



FINAL REPORT

FOUNDATION INVESTIGATION REPORT

New Salt Storage Facility at Kakabeka patrol Yard, Highway 11/17, Kakabeka Falls, District of Thunder Bay, Ontario

Agreement No. 6014-E-0017

Assignment No. 13

WO 2016-11029

Geocres No. 52A-221

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July 06, 2016

Ministry of Transportation

Foundation Investigation Report

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Type of Document:

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Project Name:

New Salt Storage Facility at Kakabeka Patrol Yard, Highway 11/17, Kakabeka Falls, District of Thunder Bay

Project Number:

ADM-00223648-L0

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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 salt storage facility located at the Kakabeka Patrol Yard, which is located on Highway 11/17, about 1 km south of Kakabeka Falls, in the Municipality of Oliver Paipoonge, in the District of Thunder Bay. The work was undertaken under Agreement # 6014-E-0017, Assignment No. 13. The terms of reference (TOR) were presented in the Ministry of Transportation (MTO) letter received on May 27, 2016. The location of the new salt storage building with dimensions of about 18.3 m x 24.4 m (60 ft x 80 ft) was laid out in the field by the MTO.

The purpose of the investigation is to establish the existing subsurface conditions at the proposed location of the patrol yard structure near the proposed building. 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 Kakabeka Patrol Yard is located on Highway 11/17, about 1 km south of Kakabeka Falls, within the Municipality of Oliver Paipoonge, in the District of Thunder Bay; see Key Map on Drawing 1 in Appendix B. The topography of the site is relatively flat with a slight slope to the northwest and a steep drop in grade of about 1.4 m to 1.5 m bordering the northwest wall of the proposed structure. A partial retaining wall was also observed at the steep drop; see photographs in Appendix A and Drawings 1 and 2, in Appendix B.

At the time of the investigation, the area within the building footprint contained five (5) large salt solution, above ground storage tanks. To the south of the proposed building are two rectangular salt storage structures, to the east is a round salt storage dome, and further to the south is a garage and administrative building. The site plan is provided on Drawing 1 in Appendix B.

During the fieldwork, the general site conditions were assessed. Select photographs are provided in Appendix A.

1.2.2 Geological Setting

According to the MNR Northern Ontario Engineering Geology Terrain Data Base Map, Ontario Geological Survey Map 5047, Scale 1:100,000, dated 1981, the underlying native soil at the site

predominantly consists of gravel and sand glaciolacustrine delta deposits. The local relief is mainly a low plain with terraced sections and dry surface conditions.

According the Ontario Geological Survey, Precambrian Geology Compilation Series, Map No. 2664, Thunder Bay Sheet, Scale 1:250,000, issued 2001, the bedrock at the site is described as from the Paleoproterozoic Era (1.6 to 2.5 Ga) and in particular part of the Animike Group (1.6 to 2.2 Ga). The rock is of sedimentary composition and consists of mudstone (argillite), limestone, iron formation, and basalt from the Upper Gunflint formation (1878 Ma).

1.3 Investigation Procedures

1.3.1 Field Work

The field investigation was carried out during June 13, 14, and 17, 2016. The field program consisted of drilling four (4) sampled boreholes (BH101, BH102, BH103 and BH104) located just outside the perimeter of the structure, at all four corners (see Drawing 1 in Appendix B). BH101 was advanced to a depth of about 15.5 m below ground surface, and the remaining boreholes were advanced to depths ranging between about 10.5 m and 10.6 m below ground surface.

The borehole locations were referenced to the MTM NAD83 (ON-15) coordinate system and the ground surface elevations were surveyed by **exp** personnel, with reference to a benchmark provided by the client (the designed finished floor elevation of the garage and administrative building). The benchmark was located at the most southern point of the concrete apron outside the Bay 5 door, with a geodetic elevation of 285.29 m (936.0 ft).

The boreholes were advanced using a truck-mounted CME 55 drill rig, equipped with continuous flight hollow stem augers. All borehole drilling/sampling were operated by a specialist drilling contractor, Cartwright Drilling Inc.

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 D1586), and were generally performed at intervals of about 0.75 m, in the upper 6 m, and 1.5 m intervals thereafter. The original field (uncorrected) SPT "N" values were recorded on the borehole logs as recommended in the Canadian Foundation Engineering Manual and used to provide an assessment of *in-situ* compactness (cohesionless) or consistency (cohesive) soils.

At boreholes BH101, BH102 and BH104, the groundwater level depths could not be measured as the boreholes caved/collapsed at depths less than that of the groundwater table. A temporary standpipe was installed at BH103 on June 14, 2016, and the groundwater depth was measured on June 17, 2016. The standpipe was removed from the ground at that time. The measured groundwater level and details of the standpipe construction are provided on the borehole log, in Appendix C. All boreholes were backfilled with a mixture of bentonite and auger cuttings. The borehole decommissioning was in general 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. All of the recovered soil samples were placed in labelled moisture-proof bags which were brought to **exp's** Thunder Bay laboratory for additional visual, textual and olfactory examination, and for subsequent examination by a geotechnical engineer and laboratory 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. Atterberg Limits tests were carried out on select cohesive soil samples. All of the laboratory tests were carried out in accordance with MTO and/or ASTM standards as appropriate, at the **exp** laboratory in Thunder Bay, Ontario.

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.

1.4 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 select 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 sections 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 a layer of fill material consisting of sand with silt and gravel, overlying sand deposits, overlying silt, and overlying silty clay to silt till deposits. A brief summary of the soil and groundwater conditions encountered in the boreholes is provided below.

1.4.1 Fill: Poorly Graded Sand with Silt and Gravel

Poorly graded sand with silt and gravel fill was encountered surfacing boreholes BH103 and BH104, and beneath the asphalt at BH101 and BH102. The asphalt thickness was about 150 mm at both boreholes. The fill was generally described as loose to dense, brown, and damp to moist. The SPT "N" values ranged between about 9 and 31 blows per 300 mm penetration, with an average "N" value of about 19.

The fill extended to depths ranging between about 0.8 m and 1.5 m below ground surface, with elevations ranging between about 283.9 m and 284.3 m.

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

Moisture content:

2.1% to 3.8%

Grain size distribution:

23% gravel;

66% sand; and

11% silt and clay size.

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 Sand

Sand was encountered underlying the fill. The sand was generally described as poorly graded, loose to compact, brown, and moist to wet at depth. The SPT "N" values ranged between 7 and 20 blows per 300 mm penetration, with an average "N" value of about 12. The sand extended to depths ranging between about 5.5 m and 7.6 m below ground surface, with elevations ranging between about 277.8 m and 279.5 m.

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

Moisture content:

2.6% to 18.2%

Grain size distribution:

0% to 8% gravel;

71% to 97% sand; and

3% to 29% silt and clay size.

Total saturated unit weights have been calculated based on the moisture contents at and below the estimated groundwater table (about 6 m below ground surface). Moisture content was tested for only one sample below 6 m depth, and the result was about 15.1%; the total saturated unit weight is about 21.7 kN/m³.

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 Silt

Silt was generally encountered beneath the sand. The silt was generally described as sandy silt to clayey silt with sand, loose to compact (firm to stiff), brown to grey, and wet. The SPT “N” values ranged between 7 and 24 blows per 300 mm penetration, with an average “N” value of about 12. The silt extended to depths ranging between about 7.6 m and about 9.2 m below ground surface, and elevations ranging between 275.9 m and 277.4 m.

