

**MTO Agreement No. 5011-E-0010
WO No. 2011-11034
Proposed Sand/Salt Storage Facility
Porquis Junction Patrol Yard
Foundation Investigation and
Design Report
Geocres No. 42A-95
March 2013**

Prepared for:
Ontario Ministry of Transportation
Northeastern Region
447 McKeown Avenue
North Bay, Ontario
CANADA P1B 9S9

Prepared by:
GENIVAR Inc.
294 Rink Street, Suite 103
Peterborough, Ontario K9J 2K2

Project No. 121-17876-00



Project No. 121-17876-00

March 20, 2013

Mr. Jean-Pierre Perron, P. Eng.
MTO Project Manager
Ontario Ministry of Transportation
Northeastern Region
447 McKeown Avenue
North Bay, Ontario P1B 9S9

**Re: MTO Agreement No. 5011-E-0010 / WO No.: 2011-11034
Proposed Sand/Salt Storage Facility – Porquis Junction Patrol Yard
Foundation Investigation and Design Report (Geocres No. 42A-95)**

Dear Mr. Perron:

We are pleased to submit our Foundation Investigation and Design Report for the proposed Sand/Salt Storage Facility at the Ontario Ministry of Transportation Northeastern Region (MTO) Porquis Junction Patrol Yard in Porquis Junction, Ontario. A borehole and laboratory testing program was conducted to assess soil and groundwater conditions at the site and provide recommendations for foundation design for the proposed structure.

This report presents the investigation methodology and findings, and was completed in accordance with the Terms of Reference provided in MTO Agreement #5011-E-0010.

We trust that this report meets your current requirements. Please contact us if you have any questions.

Yours truly,
GENIVAR Inc.

A handwritten signature in blue ink, appearing to read "J. Stephen Ash".

J. Stephen Ash, P. Eng., P. Geo.
Director, Environment

Table of Contents

Transmittal Letter
Table of Contents

1. INTRODUCTION	1-1
2. SITE DESCRIPTION AND REGIONAL GEOLOGY.....	2-1
2.1 Site Description.....	2-1
2.2 Regional Geology	2-1
3. HISTORIC REPORT REVIEW.....	3-1
4. INVESTIGATION PROCEDURES.....	4-1
4.1 Subsurface Investigation	4-1
4.2 Laboratory Testing	4-2
5. SUBSURFACE CONDITIONS.....	5-1
5.1 Soil Profile Summary	5-1
5.1.1 Asphalt Pavement	5-1
5.1.2 Granular Fill.....	5-1
5.1.3 Silty Clay	5-1
5.1.4 Silt	5-2
5.1.5 Silty Sand	5-3
5.1.6 Dynamic Cone Penetration Testing	5-3
5.2 Groundwater Conditions	5-4
6. GEOTECHNICAL DESIGN CONSIDERATIONS.....	6-1
6.1 “Red Flag” Conditions and NSSP’s	6-1
6.2 Mitigation of Settlement Potential	6-2
6.3 Structure Foundation Design Options.....	6-2
6.4 Frost Penetration Depth.....	6-3
6.5 Preferred Foundation Option	6-4
6.6 Resistance to Lateral Loads	6-4
6.7 Backfill and Lateral Earth Pressure	6-5
6.8 Seismic Design	6-6
6.9 Dewatering and Drainage	6-6
6.10 Excavations and General Construction Consideration	6-7
7. MISCELLANEOUS INFORMATION	7-1
8. CLOSURE	8-1

Drawings

Drawing 1	Borehole Location Plan
Drawing 2	Soil Strata

Tables

Table 4-1	Borehole Numbers, Drilling Depths and Elevations.....	4-2
Table 4-2	Soil Testing Program – Porquis Junction Patrol Yard.....	4-2
Table 5-1	Summary of Groundwater Levels	5-4
Table 6-1	Foundation Design Alternatives	6-3
Table 6-2	General Backfill Properties	6-5
Table 6-3	Recommended Unfactored Parameters for Temporary Shoring Design.....	6-6
Table 6-4	Soil Classification for Excavation	6-7
Table 7-1	Summary of Task Responsibilities and Personnel	7-1

Appendices

Appendix A	Borehole Explanation Forms, Borehole Logs
Appendix B	Summary of Particle Size Distribution Results (Table B1), Particle Size Distribution Analyses (Figures B1 to B4), Plasticity Chart (Figure B5)
Appendix C	Site Photographs

1. Introduction

GENIVAR Inc. (GENIVAR) was retained by the Ontario Ministry of Transportation Northeastern Region (MTO) to undertake a foundation investigation for the proposed construction of a sand/salt storage facility at the Porquis Junction Patrol Yard, located on Highway 67, 0.4 kilometers east of the junction of Highway 11 and Highway 67 in Porquis Junction, Ontario. The purpose of the investigation was to assess subsurface conditions at the site and provide recommendations for foundation design at the designated structure location.

The geotechnical investigation was conducted in accordance with MTO Agreement #5011-E-0010. This Foundation Investigation and Design Report includes factual results of the geotechnical investigation carried out at the Porquis Junction site, including the field and laboratory testing information, and geotechnical recommendations for foundation design and construction, including a discussion on foundation design alternatives.

2. Site Description and Regional Geology

2.1 Site Description

The Porquis Junction Patrol Yard (site) is located on Highway 67 approximately 0.4 kilometres east of the junction of Highway 11 and Highway 67 in the town of Porquis Junction, Ontario. A Site Plan is included as Drawing 1 and colour photographs of the site are included in Appendix C.

The site is level and no drainage ditches are present; three (3) stormwater catch basins were noted to be present in the central area. Site access is from Highway 67. Surrounding land uses are residential to the east and south, and mixed deciduous and coniferous forest areas to the west and north. No bedrock outcrops were visible on site.

The site is an operational MTO Patrol Yard, and is currently occupied by a number of structures, including:

- 9-bay garage/office;
- 1 small storage shed;
- 1 large salt dome;
- 2 small salt sheds;
- 1 catch basin off northeast corner of the garage, which flows east to a second catch basin, then flows north with another trunk in an easterly direction;
- 1 septic bed northwest of the garage;
- 1 oil / water separator;
- 1-910 L above ground storage tank, contents unknown;
- 1-4,250 L above ground waste oil tank; and
- 2-4,250 L above ground diesel fuel storage tank.

A grassed area exists to the north of the garage and surrounds asphalt parking areas. There is a paved driveway from Highway 67 leading to the existing sand dome and salt sheds.

2.2 Regional Geology

Two different map sources were consulted to determine the regional geology in the Porquis Junction area: i) Ontario Geological Map 2659 Porquis Junction Sheet published by the Ontario Department of Mines, and ii) Miscellaneous Data Release 160 of 'Northern Ontario Engineering Geology Terrain Study Data Base Map' published by the Ministry of Natural Resources (MNR).

Based on the mapping information, the site is located in a glaciolacustrine plain within the Barlow-Ojibway Formation. Local soil deposits comprise predominantly varved silty clay material of glaciolacustrine origin.

The glaciolacustrine sediments are underlain by Archean bedrock of the Stoughton Roquemaure Group, comprised of komatiitic and tholeiitic volcanic rocks. Bedrock was not encountered in the current site investigation, so actual bedrock types below the site and proposed structure are not known.

3. Historic Report Review

Previous geotechnical report for the Porquis Junction Patrol yard was obtained from the MTO Geocres Library in Downsview, Ontario. This patrol yard was the subject of a geotechnical investigation in 1959 when the site was first developed as an MTO Patrol Yard. The results of the geotechnical investigation are summarized in a technical letter, dated July 10, 1959, titled *"Foundation Investigation for Proposed Garage Site - Porquis Junction, Highway 67, District 16"* (Geocres 42A-12).

