



## **FINAL REPORT**

### **FOUNDATION INVESTIGATION REPORT**

**New Storage Structure at McKerrow Patrol Yard, Hwy 17, Township of Baldwin,  
Sudbury Area**

**Agreement No. 5013-E-0008**

**Assignment No. 7**

**WO 2015-11006**

#### **Prepared for:**

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May 22, 2015



# Ministry of Transportation

## Foundation Investigation Report

Agreement No. 5013-E-0008

Assignment No. 7

WO 2015-11006

Geocres No. 411-332

### Type of Document:

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### Project Name:

New Storage Structure at McKerrow Patrol Yard, Hwy 17, Township of Baldwin, Sudbury Area

### Project Number:

ADM-00028245-H0

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05/22/2015



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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 the McKerrow Patrol Yard, which is located on Hwy 17 in the Township of Baldwin, Sudbury 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 location of the new storage structure with dimensions of 24.4 m x 42.7 m is specified in the TOR (site map PLAN H-332-17-1).

The purpose of the investigation is to establish the existing subsurface conditions at the proposed location of the patrol yard structure 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 geotechnical investigation and laboratory testing are included in this report. The report has been prepared specifically and solely for the projects described in the report. A hydrogeological assessment at the site was not in a scope of this investigation.

## 1.2 Site Description and Geological Setting

### 1.2.1 Site Description

The McKerrow Patrol Yard is located on Hwy 17 in the Township of Baldwin, Sudbury area, approximately 3 km east of the Hwy 6 and Hwy 17 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, salt sheds, and sand/gravel stockpiles. The existing sand dome of about 31 m diameter is located approximately 55 m northeast of the existing MTO benchmark BM (Elev. 209.060 m) as marked on the site map, PLAN H-332-17-1, provided by MTO and shown on Drawing 1 in Appendix B. The existing salt sheds are located approximately 2 m west of the existing sand dome. The sand stockpile is about 28 m in diameter and is located approximately 8 m east of the sand dome, while the gravel stockpile is located about 25 m northeast of the sand dome. The site plan is as shown on Drawing 1 in Appendix B.

### 1.2.2 Geological Setting

According to Bedrock Geology of Ontario Map 2544 (Ministry of Northern Development and Mines, Ontario), the bedrock underlying the site is from the Mesoproterozoic geologic era (approximately 0.57 to 1.6 billion years old) and falls under Central Gneiss Belt which consists of migmatitic rocks and gneisses of uncertain protolith commonly layered biotite gneisses and migmatites and locally includes quartzofeldspathic gneisses, orthogneisses, and paragneisses.



According to Surficial Geology Map by the Province of Ontario's Ministry of Northern Development, Mines and Forestry (MNDMF), the surficial deposit in this area is a discontinuous layer of drift Precambrian deposit.

## 1.3 Investigation Procedures

### 1.3.1 Field Work

The current field investigation was carried out during March 16 and March 17, 2015. The field program consisted of drilling four (4) sampled boreholes (BH M15-1, BH M15-2, BH M15-3, and BH M15-4) and four (4) dynamic cone penetration test (DCPT) adjacent to each sampled boreholes. The boreholes were initially planned to be drilled at the each corner of the proposed building. However, the borehole locations were dictated by accessibility to these locations at the site at the time of drilling. The existing sand dome obstructed the drilling of BH M15-4, so that borehole was drilled at the best accessible location adjacent to the initially proposed location of that borehole. Drawing 1 in Appendix B shows the locations of four boreholes. The depths of the boreholes were around 10 m.

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 southwest of the sand dome (MTO BM Elevation 209.060 m), as shown in the site map provided by MTO (PLAN H-332-17-1).

The boreholes were advanced using a track-mounted CME 55 drill rig, equipped with continuous flight hollow stem augers/diamond drill with NW casing. All borehole drilling/sampling were operated by a specialist drilling contractor, LandCore Drilling Co. Ltd.

During the drilling operation, soil samples were obtained using a 51 mm outside diameter split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586), 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. All boreholes were encountered with sand heaving at a depth ranging from 2.1 m to 3.0 m. In this case, wash boring was utilized to facilitate taking representative samples at designated elevation with reasonable accuracy. A dynamic cone penetration test (DCPT) was performed in the vicinity of each borehole to assess relative density of the soil.

At each borehole, the groundwater level measurements were carried out in the open auger holes before starting of wash boring. The measured groundwater levels 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 a member 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 April 1962 related to this site and named "Foundation Investigation Report for Proposed D.H.O. Patrol Yard at Hwy 17, 1.5 Miles West of McKerrow, District of Sudbury, District No.17" (GEOCRES 41100-020) is provided by MTO. The locations of the historical boreholes drilled in April 1962 are shown on Drawing 1 in Appendix B and the soil stratigraphy assessed during that investigation is shown on the attached drawing in Appendix E.

## 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 storage structure alignments 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 silty sand fill/ gravelly sand fill to silt, underlain by sand deposits and followed by silty sand deposits. A brief summary of the soil and groundwater conditions encountered in the boreholes is provided below.



### 1.4.1 Fill: Gravelly Sand/Silty Sand

Gravelly sand/silty sand fill was encountered below 25 mm thick layer of asphalt in BH M15-1 and BH M15-4 and at ground surface in BH M15-2. The thickness of gravelly sand/ silty sand fill layer ranged from 0.8 m to 1.5 m extending from Elev. 208.4 m to 206.5 m.

This layer consists of fine gravel, fine to coarse sand, few to some silt. The material is blackish grey to brown in color and moist. The SPT “N” values within this layer is about 30 blows per 300 mm of penetration, suggesting compact 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:

- 5.3% to 30.8%

Grain size distribution:

- 30% gravel;
- 63% sand; and
- 7% silt and clay.

The results of moisture content and grain size distribution tests are provided on the record of the 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 Silt

A layer of silt was encountered at the ground surface in BH M15-3 and below gravelly sand fill layer in BH M15-2 and BH M15-4. The thickness of silt layer ranged from 0.7 m to 1.5 m extending from Elev. 207.8 m to 206.8 m. .

This layer consists of silt, trace gravel, trace to few sand, and trace to few clay. At BH M15-3, the silt layer contains trace of organics. It is grey and brown in color and moist. At BH M15-4 the silt layer was frozen. The SPT “N” values within this layer ranged from 21 and 55 blows per 300 mm of penetration, suggesting compact to very dense relative density of this layer, but more typically compact to dense condition.

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

Moisture content:



- 17.4% to 23.4%

Grain size distribution:

- 1% gravel
- 4% to 7% sand;
- 89% to 91% silt; and
- 2% to 6% clay.

The results of moisture content and grain size distribution tests are provided on the record of the 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 Sand

A layer of sand was encountered below silty sand fill layer in BH M15-1 and below silt layer in BH M15-2, BH M15-3 and BH M15-4. The thickness of sand layer ranged from 3.8 m to 8.3 m extending from Elev. 207.1 m to 198.3 m. Sampling of BH M15-1 and BH M15-4 were terminated within this layer.