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

Moisture content:

21.8% to 30.3%

Grain size distribution:

0% gravel;

5% to 39% sand;

49% to 79% silt; and

12% to 16% clay sizes.

Total saturated unit weights have been calculated based on the moisture contents and are estimated to range from about 19.0 to 20.3 kN/m³. Two (2) Atterberg Limits test were performed on representative samples of the silt (BH101-S10 and BH103-S9). The results indicated that the samples are of low plasticity. The data is shown on the plasticity chart, Figure 6. The liquid limit, plastic limit and plasticity index ranged between about 20 and 25, 14 and 17, and 5 and 8, respectively.

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 3, in Appendix D and Atterberg Limits test are provided on Figure 6 in Appendix D.

1.4.4 Silty Clay to Silt Till

Silty clay to silt till was encountered at underlying the silt to sandy silt, and sand. The till consisted of deposits of silty clay, clayey silt, silt with sand, and silt. The till was generally described as compact to very dense, grey, and moist. Occasional cobbles and boulders were encountered at BH102. The SPT “N” values ranged between 10 and 100 (i.e. SPT refusal) blows per 300 mm penetration, with an average “N” value of about 65. The till extended to the termination depth of all boreholes, with depths ranging between about 10.5 m and about 15.5 m below ground surface, and elevations ranging between 269.9 m and 275.0 m.

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

Moisture content:

14.4% to 32.1%

Grain size distribution:

0% to 6% gravel;

5% to 20% sand;

46% to 62% silt; and

17% to 49% clay sizes.

Total saturated unit weights have been calculated based on the moisture contents and are estimated to range from about 18.7 to 21.8 kN/m³. Four (4) Atterberg Limits test were performed on representative samples of the till (BH101-S12, BH102-S10, BH103-S10 and BH104-S12). The results indicated that the samples are of low to medium plasticity. The data is shown on the plasticity chart, Figure 6. The liquid limit, plastic limit and plasticity index ranged between about 25 and 47, 13 and 20 and 12 and 27, respectively.

The results of the moisture content, grain size distribution and Atterberg Limits test are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution are also provided on Figures 4 and 5 in Appendix D, and Atterberg Limits test are provided on Figure 6 in Appendix D.

1.5 Groundwater Conditions

Information on groundwater levels at the site was obtained by measuring the water levels in the open boreholes after completion of drilling. A temporary standpipe was installed at BH103. The groundwater levels encountered in the boreholes are shown on the borehole logs and presented below in Table 1.1.

Seasonal variations in the water table should be expected, or after periods of extended precipitation or drought, and, as such, may differ at other times.

Table 1.1. Groundwater data

Borehole	Date Completed	Date Measured	Ground Surface Elevation ²	Depth to Water ³	Groundwater Elevation
BH101	Jun. 13/16	Jun. 13/16	285.39	dry ⁴	--
BH102	Jun. 13/16	Jun. 13/16	285.47	dry ⁴	--
BH103 ⁵	Jun. 14/16	Jun. 17/16	284.97	6.52	278.45
BH104	Jun. 14/16	Jun. 14/16	285.04	dry ⁴	--
Notes: 1) All units in metres. 2) Elevations surveyed are referenced to the client provided benchmark (the designed finished floor elevation of the garage and administrative building). The benchmark was located at the most southern point of the concrete apron outside the Bay 5 door, with a geodetic elevation of 285.29 m (936.0 ft). 3) Depths are relative to ground surface. 4) Indicates no groundwater encountered in open boreholes. 5) Temporary standpipe installed.					

At BH101, BH102 and BH104, the boreholes caved/collapsed at depths of about 4.5 m (280.9 m elevation), 5.1 (280.4 m elevation) and 3.1 m (281.9 m elevation), respectively; no groundwater was encountered at these boreholes.

July 6, 2016

1.6 CLOSURE

A subsurface investigation is a limited sampling of a site; the subsurface conditions have been established only at the test hole locations. Should conditions at the site be encountered which differ from those reported at the test locations, we require that we be notified immediately in order to assess this additional information and our recommendations, as appropriate. It may then be necessary to perform additional investigation and analysis.

Contractors bidding on or undertaking any proposed work at this site should, relative to the subsurface conditions, decide on their own investigations, if deemed necessary, as well as their own interpretations of the factual results provided herein, so 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 Ahileas Mitsopoulos, P.Eng., Nimesh Tamrakar, M.Eng, EIT., Demetri N. Georgiou, MASc. P.Eng., and Silvana Micic, Ph.D., P.Eng. It was reviewed by TaeChul Kim, P.Eng. and by Stan E. Gonsalves, M.Eng., P.Eng., Designated MTO Foundation Contact. The field investigation was conducted by Robert Moen. B.Eng, EIT.

Yours truly,

exp Services Inc.



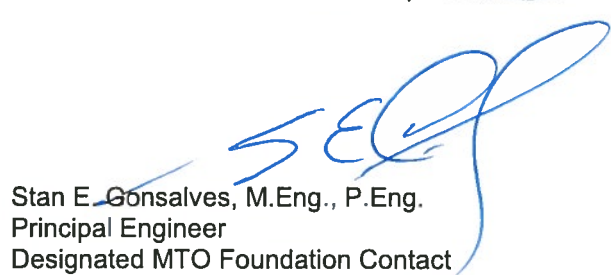
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Principal Engineer
Designated MTO Foundation Contact



Encl.

Appendix A – Photographs



Photo 1. Facing southeast towards BH101 location and the garage/administration building



Photo 2. Facing southwest along the proposed south building footprint. The existing salt storage buildings are observed



Photo 3. Facing northwest along the proposed west building footprint. The salt storage solutions in the ASTs is observed on the right