The geotechnical investigation consisted of sampling three (3) boreholes supplemented by seven (7) dynamic cone penetration tests (DCPT). The soil stratigraphy at the site was found to be quite uniform and consisted of a 3.0 metre (m) to 3.9 m thick layer of varved silty clay, underlain by sandy silt deposits. The varved clay was found to have a shear strength in excess of 100 kPa, while an average SPT N value of 18 blows per 305 mm (1 ft) was recorded in the sandy silt layer. No bedrock or groundwater was encountered during the investigation.

In 2008 and 2009, the patrol yard was the subject of an investigation to determine the extent and magnitude of soil contamination onsite, attributed to former fuelling operations. The results of the soil investigation are summarized in a report, dated May 2009, titled *"Soil Contamination Delineation – Final Report, 3234 Highway 67, Town of Porquis Junction, Ontario, GWP 5274-04-00"*. The 2009 report covered, among other items, a subsurface investigation consisting of sampling 37 boreholes. The soil stratigraphy at the site was found to consist of a sand and gravel fill layer, followed by silty clay, silty fine sand to silty sand, and a soft, saturated silt till layer. Samples were tested for compliance with Ministry of Environment Table 2 criteria for petroleum hydrocarbons (PHC). The investigation found that approximately 8,692 cubic metres of contaminated material was present from a depth of 1.22 metres below ground surface to 4.88 metres below ground surface.

As part of the 2009 report, a geotechnical investigation was completed to gather information as it pertained to excavation, maintaining structural integrity of the existing garage foundations, backfill, and pavement restoration. The results of the geotechnical investigation, completed in 2008, are summarized in a report entitled *"Draft Foundation Investigation and Design Report – Porquis Junction Patrol Yard Environmental Clean-up, Highway 67, New Liskeard Area, G.W.P. 5274-04-00."*, and is included in Appendix A of the May 2009 Soil Contamination Delineation report. The geotechnical investigation consisting of sampling three (3) boreholes supplemented by DCPTs, which were carried out adjacent to each borehole and below the sampled depth in two of the boreholes. The soil stratigraphy consisted of a surficial pavement or topsoil layer, overlying a layer of silty clay, followed by silt, silty sand, and sand deposits. The clay was replaced by a sand fill layer in one of the boreholes. The clay was found to have SPT N values of 10 to 20 blows per 305 mm (1 ft). The sand fill layer was found to have SPT N values of 25 blows per 305 mm in the upper 0.9 m of the layer, with SPT N values dropping to 1 to 7 blows per 305 mm below this depth. The silt layer yielded SPT N values of 7 to 23 blows per 305 mm (1 ft), while the silty sand layer yielded SPT N values of 1 to 9 blows per 305mm, with occasional zones having N values of 11 to 20 blows per 305mm (1 foot), and 80 to 100 blows per 305mm (1 foot). No bedrock was encountered during the investigation, and groundwater levels were not recorded during drilling.

4. Investigation Procedures

4.1 Subsurface Investigation

A borehole investigation was performed at the subject site between September 13 and 14, 2012. The investigation consisted of advancing five (5) exploratory boreholes, designated as BH12-1 through BH12-5, commencing from existing ground level. Borehole locations are shown on Drawing 1 and were located at each of the four corners and center of the proposed storage structure, as required by the Terms of Reference for the assignment.

MTO minimum requirements for the borehole investigation outlined a maximum drilling depth of 15.0 metres below ground surface (mbgs), unless refusal was encountered at a shallower depth or justification for deeper drilling is authorized by the MTO Project Manager. In boreholes BH12-2 and BH12-3, augering was terminated at a depth of 15.7 mbgs in dense to very dense silty sand deposits. In boreholes BH12-1 and BH12-5, augering was terminated at depths of 15.7 mbgs and 7.1 mbgs, respectively, in loose to compact silty sand. Dynamic Cone Penetration Tests (DCPTs) were subsequently advanced below the sampling depths at those locations. Refusal occurred at 15.2 mbgs below ground surface in borehole BH12-5 but did not occur at BH12-1, which was terminated in compact material at a depth of 22.9 mbgs. It should be noted that borehole BH12-4 was terminated prematurely at 1.5 m depth, as instructed by MTO Area Office Staff, due to existing soil contamination found at that location.

The longitude and latitude of the individual borehole locations were obtained using a hand-held GPS unit in the WGS 84 reference system. These coordinates were subsequently converted to MTO standard coordinates (Northings and Eastings). Borehole elevations were surveyed to a known benchmark; in this case, a nail in the asphalt located north of the existing salt dome has a reported geodetic elevation of 291.584 metres above sea level (mASL). Borehole elevations and coordinates are shown on Drawing 1, and are provided on the borehole logs included in Appendix A.

Drilling and soil sampling were completed using a truck-mounted drill rig operating under the supervision of an experienced GENIVAR soils technician. The boreholes were advanced to the sampling depths by means of continuous flight hollow stem augers. Standard Penetration Test (SPT) N values were recorded for the sampled intervals as the number of blows required to drive a split spoon sampler 305 mm into the soil, using a 63.5 kilogram drop hammer falling 750 mm (ASTM D1586 procedure). Refusal depth for the purposes of this investigation are defined in the MTO Terms of Reference as the depth at which SPT N values exceed 100 blows for 305 mm of penetration. SPT N values are used in this report to assess consistency for cohesive soils and relative density for non-cohesive materials.

Soil samples were collected using SPT procedures at approximately 0.75 m intervals to a depth of 5.0 m, and at 1.5 m intervals thereafter to the termination depth, which was less than 20 m, as per the Terms of Reference. The sampled soil materials from discrete units were logged in the field using visual and tactile methods, and were then placed in labeled plastic bags for transport, future reference, possible laboratory testing, and storage. Soils for laboratory moisture content testing were placed in sealed laboratory jars for transport.

In cohesive deposits, where the consistency of the soil permitted, relatively undisturbed samples were taken with 70 mm diameter thin-walled Shelby tubes, which were pushed into the bottom of the borehole using the hydraulic ram of the drill rig. The Shelby tubes were preserved for transport and storage and possible inspections and laboratory testing. In situ undrained shear strength (c_u) of the soil was measured using an ASTM tapered field vane and standardized procedures.

DCPTs were completed below a depth of 15.7 m in borehole BH12-1 and below a depth of 7.1 m in borehole BH12-5. In the DCPT, a 51 mm diameter, 60° Apex cone point, screw-attached to the tip of A-size rods, was driven into the ground using the same driving energy as in the SPT method. By recording the number of blows to drive the cone/rod assembly into the soil every 305 mm, a qualitative record of

relative density/consistency is obtained. Although the interpretation of the test results may be difficult because no soil samples are obtained through this method, and the penetration resistances are not necessarily equivalent to N values or undrained shear strengths, useful information is gained by the continuity of the results and by the elimination of unbalanced hydrostatic effects which may affect SPT N values. In some deposits, soil adhesion to the drill rod assembly may affect DCPT results, and therefore should be taken into account in the geotechnical assessments. Groundwater conditions within the boreholes were observed during drilling, prior to backfilling.

All boreholes were backfilled with drill cuttings mixed with bentonite hole plug, and the top portion of the boreholes was sealed with emulsified asphalt. The backfill material was compacted with the drill rig. As such, the boreholes are abandoned in accordance with O. Reg. 903 requirements, as amended. Table 4.1 below summarizes the borehole numbers and drilling depths and the surveyed elevations.