This layer consists of medium to fine sand, trace gravel, and trace to little silt. It is reddish to greyish brown in color and wet. The SPT “N” values within this layer typically ranged from 2 to 18 blows per 300 mm of penetration. One SPT “N” value of 34 blows per 300 mm penetration was encountered in BH M15-3. SPT “N” values measured within this layer suggests that the sand layer is very loose to compact in relative density.

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

Moisture content:

- 20.2% to 30.8%

Grain size distribution:

- 1% gravel
- 85% to 99% sand;
- 1% to 15% silt and clay

The results of moisture content and grain size distribution tests are provided on the record of the borehole sheets in Appendix C. The results of the grain size distribution tests are also provided on Figure 3 in Appendix D.



#### 1.4.4 Silty Sand

A layer of silty sand was encountered below sand layer in BH M15-2 and BH M15-3. The thickness of silty sand layer ranged from 3.7 m to 5.2 m extending from Elev. 203.3 m to 198.1 m. Sampling of BH M15-2 and BH M15-3 were terminated within this layer.

This layer consists of sand and trace to some silt. It is greyish brown in color, wet. The SPT "N" values within this layer ranged from 2 to 10 blows per 300 mm of penetration, suggesting very loose to compact 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:

- 22.3% to 29.2%

Grain size distribution:

- 66% to 99% sand;
- 1% to 34% silt and clay

The results of moisture content and grain size distribution tests are provided on the record of the borehole sheets in Appendix C. The results of the grain size distribution tests are also provided on Figure 4 in Appendix D.

### 1.5 Groundwater Conditions

Information regarding groundwater levels at the site was obtained measuring the water levels in the open auger holes before starting wash boring to advance the boreholes. The groundwater levels measured in the boreholes are shown on Table 1.1 and borehole logs. Water levels measured in open holes might not be stabilized due to short term observation.

Table 1.1 Groundwater levels at the site

Borehole No.	Date of Drilling	Groundwater Level	
		Depth, (m)	Elevation, (m)
BH-1	03/16/2015	1.2	206.85
BH-2	03/16/2015	1.2	207.1
BH-3	03/16/2015	1.2	206.6
BH-4	03/16/2015	0.9	207.47



May 22, 2015

## 1.6 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.

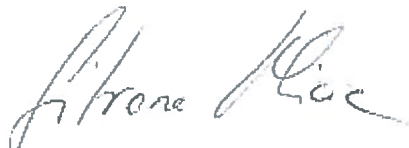
This Foundation Investigation Report has been prepared by Silvana Micic, Ph.D., P.Eng. and Nimesh Tamrakar, M.Eng. and reviewed by TaeChul Kim, M.E.Sc., P.Eng. and Stan E. Gonsalves, M.Eng., P.Eng., Designated MTO Foundation Contact. The field investigation was conducted by Nimesh Tamrakar, M.Eng.

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.**

  
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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 east from location of BH M15-2



Photo 2. Facing north from location of BH M15-2





Photo 3. Facing south from location of BH M15-2



Photo 4. Facing northeast from location of BH M15-1





Photo 5. Facing west from location of BH M15-1

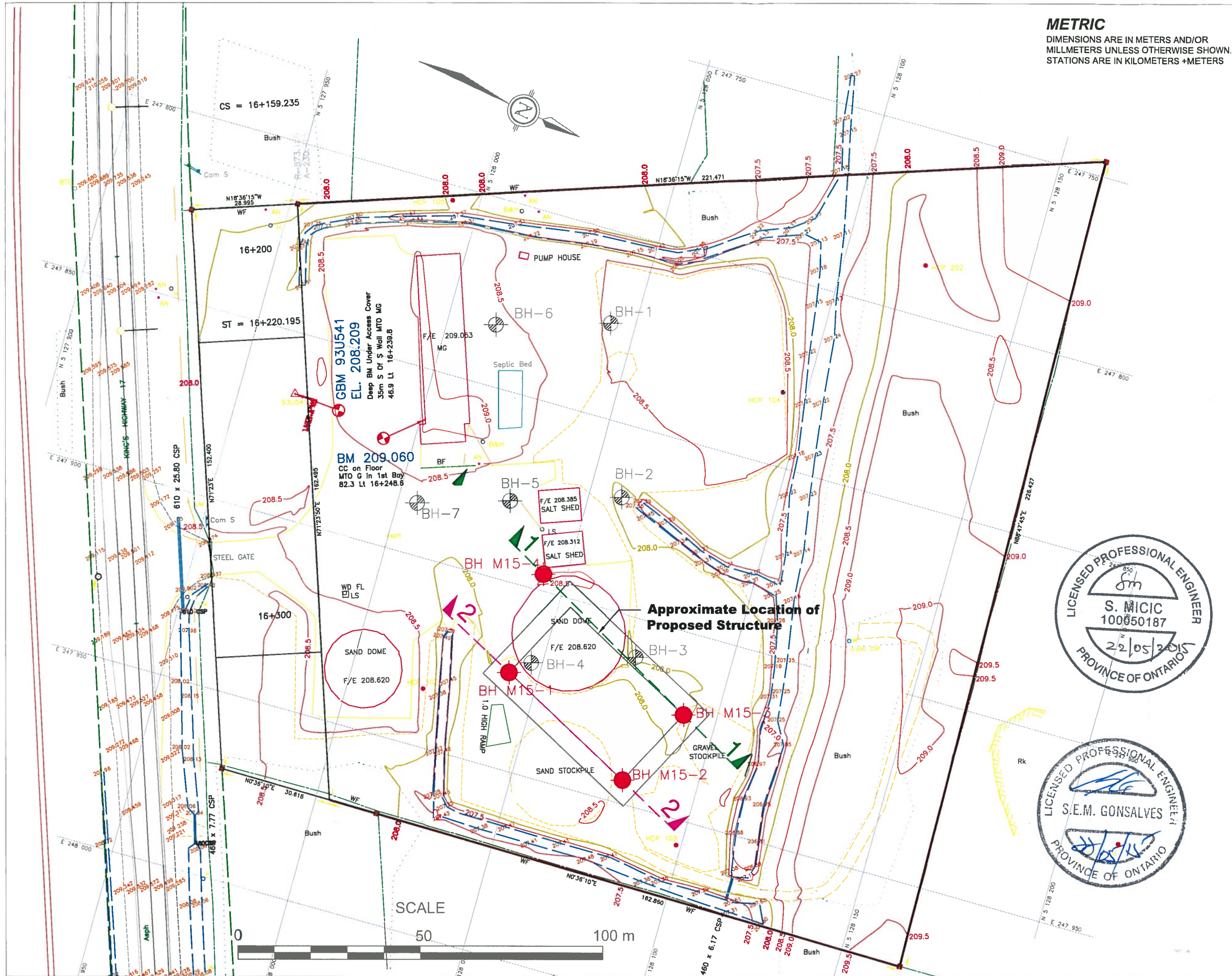


Photo 6. Facing northeast from location of BM



## **Appendix B – Drawings**





**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**  
Mckerrrow Patrol Yard  
Site Plan

SHEET  
1

exp

exp Services Inc.