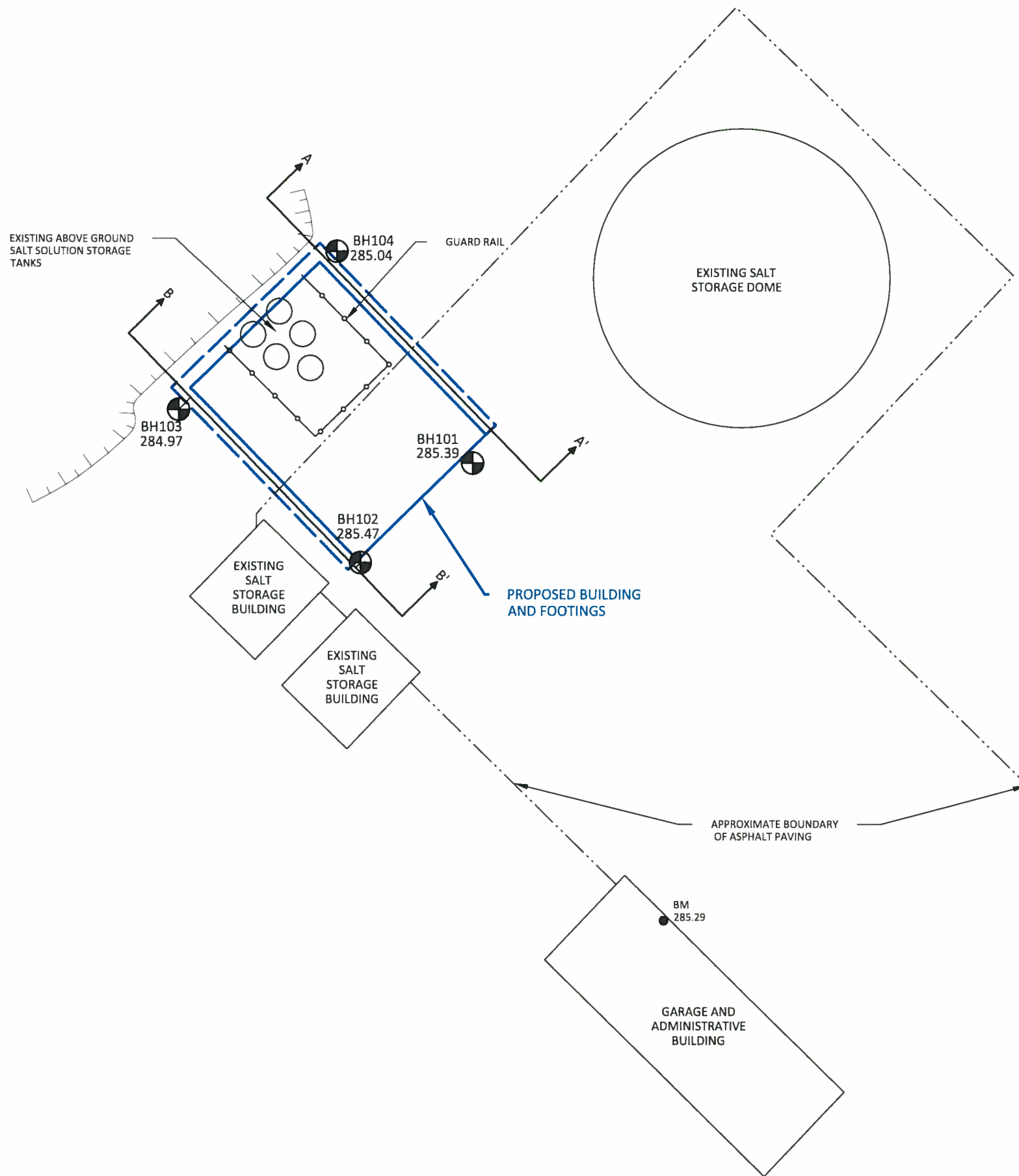


Photo 4. Facing south along the proposed north building footprint. Steep slope, including retaining wall is noted on the right and the salt solution ASTs are noted on the left.



Photo 5. Facing south towards location of BM (south corner of Bay 5) at the garage / administration building

Appendix B – Drawings



Agreement No. 6014-E-0017
Assignment No. 13
WO 2016-11029

KAKABEKA PATROL YARD
(Highway 11/17, Kakabeka Falls, ON)
PLAN

DWG
1

*exp.

exp Services Inc.

KEY PLAN

LEGEND

BH101 285.39 BOREHOLE LOCATION
GROUND SURFACE ELEVATION IN METRES

BM 285.29 BENCHMARK LOCATION
LOCAL ELEVATION IN METRES

BH No.	APPROX. ELEV. (m)	MTM COORDINATES	
		NORTH	EAST
BH101	285.39	5,362,008	334,118
BH102	285.47	5,361,993	334,108
BH103	284.97	5,362,001	334,080
BH104	285.04	5,362,026	334,104

NOTES

1. ALL DIMENSIONS ARE IN METRES.

2. BASE MAP PROVIDED BY CLIENT.

3. MTM COORDINATES BASE ON MTM ZONE ON-15 PROJECTION.

4. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. THE PROPOSED AND EXISTING STRUCTURE DETAILS/WORKS ARE SHOWN FOR ILLUSTRATION PURPOSES ONLY.

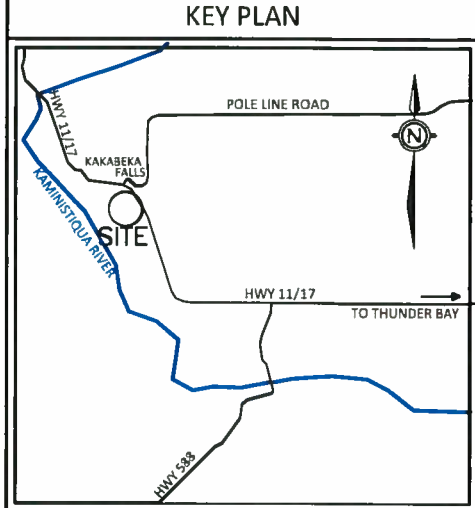
5. BENCHMARK LOCATED ON CONCRETE APRON AT SOUTHERN MOST POINT OF OUTSIDE OF BAY 5 DOOR, AT ONSITE GARAGE/ADMINISTRATIVE BUILDING.

REVISIONS

DATE	BY	DESCRIPTION

GEOCREs No. 52A-221
Date: June 27, 2016
Drawn By: RM

Project No. ADM-00223648-LO
Scale : 1:500
Checked By: AM
Checked By: DG



LEGEND

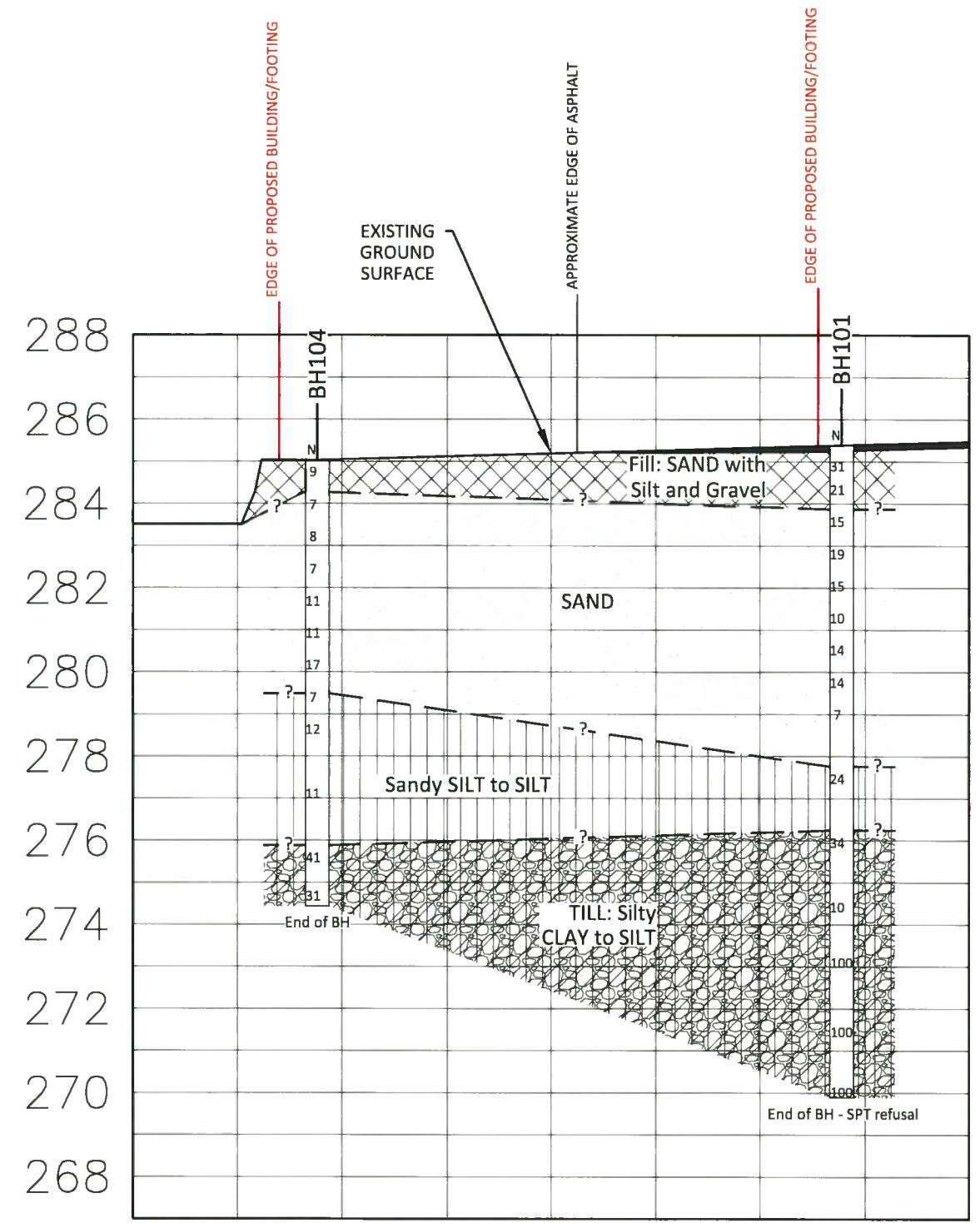
N STANDARD PENETRATION TEST
(BLOWS/0.3 m)

