▪ Avoid potential differential settlement</li> </ul>	<ul style="list-style-type: none"> <li>▪ Not practical and no apparent benefits over shallow foundation option</li> </ul>	<ul style="list-style-type: none"> <li>▪ Much higher relative costs compared to shallow foundation option</li> </ul>	

## 2.2.2 Footing Elevation

Based on the results of the geotechnical investigation and a requirement for adequate protection against frost penetration in the project area (i.e. a minimum 1.9 m below the lowest surrounding area, see Section 2.2.5), the following founding elevations of strip/spread footings are recommended:

Table 2.2 Recommendations for footing elevation

Soil at Founding Level	Foundation Elevation (m)	Depth Below Existing Grade
Native Compact to Very Dense Silty Sand	315.3	1.9 m to 2.4 m
Bedrock (BH F15-2)		2.4 m
Granular Engineered Fill Over Native Soil/Bedrock		1.9 m to 2.4 m

## 2.2.3 Geotechnical Resistances

In the context of the CHBDC, a satisfactory foundation design would require, in terms of Limit States Design, the factored geotechnical resistance of its foundation to withstand and not exceed the imposed Ultimate Limit State loads - (ULS) Design Approach, and its ability to deform acceptably under the Service Limit State loads - (SLS) Design Approach. These associated loads are typically known as unfactored and factored loads, respectively. Therefore, strip/spread footings placed on the properly prepared subgrade at the design elevation given in Table 2.2, should be designed based on the factored resistances at ULS and geotechnical reactions at SLS for 25 mm of settlement given in Table 2.3 below. The footing width of 3 m is assumed (i.e. the Cartier Patrol Yard project). Settlement of the footings under the loading from the stockpiles inside the structures which will occur after their construction is considered and discussed in Section 2.6.2. In determining the settlement characteristics of the proposed buildings (tolerable total and differential settlement), the unfactored loads are required to be provided by the Structural or Design Engineer.

Table 2.3 Geotechnical resistance at ULS and geotechnical reaction at SLS for a 3 m wide footing

Soil at Founding Level	Width of Footing (m)	Factored Geotechnical Resistance at ULS (kPa)	Geotechnical Reaction at SLS (kPa) (for 25 mm settlement)
Native Compact to Very Dense Silty Sand	3	850	300
Bedrock		10000	n.a.*
Granular Engineered Fill Over Native Soil/Bedrock		850	350

*\*- A geotechnical resistance at SLS for 25 mm of settlement will be greater than the factored geotechnical resistance at ULS, since the intact granitic gneiss bedrock is considered to be a relatively unyielding material.*

Since the ULS resistance and the settlement depend on the footing size and depth of embedment, the geotechnical resistances given in Table 2.3 should be reviewed if the selected footing width or founding elevations differ from those given in the table. Similarly, if an inclined load is applied instead of a vertical load, which is used in these calculations, the values given in Table 2.3 has to be reviewed to take into account those inclinations.

Prior to placing footings, the exposed native subgrade should be inspected according with OPSS 902. A Qualified Geotechnical Engineer should check that the design foundation elevation is achieved and all unsuitable soils including fill, organics and those soils with the USCS classification of CH, OH, MH, OL or PT have been removed.

Due to the variable nature of the bedrock surface at the proposed buildings, it is possible that in some locations, continuous strip footing may transition from being founded partially on bedrock and partially on native silty sand soil. The large difference in stiffness between these two foundation strata could result in undesirable differential settlements between foundation units and potentially cracking at the transition point of strip footings. A design detail will be required at these transition points to accommodate potential small differential settlements and ensure the performance of the footing and foundation wall. The placement of engineered fill materials below the footings can minimize the risk of differential settlements. A minimum 300 mm thickness of engineered fill (i.e. Granular A) should be placed above the native soil at the bedrock and soil transition zone and compacted to 100% of the material's Standard Proctor Maximum Dry Density (SPMDD).

## 2.2.4 Resistance to Lateral Loads

Resistance to lateral forces/sliding resistance between the subgrade and concrete should be calculated in accordance with Section 6.7.5 of the CHBDC. The unfactored values of the coefficient of friction,  $\tan \delta$ , between the base of cast-in-place concrete footing and the granular subgrade soils below the frost level are presented in Table 2.4.

Table 2.4 Recommendations for coefficient of friction

Interface	Coefficient of Friction, $\tan \delta^*$
Concrete footings and bedrock	0.70
Concrete and native compact to very dense silty sand	0.45
Concrete footings and engineered fill	0.60

\*- based on NAVFAC 1986, Table 1, pg. 7.2-63

A factor of 0.8 should be applied in calculation of the horizontal resistance in accordance with CHBDC.

In a case of the unbalanced lateral earth pressures caused by sand/salt stockpiles being piled against the perimeter walls, these walls should be designed based on the following geotechnical parameters assuming a triangular lateral earth pressure distribution:

- Unit weight of sand stockpile material =  $20 \text{ kN/m}^3$
- Unit weight of salt stockpile material =  $12 \text{ kN/m}^3$
- Friction angle of sand/salt stockpile material =  $30^\circ$
- Lateral earth pressure coefficient ( $K_o$ ) = 0.5

### 2.2.5 Frost Protection

According to Ontario Provincial Standard Drawing (OPSD – 3090.101), the frost depth in the Township of Pringle is about 1.9 m. Consequently, all footings exposed to seasonal freezing conditions should be protected from frost action by at least 1.9 m of soil cover or equivalent insulation.

## 2.3 Earthquake Considerations

Recommendations for the geotechnical aspects to determine the earthquake loading are presented below.

### Subsoil Conditions:

The subsoil and groundwater information at this site have been examined in relation to Section 4.1.8.4 A of the Ontario Building Code (OBC, 2012). The subsoil generally consists of sand fill and silty sand layers, underlain by sloping bedrock located at the depth of approximately between 2.4 m and 10.7 m below the ground surface. It is expected that the foundations will be founded in the silty sand layer. The reported N-values for the soil below the founding level ranged from 3 to over 100 blows for 300 mm of penetration, with an average value being greater than 50 blows per 300 mm of penetration.

### Corrected N-Values $N_{60}$ :

The Average Standard Penetration Resistance shown in Table 4.1.8.4.A. Site Classification for Seismic Site Response in OBC 2012 refers to  $N_{60}$  which is defined as "Average Standard Penetration Resistance for the top 30 m, corrected to a rod energy efficiency of 60% of the theoretical maximum". It should be noted that the drillers in the North Bay area do not have their rod energy efficiencies measured and therefore, computed  $N_{60}$  values are not available for this site. In our opinion, the reported N-values could be considered as an approximate equivalent to the normalized  $N_{60}$  values as noted in the OBC 2012 for the purpose of establishing the site classification.



#### Depth of Boreholes:

Table 4.1.8.4.A. Site Classification for Seismic Site Response in OBC 2012 indicated that the average properties in the top 30 m are to be used to determine the site classification. The four (4) boreholes advanced for building construction at this site were approximately 9.8 m deep. The total overburden thickness ranged from 2.4 m (south-west corner) to 10.7 m (south-east corner) at the tested locations. The overburden soils are typically underlain by granite gneiss bedrock of fair to excellent quality.

#### Site Classification:

Based on the above assumptions and interpretations, and the soil conditions, the Site Class for this site is estimated to be Class "C" as per Table 4.1.8.4.A, Site Classification for Seismic Site Response, OBC 2012.

These parameters should be reviewed by the Structural Engineer.

## **2.4 Liquefaction Considerations**

According to the observed soil properties, the subsoil in some areas (i.e. BH F15-3) could potentially be susceptible to liquefaction. Accordingly, liquefaction analyses have been performed using the Seed's approach, which is recommended by the CFEM (4<sup>th</sup> Edition 2006; Chapter 6, pg.101). This approach defines a factor of safety against liquefaction as the ratio of the induced cyclic stress ratio over the cyclic resistance ratio. The calculated factor of safety for the site subsoil in vicinity of BH F15-3 is generally more than 1.0. As a result, liquefaction is not likely to occur in the upper soils at the project site for the earthquake having 10% probability of exceedance in a 50-year period.

## **2.5 Perimeter Wall and Floor Construction**

The perimeter wall of the proposed structures may be constructed as a cantilever retaining wall with an extended heel toward the inside of the structure and founded on native soils. Structural steel bars should be provided in the footings and in the walls. The asphalt floor will be designed inside the structure. The construction of spread footing and subgrade for the asphalt floor may be carried out in accordance with the following recommendations:

Prior to construction, all obviously unsuitable material should be fully removed from the entire underfooting and underfloor area (see Section 2.7). Following rough grading, the exposed subgrade should be proofrolled with a roller under the full-time supervision of a qualified geotechnical personnel. Any soft spots detected during proofrolling should be sub-excavated and replaced with approved materials compacted to at least 98 % of the SPMDD. The prepared subgrade should be covered with at least 200 mm thick layer of OPSS PROV (Aggregates) Granular A compacted to not less than 100% of the material's SPMDD, crowned slightly in the central area.

Around the perimeter of the building the ground surface should be sloped on a positive grade away from the structure to promote surface water run-off and reduce groundwater infiltration adjacent to the foundations. Permanent perimeter drains are not required if the interior base is set at least 200 mm

above the exterior grade and the grade is sloped away from the structure. However, a permanent subfloor drainage system may be required to collect salt-bearing water. In order to minimize contamination into the native soils and subsequently into the groundwater, a barrier such as a compacted low-permeability clay liner or geomembrane should be installed below the salt storage area. In practice the use of geomembrane shows advantage over the compacted clay liner in terms of improved performance of the barrier. The geomembrane should be installed on a minimum 75 mm thick sand layer (OPSS PROV 1004 or OPSS PROV 1002) and covered with a 300 mm thick layer of sand fill on top of the geomembrane in order to protect it from the overlying pavement structure.

## 2.6 Stability and Settlement Analyses

### 2.6.1 Stability

To assess the global stability of the storage structures and to check that a minimum Factor of Safety of 1.3 will be achieved for the maximum height sand/salt stockpiles, a series of slope stability analyses were performed. The static slope stability analyses were performed using the Morgenstern-Price method developed on the basis of limit equilibrium. The SLOPE/W computer program developed by GeoSlope International was employed for computation.

Stability assessments were performed for two proposed new structures: (i) a sand dome storage structure (~38 m in diameter) assuming that the maximum sand stockpile could be 10.9 m high (Figure G1), and (ii) a salt shed of 12.2 m x 21.3 m dimensions assuming that the maximum salt stockpile could be 4.0 m having the side slopes of 1.5H:1V as shown on Figure G2. The stratigraphy and groundwater condition at the site were developed based on the results of the geotechnical investigation presented in Part I - Foundation Investigation Report.

Given the above, effective stress analyses for a long term stability assessment were performed taking into consideration the subsoil conditions encountered directly beneath and adjacent the proposed structures.

Tabulated below in Table 2.5 are the soil parameters used for the slope stability analyses. The soil parameters were generally estimated based on the results of field and laboratory investigation.