KEY PLAN

LEGEND

BM (Bench Mark)

Borehole Locations(March, 2015)

Approximate Historical Borehole Locations (April, 1962)

BH No.	APPROX. ELEV.	MTM CO-ORDINATES	
		NORTH	EAST
BM	209.060	5128000	247865
BH M15-1	208.06	5128042	247924
BH M15-2	208.31	5128080	247944
BH M15-3	207.82	5128091	247922
BH M15-4	208.38	5128044	247896

NOTE

Locations of the historical boreholes have been taken from the MTO Drawing No. 62-F-28 A.

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.

DATE	BY	DESCRIPTION
2015.05.22	SM	FINAL SUBMISSION
2015.04.30	SM	SUBMISSION FOR MTO REVIEW

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

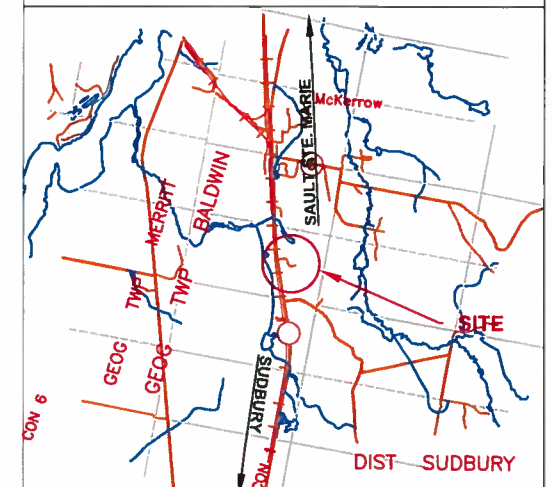
Mckerrow Patrol Yard  
Soil Strata

SHEET  
2



exp Services Inc.

### KEY PLAN



### LEGEND

- Borehole Locations (March, 2015)
- Approximate Historical Borehole Locations (April, 1962)
- Standard Penetration Test (Blows/0.3 m)
- Groundwater Level Measured in the Open Hole

### SOIL STRATA SYMBOLS

- FILL
- SILTY SAND
- SAND
- SILT

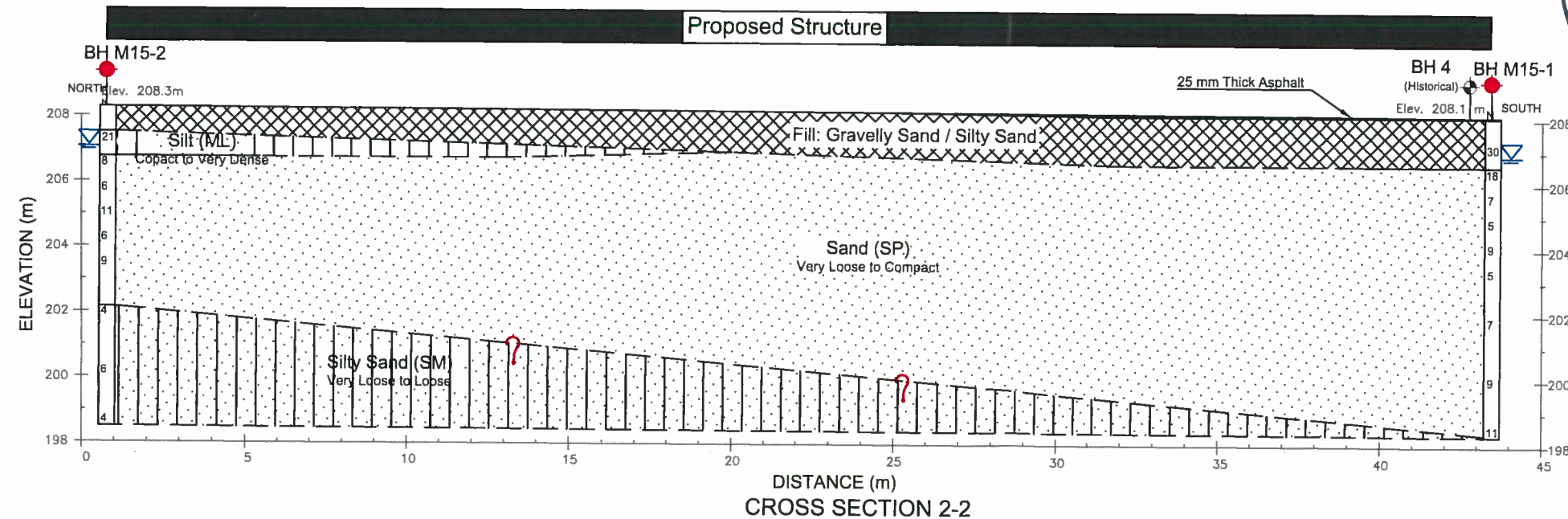
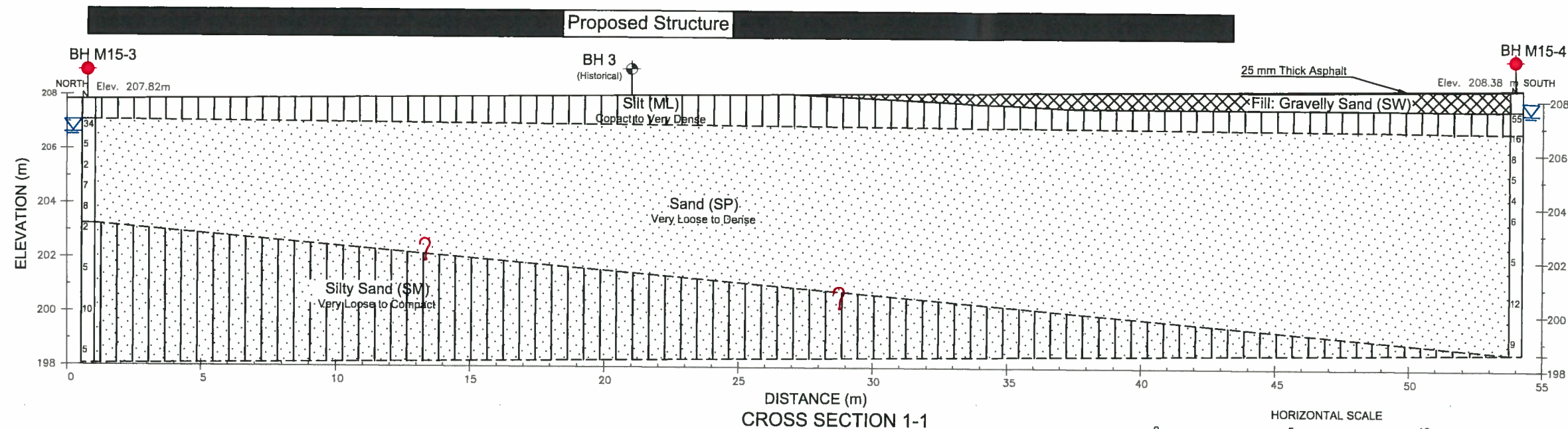
BH No.	APPROX. ELEV.	MTM CO-ORDINATES	
		NORTH	EAST
BH M15-1	208.06	5128042	247924
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BH M15-4	208.38	5128044	247896

### NOTE

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DATE	BY	DESCRIPTION
2015.05.22	SM	FINAL SUBMISSION
2015.04.30	SM	SUBMISSION FOR MTO REVIEW
GEORES NO. 411-332		
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.