▽ MEASURED WATER LEVEL

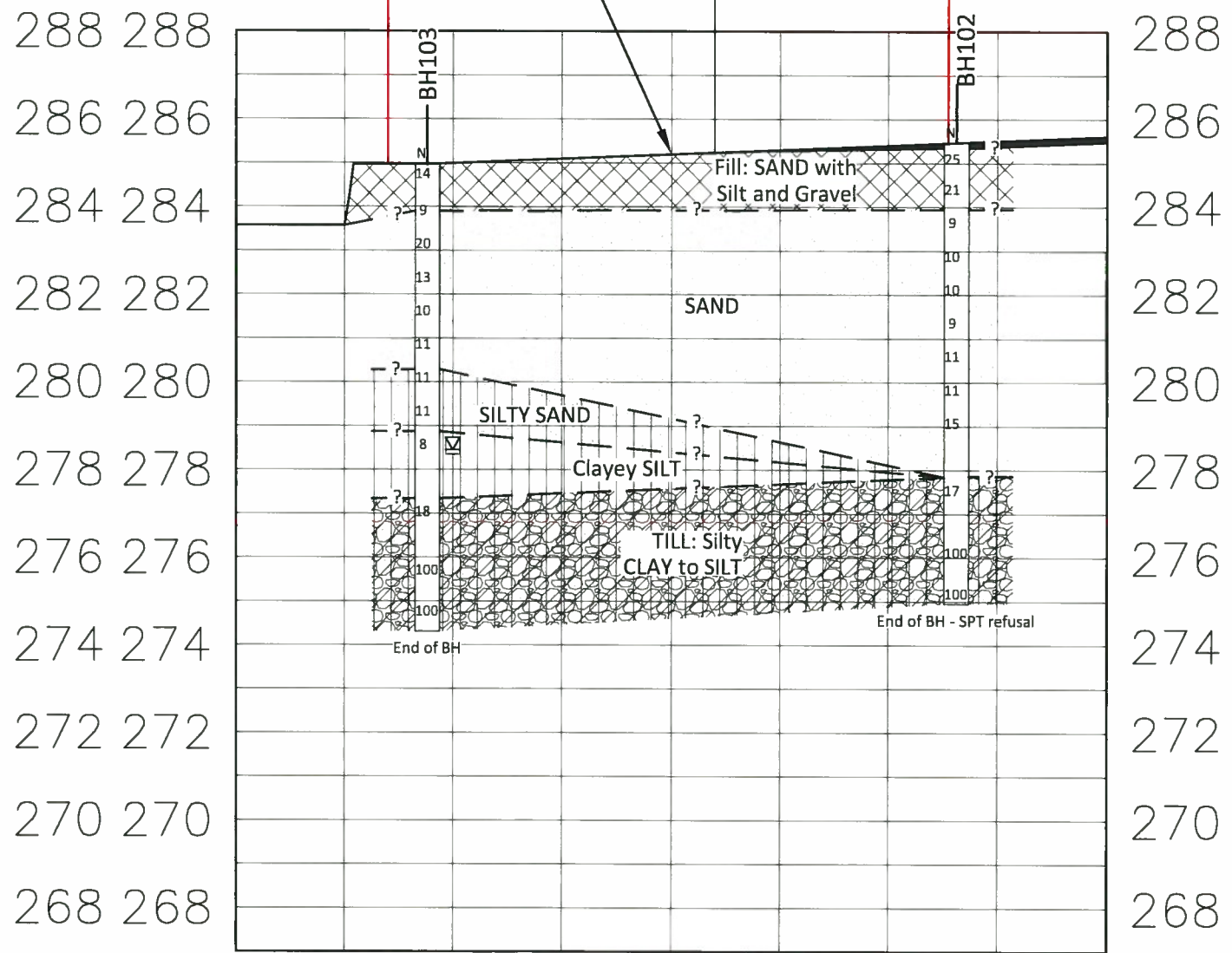
BH No.	APPROX. ELEV. (m)	MTM COORDINATES	
		NORTH	EAST
BH101	285.39	5,362,008	334,118
BH102	285.47	5,361,993	334,108
BH103	284.97	5,362,001	334,080
BH104	285.04	5,362,026	334,104

- NOTES
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 - BENCHMARK LOCATED ON CONCRETE APRON AT SOUTHERN MOST POINT OF OUTSIDE OF BAY 5 DOOR, AT ONSITE GARAGE/ADMINISTRATIVE BUILDING.

REVISIONS		
DATE	BY	DESCRIPTION
GEOCREs No. 52A-221		Project No. ADM-00223648-L0
Date: June 28, 2016		Horizontal Scale : 1:300
Drawn By: RM		Vertical Scale : 1:150
Checked By: DG		



A - A'
NORTHEAST SECTION



B-B'
SOUTHWEST SECTION



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 generally the ASTM D2487-11 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) with some modification to reflect current MTO practices. 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.