Table 2.5 Soil properties used in slope stability analyses

Material Type	Effective Stress Parameters		
	$\phi$ (degrees)	c (kPa)	$\gamma$ (kN/m <sup>3</sup> )
Engineered Fill	35	0	22
Compact to Very Dense Silty Sand	32	0	19
Sand Stockpile Material	30	0	20
Salt Stockpile Material	30	0	12

The graphical results of these analyses can be seen in Appendix G. As shown on Figures G1, the results of stability analyses for an approximately 10.9 m high sand stockpile (in the center, with the side slopes of 2.7H:1V) restrained with concrete walls on both sides in the dome building suggest that the factor of safety greater of 1.3 (i.e. min FOS=1.6) can be obtained for a deep-seated failure surface. The similar results (i.e. min FOS =2.0) were obtained for the approximately 7.8 m high salt stockpile (in the center, with the side slope of 1.5H:1V) restrained with concrete walls in the salt shed, as shown on Figure G2.

## 2.6.2 Settlement

To evaluate the maximum settlement and differential settlement values bellow the sand and salt stockpile loadings in the proposed storage buildings, a 3D computer program; Settle3D (Rocscience) was employed. Considering the cohesionless nature of the soil material encountered at the site it is anticipated that only an immediate settlement would be occurred under the loadings. The elastic moduli of deformation for the encountered soil layers used in the settlement model are evaluated based on the results of the SPT and DCPT as per CHBDC. The parameters are listed in Table 2.6.

Table 2.6 Soil properties used in settlement analyses

Material Type	$\gamma$ (kN/m <sup>3</sup> )	E (MPa)	Poisson's Ratio
Engineered Fill	22	120	0.3
Compact to Very Dense Silty Sand	19	35	0.3
Sand Stockpile Material	20	-	-
Salt Stockpile Material	12	-	-

The geometry of the stockpiles was assumed based on its maximum allowable capacity: (i) sand dome storage - a maximum height of approximately 10.9 m at the center and 3.8 m along the sides at the concrete wall, and (ii) salt shed storage – a maximum height of approximately 7.8 m at the center and 3.8 m along the sides at the concrete wall. Due to limitation of the computer program to model the sloping rock surface, the settlements under the maximum capacities of stockpiles were computed assuming two different bedrock's elevation: (i) at the depth of 3.7 m below the surrounding ground and (ii) at the depth of 10.7 m below the surrounding ground. It is anticipated that these two cases will give the range of possible scale of settlement beneath the structures. The models for these two cases are illustrated on Figures H1 and H2 included in Appendix H.

The results of the settlement analyses are plotted on Figure H3 and H4 (Appendix H). The estimated settlements under the stockpile at the centre and at the edges of the stockpile (i.e. location of footings) are presented in Table 2.7.

Table 2.7 Results of settlement analyses

Foundation Soil Type	Estimated Settlement (mm)					
	Sand Dome Structure			Salt Shed Structure		
	East Edge	Centre	West Edge	East Edge	Centre	West Edge
Compact to Very Dense Silty Sand	7-18	25-68	8-25	5-23	15-39	4-20

The calculated settlements are anticipated to occur immediately after the stockpile loadings are applied or within a time period of about 14 days. However, the loadings and consequent settlement would be occurred after the footings have been constructed. Therefore, the footings for these structures have to be design under the full allowable stockpile loadings. The geometries of stockpiles under the full allowable loadings including their maximum heights are recommended above. It is also recommended that the designer include detailed procedures in the contract drawings and note.

## 2.7 Site Preparation and Engineered Fill Construction

As mentioned previously, the areas within the limits of the buildings should be stripped and cleared of surface vegetation, topsoil and debris prior to construction. Any soils containing excessive organics or loose/disturbed materials are not suitable for the subgrade of building foundations, floor slabs or engineered fill. Therefore, areas with those soils should be excavated and replaced with engineered fill comprised of Granular A or Granular B, Type I or Type II.

Engineered fill could be placed after stripping all topsoil, organic matter, fill and other compressible, weak and deleterious materials within an area extending at least 1.0 meters beyond the outside edge of the founding level of any footings. After stripping, the entire area should be heavily proof-rolled inspected and approved by a Geotechnical Engineer. Engineered fill should be placed in accordance with OPSS 501 and SP SP105S21. The fill material should be placed in thin layers not exceeding approximately 300 mm when loose. Oversize particles larger than 120 mm should be discarded, and each fill layer should be uniformly compacted with heavy compactors, suitable for the type of fill used. The engineered fill below the footing and floor slab should be compacted to 100% of its SPMDD, while within outside/exterior paved areas, the fill should be compacted to 98% of its SPMDD.

Full-time geotechnical inspection and quality control (by means of frequent field density and laboratory testing) should be provided by the Geotechnical Engineer. Every lift should be evaluated by a sufficient number of tests to ensure that the level of compaction is constantly achieved and the compaction procedure is applied.

## 2.8 Excavation and Groundwater Control

For the construction of the proposed structure, excavations at least about 1.9 m depth will be required. The excavations are expected to encounter mostly sandy materials and above the groundwater level.

All excavations should be carried out in accordance with the latest version of the Occupational Health and Safety Act. For the purpose of the act, the existing materials are considered as Type 3 soils above the groundwater table and Type 4 soils below the groundwater table. Temporary excavations (i.e. those that are open only for a short period) above the groundwater table may be made with side slopes not steeper than about 1H:1V, while the temporary slopes below the groundwater table have to be formed at 3H:1V unless a suitable dewatering system is installed to lower the water level below the base of the excavation.

Excavations are expected to be fairly shallow and above groundwater levels. Accordingly, no special groundwater control measures would be required. Any perched water during construction can be pumped. The exterior grade should be shaped to encourage runoff away from the structure.

It is possible that cobbles and rock pieces will be present in the overburden, particularly near the soil/bedrock interface and these obstructions may influence the speed of excavations. A Non Standard Special Provision (NSSP) should be included to alert contractors (Appendix I).

Significant bedrock excavation is not anticipated. However, if excavation of bedrock is required, it can be carried out using line drilling and pre-shearing approaches to minimize overbreak and rock shatter. Pre condition surveys should be done and monitoring carried out during any blasting, if any, to insure that MTO requirements for allowable vibrations are met.

A geotechnical qualified personnel should be on-site during the foundation installation and for fill material placement, to verify the design assumptions, and to verify the design recommendations.

May 22, 2015

### 3 CLOSURE

The comments given in this report are intended only for the guidance of design engineers. The number of boreholes required to determine the localized underground conditions between boreholes affecting construction costs, techniques, sequencing, equipment, scheduling, etc. could be greater than has been carried out for design purposes. Contractors bidding on or undertaking the works should, in this light, decide on their own investigations, as well as their own interpretations of the factual borehole results, so that they may draw their own conclusions as to how the subsurface conditions may affect them.

This Foundation Investigation and Design Report has been prepared by Silvana Micic, Ph.D., P.Eng. and Nimesh Tamrakar, M.Eng. and reviewed by TaeChul Kim, M.E.Sc., P.Eng. and Stan E. Gonsalves, M.Eng., P.Eng., Designated MTO Foundation Contact. The field investigation was conducted by Nimesh Tamrakar, M.Eng.

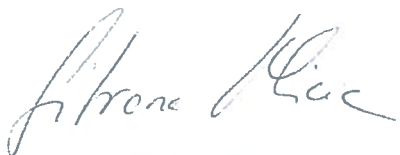
We trust that these comments provide you with sufficient information to proceed with design. Should you have any questions, please do not hesitate to contact this office.

Yours truly,

**exp Services Inc.**

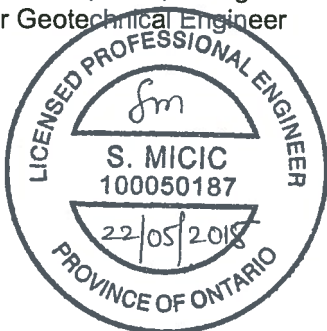


Nimesh Tamrakar, M.Eng.  
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Senior Geotechnical Engineer

Encl.



Stan E. Gonsalves, M.Eng., P.Eng.  
Principal Engineer  
Designated MTO Foundation Contact



## **Appendix A – Photographs**





Photo 1: Facing west from location of BH F15-4 (the existing salt shed)



Photo 2: Facing north from location of BH F15-4





Photo 3: Facing south from location of BH F15-2



Photo 4: Facing east from southwest corner of patrol yard (the existing sand dome structure on the left)



Photo 5: Facing north from location of BH F15-3



Photo 6: Facing east from location of BH F15-3

## **Appendix B – Drawings**



DIMENSIONS ARE IN METERS AND/OR  
MILLIMETERS UNLESS OTHERWISE SHOWN.  
STATIONS ARE IN KILOMETERS + METERS

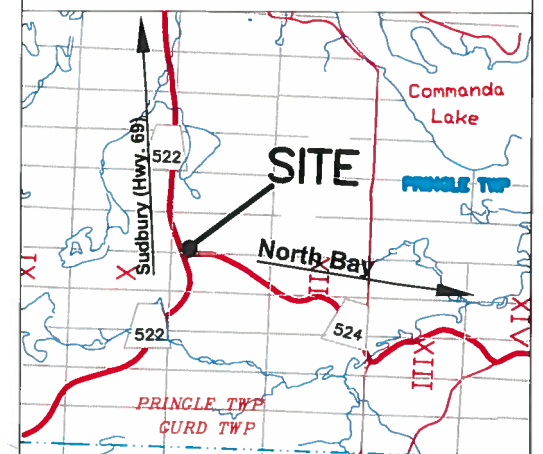


SHEET


1

exp Services Inc.