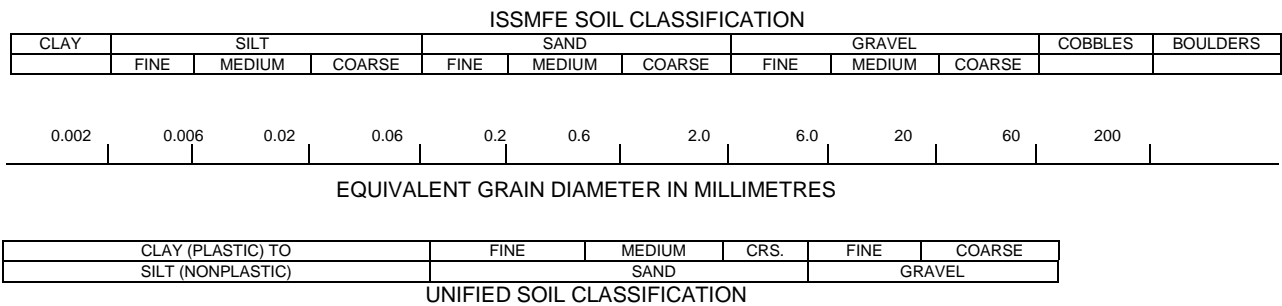
*Seam:* a thin, confined layer of soil having different particle size, texture, or color from materials above and below.

*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:

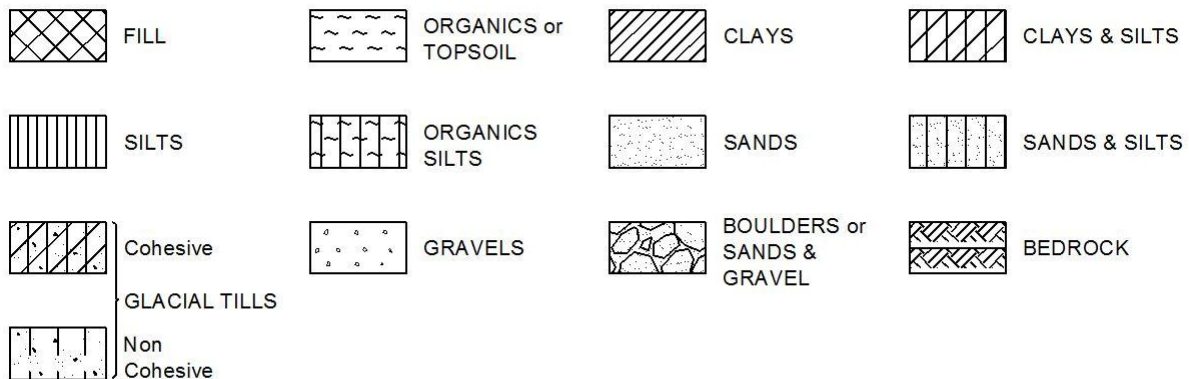
Table c: Consistency of Cohesive Soil

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

$u_w$	kPa	Pore water pressure
$r_u$	1	Pore pressure ratio
$\sigma$	kPa	Total normal stress
$\sigma'$	kPa	Effective normal stress
$\tau$	kPa	Shear stress
$\sigma_1, \sigma_2, \sigma_3$	kPa	Principal stresses
$\varepsilon$	%	Linear strain
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	%	Principal strains
E	kPa	Modulus of linear deformation
G	kPa	Modulus of shear deformation
$\mu$	1	Coefficient of friction

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	Coefficient of volume change
$c_c$	1	Compression index
$c_s$	1	Swelling index
$c_r$	1	Recompression index
$c_v$	m <sup>2</sup> /s	Coefficient of consolidation
H	m	Drainage path
$T_v$	1	Time factor
U	%	Degree of consolidation
$\sigma'_{v0}$	kPa	Effective overburden pressure
$\sigma'_p$	kPa	Preconsolidation pressure
$\tau_f$	kPa	Shear strength
$c'$	kPa	Effective cohesion intercept
$\phi'$	—°	Effective angle of internal friction
$c_u$	kPa	Apparent cohesion intercept
$\phi_u$	—°	Apparent angle of internal friction
$\tau_R$	kPa	Residual shear strength
$\tau_r$	kPa	Remoulded shear strength
$S_t$	1	Sensitivity = $c_u/\tau_r$

### PHYSICAL PROPERTIES OF SOIL

$P_s$	kg/m <sup>3</sup>	Density of solid particles
$\gamma_s$	kN/m <sup>3</sup>	Unit weight of solid particles
$\rho_w$	kg/m <sup>3</sup>	Density of water
$\gamma_w$	kN/m <sup>3</sup>	Unit weight of water
$\rho$	kg/m <sup>3</sup>	Density of soil
$\gamma$	kN/m <sup>3</sup>	Unit weight of soil
$\rho_d$	kg/m <sup>3</sup>	Density of dry soil
$\gamma_d$	kN/m <sup>3</sup>	Unit weight of dry soil
$\rho_{sat}$	kg/m <sup>3</sup>	Density of saturated soil
$\gamma_{sat}$	kN/m <sup>3</sup>	Unit weight of saturated soil
$\rho'$	kg/m <sup>3</sup>	Density of submerged soil
$\gamma'$	kN/m <sup>3</sup>	Unit weight of submerged soil
$e$	1, %	Void ratio
$n$	1, %	Porosity
$w$	1, %	Water content
$S_r$	%	Degree of saturation
$W_L$	%	Liquid limit
$W_P$	%	Plastic limit
$W_s$	%	Shrinkage limit
$I_p$	%	Plasticity index = $(W_L - W_P)$
$I_L$	%	Liquidity index = $(W - W_P)/I_p$
$I_C$	%	Consistency index = $(W_L - W)/I_p$
$e_{max}$	1, %	Void ratio in loosest state
$e_{min}$	1, %	Void ratio in densest state
$I_D$	1	Density index = $(e_{max} - e)/(e_{max} - e_{min})$
D	mm	Grain diameter
$D_n$	mm	N percent - diameter
$C_u$	1	Uniformity coefficient
h	m	Hydraulic head or potential
q	m <sup>3</sup> /s	Rate of discharge
v	m/s	Discharge velocity
i	1	Hydraulic gradient
k	m/s	Hydraulic conductivity
j	kN/m <sup>3</sup>	Seepage force