ISSMFE SOIL CLASSIFICATION											
CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE		
<div><div>0.002</div><div>0.006</div><div>0.02</div><div>0.06</div><div>0.2</div><div>0.6</div><div>2.0</div><div>6.0</div><div>20</div><div>60</div><div>200</div></div>											
EQUIVALENT GRAIN DIAMETER IN MILLIMETRES											
CLAY (PLASTIC) TO				FINE		MEDIUM		CRS.	FINE	COARSE	
SILT (NONPLASTIC)				SAND				GRAVEL			
UNIFIED 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:

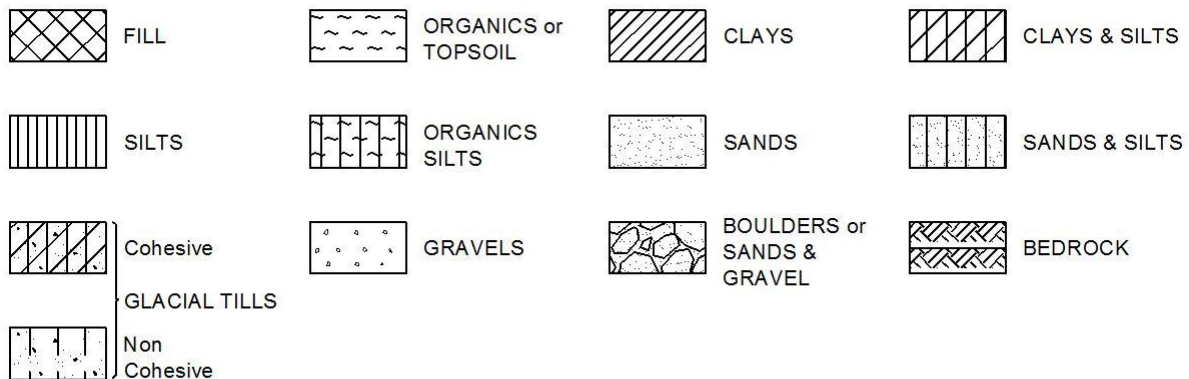
Table c: Consistency of Cohesive Soil

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
σ	kPa	Total normal stress
σ'	kPa	Effective normal stress
τ	kPa	Shear stress
$\sigma_1, \sigma_2, \sigma_3$	kPa	Principal stresses
ε	%	Linear strain
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	%	Principal strains
E	kPa	Modulus of linear deformation
G	kPa	Modulus of shear deformation
μ	1	Coefficient of friction

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	Coefficient of volume change
c_c	1	Compression index
c_s	1	Swelling index
c_r	1	Recompression index
c_v	m ² /s	Coefficient of consolidation
H	m	Drainage path
T_v	1	Time factor
U	%	Degree of consolidation
σ'_{v0}	kPa	Effective overburden pressure
σ'_p	kPa	Preconsolidation pressure
τ_f	kPa	Shear strength
c'	kPa	Effective cohesion intercept
ϕ'	—°	Effective angle of internal friction
c_u	kPa	Apparent cohesion intercept
ϕ_u	—°	Apparent angle of internal friction
τ_R	kPa	Residual shear strength
τ_r	kPa	Remoulded shear strength
S_t	1	Sensitivity = c_u/τ_r

PHYSICAL PROPERTIES OF SOIL

P_s	kg/m ³	Density of solid particles
γ_s	kN/m ³	Unit weight of solid particles
ρ_w	kg/m ³	Density of water
γ_w	kN/m ³	Unit weight of water
ρ	kg/m ³	Density of soil
γ	kN/m ³	Unit weight of soil
ρ_d	kg/m ³	Density of dry soil
γ_d	kN/m ³	Unit weight of dry soil
ρ_{sat}	kg/m ³	Density of saturated soil
γ_{sat}	kN/m ³	Unit weight of saturated soil
ρ'	kg/m ³	Density of submerged soil
γ'	kN/m ³	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 ³ /s	Rate of discharge
v	m/s	Discharge velocity
i	1	Hydraulic gradient
k	m/s	Hydraulic conductivity
j	kN/m ³	Seepage force

RECORD OF BOREHOLE No BH101

1 OF 1

METRIC

W.P. _____ LOCATION **Kakabeka Patrol Yard - MTM ON-15 5,362,008N 334,118E** ORIGINATED BY **RM**
 DIST **61** HWY **Hwy 11/17** BOREHOLE TYPE **CME 55 Truck Mount / HSA** COMPILED BY **AM**
 DATUM **Geodetic** DATE **6.13.16 - 6.13.16** CHECKED BY **DG**

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE	W _p	W	W _L		
285.4	Asphalt							20 40 60 80 100		20 40 60				GR SA SI CL
286.0	ASPHALT - about 150 mm													
0.2	Poorly Graded Sand with Silt and Gravel (FILL) - dense to compact, brown, damp to moist		S1	SS	31		285				○			23 66 (11)
			S2	SS	21						○			
283.9							284							
1.5	Well Graded SAND with Silt - compact, brown, moist		S3	SS	15						○			6 86 (8)
			S4	SS	19		283				○			
			S5	SS	15		282				○			
			S6	SS	10						○			
			S7	SS	14		281				○			
														No Recovery
280.1	Poorly Graded SAND - compact, brown, moist, medium grained		S8	SS	14		280				○			8 87 (5)
5.3	- becoming loose, wet at about 6.1 m depth		S9	SS	7		279				○			
							278							
277.8	SILT - compact, brown, wet - becoming grey at about 7.8 m depth		S10	SS	24		277				○			0 5 79 16
7.6														
276.2	Silty CLAY to SILT (TILL) - loose to very dense, grey, moist		S11	SS	34		276				○			
9.2							275							
			S12	SS	10		274				○			0 5 46 49
			S13	SS	100		273				○			
							272							
			S14	SS	100		271				○			
269.9	End of Borehole - refusal to SPT		S15	SS	100		270				○			
15.5														

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

RECORD OF BOREHOLE No BH102

1 OF 1

METRIC

W.P. _____ LOCATION **Kakabeka Patrol Yard - MTM ON-15 5,361,993N 334,108E** ORIGINATED BY **RM**
 DIST **61** HWY **Hwy 11/17** BOREHOLE TYPE **CME 55 Truck Mount / HSA** COMPILED BY **AM**
 DATUM **Geodetic** DATE **6.13.16 - 6.13.16** CHECKED BY **DG**

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)								
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				w _p w w _L								
285.5	Asphalt							20	40	60	80	100					GR	SA	SI	CL
286.0	ASPHALT - about 150 mm																			
0.2	Poorly Graded Sand with Silt and Gravel (FILL) - compact, brown, moist		S1	SS	25		285													
			S2	SS	21															
284.0							284													
1.5	Poorly Graded SAND - loose to compact, brown, moist, fine grained		S3	SS	9															
			S4	SS	10		283													
			S5	SS	10		282							○			0	95	(5)	
			S6	SS	9		281							○			0	97	(3)	
			S7	SS	11		280													
	- becoming medium grained at about 4.8 m depth		S8	SS	11															
			S9	SS	15		279													
							278													
277.8	Silty CLAY to SILT (TILL) - compact to very dense, grey, moist		S10	SS	17		277										1	9	50	40
7.6			S11	SS	100		276													
	- occasional cobbles and boulders noted during augering at about 9.5 m depth		S12	SS	100															
275.0	End of Borehole - refusal to SPT						275													
10.5																				

ONL MOT F-16126-AG - ADM-00223648-L0 - MTO 13 - SALT STORAGE BLDG - KAKABEKA PATROL YARD GPJ ON MOT.GDT 6/28/16

RECORD OF BOREHOLE No BH103

1 OF 1

METRIC

W.P. _____ LOCATION **Kakabeka Patrol Yard - MTM ON-15 5,362,001N 334,080E** ORIGINATED BY **RM**
 DIST **61** HWY **Hwy 11/17** BOREHOLE TYPE **CME 55 Truck Mount / HSA** COMPILED BY **AM**
 DATUM **Geodetic** DATE **6.14.16 - 6.14.16** CHECKED BY **DG**