### KEY PLAN



### LEGEND

- 
 BM (Bench Mark)  
 Borehole Locations (March, 2015)  
 Approximate Historical Borehole/ DCPT Locations (July, 1964)

BH No.	APPROX. ELEV.	MTM CO-ORDINATES	
		NORTH	EAST
MTOBM 758455	317.56	5093925	292370
BH F15-1	317.65	5093895	292388
BH F15-2	317.71	5093870	292389
BH F15-3	317.19	5093857	292439
BH F15-4	317.41	5093891	292419

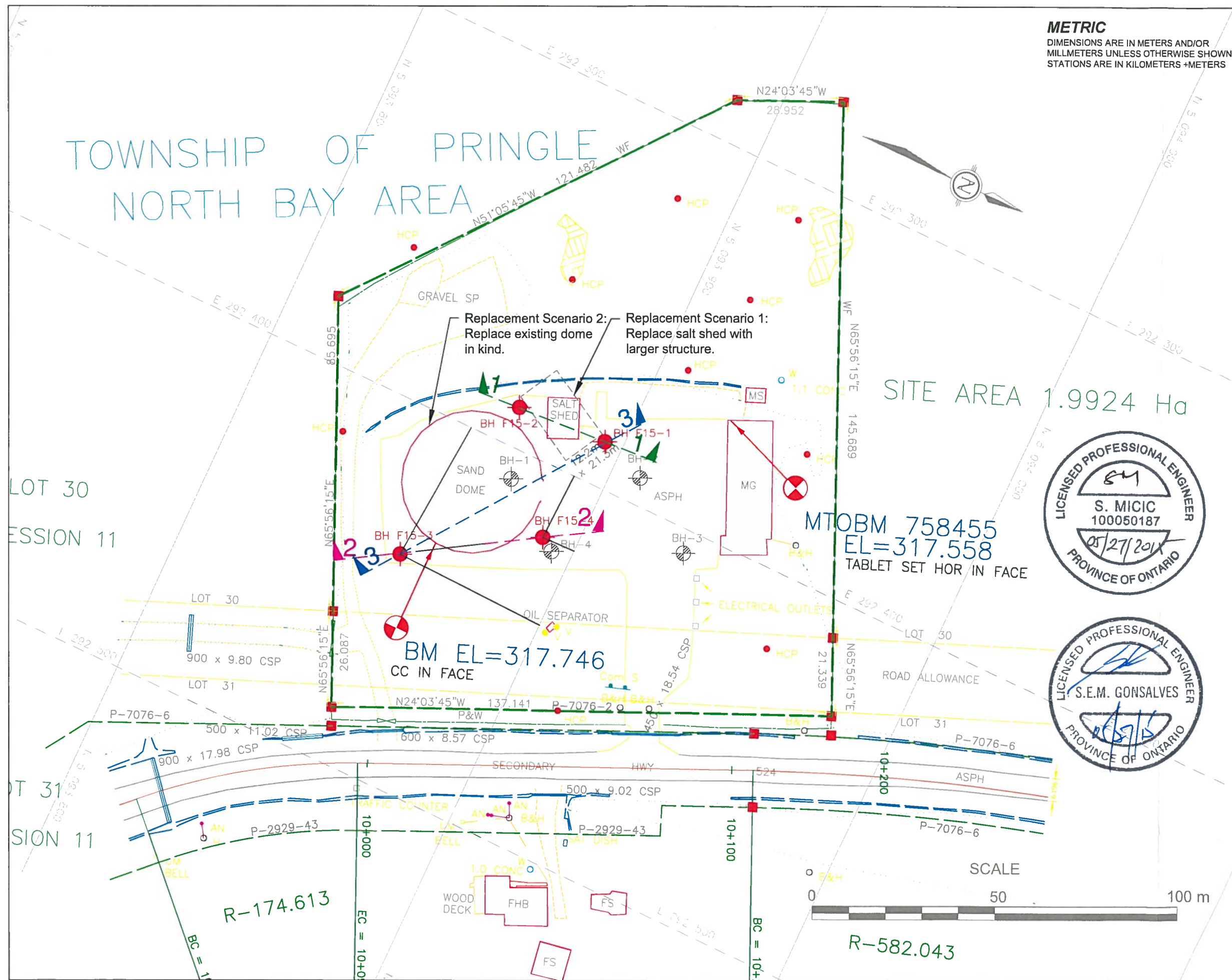
NOTE

Locations of the historical boreholes have been taken from the MTO Drawing No. 64-F-52 A and the base plan has been provided by MTO.

This drawing is for site information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office. Downsview. Information contained in the report and related documents are specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.

2015.05.22	SM	FINAL SUBMISSION	
2015.04.30	SM	SUBMISSION FOR MTO REVIEW	
DATE	BY	DESCRIPTION	
		GEOCRES NO. 31E-352	
SCALE	SEE SCALE BAR	PROJECT NO. ADM-00028245-H0	
SUBM'D SM	CHECKED SM	DATE 2015.05.21	
DRAWN NT	CHECKED SG	APPROVED SG	DWG. 01





**METRIC**  
DIMENSIONS ARE IN METERS AND/OR  
MILLIMETERS UNLESS OTHERWISE SHOWN.  
STATIONS ARE IN KILOMETERS + METERS



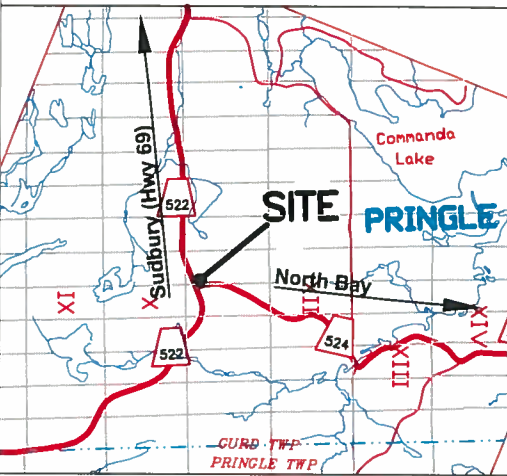
Agreement No. 5013-E-0008  
Assignment No. 7  
WO 2015-11006

**SAND AND SALT STORAGE  
STRUCTURES**  
Farley's Corner Patrol Yard  
Soil Strata

SHEET  
2

exp. **exp Services Inc.**

KEY PLAN



- Borehole Locations (March, 2015)
- Approximate Historical Borehole/ DCPT Locations (July, 1964)
- N Standard Penetration Test (Blows/0.3 m)
- Groundwater Level Measured in the Open Hole

SOIL STRATA SYMBOLS

- FILL
- SILTY SAND
- BEDROCK

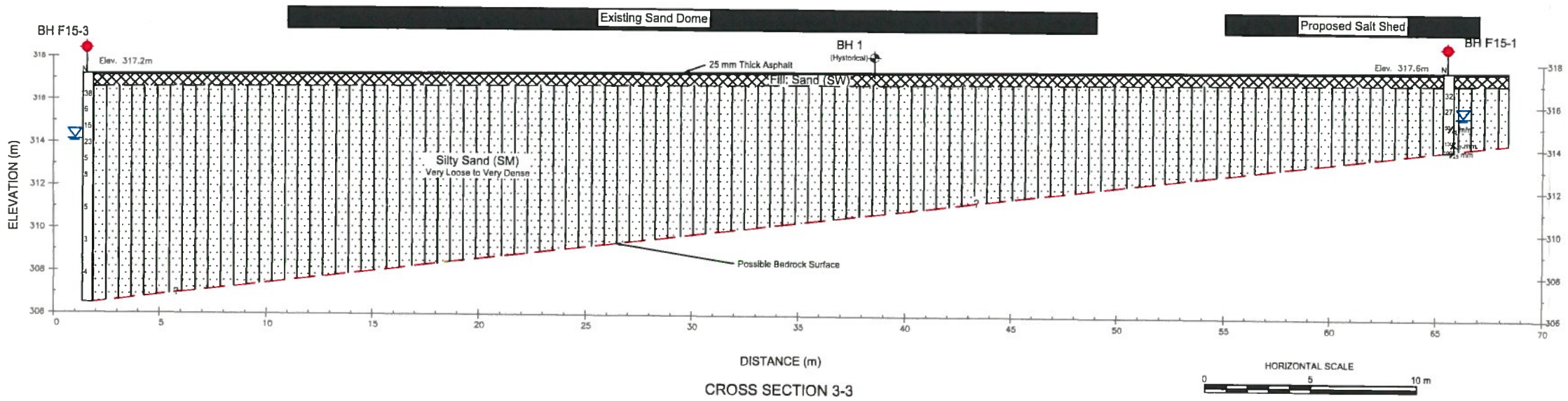
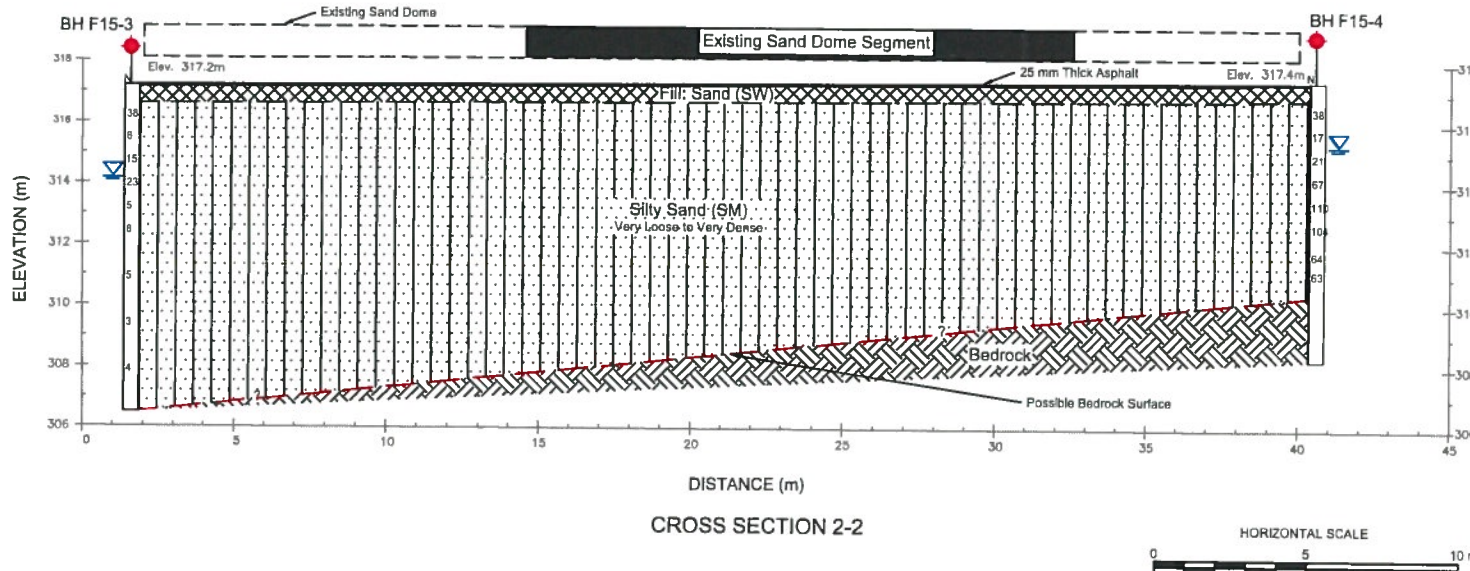
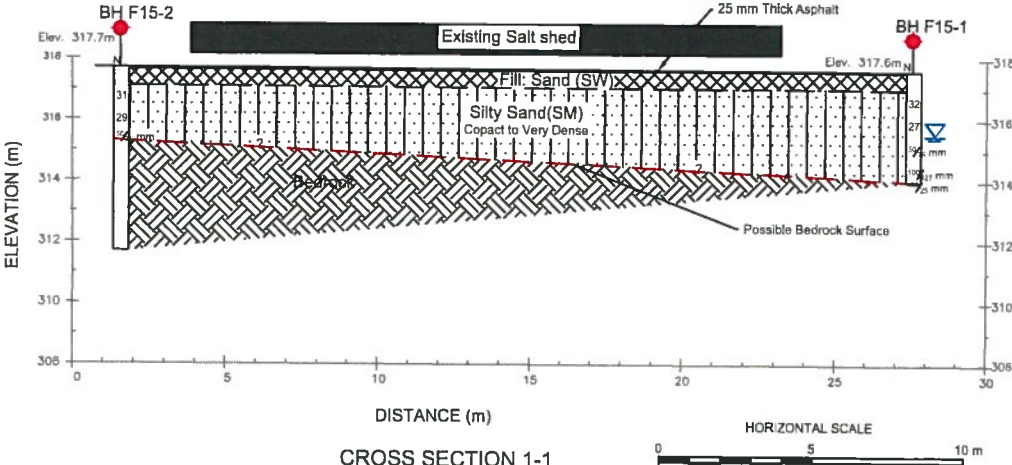
BH No.	APPROX. ELEV.	MTM CO-ORDINATES	
		NORTH	EAST
BH F15-1	317.65	5093895	292388
BH F15-2	317.71	5093870	292389
BH F15-3	317.19	5093857	292439
BH F15-4	317.41	5093891	292419

NOTE

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2015.05.22	SM	FINAL SUBMISSION
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DATE	BY	DESCRIPTION
		GEOCRES NO. 31E-352
SCALE	SEE SCALE BAR	PROJECT NO. ADM-00028245-H0
SUBM'D SM	CHECKED SM	DATE 2015.05.21
DRAWN NT	CHECKED SG	APPROVED SG DWG. 02



## **Appendix C – Borehole Logs**

# Explanation of Terms Used on Borehole Records

## SOIL DESCRIPTION

Terminology describing common soil genesis:

*Topsoil:* mixture of soil and humus capable of supporting good vegetative growth.