Table 4-1: Borehole Numbers, Drilling Depths and Elevations

Borehole No.	Drilling Depth Below Existing Ground Surface (mbgs) / Elevation (mASL)	Dynamic Cone Penetration Test Depth (m)
BH12-1	15.7 / 275.6	15.7 to 22.9
BH12-2	15.7 / 275.6	
BH12-3	15.7 / 275.6	
BH12-4	1.5 / 289.7	7.1 to 15.2
BH12-5	7.1 / 284.0	

4.2 Laboratory Testing

The following soil testing program, as summarized in Table 4.2, was completed on selected soil samples to confirm the textural classifications and provide geotechnical parameters of the encountered materials.

Table 4-2: Soil Testing Program – Porquis Junction Patrol Yard

Test	ASTM Standard	Number of Samples
Natural Moisture Content	ASTM D2216	42
Particle Size Analysis	ASTM D422	12
Atterberg Limits	ASTM D4318	4

The minimum number of laboratory tests was set at 25 percent of the samples, according to the MTO Terms of Reference. Low complexity soil tests were completed at GENIVAR's RAQ's certified laboratory in Peterborough. Laboratory testing results are presented on the borehole logs and in Appendix B.

5. Subsurface Conditions

The subsurface conditions were explored at the five (5) borehole locations designated as BH12-1 to BH12-5. Borehole locations are shown in Drawing 1 while the soil strata are provided in two cross sections presented on Drawing 2. Detailed borehole logs are provided in Appendix A, and laboratory test results with the summary tables are included in Appendix B.

5.1 Soil Profile Summary

All five (5) of the boreholes encountered a thin layer of asphalt overlying loose to compact granular fill. A stiff to very stiff silty clay layer was encountered beneath the fill, overlying a stiff to hard silt layer, which in turn is underlain by a silty sand layer extending to the borehole termination depths of 7.1 m to 15.7 m below ground surface (mbgs) and elevations between 284.0 and 275.6 mASL. DCPTs advanced to 22.9 m depth in borehole BH12-1 and to 15.2 m depth in BH12-5 indicate the presence of compact to dense materials. Descriptions of individual soil units are provided in the following subsections.

5.1.1 Asphalt Pavement

A 75 mm thick layer of asphaltic concrete (hot laid mix) was encountered at surface, at each of the borehole locations.

5.1.2 Granular Fill

Below the asphalt pavement, boreholes BH12-1 to BH12-5 encountered a granular fill layer (pavement base/subbase), consisting of 0.15 m to 0.20 m of gravelly sand, underlain by sand with some gravel, extending to the depths (metres below ground surface or mbgs) and elevations (geodetic) shown below:

<u>Borehole No.</u>	<u>Depth to Bottom of Fill Layer (Elevation)</u>
BH12-1	0.8 mbgs (290.6 mASL)
BH12-2	1.4 mbgs (289.9 mASL)
BH12-3	1.4 mbgs (289.9 mASL)
BH12-4	1.2 mbgs (290.0 mASL)
BH12-5	1.4 mbgs (289.7 mASL)

Laboratory particle size distribution analysis for one (1) sample from the fill layer was completed, and results according to the Unified Soil Classification System (USCS) are summarized below and shown on Figure B1 of Appendix B:

- Gravel (greater than 4.75 mm size) - 18 %
- Sand (0.075 mm to 4.75 mm size) - 74 %
- Silt and Clay (less than 0.075 mm size) - 8 %

Standard Penetration Test results (N Values) recorded in the fill layer ranged between 5 and 18 blows per 305 mm of penetration, indicating loose to compact relative density.

Laboratory determined moisture contents ranged between 12 % and 32 % for samples of the fill, indicating moist to wet material.

5.1.3 Silty Clay

Beneath the granular fill layer, a layer of silty clay with a trace of fine sand was encountered, extending to depths (mbgs) and elevations (geodetic) shown below:

<u>Borehole No.</u>	<u>Depth to Bottom of Silty Clay Layer (Elevation)</u>
BH12-1	4.4 mbgs (286.9 mASL)
BH12-2	5.5 mbgs (285.8 mASL)
BH12-3	3.7 mbgs (287.6 mASL)
BH12-4	N/A
BH12-5	3.7 mbgs (287.4 mASL)

Thus, the thickness of the silty clay layer varied from 2.3 m at boreholes BH12-3 and BH12-5 to 3.62 m at BH12-1, and 4.1 m at borehole BH12-2.

Laboratory particle size distribution analyses for four (4) samples from the silty clay layer were completed, and results according to USCS are summarized below and shown on Figure B2 of Appendix B:

➤ Gravel (greater than 4.75 mm size)	-	0 % to 3 %
➤ Sand (0.075 mm to 4.75 mm size)	-	2 % to 8 %
➤ Silt (0.002 mm to 0.075 mm size)	-	31 % to 37 %
➤ Clay (less than 0.002 mm size)	-	54 % to 67 %

Atterberg Limits tests performed on four (4) samples from the silty clay deposit yielded the following index values:

➤ Liquid Limit (w_L)	-	39 % to 48 %
➤ Plastic Limit (w_P)	-	21 % to 23 %
➤ Plasticity Index (I_P)	-	18 % to 25 %

From the USCS plasticity chart included as Figure B5 in Appendix B, the samples may be classified as inorganic clay of medium plasticity (CI).

The natural moisture content of samples recovered from this layer ranged from 20 % to 38 %, based on laboratory testing, indicating about plastic limit (APL) to wetter than plastic limit (WTPL) material.

Standard Penetration Test results (N values) recorded in the silty clay deposit ranged from 4 to 12 blows per 305 mm of penetration. Undrained shear strengths, as measured by field vane methods, were 100 kPa. Undrained shear strengths also were estimated from pocket penetrometer readings taken in split spoon samples of the silty clay deposit, and were found to be in excess of 120 kPa. Based on these results, the consistency of the silty clay deposit is described as stiff to very stiff. The sensitivity of the silty clay layer was measured once and found to be 7.0 (relatively sensitive clay).

5.1.4 Silt

A layer of silt with trace to some clay was encountered beneath the silty clay layer in boreholes BH12-1, BH12-2, BH12-3 and BH12-5. The silt layer is 0.7 m to 2.5 m thick and extends to the depths (mbgs) and elevations (geodetic) shown below:

<u>Borehole No.</u>	<u>Depth to Bottom of Silt Layer (Elevation)</u>
BH12-1	6.5 mbgs (284.8 mASL)
BH12-2	8.0 mbgs (283.3 mASL)
BH12-3	5.6 mbgs (285.7 mASL)
BH12-4	N/A
BH12-5	4.4 mbgs (286.7 mASL)

Laboratory particle size distribution analyses for four (4) samples of the silt unit were completed, and results are summarized below and shown on Figure B3 of Appendix B:

- Gravel (greater than 4.75 mm size) - 0 %
- Sand (0.075 mm to 4.75 mm size) - 1 % to 3 %
- Silt (0.002 mm to 0.075 mm size) - 83 % to 93 %
- Clay (less than 0.002 mm size) - 6 % to 14 %

The silt exhibits dilatant to slightly plastic behaviour depending on clay content. Standard Penetration Test results (N values) ranged from 9 to 33 blows per 305 mm of penetration, indicating stiff to hard consistency.

Laboratory determined moisture content ranged between 19 % and 22 % for the silt samples, generally indicating wet material.