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
285.0	Sand and Gravel							20	40	60	80	100					
0.0	Poorly Graded Sand with Silt and Gravel (FILL) - compact to loose, brown, moist, trace organics		S1	SS	14												
283.9			S2	SS	9		284										
1.1	Poorly Graded SAND - loose to compact, brown, moist		S3	SS	20		283										
			S4	SS	13		282										
			S5	SS	10		281										
			S6	SS	11		280										
280.4			S7	SS	11		280										0 71 (29)
4.6	SILTY SAND - compact, brown, moist - becoming wet, medium grained at about 5.3 m depth		S8	SS	11		279										
278.9			S9	SS	8		278										0 29 59 12
6.1	Clayey SILT with Sand - firm to stiff, brown, wet						277										
277.3			S10	SS	18		276										6 20 57 17
7.6	Clayey SILT to SILT with Sand (TILL) - compact to very dense, grey, moist		S11	SS	100		275										
			S12	SS	100												
274.3	End of Borehole																
10.7	 <																

ONL MOT F-16126-AG - ADM-00223648-L0 - MTO 13 - SALT STORAGE BLDG - KAKABEKA PATROL YARD GPJ ON MOT.GDT 6/28/16

RECORD OF BOREHOLE No BH104

1 OF 1

METRIC

W.P. _____ LOCATION **Kakabeka Patrol Yard - MTM ON-15 5,362,026N 334,104E** ORIGINATED BY **RM**
 DIST **61** HWY **Hwy 11/17** BOREHOLE TYPE **CME 55 Truck Mount / HSA** COMPILED BY **AM**
 DATUM **Geodetic** DATE **6.14.16 - 6.14.16** CHECKED BY **DG**

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				W _p W W _L				
								20	40	60	80	100	20	40		
285.0	Sand and Gravel															
0.0	Poorly Graded Sand with Silt and Gravel (FILL) - loose, brown, moist		S1	SS	9											
284.3																
0.8	Poorly Graded SAND - loose to compact, brown, moist, fine grained		S2	SS	7											
			S3	SS	8											
			S4	SS	7											
			S5	SS	11											
			S6	SS	11											
			S7	SS	17											
279.5	- becoming wet at about 5.3 m depth		S8	SS	7											
5.5	Sandy SILT - loose, brown, wet		S9	SS	12											
			S10	SS	11											
275.9																
9.2	Clayey SILT to SILT with Sand (TILL) - dense, grey, moist		S11	SS	41											
274.4			S12	SS	31											
10.6	End of Borehole															

ONL MOT F-16126-AG - ADM-00223648-L0 - MTO 13 - SALT STORAGE BLDG - KAKABEKA PATROL YARD GPJ ON MOT.GDT 6/28/16

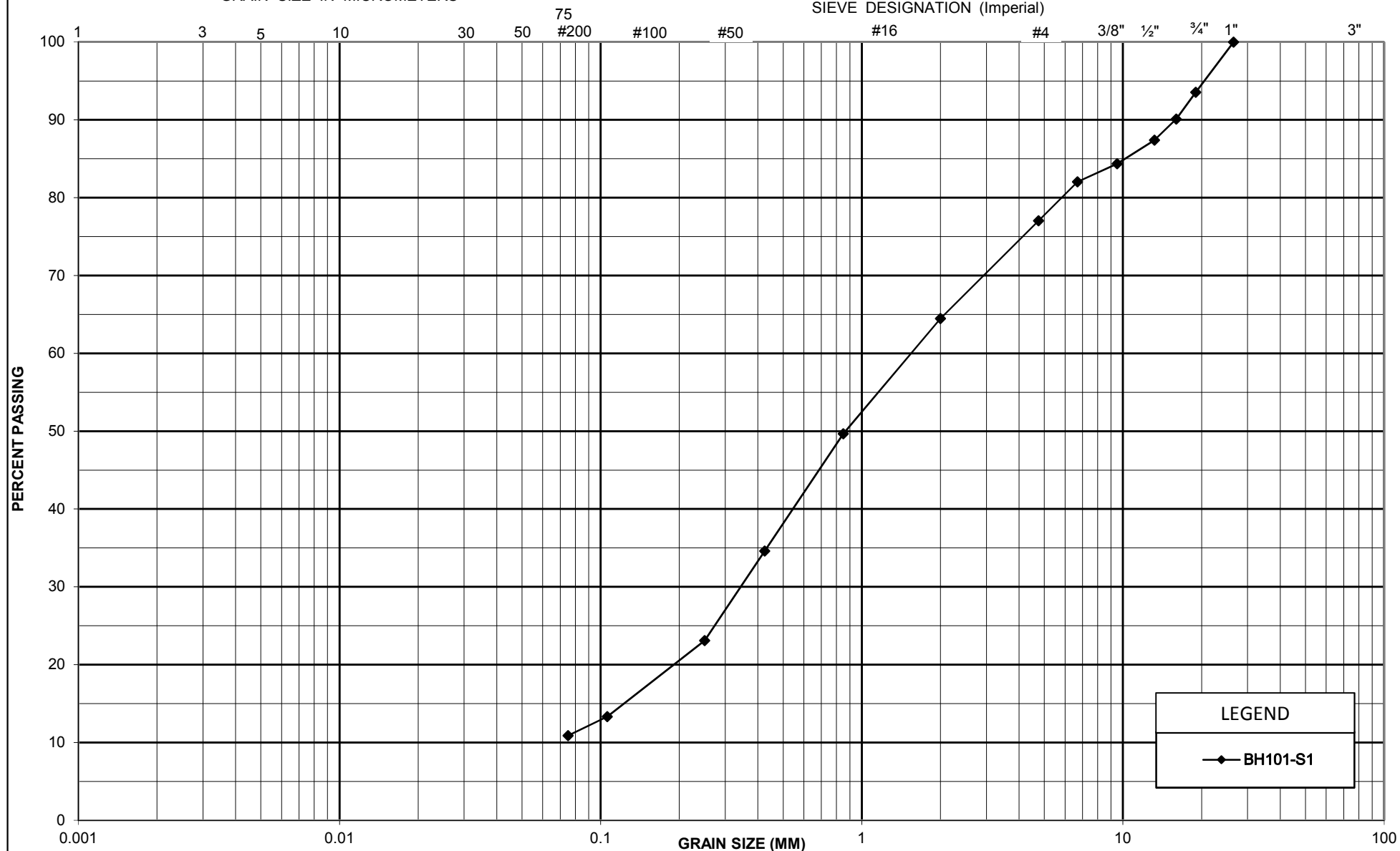
Appendix D – Laboratory Data

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse

GRAIN SIZE IN MICROMETERS

SIEVE DESIGNATION (Imperial)