*Peat:* fibrous fragments of visible and invisible decayed organic matter.

*Fill:* where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc.; none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.

*Till:* the term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

Terminology describing soil structure:

*Desiccated:* having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.

*Stratified:* alternating layers of varying material or color with the layers greater than 6 mm thick.

*Laminated:* alternating layers of varying material or color with the layers less than 6 mm thick.

*Fissured:* material breaks along plane of fracture.

*Varved:* composed of regular alternating layers of silt and clay.

*Slickensided:* fracture planes appear polished or glossy, sometimes striated.

*Blocky:* cohesive soil that can be broken down into small angular lumps which resist further breakdown.

*Lensed:* inclusion of small pockets of different soil, such as small lenses of sand scattered through a mass of clay; not thickness.

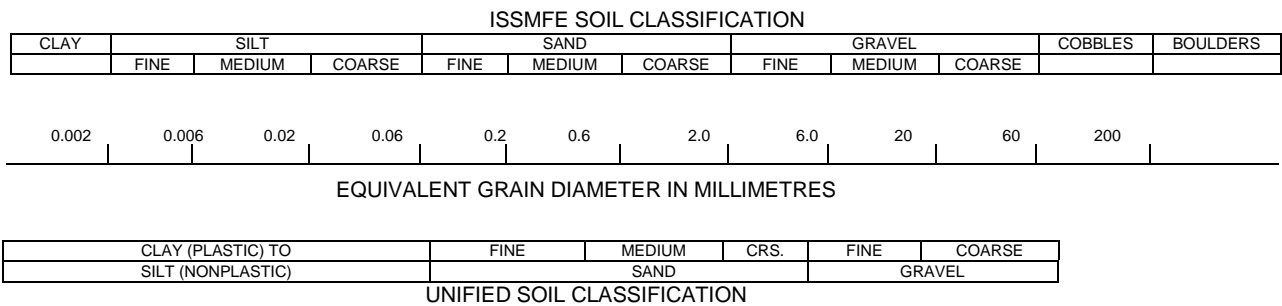
*Seam:* a thin, confined layer of soil having different particle size, texture, or color from materials above and below.

*Homogeneous:* same color and appearance throughout.

*Well Graded:* having wide range in grain sized and substantial amounts of all predominantly on grain size.

*Uniformly Graded:* predominantly on grain size.

All soil sample descriptions included in this report follow the ASTM D2487-11 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System). The system divides soils into three major categories: (1) coarse grained, (2) fine-grained, and (3) highly organic. The soil is then subdivided based on either gradation or plasticity characteristics. The system provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification. The classification excludes particles larger than 76 mm. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually in accordance with ASTM D2488-09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems. Others may use different classification systems; one such system is the ISSMFE Soil Classification.



Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present and as described below in accordance with Note 16 in ASTM D2488-09a:

Table a: Percent or Proportion of Soil, Pp

	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	$5 \leq Pp \leq 10\%$
Little	$15 \leq Pp \leq 25\%$
Some	$30 \leq Pp \leq 45\%$
Mostly	$50 \leq Pp \leq 100\%$

The standard terminology to describe cohesionless soils includes the compactness as determined by the Standard Penetration Test 'N' value:

Table b: Apparent Density of Cohesionless Soil

	'N' Value (blows/0.3 m)
Very Loose	$N < 5$
Loose	$5 \leq N < 10$
Compact	$10 \leq N < 30$
Dense	$30 \leq N < 50$
Very Dense	$50 \leq N$



The standard terminology to describe cohesive soils includes consistency, which is based on undrained shear strength as measured by insitu vane tests, penetrometer tests, unconfined compression tests or similar field and laboratory analysis, Standard Penetration Test 'N' values can also be used to provide an approximate indication of the consistency and shear strength of fine grained, cohesive soils:

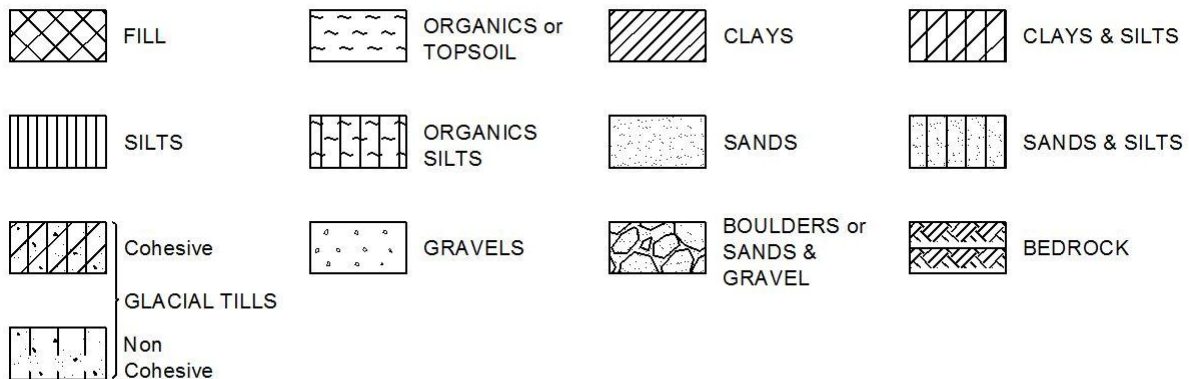
Table c: Consistency of Cohesive Soil

Consistency	Vane Shear Measurement (kPa)	'N' Value
Very Soft	<12.5	<2
Soft	12.5-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very Stiff	100-200	15-30
Hard	>200	>30

Note: 'N' Value - The Standard Penetration Test records the number of blows of a 140 pound (64kg) hammer falling 30 inches (760mm), required to drive a 2 inch (50.8mm) O.D. split spoon sampler 1 foot (305mm). For split spoon samples where full penetration is not achieved, the number of blows is reported over the sampler penetration in meters (e.g. 50/0.15).

## STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols:



## WATER LEVEL MEASUREMENT



Open Borehole or Test Pit



Monitoring Well, Piezometer or Standpipe

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

SS	Split spoon sample (obtained from the Standard Penetration Test)
WS	Wash sample
BS	Bulk sample
TW	Thin wall sample or Shelby tube
PS	Piston sample
AS	Auger sample
VT	Vane test
GS	Grab sample
HQ, NQ, etc.	Rock core samples obtained with the use of standard size diamond drilling bits

### STRESS AND STRAIN

	kPa	Pore water pressure
	1	Pore pressure ratio
	kPa	Total normal stress
	kPa	Effective normal stress
	kPa	Shear stress
	kPa	Principal stresses
	%	Linear strain
	%	Principal strains
E	kPa	Modulus of linear deformation
G	kPa	Modulus of shear deformation
	1	Coefficient of friction

### MECHANICAL PROPERTIES OF SOIL

	$\text{kPa}^{-1}$	Coefficient of volume change
	1	Compression index
	1	Swelling index
	1	Recompression index
	$\text{m}^2/\text{s}$	Coefficient of consolidation
H	m	Drainage path
$T_v$	1	Time factor
U	%	Degree of consolidation
	kPa	Effective overburden pressure
	kPa	Preconsolidation pressure
	kPa	Shear strength
	kPa	Effective cohesion intercept
		Effective angle of internal friction
	kPa	Apparent cohesion intercept
		Apparent angle of internal friction
	kPa	Residual shear strength
	kPa	Remoulded shear strength
	1	Sensitivity = $c$

### PHYSICAL PROPERTIES OF SOIL

	$\text{kg}/\text{m}^3$	Density of solid particles
	$\text{kN}/\text{m}^3$	Unit weight of solid particles
	$\text{kg}/\text{m}^3$	Density of water
	$\text{kN}/\text{m}^3$	Unit weight of water
	$\text{kg}/\text{m}^3$	Density of soil
	$\text{kN}/\text{m}^3$	Unit weight of soil
	$\text{kg}/\text{m}^3$	Density of dry soil
	$\text{kN}/\text{m}^3$	Unit weight of dry soil
	$\text{kg}/\text{m}^3$	Density of saturated soil
	$\text{kN}/\text{m}^3$	Unit weight of saturated soil
	$\text{kg}/\text{m}^3$	Density of submerged soil
	$\text{kN}/\text{m}^3$	Unit weight of submerged soil
	1, %	Void ratio
	1, %	Porosity
		Water content
	%	Degree of saturation
	%	Liquid limit
	%	Plastic limit
	%	Shrinkage limit
	%	Plasticity index = $(W$
	%	Liquidity index = $(W$
	%	Consistency index = $(W$
	1, %	Void ratio in loosest state
	1, %	Void ratio in densest state
	1	Density index = $(e$
D	mm	Grain diameter
	mm	N percent - diameter
	1	Uniformity coefficient
h	m	Hydraulic head or potential
q	$\text{m}^3/\text{s}$	Rate of discharge
v	m/s	Discharge velocity
i	1	Hydraulic gradient
k	m/s	Hydraulic conductivity
j	$\text{kN}/\text{m}^3$	Seepage force

Brampton, Ontario

## RECORD OF BOREHOLE No BH F15-1

1 OF 1

METRIC

W. P. WO 2015-11006

LOCATION Farley's Corner Patrol Yard, MTM Z10 292388m E 5093895m N

ORIGINATED BY NT

DIST Hwy 524



BOREHOLE TYPE CME-55, Hollow stem auger drill, not cased

COMPILED BY ET

DATUM BM ELEV. 317.558m MTM Z10 292370m E 5093925m N

DATE 2015/03/24 - 2015/03/24

CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH: Cu, KPa ○ UNCONFINED + FIELD VANE × QUICK TRIAXIAL LAB VANE													WATER CONTENT (%)
								20	40	60	80	100	20	40	60		80	100	10	20	30
317.6	Ground Surface																				
317.0	ASPHALT 25 mm thickness FILL: SAND (SW) Sand with few silt, few gravel, blackish brown, moist		1	AS1													○				
317.0	SILTY SAND (SM) few gravel, few to little silt, brown, moist, compact to very dense		2	SS2	32												○				
			3	SS3	27													○			
	- Becoming very dense		4	SS4	50/ 76mm													○			
			5	SS5	100/ 127mm													○			
314.0	Auger/split spoon refusal- Possible Bedrock END OF BOREHOLE		6	SS6	100/ 25mm																
3.7	NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before used by others. 3. Groundwater level was measured in the open hole																				