Brampton, Ontario

## RECORD OF BOREHOLE No BH M15-1

1 OF 1

METRIC

W. P. WO 2015-11006

LOCATION Mckerrow Patrol Yard, MTM Z12 E247924 N5128042

ORIGINATED BY NT

DIST Sudbury, Hwy 17

BOREHOLE TYPE CME-55, Hollow stem auger/ Diamond drill, Cased hole (below 1.52m)

COMPILED BY ET

DATUM BM ELEV 209.06m MTM Z12 E247865 N5128000

DATE 2015/03/17 - 2015/03/17

CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
208.1	Ground Surface																
206.0	ASPHALT 25 mm thickness FILL: SILTY SAND(SM) trace gravel, trace organics, black/grey, moist, compact		1	AS1													
			2	SS2	30												
206.5																	
1.5	SAND (SP) medium to fine sand, trace gravel, trace silt & clay, reddish to greyish brown, wet, loose to compact		3	SS3	18											1 95 (4)	
			4	SS4	7												
			5	SS5	5												
			6	SS6	9												
			7	SS7	5												
			8	SS8	7											0 99 (1)	
			9	SS9	9												
198.3			10	SS10	11												
9.8	END OF SAMPLING																
197.4																	
10.7	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. Wash boring technique was used to advanced borehole below 1.52m depth 4. Groundwater level was measured in the open auger hole																

OPG\_EXP RECORD OF BOREHOLE 5013-E-0008 ASSIG. 7(MCKERROW)-BH LOGS.GPJ ONTARIO MOT.GDT 4/24/15

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



Brampton, Ontario

## RECORD OF BOREHOLE No BH M15-2

1 OF 1

METRIC

W. P. WO 2015-11006

LOCATION Mckerrow Patrol Yard, MTM Z12 E247944 N5128080

ORIGINATED BY NT

DIST Sudbury, Hwy 17

BOREHOLE TYPE CME-55, Hollow stem auger/ Diamond drill, Cased hole (below 1.52m)

COMPILED BY ET

DATUM BM ELEV 209.06m MTM Z12 E247865 N5128000

DATE 2015/03/16 - 2015/03/16

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		
208.3	Ground Surface							20	40	60	80	100		
	FILL: GRAVELLY SAND(SW) few silt, grey, moist		1	AS1										
207.6 0.8	SILT (ML) trace sand, trace clay, grey, moist, compact		2	SS2	21									0 5 91 4
206.8 1.5	SAND (SP) medium to fine sand, trace gravel, trace silt & clay, reddish to greyish brown, wet, very loose to compact		3	SS3	8									
			4	SS4	6									1 95 (4)
			5	SS5	11									
			6	SS6	6									
			7	SS7	9									
202.2 6.1	SILTY SAND (SM) greyish brown, wet, very loose to loose		8	SS8	4									
	- becoming reddish brown sand		9	SS9	6									
198.6 9.8	END OF SAMPLING		10	SS10	4									0 77 (23)
197.6 10.7	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. Wash boring technique was used to advanced borehole below 1.52m depth 4. Groundwater level was measured in the open auger hole													

OPG\_EXP RECORD OF BOREHOLE 5013-E-0008 ASSIG. 7(MCKERROW)-BH LOGS.GPJ ONTARIO MOT.GDT 4/24/15

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



## 1 OF 1

METRIC

ORIGINATED BY NT

COMPILED BY ET

CHECKED BY SM

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



Brampton, Ontario

## RECORD OF BOREHOLE No BH M15-4

1 OF 1

METRIC

W. P. WO 2015-11006

LOCATION Mckerrow Patrol Yard, MTM Z12 E247896 N5128044

ORIGINATED BY NT

DIST Sudbury, Hwy 17

BOREHOLE TYPE CME-55, Hollow stem auger/ Diamond drill, Cased hole (below 1.52m)

COMPILED BY ET

DATUM BM ELEV 209.06m MTM Z12 E247865 N5128000

DATE 2015/03/17 - 2015/03/17

CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
208.4	Ground Surface													
208.0	ASPHALT 25 mm thickness FILL: GRAVELLY SAND(SW) few silt, brown, moist		1	AS1			208							30 63 (7)
207.6	SILT (ML) few sand, trace clay, brown, frozen, very dense		2	SS2	55		207							0 7 91 2
206.9	SAND (SP) medium to fine sand, few to little silt and clay, wet, loose to compact		3	SS3	16		206							
			4	SS4	8		205							
			5	SS5	5		204							
			6	SS6	4		203							
			7	SS7	6		202							
			8	SS8	5		201							
			9	SS9	12		200							
			10	SS10	9		199							
198.6	END OF SAMPLING						198							0 92 (8)
197.7	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. Wash boring technique was used to advanced borehole below 1.52m depth 4. Groundwater level was measured in the open auger hole													

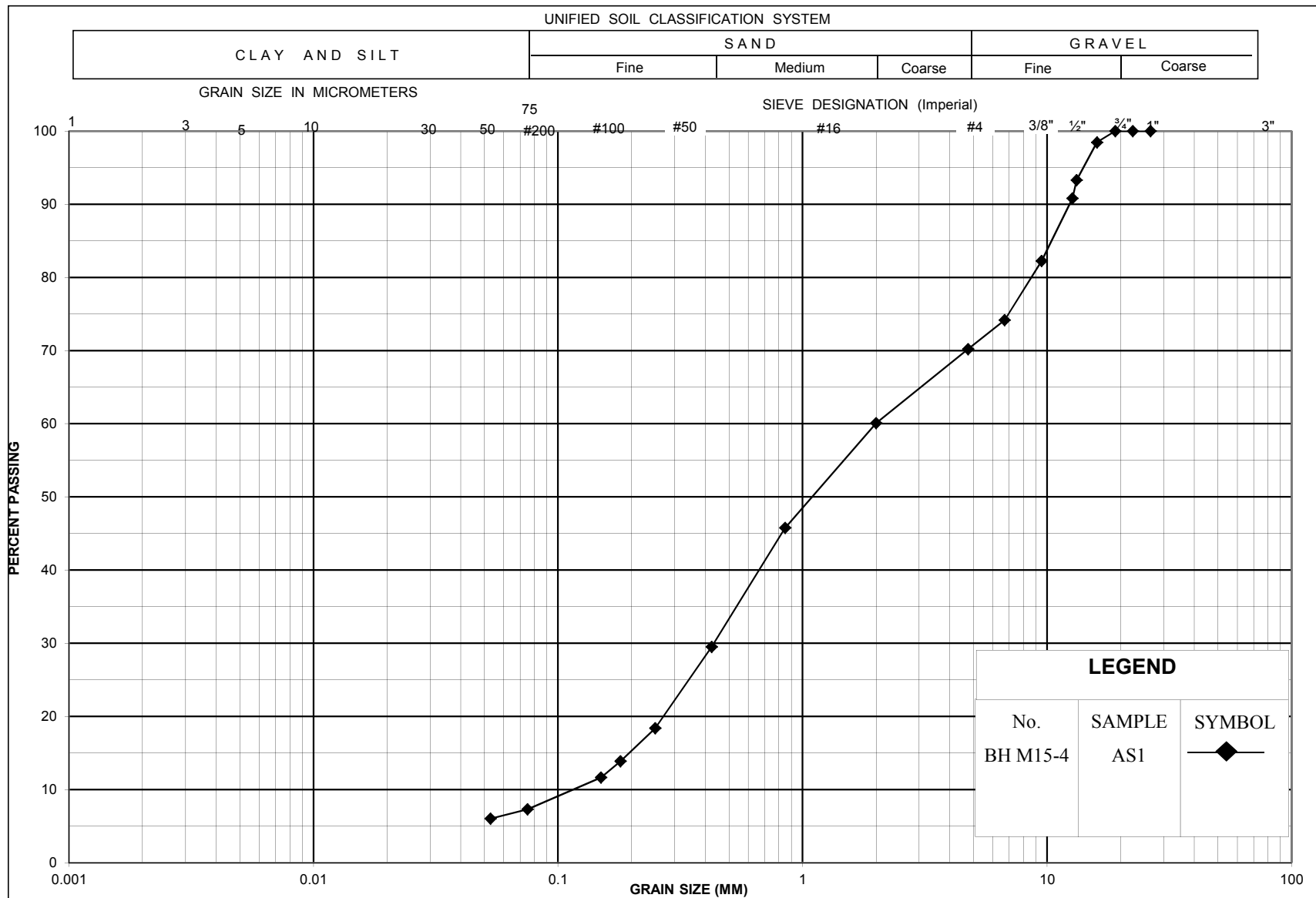
OPG\_EXP RECORD OF BOREHOLE 5013-E-0008 ASSIG. 7(MCKERROW)-BH LOGS.GPJ ONTARIO MOT.GDT 4/24/15