LEGEND
—●— BH101-S1



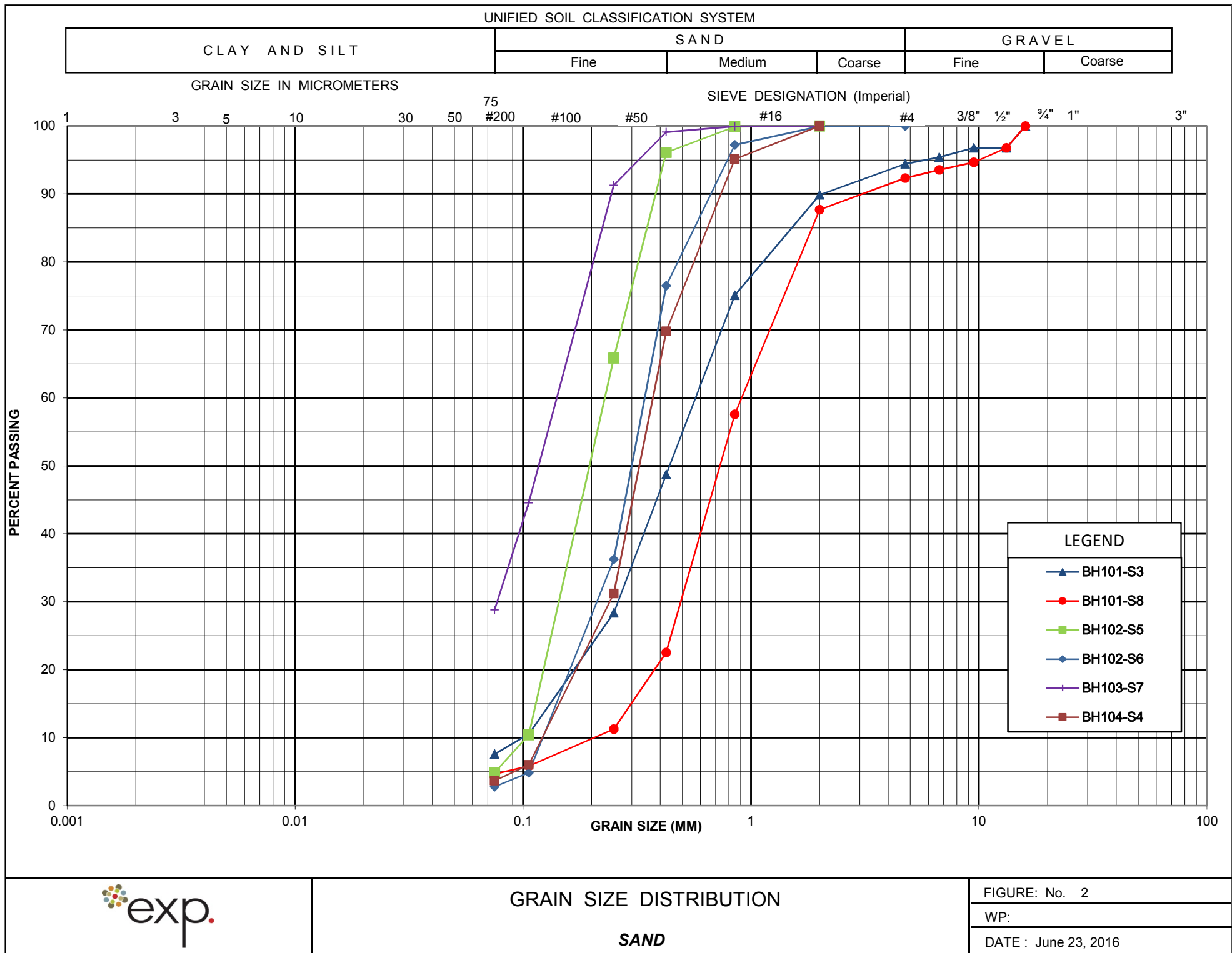
GRAIN SIZE DISTRIBUTION

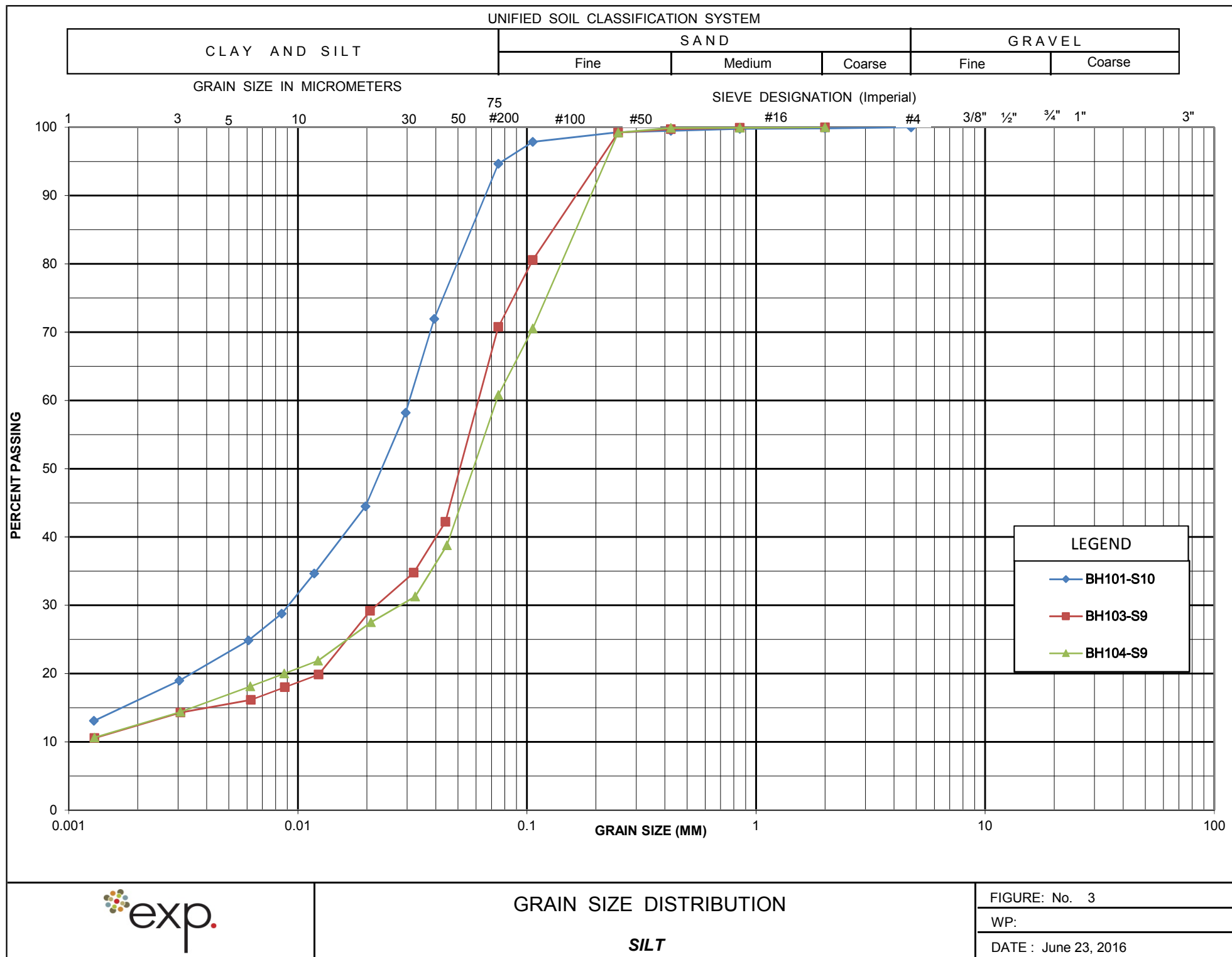
Poorly Graded Sand with Silt and Gravel (FILL)