5.1.5 Silty Sand

A silty sand layer with traces of gravel and clay was encountered beneath the silt layer in boreholes BH12-1, BH12-2, BH12-3 and BH12-5. The silty sand extends to end of sampling depths (mbgs) and elevations (geodetic) shown below:

<u>Borehole No.</u>	<u>Sampled Depth (Elevation)</u>
BH12-1	15.7 mbgs (275.6 mASL)
BH12-2	15.7 mbgs (275.6 mASL)
BH12-3	15.7 mbgs (275.6 mASL)
BH12-4	N/A
BH12-5	7.1 mbgs (284.0 mASL)

Laboratory particle size distribution analyses for three (3) samples of the material were completed, and results are summarized below and shown in Figure B4 of Appendix B:

- Gravel (greater than 4.75 mm size) - 4 % to 6 %
- Sand (0.075 mm to 4.75 mm size) - 51 % to 54 %
- Silt (0.002 mm to 0.075 mm size) - 34 % to 36 %
- Clay (less than 0.002 mm size) - 7 % to 8 %

Laboratory determined moisture content ranged between 10 % and 22 %, indicative of wet material.

Standard Penetration Test results (N Values) recorded in the unit ranged between 1 and 64 blows per 305 mm of penetration, indicating very loose to very dense (generally loose to compact) relative density. Lower N values are probably related to disturbance from sampling in submerged conditions.

5.1.6 Dynamic Cone Penetration Testing

Dynamic cone penetration testing (DCPT) was performed below the borehole termination depths of 15.7 mbgs and 7.1 mbgs at boreholes BH12-1 and BH12-5, respectively, and extended to depths of 22.9 m and 15.2 mbgs, respectively. Refusal, defined by MTO as 100 blows per 305 mm of penetration, was encountered only at borehole BH12-5 at a depth of 15.2 mbgs (elevation 275.0 mASL). Compact soils extend below the 22.9 m termination depth in BH12-1.

5.2 Groundwater Conditions

Groundwater conditions were observed in the open boreholes upon completion of drilling. Results are summarized in Table 5.1.

Table 5-1: Summary of Groundwater Levels

Location	Measured Groundwater Depth, mbgs (elevation mASL)	Date Measured
BH12-1	4.0 (287.3)	*inferred from soil moisture, colour
BH12-2	3.3 (288.0)	*inferred from soil moisture, colour
BH12-3	2.3 (289.0)	14 September 2012
BH12-5	3.7 (287.4)	14 September 2012

Note: mbgs = metres below ground surface; no groundwater measured BH12-4

Based on the water level measurements, soil moisture conditions and changing color of the inspected soil samples, the groundwater/piezometric level within the footprint of the proposed structure, at the time of the field investigation, was estimated to be between approximately 2.5 m and 4.0 m below ground surface (elevation 287.5 mASL to 289.0 mASL).

It should be noted that groundwater levels may fluctuate seasonally and in response to climatic conditions. Due to the fine-grained soils at the site, a potential for development of shallow perched groundwater exists after wet seasons and periods of rainfall.

6. Geotechnical Design Considerations

The proposed sand/salt storage facility at Porquis Patrol Yard will be constructed at the location shown in Drawing 2, and will have a rectangular footprint of approximate dimensions 18.3 m × 24.4 m. Foundation engineering guidelines presented in this section have been developed based on the soil conditions investigated and described in Section 5, and in accordance with the most recent edition of the Canadian Highway Bridge Design Code (CHBDC) and the most recent edition of the Canadian Building Code in effect for MTO projects.

Five (5) boreholes (BH12-1 to BH12-5) were drilled to assess the subsurface conditions at the proposed storage facility. The boreholes encountered a thin layer of asphalt overlying loose to compact granular fill. A stiff to very stiff silty clay layer was encountered beneath the fill, overlying a stiff to hard silt layer, which in turn was underlain by a silty sand layer extending to the borehole termination depths of 7.1 m to 15.7 m below ground surface (mbgs) and elevations between 284.0 mASL and 275.6 mASL.

The groundwater/piezometric surface was measured/estimated to be approximately 2.5 m and 4.0 m below ground surface (elevation 287.5 mASL to 289.0 mASL) at the time of the investigation, generally occurring within the low permeability silty clay unit.

6.1 “Red Flag” Conditions and NSSP’s

Soil and groundwater conditions at the Porquis Junction site present some challenges for design and construction of the foundation for the new sand/salt storage facility.

Contaminated soil was encountered at BH12-4 and remediation may be required prior to construction. Alternatively, contaminated soils may have to be removed and disposed of during construction according to Provincial Regulations.

A high groundwater table, generally at elevations between 287.5 mASL to 288.5 mASL (2.5 m and 4.0 m below the ground surface) presents a possible challenge for foundation construction. Depending on the depth of the foundation excavations and conditions at the time of construction, dewatering requirements may range from pumping in filtered sumps and ditching, to pumping from wellpoints.

Dilatant zones of saturated silt exist and if disturbed these soils may destabilize and take on a liverish, jelly-like appearance. Protective measures are required to maintain adequate excavation stability and foundation bearing capacity. Mitigation measures for shoring and groundwater drainage are provided in Sections 6.7 and 6.9.

The following Non-standard Special Provisions (NSSP’s) are presented to address “Red Flag” conditions.

- NSSP 1. The Contractor is advised that contaminated soils exist at the site, and remediation/soil removal protocols, according to Provincial Regulation, must be followed when working with these materials.
- NSSP 2 The Contractor should be notified that the overburden soils include silty clay to silt materials that are susceptible to sloughing and loosening in wet conditions. The Contractor shall ensure that appropriate construction procedures and equipment are available and used as necessary to maintain stable excavations and drainage, to allow for construction in the dry.

A silty clay and silt layer is present below the structure and is prone to consolidation settlement due to the structural loadings, and more importantly loadings imposed by the sand/salt stockpiles. Settlement potential and mitigation measures are discussed in Section 6.2, and foundation design options subsequently discussed in Section 6.3 are presented under the assumption that settlement potential due

to the loadings is mitigated in advance of construction. Otherwise, structural adjustments and building maintenance may be required.

6.2 Mitigation of Settlement Potential

The theoretical settlement potential was predicted using the Skempton (1944) empirical correlation for the compression index: $C_c=0.009$ (LL- 10) and $C_s=10\%$ of C_c . The settlement analysis assumes 3.5 m thick of upper silty clay layer underlain by a 2.0 m thick layer of silt. The analyses consider three scenarios for loadings imposed by sand and salt stockpiles. The following three scenarios were considered to evaluate settlement potential due to loadings imposed by the sand and salt stockpiles within the storage facility.

- Scenario No. 1: Salt stockpiles placed to the rear of the facility to the maximum allowable height of the “push wall” (3.6 m), with the stockpile periodically replenished throughout the winter. Assumed total weight = 9800 kN (1000 Tonnes).
- Scenario No. 2: Winter sand stacked to the maximum allowable height of the “push wall” at the rear of the facility, occupying $\frac{3}{4}$ of building’s footprint, with an additional 4900 kN (500 Tonnes) salt stockpile within the front $\frac{1}{4}$ of the building.
- Scenario No. 3: Storage facility loaded to full capacity. This scenario would consist of winter sand stacked to the maximum height of the “push wall”, with the stockpile area covering the entire footprint of the building.

The estimated effective stress increases (Δp) and the total and differential settlements for each loading are summarized as follows:

Scenario No.	Effective Stress Increase (Δp), kN/m ²	Total Settlement (mm)	Differential Settlement (mm)
Scenario No.1	12.5	30	18
Scenario No.2	46.6	75	30
Scenario No.3	51.3	80	45

Consolidation settlement for the worst case scenario, assuming normally consolidated cohesive soil, is estimated at 80 mm. Differential settlement potential is estimated at 45 mm. The value of the immediate settlement for the silt layer of about 5 to 10 mm was included in the total settlement listed above.