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



## **Appendix D – Laboratory Data**

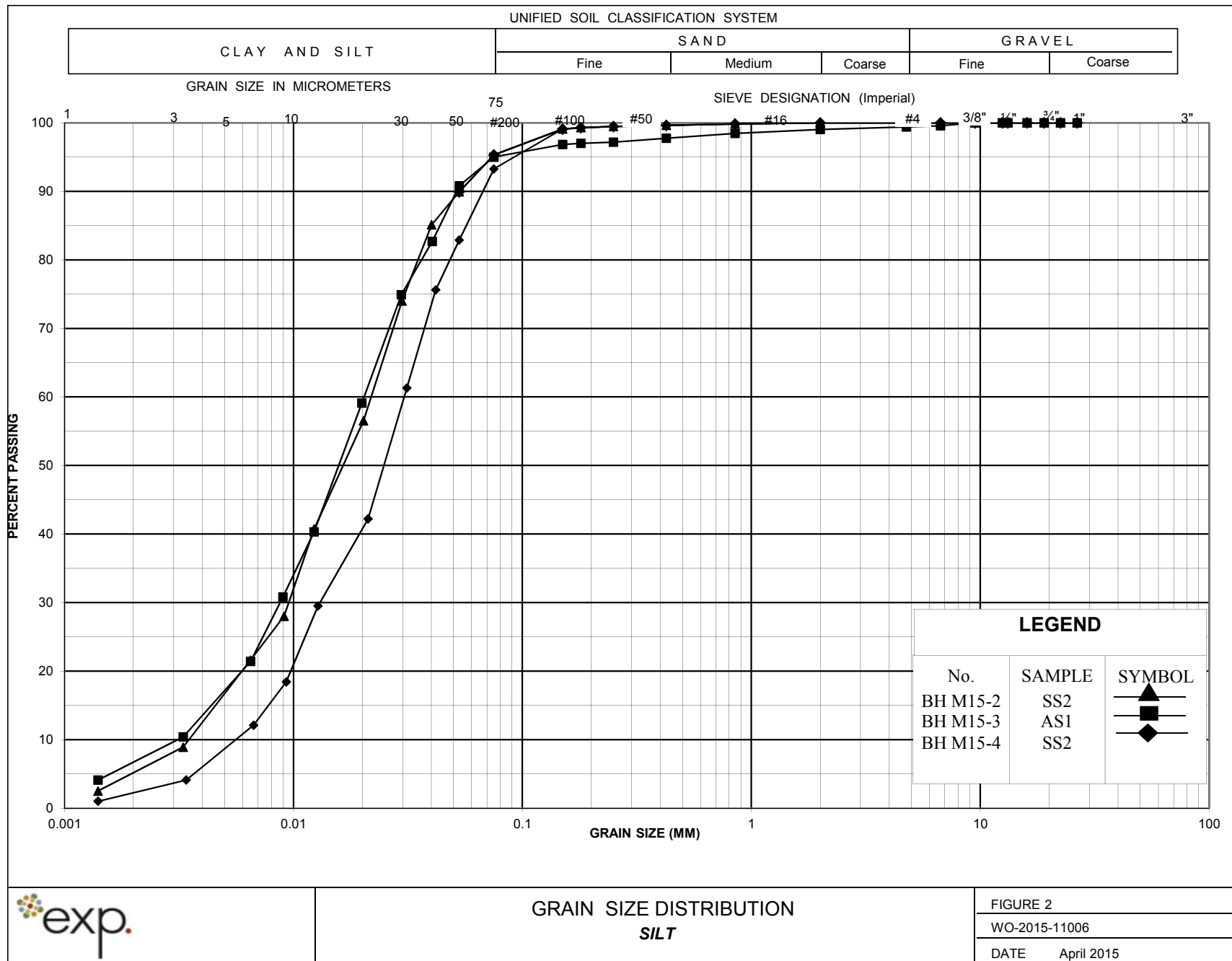




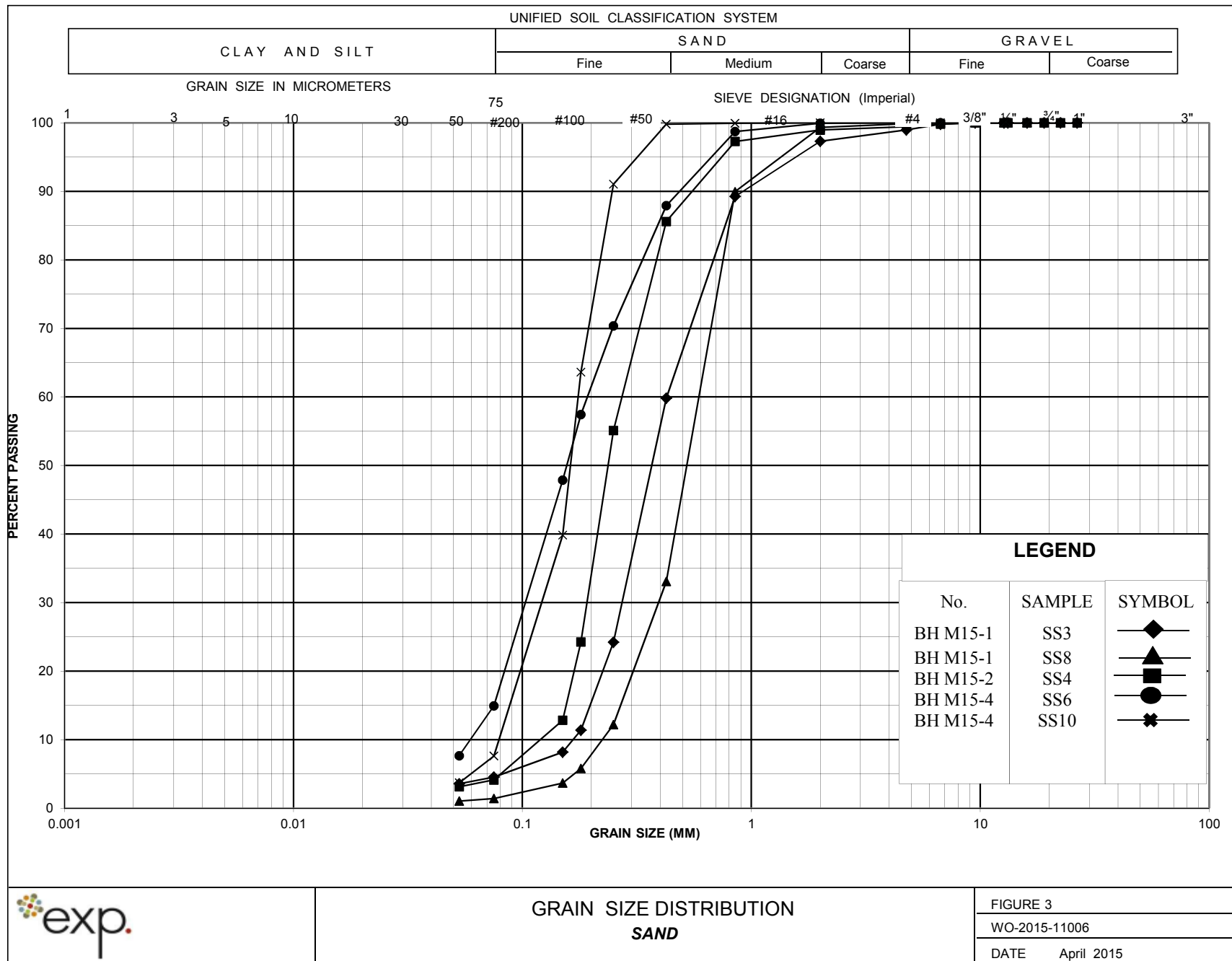
**GRAIN SIZE DISTRIBUTION**  
**FILL: GRAVELLY SAND/ SILTY SAND**

FIGURE 1  
 WO-2015-11006  
 DATE April 2015

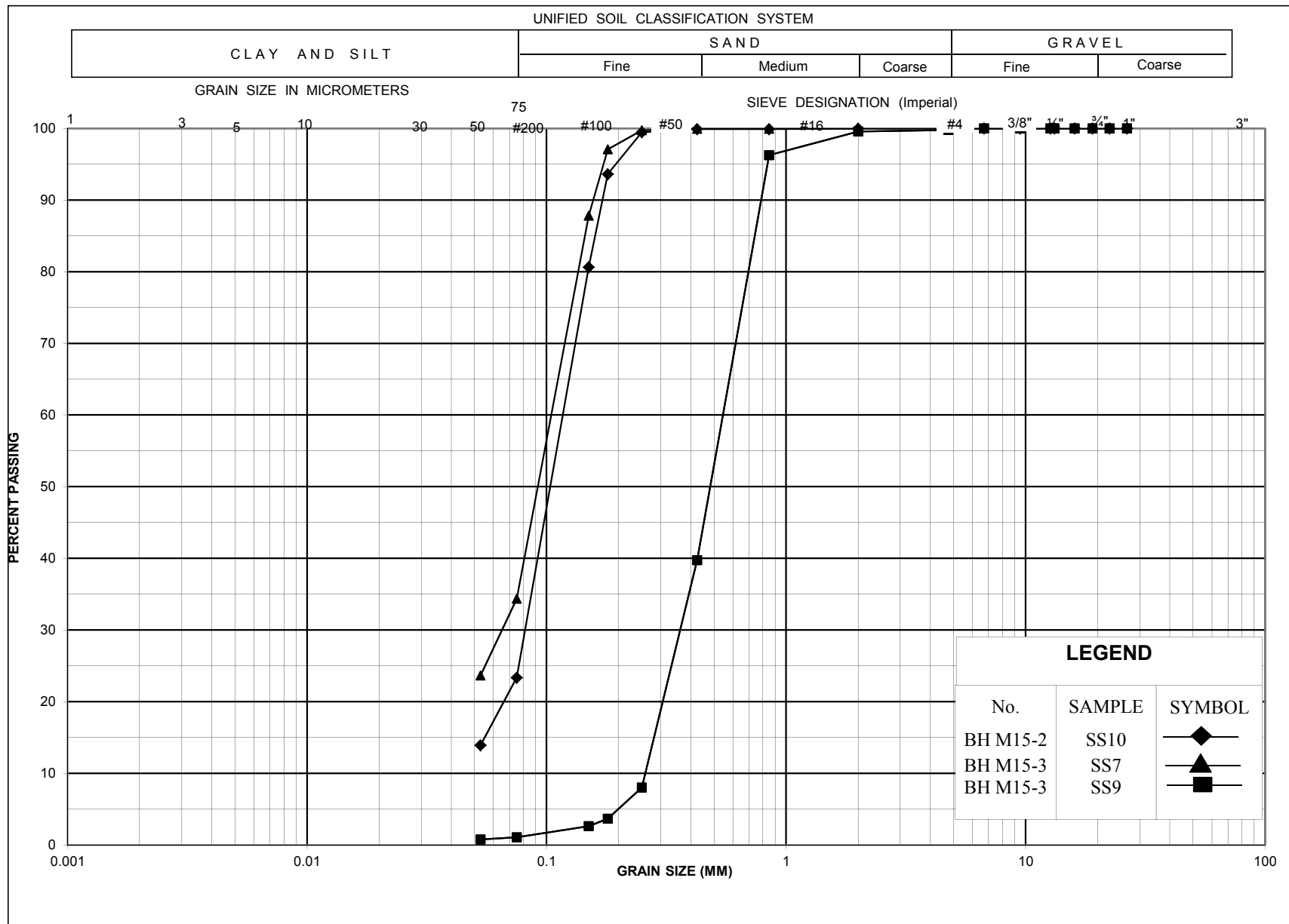








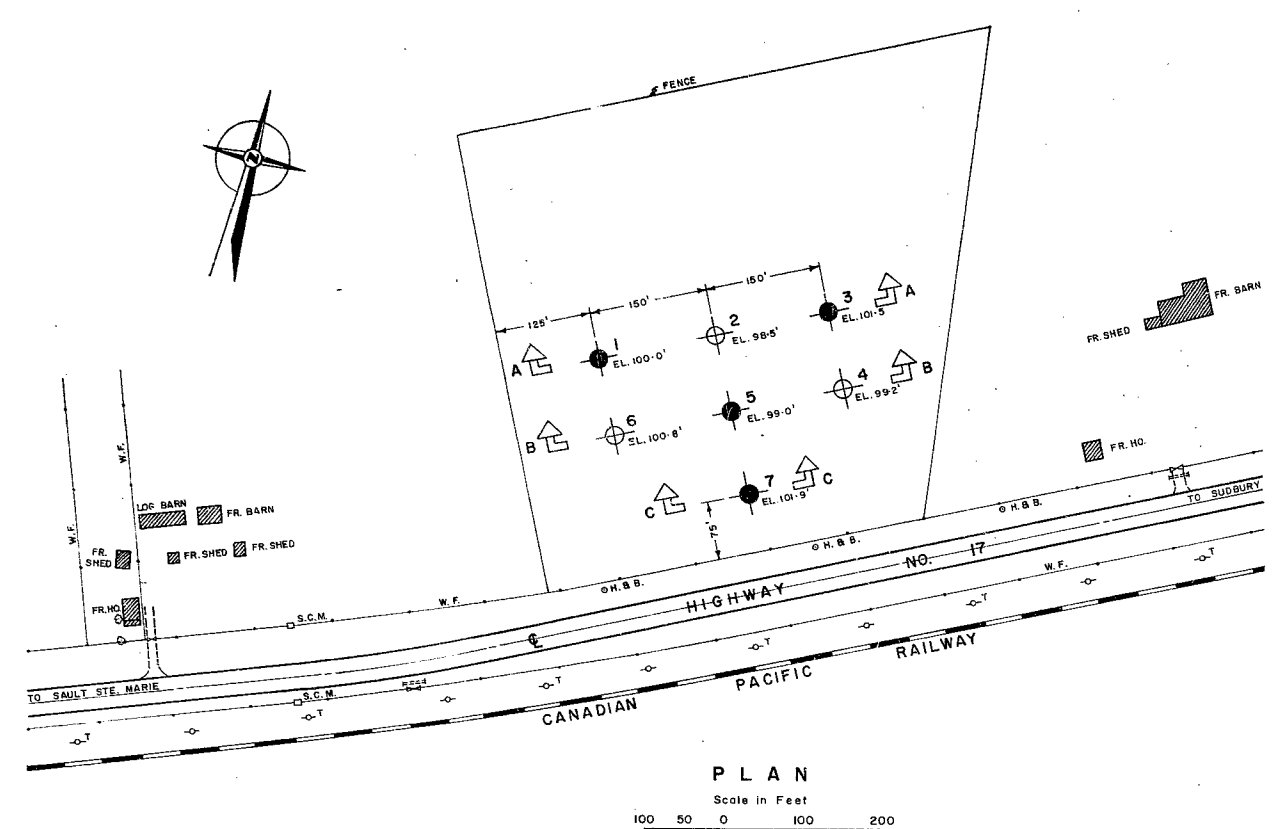




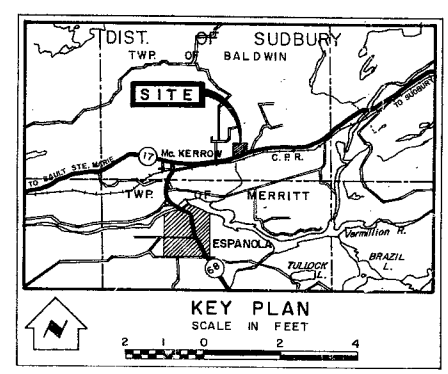