OPG\_EXP RECORD OF BOREHOLE 5013-E-0008 ASSIG. 7(FARLEY'S CORNER)- BH LOGS.GPJ ONTARIO MOT.GDT 5/20/15

Brampton, Ontario

## RECORD OF BOREHOLE No BH F15-2

1 OF 1

METRIC

W. P. WO 2015-11006

LOCATION Farley's Corner Patrol Yard, MTM Z10 292389m E 5093870m N

ORIGINATED BY NT

DIST Hwy 524

BOREHOLE TYPE CME-55, Hollow stem auger/ diamond drill, cased hole

COMPILED BY ET

DATUM BM ELEV. 317.558m MTM Z10 292370m E 5093925m N

DATE 2015/03/23 - 2015/03/23

CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
317.7	Ground Surface																
317.0	ASPHALT 25 mm thickness		1	AS1													8 82 (10)
317.1	FILL: SAND (SW) few gravel, few silt, blackish brown, moist																
0.6			2	SS2	31		317										
	SILTY SAND (SM) few gravel, little silt, brown, moist, frozen, compact to very dense		3	SS3	29		316										8 67 (25)
			4	SS4	50/76.2mm												
315.3																	
2.4	BEDROCK - Granite Gneiss		5	NQ			315										
	Length (m) RQD (%)		6	NQ													
	Run 1 0.33 61.0																
	Run 2 0.64 72.0																
	Run 3 1.04 90.0		7	NQ			314										
	Run 4 1.52 93.0																
			8	NQ			313										
311.7							312										
6.0	END OF BOREHOLE																
	NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before used by others. 3. No groundwater level was measured since washboring techniques was used to advance borehole																

OPG\_EXP RECORD OF BOREHOLE 5013-E-0008 ASSIG. 7(FARLEY'S CORNER)-BH LOGS.GPJ ONTARIO MOT.GDT 5/20/15

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

Brampton, Ontario

## RECORD OF BOREHOLE No BH F15-3

1 OF 1

METRIC

W. P. WO 2015-11006

LOCATION Farley's Corner Patrol Yard, MTM Z10 292439m E 5093857m N

ORIGINATED BY NT

DIST Hwy 524

BOREHOLE TYPE CME-55, Hollow stem auger drill, not cased

COMPILED BY ET

DATUM BM ELEV. 317.558m MTM Z10 292370m E 5093925m N

DATE 2015/03/23 - 2015/03/23

CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH: Cu, KPa							WATER CONTENT (%)
								○ UNCONFINED × QUICK TRIAXIAL	+ FIELD VANE LAB VANE						
317.2	Ground Surface							20 40 60 80 100		10 20 30				GR SA SI CL	
317.0	ASPHALT 25 mm thickness		1	AS1			317								
316.6	FILL: SAND (SW) Brown sand, with little silt and clay and gravel, moist to frozen														
0.6	SILTY SAND (SM) trace to few gravel, few to little silt, trace clay, reddish to greyish brown, moist to wet, very loost to dense		2	SS2	38		316							0 76 (24)	
			3	SS3	6		315								
			4	SS4	15		314							7 84 (9)	
	-Becoming fine		5	SS5	23		313								
			6	SS6	5		312								
			7	SS7	8		311							0 86 13 1	
			8	SS8	5		310								
			9	SS9	3		309								
	-Becoming more silty		10	SS10	4		308							0 86 (14)	
307.4	END OF SAMPLING						307								
9.8															
306.5	Refusal on DCPT (Possible Bedrock) END OF BOREHOLE														
10.7	NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before used by others. 3. Groundwater level was measured in open hole														

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

OPG\_EXP RECORD OF BOREHOLE 5013-E-0008 ASSIG. 7(FARLEY'S CORNER)-BH LOGS.GPJ ONTARIO MOT.GDT 5/20/15

Brampton, Ontario

## RECORD OF BOREHOLE No BH F15-4

1 OF 1

METRIC

W. P. WO 2015-11006

LOCATION Farley's Corner Patrol Yard, MTM Z10 292419m E 5093891m N

ORIGINATED BY NT

DIST Hwy 524

BOREHOLE TYPE CME-55, Hollow stem auger/ diamond drill, cased hole

COMPILED BY ET

DATUM BM ELEV. 317.558m MTM Z10 292370m E 5093925m N

DATE 2015/03/24 - 2015/03/24

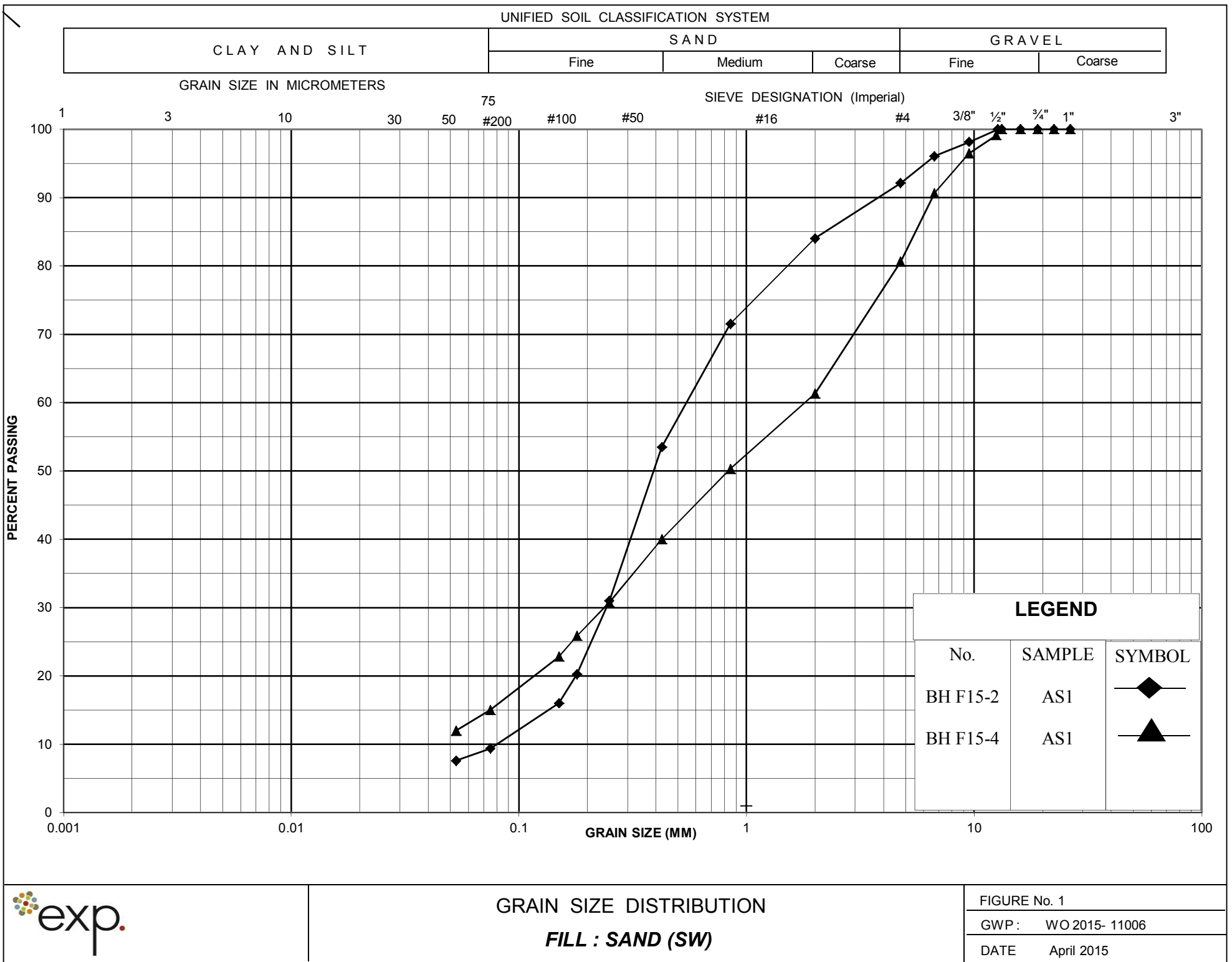
CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
317.4	Ground Surface																
317.0	ASPHALT 25 mm thickness		1	AS1			317										19 66 (15)
316.8	FILL: SAND (SW) little gravel, little silt, brown, moist, frozen																
0.6	Silty Sand (SM) trace to little gravel, few to little silt, blackish brown to brown, moist to wet, compact to very dense		2	SS2	38		316										
			3	SS3	17												3 89 (8)
			4	SS4	21		315										
			5	SS5	67		314										
			6	SS6	110		313										2 87 (11)
			7	SS7	104												
			8	SS8	64		312										19 63 (18)
			9	SS9	63		311										
310.4																	
7.0	BEDROCK - Granite Gneiss		10	NQ			310										
	Length (m) RQD (%)																
	Run 1 0.58 96.0																
	Run 2 1.52 100.0																
			11	NQ			309										
308.3																	
9.1	END OF BOREHOLE																
	NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before used by others. 3. Groundwater level was measured in the open auger hole																