If warranted by building design tolerances for deflection, the settlement potential due mainly to stockpile loading could be mitigated with a preloading program using a fill surcharge and possibly a vertical wick drainage system. Wick drains, if used, would need to extend to a depth of 6 m to 8 m below ground and be installed on a triangular grid at an approximate spacing of 2 m. The height of the surcharge should be at least 2.5 m and extend at least 2.5 m beyond the structure footprint, and should remain in place for at least four (4) months. Applying a higher surcharge loading for a longer period could alleviate the need for wick drains, but the duration of preloading in this case would be in excess of six (6) months.

If the proposed building can tolerate up to 80 mm of settlement (45 mm differential), or if the structure can be equipped with adjustable supports that MTO can maintain, then preloading may not be necessary. Alternately, if reduced stockpile loadings can be used and building settlements can be monitored and adjusted as required, then preloading may not be required.

6.3 Structure Foundation Design Options

Based on the results of this investigation, several foundation options are available, including shallow and deep foundations. The preferred foundation option should be determined in view of following factors:

- Existing Subsurface Conditions
- Serviceability
- Advantages/Disadvantages
- Reliability
- Risk/ Consequences

Comments for consideration of foundation design alternatives are provided in Table 6-1.

Table 6-1: Foundation Design Alternatives

Foundation Type	Advantages/ Disadvantages	Reliability	Risks/ Consequences	Recommendations
Strip Footing on Native Silty Clay Layer	Low cost, lower foundation capacity versus deep foundation, may require groundwater control to prevent subgrade disturbance. Excavation of contaminated soil is required.	Good, provided that good construction practices are used to minimize soil disturbance.	Pumping may be required depending on seasonal groundwater/ moisture conditions. Excavation shoring may be necessary.	Recommended, provided good construction practices are used. Options include shallower insulated footings and use of clear stone fill to stabilize the subgrade level. Foundation must be below frost or insulated, unless stone layer is used (see Section 6.5).
Slab-on-Grade	Medium cost, medium geotechnical resistance, insulation required, larger foundation settlement versus deep foundation.	Good. Insulation required and must extend beyond structure.	Removal of shallow deleterious material and/or existing soil improvement is required. Larger excavation/disturbed area required for insulation component.	Not Recommended due to economic and constructability reasons.
Drilled and Cast-in-Place Concrete Foundation	High bearing resistance, low settlement, protection of subgrade against disturbance not as critical as for shallow foundations, high cost. Possibility of encountering cobbles and boulders during drilling.	Good	Must extend to deeper competent material. Liners may be required. Construction difficulties if boulders encountered during drilling.	Not Recommended due to economic and constructability reasons.
Steel H Piles	High bearing resistance, negligible settlement, protection of subgrade against disturbance not as critical as for shallow foundations, high cost. Possibility of encountering cobbles and boulders. May reduce contaminated soil excavation requirements.	Good	Must extend to deeper competent material. Vibrations and/or soil disturbance may be an issue for nearby structures.	Not Recommended due to economic and constructability reasons.

6.4 Frost Penetration Depth

The recommended design frost protection depth for the site area is 2.5 m (Source: MTO Pavement Design and Rehabilitation Manual). Therefore, a permanent soil cover of about 2.5 m or its thermal

equivalent of high density insulation is required for frost protection of foundations. Slight grade raises may be possible to provide adequate frost protection for footings situated above the groundwater level.

6.5 Preferred Foundation Option

Based on the results of this investigation, the proposed sand/salt storage facility can be supported on spread/strip footings founded on the undisturbed silty clay layer, with a recommended highest founding level at 1.5 m below existing grade (between elevation 289.6 mASL and 289.8 mASL). Unless there will be a grade raise, permanent thermal insulation equivalent to 1 m of additional soil cover is required for frost protection. Insulation shall consist of at least 50 mm of Dow Chemical HI60 (or equivalent) insulation installed according to the manufacturer's specifications. Insulation shall extend at least 1.2 m horizontally outwards, on both sides of the foundation walls to the top of the footing, and also vertically down the sides of the walls at a minimum depth of 0.3 m. All butt joints must be tight.

The other option is to lower the foundation level to 2.5 m depth (elevation 288.8 mASL to 288.6 mASL) for full frost protection, provided construction can be completed to address groundwater seepage and wet soil disturbance concerns. Dewatering, pumping and/or use of mud mats shall be considered in the construction procedures.

The following geotechnical resistances are appropriate for spread/strip footings (minimum 0.9 m width) constructed in the undisturbed silty clay at depth 1.5 m to 2.5 m below the ground surface (elevation 289.8 to 288.6 mASL):

- Factored Geotechnical Resistance at Ultimate Limit State (ULS) = 180 kPa
- Geotechnical Resistance at Serviceability Limit State (SLS) = 130 kPa

Geotechnical Resistance at Serviceability Limit State (SLS) is based on maximum total and differential settlements of 25 mm and 20 mm, respectively. Engineer approval of subgrade soil loadings is required during construction.

If groundwater and disturbance of the silty clay bearing surface is a problem, then the footing excavations could be widened and progressively backfilled with OPSS 1004 19 mm diameter clear stone fill wrapped in medium duty non-woven geotextile (e.g. Terrafix 270R or equivalent). In this case, the footing may be constructed at higher elevation (i.e. above groundwater table and within the frost penetration depth) without insulation. It is estimated that approximately 1 m of clear stone would be required below the footing grade for this design and as such, excavations would need to be at least 1.5 m wide for the footings to accommodate placement of the stone in stable excavation conditions.

Geotechnical resistances for foundation design may be increased to 300 kPa (ULS)/ 220 kPa (SLS) if the clear stone base layer described above is used.

Existing fill materials overlying the native silty clay to clayey silt layer are not suitable as structural material and should be removed to full depth. The founding subsoil must be inspected by the Geotechnical Engineer to confirm that it is suitable to support the design loads, and to confirm that all disturbed or loose soils are properly removed from below all footing areas. It should be noted that silty material at the anticipated founding level can be easily disturbed by foot traffic. Thus, the base must be covered with a minimum 50 mm thick mud slab immediately after inspection and approval.

6.6 Resistance to Lateral Loads

Resistance to lateral forces/sliding between the concrete footings and subsoils should be calculated in accordance with Section 6.7.5 of the CHBDC. The adhesion (C_a) which develops for cast-in-place concrete footings constructed on the undisturbed silty clay may be taken as 70 percent of the untrained shear strength (c_u). Thus, the average value of the adhesion for design should be taken as 50 kPa. This value shall be factored in accordance with the CHBDC, and a reduction factor of 0.8 is to be applied in calculating horizontal resistance. Resistance to lateral loads could be increased by constructing a shear

key at the bottom of the footing. The design of shear keys would require a specific analysis taking into consideration the magnitude of the horizontal loading, the magnitude of the vertical loading, and any variations in the bearing pressure due to overturning moments.

The above guidelines assume that the subgrade materials will not be disturbed by construction activities.

6.7 Backfill and Lateral Earth Pressure

Backfill behind foundation/retaining walls should consist of non-frost susceptible, free-draining backfill materials (i.e. Granular 'A' or Granular 'B' Type I or II, with no more than 8% passing the 0.75 mm sieve as per requirement of OPSS 1010 and its Amendment No. 110S13).

For insulated spread/strip footing foundations deeper than 1.5 m, if used, subdrains connected to a suitable gravity outlet should be provided at the footing level to eliminate frost adhesion and hydrostatic uplift potential.

Computation of horizontal earth pressures acting against walls should be in accordance with the CHBDC. For design purposes, the properties outlined in Table 6-2 can be assumed for backfill.