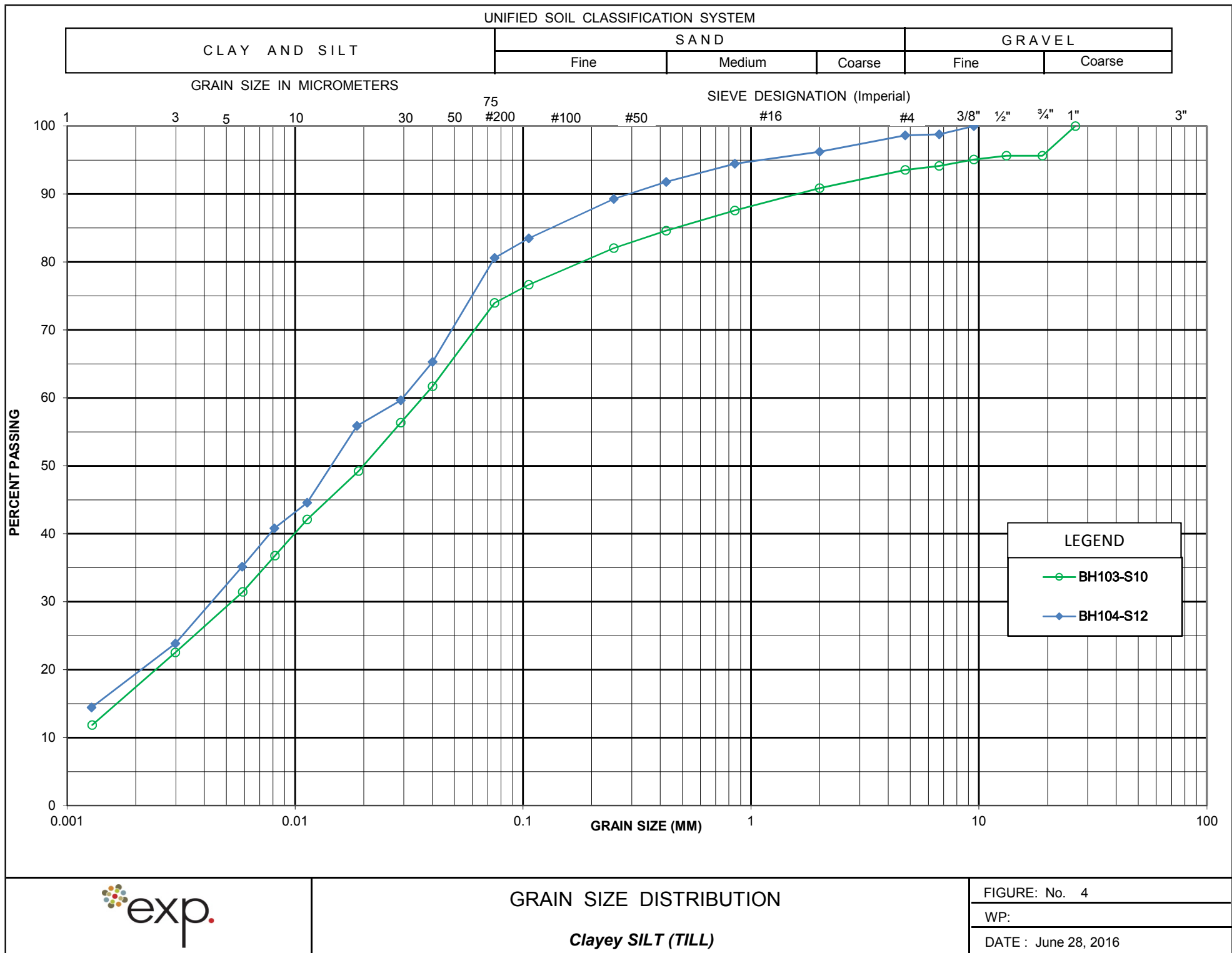
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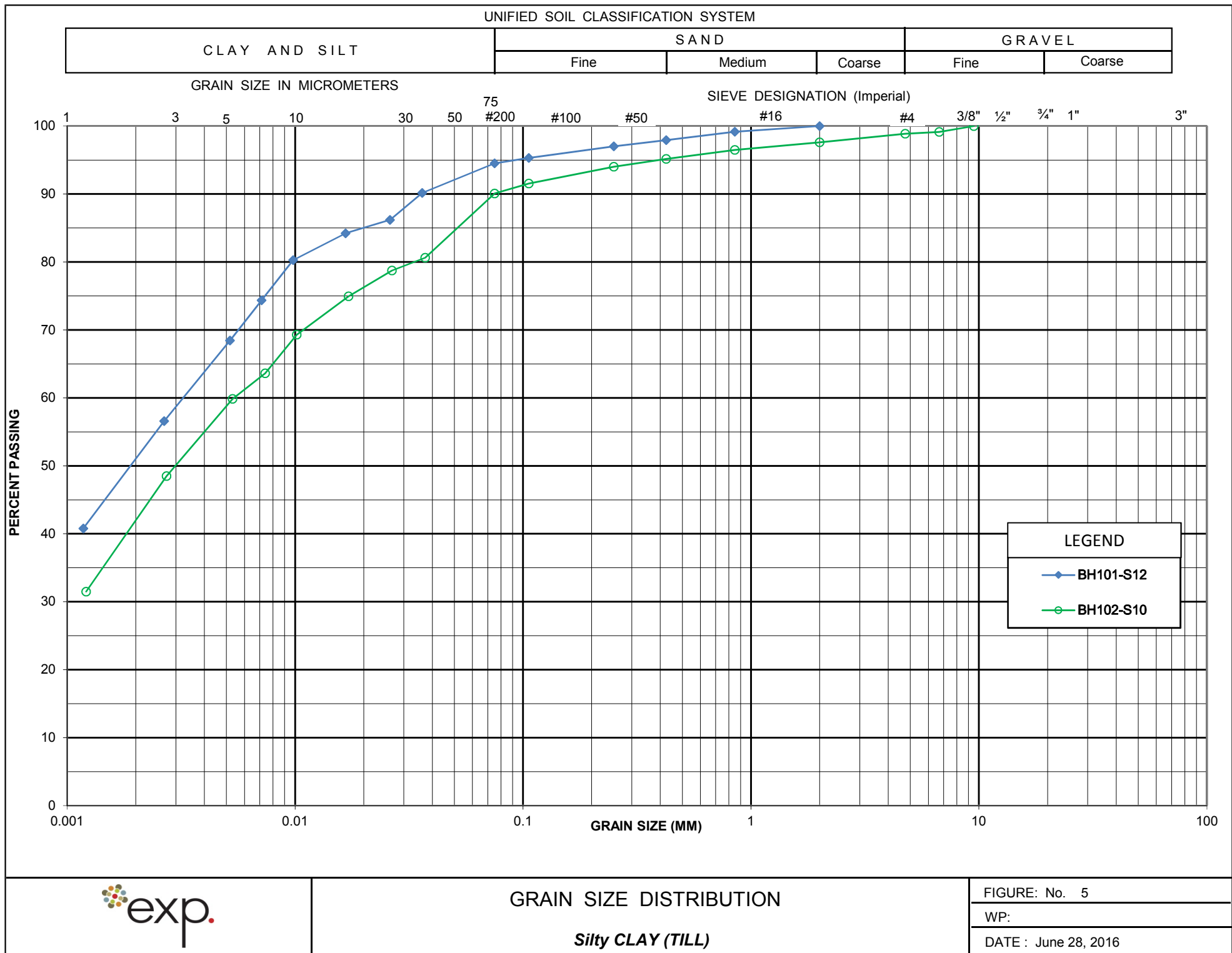
WP:

DATE : June 23, 2016









**New Salt Storage Building, Kakabeka Patrol Yard
WP No. ??, Highway 11/17, Oliver Paipoonge, Ontario**