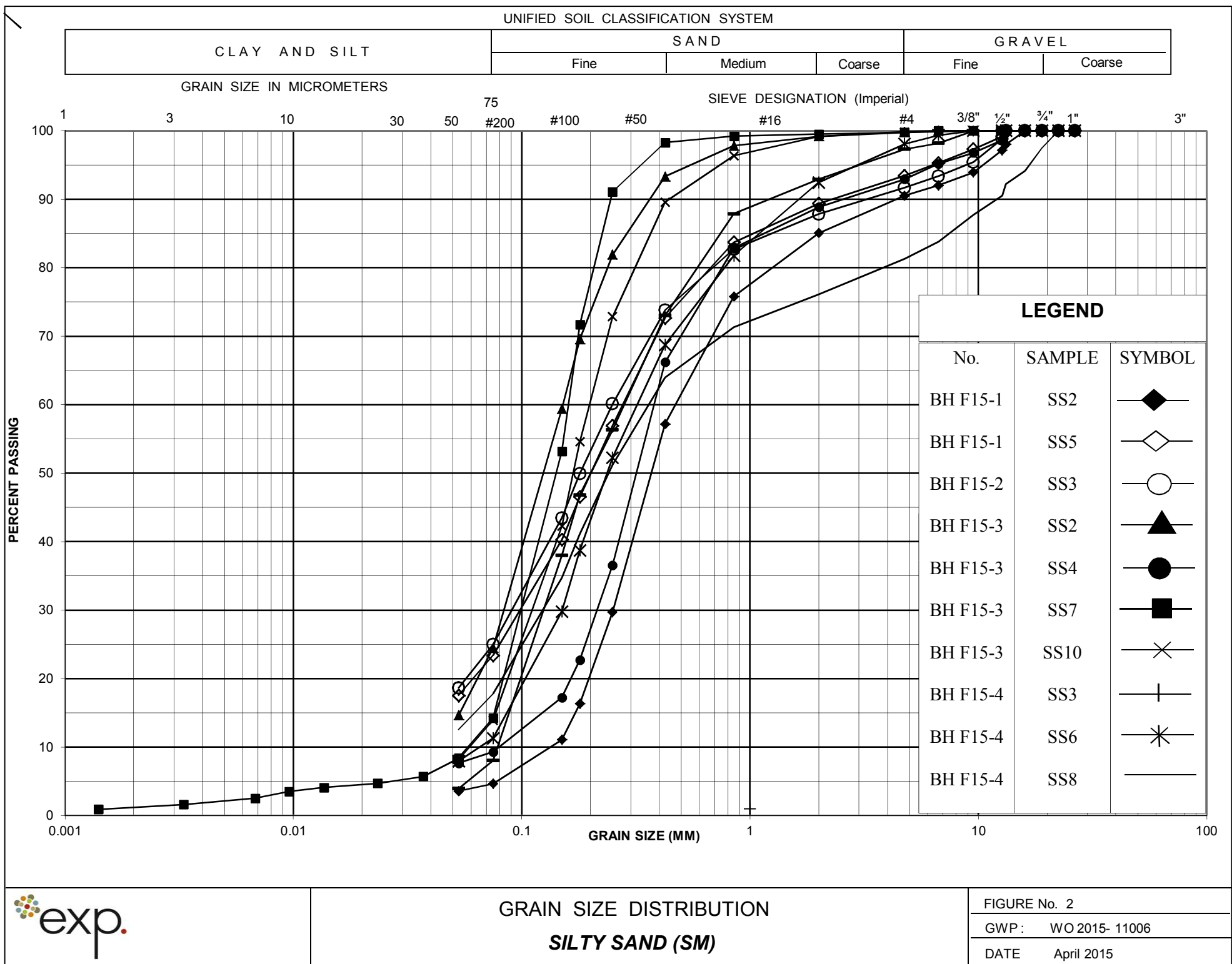
OPG\_EXP RECORD OF BOREHOLE 5013-E-0008 ASSIG. 7(FARLEY'S CORNER)-BH LOGS.GPJ ONTARIO MOT.GDT 5/20/15

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

## **Appendix D – Laboratory Data**







## **Appendix E – Rock Core Photographs**

Project NO: ADM 00028245-H0  
BH NO: 2      Run No: 1, 2 & 3  
Sample Depth: 2.4 m to 4.41 m  
Elevation: 315.3 m to 313.3 m  
Description: Granitic Gneiss  
Date: March 23, 2015



Figure E1. Rock cores from BH F15-2 - from Elev. 315.3 m to 313.3 m

Project NO: ADM 00028245-H0  
BH NO: 2      Run No: 4  
Sample Depth: 4.41 m to 5.93 m  
Elevation: 313.3 m to 311.7 m  
Description: Granitic Gneiss  
Date: March 23, 2015



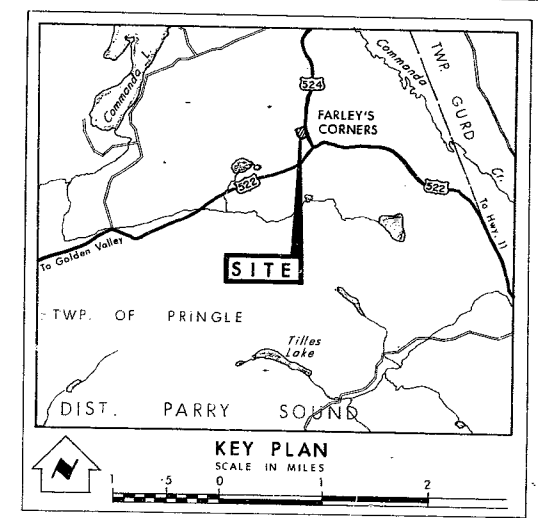
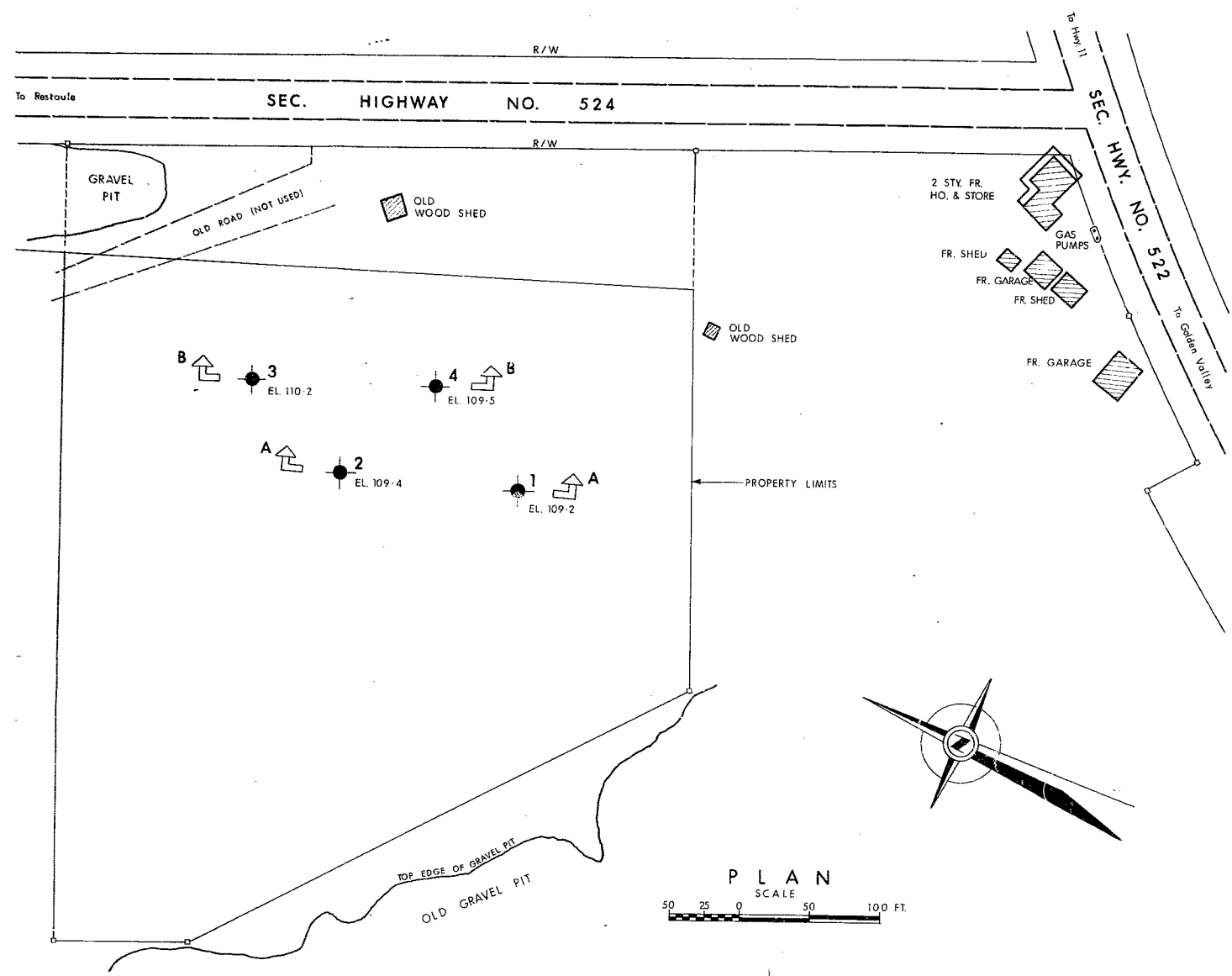
Figure E2. Rock cores from BH F15-2 - from Elev. 313.3 m to 311.7 m

Project NO: ADM 00028245-H0  
BH NO: 4                      Run No: 1 & 2  
Sample Depth: 7.0 m to 9.1 m  
Elevation: 310.4 m to 308.3 m  
Description: Granitic Gneiss  
Date: March 24, 2015



Figure E3. Rock cores from BH F15-4 – from Elev. 310.4 m to 308.3 m

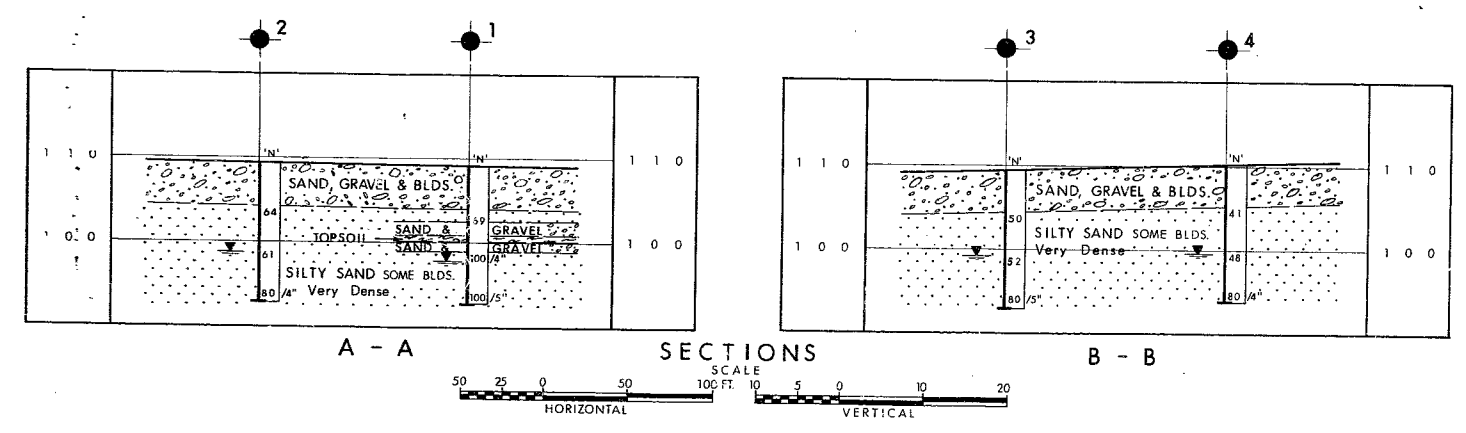
## **Appendix F – Record of Historical Geotechnical Data**



- LEGEND**
- Bore Hole
  - ▽ Water Levels established at time of field investigation. (July 1964)

**NOTE**

THE BOUNDARIES BETWEEN SOIL STRATA HAVE BEEN ESTABLISHED ONLY AT BORE HOLE LOCATIONS. BETWEEN BORE HOLES THE BOUNDARIES ARE ASSUMED FROM GEOLOGICAL EVIDENCE AND MAY BE SUBJECT TO CONSIDERABLE ERROR.