Table 6-2: General Backfill Properties

Property	Compacted Granular 'A' or Granular 'B' Type II	Compacted Granular 'B' Type I
Angle of Internal Friction ϕ (unfactored)	35°	32°
Unit Weight γ	22 kN/m ³	21 kN/m ³
Coefficients of Lateral Earth Pressure		
K_a	0.27	0.31
K_b	0.35	0.41
K_o	0.43	0.47
K^*	0.45	0.57

Notes:

- K_a is the coefficient of active earth pressure
- K_b is the backfill earth pressure coefficient for an unrestrained structure, including compaction effects
- K_o is the coefficient of earth pressure at rest
- K^* is the earth pressure coefficient for a soil loading a fully restrained structure and includes compaction effects

Earth pressure coefficients are based on the assumption that the backfill behind retaining structures is free-draining granular material and adequate drainage is provided.

The Contractor shall ensure that excavation shoring systems should be carried out in accordance with the OPSS 539. Shoring systems shall be designed by a Professional Engineer experienced in this type of work.

In Ontario, shoring typically consists of soldier pile and timber lagging or sheet piling (with or without bracing/rakers). The shoring system should be designed so that the lateral movement of any portion of the supported excavation will not exceed the established criterion for the structural performance level.

Shoring walls below grade can be designed using the following expression:

$$P = K (\gamma h + q)$$

where:

P = lateral earth pressure (kPa) acting at depth h
 K = earth pressure coefficient

γ = unit weight of backfill (kN/m³)
h = depth to point of interest in metres
q = equivalent value of surcharge on the ground surface in kPa

The above expression assumes that the perimeter drainage system prevents the build up of any hydrostatic pressure behind the structures.

The coefficients of lateral earth pressure given in Table 6-3 may be used for the design of the temporary shoring systems, based on the borehole results.

Table 6-3: Recommended Unfactored Parameters for Temporary Shoring Design

Soil Type	K_a	K_o	K_p	γ (kN/m ³)
Granular Fill	0.33	0.5	3.0	19.0
Stiff Silty Clay	0.35	0.55	2.8	18.5
Firm to Stiff Silt	0.33	0.5	3.0	18.0
Silty Sand	0.30	0.47	3.2	19.0

6.8 Seismic Design

The Ontario Building Code (OBC) specifies that the structure should be designed to withstand forces due to earthquakes. For the purpose of earthquake design, the information relevant to the geotechnical conditions at this site is the 'Site Class'. Based on the explored soil properties, in accordance with Table 4.1.8.4.A of the Ontario Building Code (2006), and in the absence of MASW tests it is recommended that Site Class 'D' (stiff soil) be applied for structural design at this site.

Seismic information for the Porquis Junction site is provided in the table below. Data from the 2005 National Building Code Seismic Hazard Calculation is provided in this table to be consistent with the 2006 Ontario Building Code.

Parameter	Porquis Junction	Source
Site Class	D	2006 Ontario Building Code Table 4.1.8.4.A
$S_a(0.2)$	0.212	2005 National Building Code Seismic Hazard Calculation
$S_a(1.0)$	0.049	2005 National Building Code Seismic Hazard Calculation
F_a	1.3	2006 Ontario Building Code Table 4.1.8.4.B
F_v	1.4	2006 Ontario Building Code Table 4.1.8.4.C

Generally, the looser the sediment, and the higher the water table, the more susceptible the soil is to liquefaction. Wet silty sand soils beneath this site, with lower relative densities, may be prone to liquefaction settlement during a severe earthquake. As such, the proposed structure should be designed with appropriate seismic bracing. Detailed liquefaction assessments are beyond the scope of this report.

6.9 Dewatering and Drainage

It is anticipated that foundation excavations will encounter groundwater at a depth between 2.5 m and 4.0 m below existing ground surface (elevations between 287.5 mASL to 289.0 mASL). Therefore, the bottom of the foundation excavation may encounter seepage, and depending on the final design/construction depth, dewatering may be required to stabilize the soil and facilitate construction. Fluctuating groundwater levels and/or perched groundwater should be anticipated at the site.

It is believed that the observed groundwater levels can be lowered by about 0.5 m by pumping from strategically placed filtered sumps and using gravity drainage. For more extensive drawdown, vacuum well points and/or deeper purge wells would be required. It is recommended that the Contractor be requested to submit dewatering schemes to the MTO Project Manager for approval, prior to construction. Dewatering procedures should follow the requirements and specifications of OPSS 517.

The predominant soils encountered in the boreholes range in texture from upper granular fill underlain by silty clay. Seepage from intermittently saturated granular layers may occur, depending on seasonal conditions at the time of construction. The silty clay soils generally exhibit characteristics of low permeability, and seepage from this type of soil into foundation excavations should be relatively slow.

Depending on the construction and dewatering procedures to be used, the Contractor should obtain a Permit to Take Water (PTTW) under Section 34 of the Ontario Water Resources Act if pumping rates will potentially exceed 50,000 L/day.

6.10 Excavations and General Construction Consideration

Construction excavations are required for foundations and utility services. Temporary excavations must be carried out in accordance with the latest edition of Ontario Regulation (O.Reg.) 213/91 of the Occupational Health and Safety Act (OHSA) as well as MTO specifications OPSS 539 – Protection Systems and OPSS 902 – Excavations and Backfilling to Structure. The soils at the site may be classified as shown below, in accordance with the OHSA.

Table 6-4: Soil Classification for Excavations

Soil Type	Above Groundwater Level	Below Groundwater Level
Fill material	Type 3	Type 4 (not expected)
Stiff Silty clay	Type 2	Type 3
Firm silt some clay	Type 3	Type 4
Silty Sand	Type 3	Type 4

Type 2 excavations may have vertical sides for the bottom 1.2 m of the excavation, and then should be cut with 1H:1V or flatter side slopes to grade. Type 3 excavations should be cut with 1H:1V or flatter side slopes. Type 4 excavations should be cut with 3H:1V or flatter side slopes. If the appropriate side slopes cannot be achieved, the excavations must be properly supported (shored). All excavation and grading procedures should follow the MTO's requirements and specifications, and management of excess material should follow the requirements of OPSS 180.

Excavations should be protected from exposure to precipitation and associated ground surface runoff and should be inspected regularly for signs of instability. If localized instability is noted during excavation or if wet conditions are encountered, excavation side slopes should be flattened as required to maintain safe working conditions.

Regular inspections by qualified geotechnical engineering personnel must be conducted for any excavation in the bedrock to confirm that conditions are safe and consistent with the requirements of the OHSA.

Since the subject site was used for many years to store road salt, and will be used in the future for the same purpose, it is expected that the new foundation will be exposed to chloride, sodium and sulfate attack. To reduce damage potential and rate of deterioration, we recommend the use of high sulfate-resistant cement (Type HS as per CSA A.23) in the concrete mix design with water-cement ratio should not exceed 0.45.

7. Miscellaneous Information

The following GENIVAR personnel and subcontractors responsible for completion of this foundation investigation are summarized in Table 7.1.

Table 7-1: Summary of Task Responsibilities and Personnel

Task	Name	Address	Phone
Buried Utility Locates	Peter Flowerday Central Cable Contractors	Wanapitae, ON	705-694-5256
Drilling	Kyle Gilmore Abraflex Drilling	Lively, ON	705-222-2272
Field Supervision	Dave Lembke, C.E.T., rcji GENIVAR Inc.	Peterborough, ON	705-743-6850
Project Coordinator	Beverly Leno, C.E.T., rcji GENIVAR Inc.	Peterborough, ON	705-743-6850
Laboratory Low Complexity	Kelly Whitney, C.E.T. GENIVAR Inc.	Peterborough, ON	705-743-6850
Report Preparation	Raid Khamis, P. Eng., PMP GENIVAR Inc.	Brampton, ON	905-799-8220
Report Review	Steve Ash, P. Eng., P. Geo. GENIVAR Inc.	Peterborough, ON	705-743-6850
RAQ's Key Contact	Jason Balsdon, M.A.Sc., P. Eng. GENIVAR Inc.	Newmarket, ON	905-853-3303

8. Closure

The data presented in this foundation investigation report, and the quality thereof, is based on a scope of work authorized by the Client. While we believe the borehole information to be representative of site conditions, subsurface conditions between and beyond the test hole locations may vary. GENIVAR accepts no liability for use of or reliance on the report information by third parties, without express written consent.