## **Appendix E – Record of Historical Geotechnical Data**

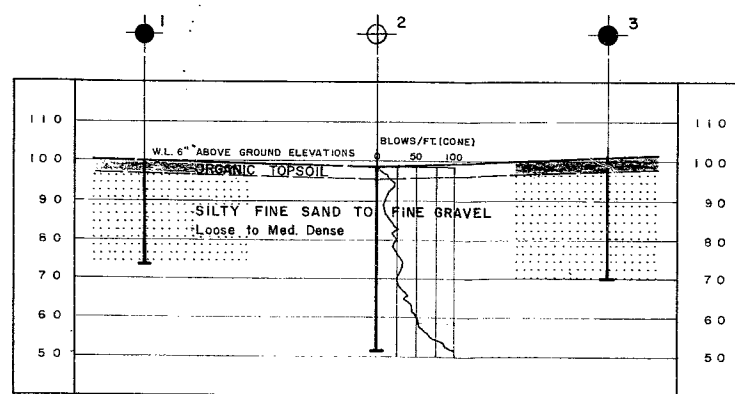




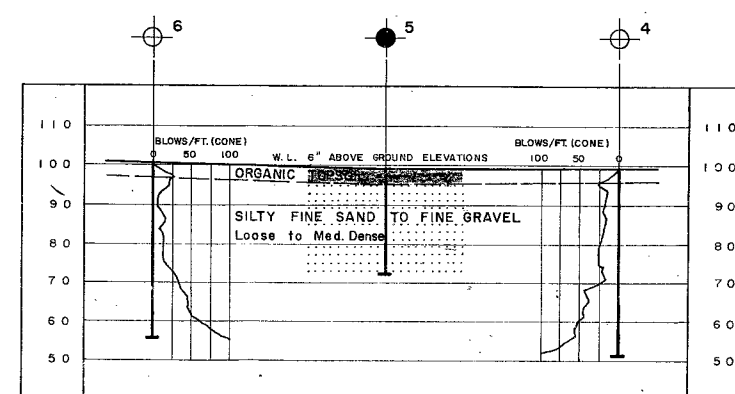
**PLAN**  
Scale in Feet  
100 50 0 100 200



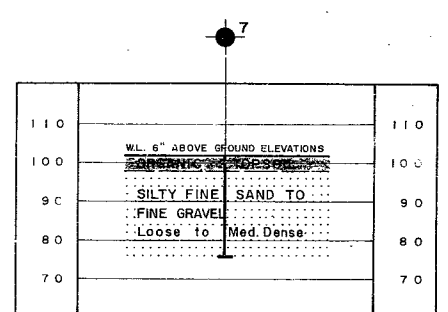
- LEGEND**
- BORE HOLE
  - ⊕ CONE PENETRATION HOLE



**SECTION A-A**  
Scale in Feet  
50 25 0 50 100  
Horizontal  
20 10 0 20 40  
Vertical



**SECTION B-B**  
Scale in Feet  
50 25 0 50 100  
Horizontal  
20 10 0 20 40  
Vertical



**SECTION C-C**  
Scale in Feet  
50 25 0 50 100  
Horizontal  
20 10 0 20 40  
Vertical

DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & RESEARCH SECTION

**McKerrow GARAGE SITE**

ORIGINATED W. KULMATICAS	DISTRICT NO. 17	DATE 17 APRIL 1962
DRAWN D. MUMFORD	W.P. NO.	JOB NO. 62-F-26
CHECKED <i>[Signature]</i>	SCALE	DRAWING NO.
APPROVED <i>[Signature]</i>	AS SHOWN	62-F-26A