DEPARTMENT OF HIGHWAYS - ONTARIO			
MATERIALS & RESEARCH SECTION			
FARLEY'S CORNERS PATROL YARD			
SHOWING POSITIONS & ELEVATIONS OF HOLES			
HWY. 524	DISTRICT 13	COUNTY PARRY SOUND	
TOWNSHIP PRINGLE	LOT 30	CON. II	
LOCATION FARLEY'S CORNERS			
DRAWN BY: D.M.	CHECKED BY: [Signature]	W.P. [Signature]	
DATE 30 JULY 1964	APPROVED BY: [Signature]	DRAWING NO. 64-F-52 A	
SCALE AS SHOWN			

REF. NO. P-7076

## **Appendix G – Results of Stability Analyses**



May 22, 2015

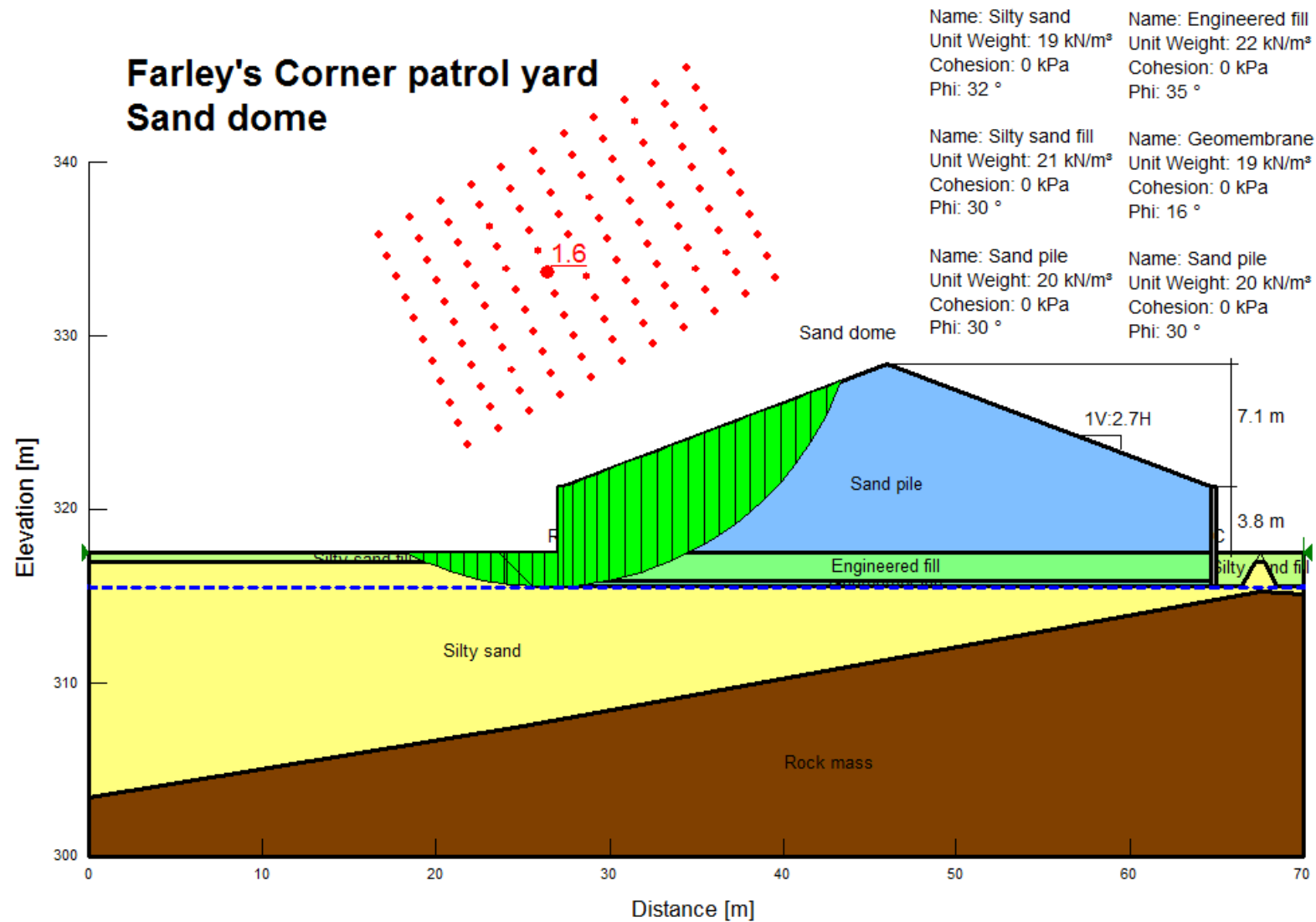


Figure G1. Results of global stability analyses on the proposed sand dome structure



May 22, 2015

## Farley's Corner patrol yard Salt building

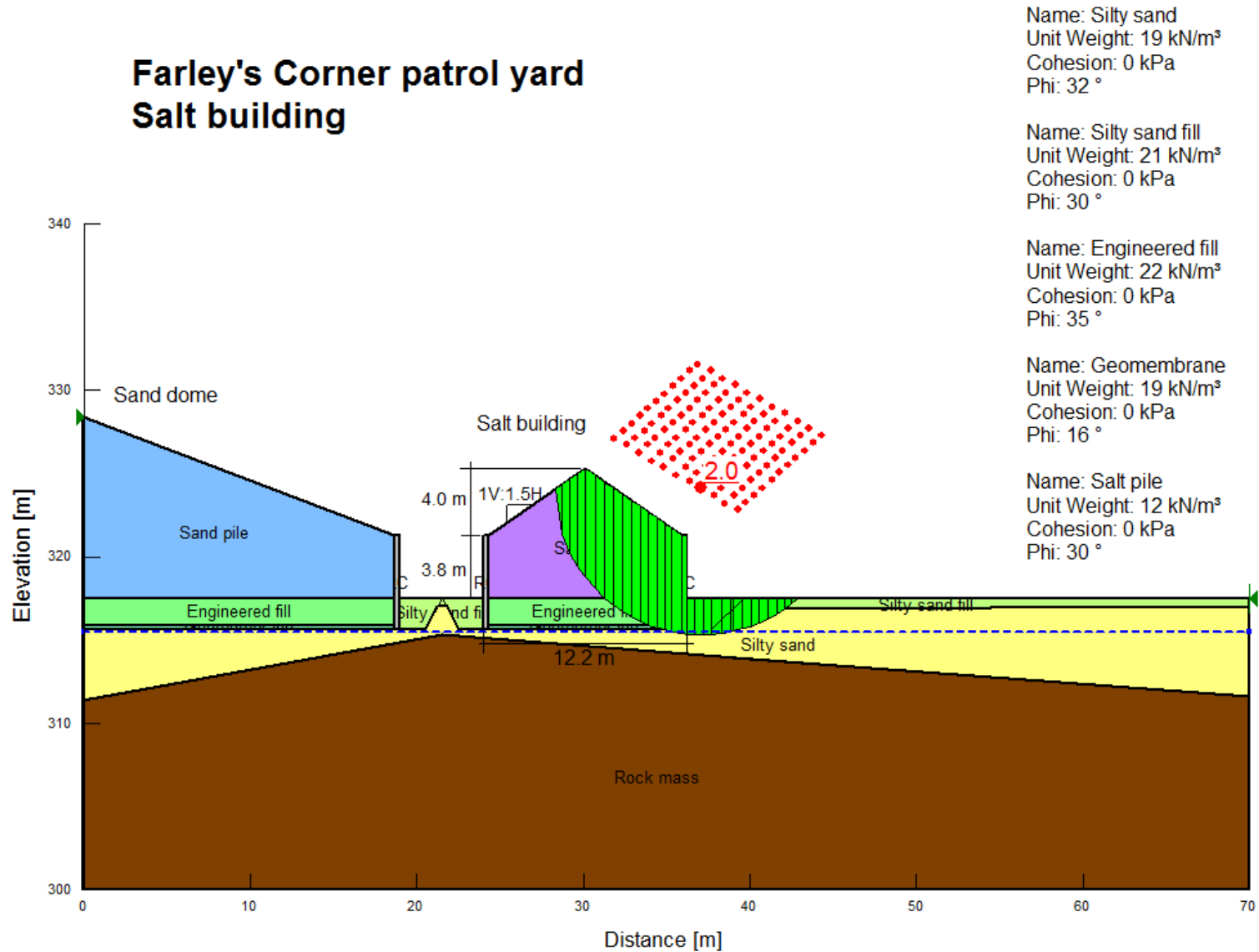


Figure G2. Results of global stability analyses on the proposed salt shed

## **Appendix H – Results of Settlement Analyses**

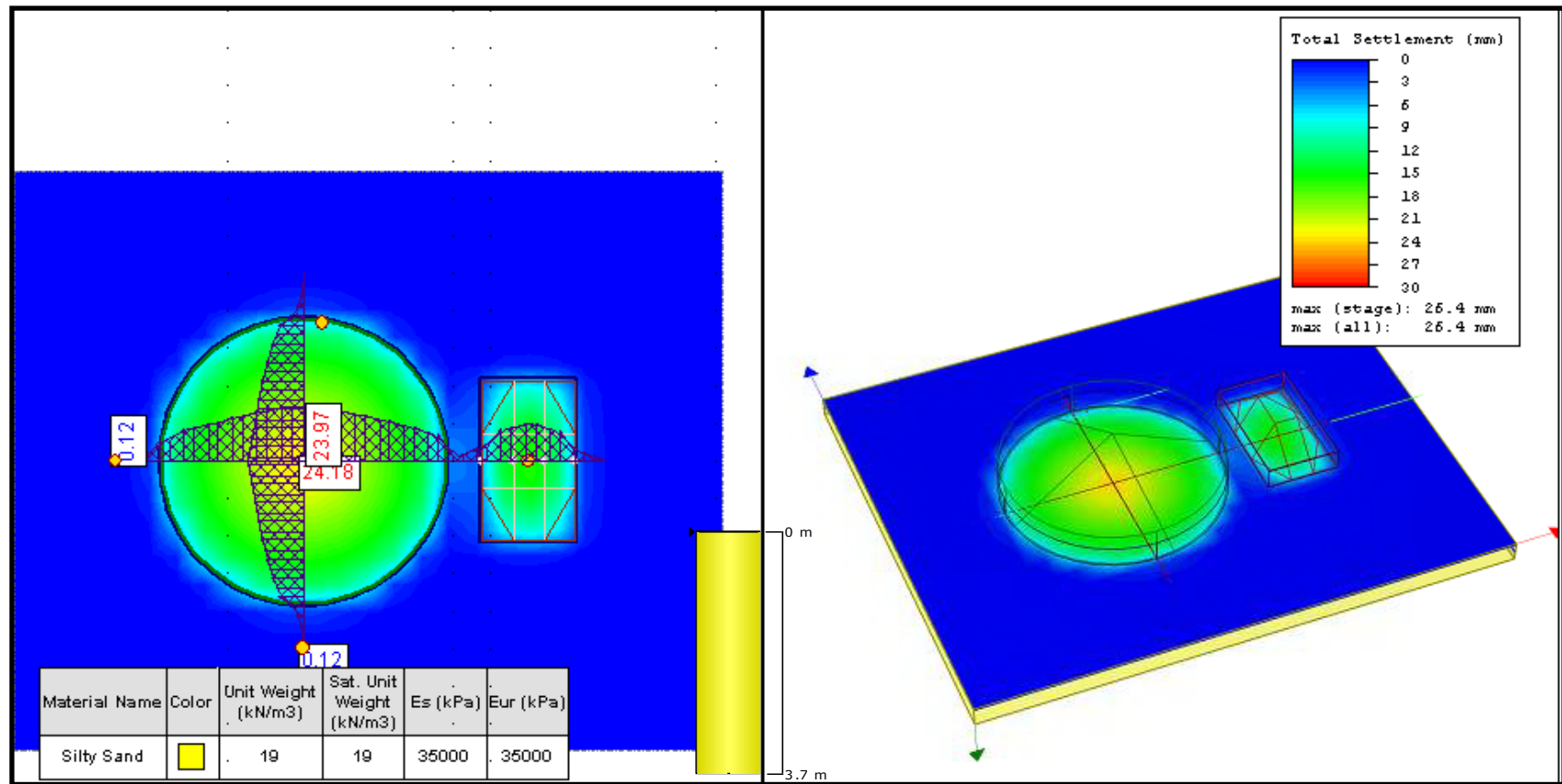


Figure H1. Settle 3D result for footing directly putting on the 3.7 m thick silty sand layer