Prepared by:
GENIVAR Inc.

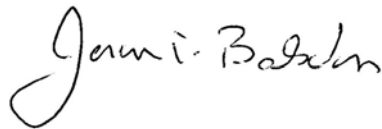


Raid Khamis, P. Eng., PMP
Geotechnical Engineer



J. Stephen Ash, P. Eng., P. Geo.
Director, Environment

Reviewed by:



Jason Balsdon, M.A.Sc., P. Eng.
Director, Environment

Drawings

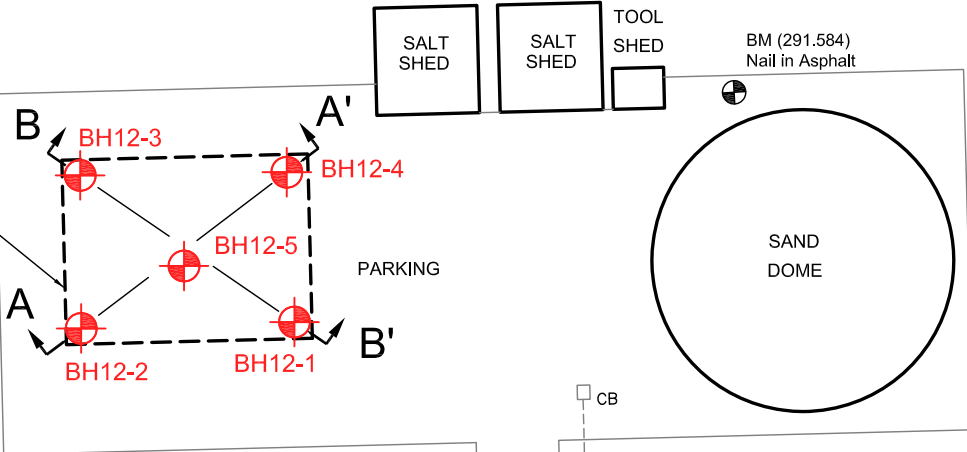
Drawing 1 – Borehole Location Plan

Drawing 2 – Soil Strata

Approximate Property Line

OLD
ASPHALT
PILE

PROPOSED
STRUCTURE



CB

CB

CB

CB

BM (291.584)
Nail in Asphalt

SAND
DOME

DITCH

Approximate Property Line

HIGHWAY 67

SEPTIC
TANK

TILE
BED

OFFICE

9 BAY GARAGE

WELL

PARKING

PLAN VIEW

SCALE 1:750

7.5 0 7.5 15.0 m

NOTES:

1. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
2. COORDINATES AT BOREHOLE LOCATIONS WERE RECORDED BY HANDHELD GPS.
3. BOREHOLE ELEVATIONS WERE SURVEYED BENCHMARK NAIL IN ASPHALT NORTH OF SAND DOME (291.584 mASL).

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES

Agreement No.: 5011-E-0010

WO No.: 2011-11034

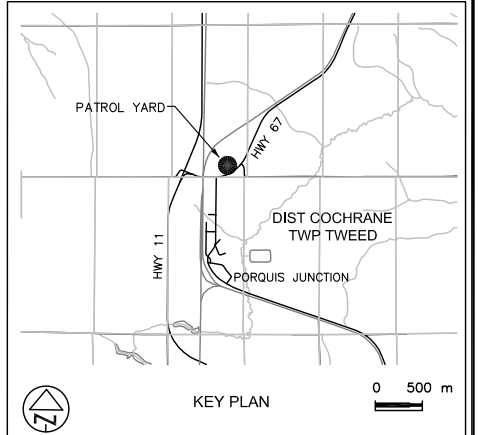


BOREHOLE LOCATION PLAN
PROPOSED SAND/SALT STORAGE
FACILITY
PORQUIS JUNCTION PATROL YARD
HIGHWAY 67

Client: MTO - Northeastern Region

DRAWING

1



LEGEND



Borehole and Cone



Benchmark (291.584 mASL)



Proposed Sand/Salt Storage Facility



A A' Line of Cross Section (See Figure 2)

BH No	ELEVATION (mASL)	COORDINATES (NAD 83 Zone17)	
		NORTHING	EASTING
12-1	291.341	5395486.1	516043.6
12-2	291.312	5395485.5	516022.4
12-3	291.301	5395500.9	516022.4
12-4	291.193	5395501.0	516042.8
12-5	291.070	5395491.7	516032.6

— NOTE —

THE ACTUAL SOIL STRATIFICATION HAS BEEN VERIFIED FROM DATA OBTAINED AT THE BOREHOLE LOCATIONS ONLY. THE INFERRED CONTACTS SHOWN ARE BASED ON GEOLOGICAL EVIDENCE AND THESE MAY VARY FROM THOSE SHOWN BETWEEN BORINGS.

REVISIONS			
	DATE	BY	DESCRIPTION

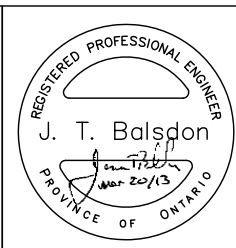
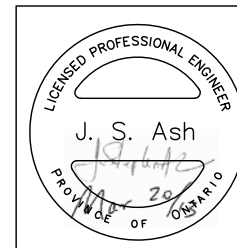
GEOCRE No. 42A-95

HWY No 67	CHECKED JSA	DATE MARCH 2013	DIST COCHRANE
SUBM'D ---	CHECKED ---	APPROVED ---	SITE ---
DRAWN PLB	CHECKED ---	APPROVED ---	DWG ---