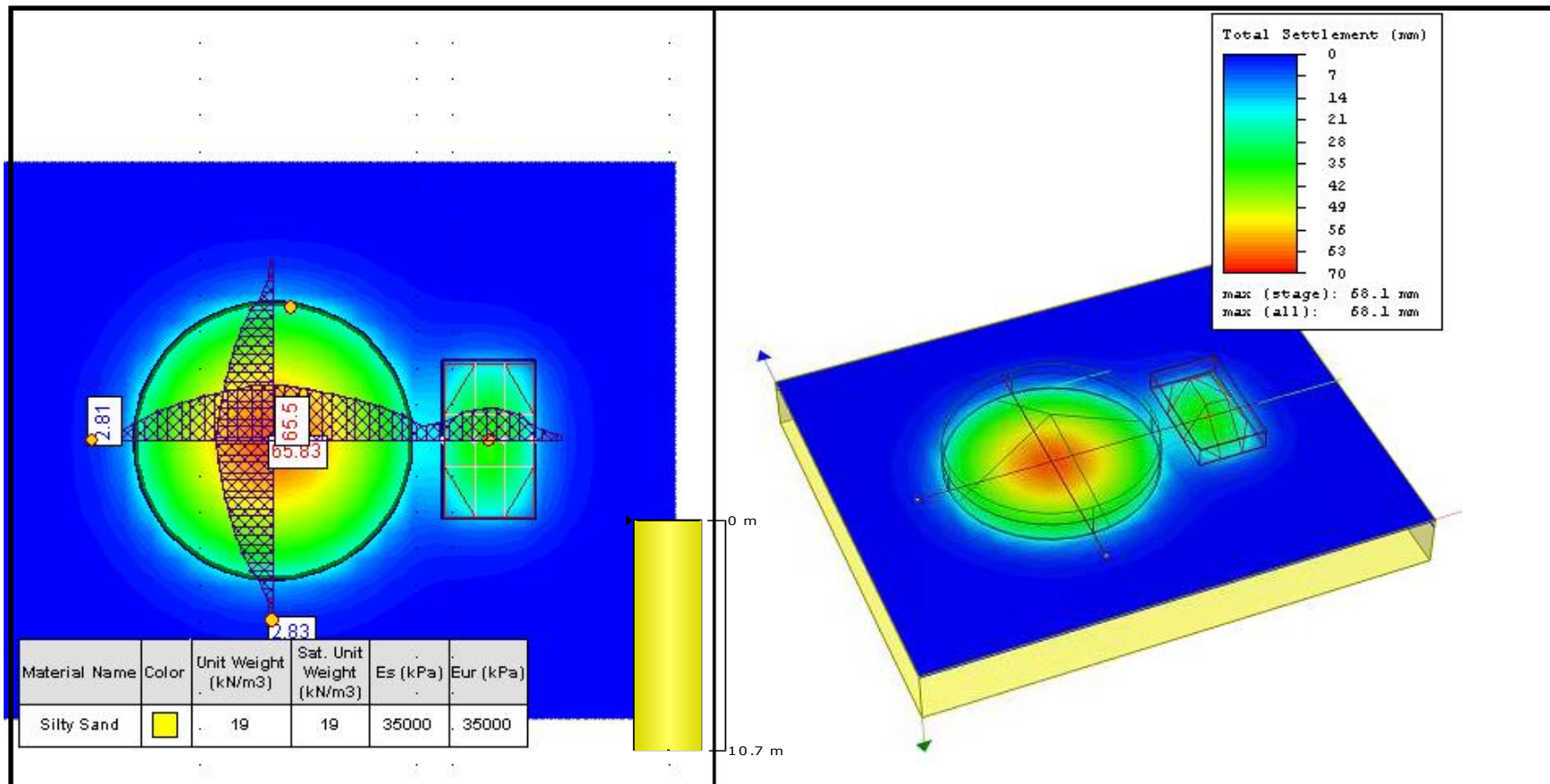


Figure H2. Settle 3D result for footing directly putting on the 10.7 m thick silty sand layer

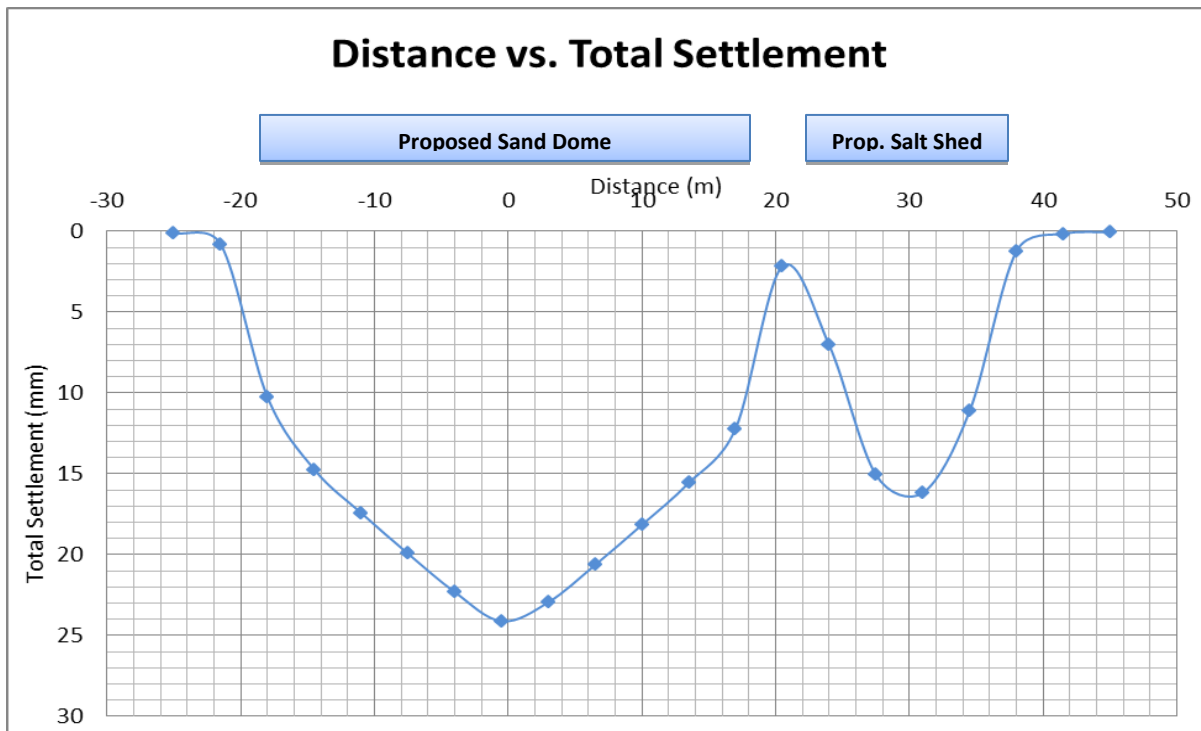


Figure H3. Settlement below footings placed on a 3.7 m thick silty sand layer

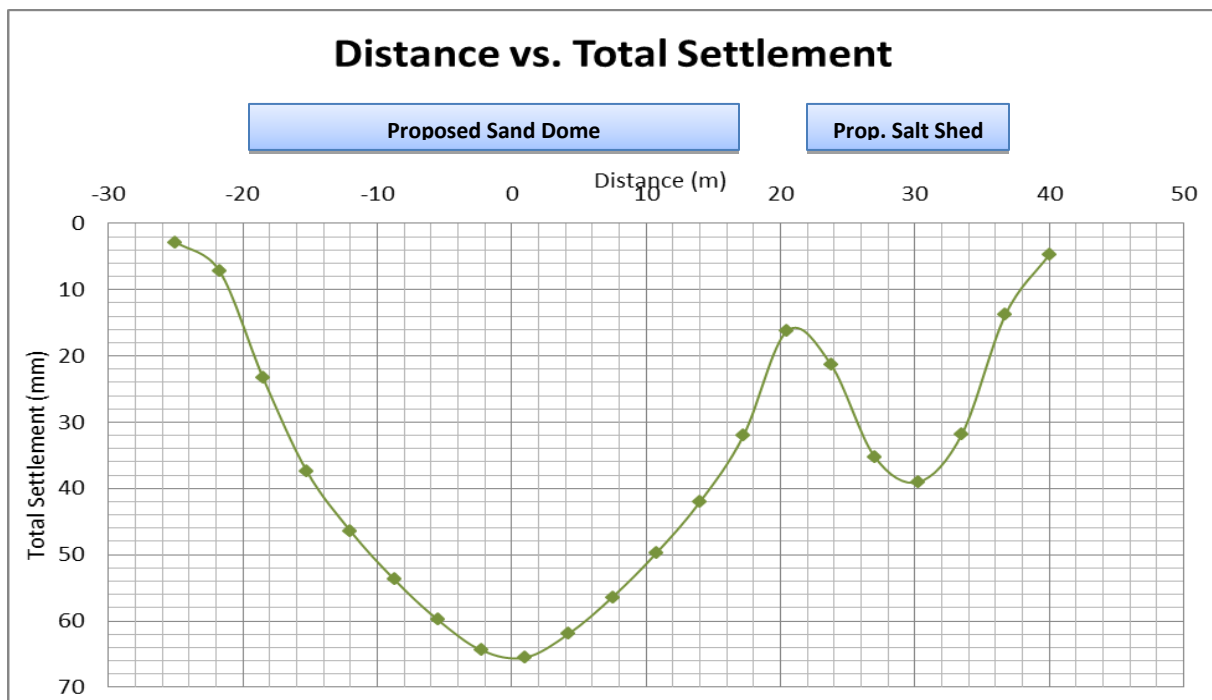


Figure H4. Settlement below footings placed on a 10.7 m thick silty sand layer

## **Appendix I – Non-Standard Special Provision**

## **NSSP FOR SLOPINIG ROCK AND COBBLES AND ROCK PIECE OBSTRUCTIONS**

### **Scope of Work**

The Contractor should be aware that there is sloping bedrock in the area. The bedrock was encountered within the upper 2.5 m of the ground surface. The overburden soils at the site consist of sand fill and native silty sand materials which may contain cobbles and rock fragments especially near the bedrock interface.

Appropriate equipment and procedures will be required to penetrate/remove cobbles and fractured bedrock that are encountered during excavation.

### **Basis of Payment**

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.