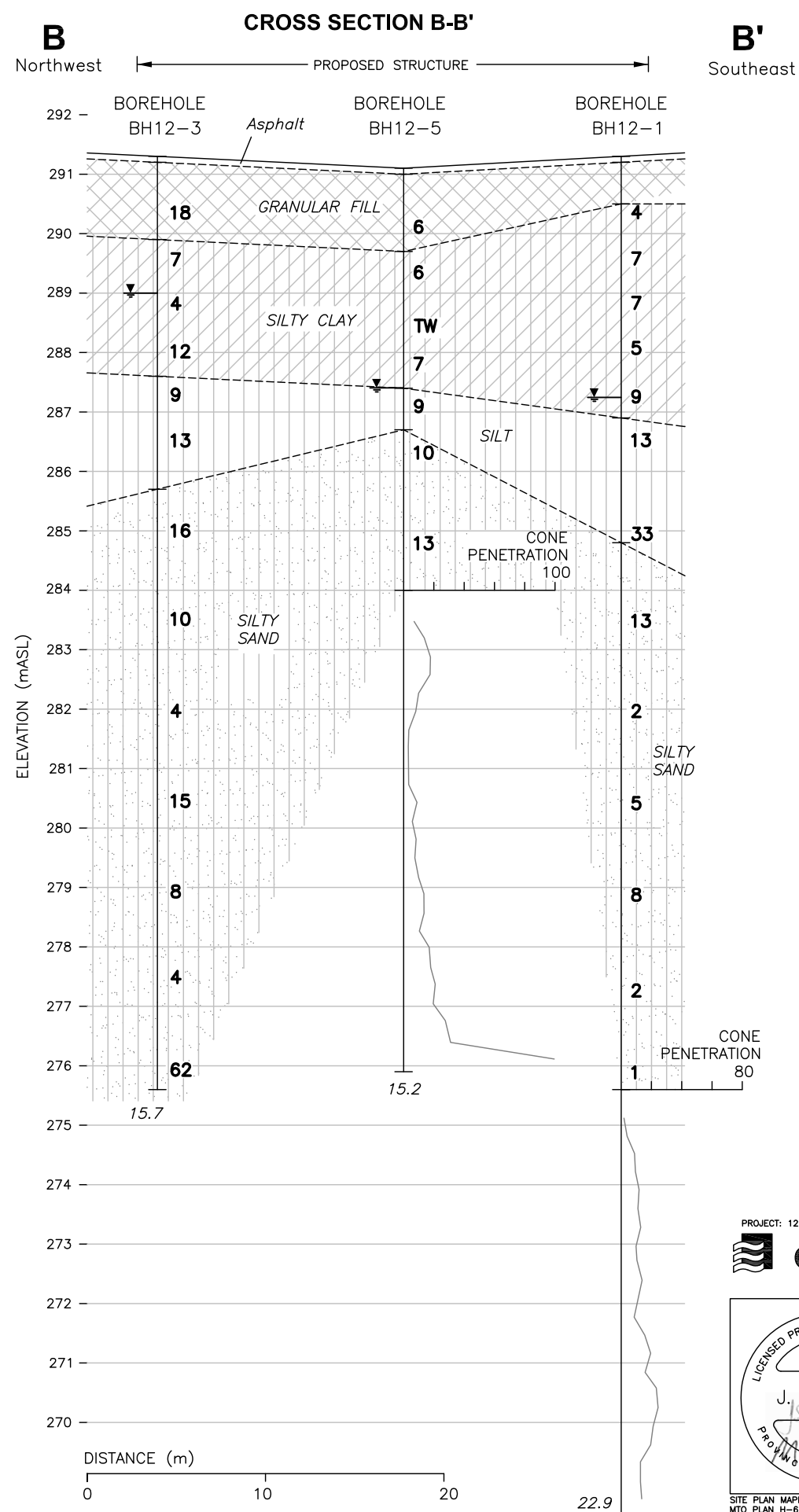
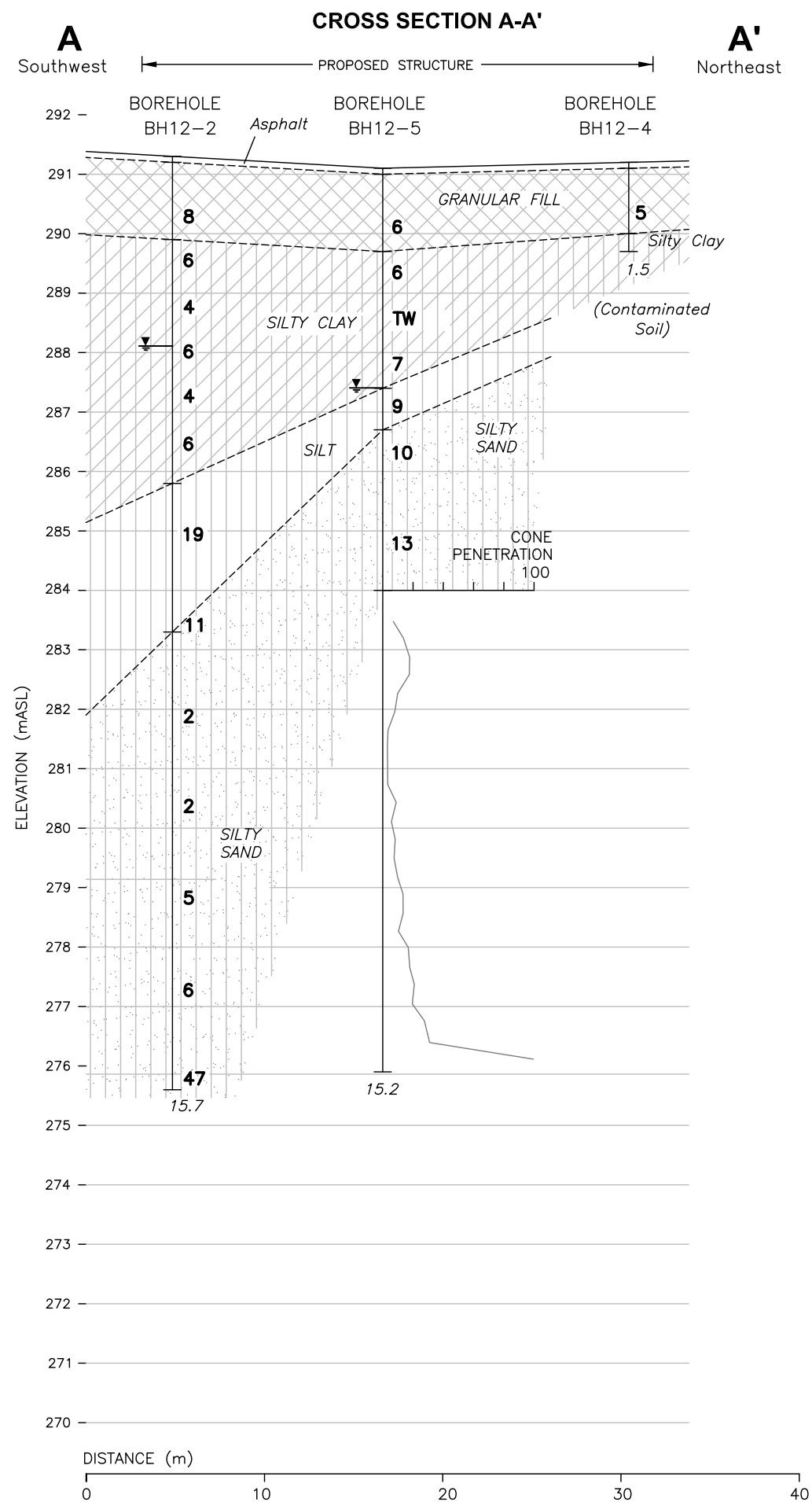
PROJECT: 121-17876-00 111-05



GENIVAR



SITE PLAN MAPPING REF. NO.:
MTO PLAN H-624-67-1 PATROL FACILITY SITE PLAN AND JAGGER
HMS LIMITED FIGURE 2, SITE PLAN, PROJECT 011297.12, SEPT 2008.

**METRIC**

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES

Agreement No.: 5011-E-0010
WO No.: 2011-11034



DRAWING


2

SOIL STRATA
PROPOSED SAND/SALT STORAGE
FACILITY
PORQUIS JUNCTION PATROL YARD
HIGHWAY 67

Client: MTO - Northeastern Region

NOTES:

1. THIS DRAWINGS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
2. COORDINATES AT BOREHOLE LOCATIONS WERE RECORDED BY HANDHELD GPS.
3. BOREHOLE ELEVATIONS WERE SURVEYED BENCHMARK NAIL IN ASPHALT NORTH OF SAND DOME (291.584 mASL).
4. BH12-4 TERMINATED AT 1.5 m DEPTH TO PREVENT CONTAMINATION OF LOWER SOILS.

LEGEND			
N	Blows/0.3m (Std. Pen Test, 475 J / blow)		
CONE	Blow/0.3m (60° Cone, 475 J / blow)		
	Inferred Groundwater Level At Time Of Investigation		
TW	75 mm Diameter Shelby Tube Sample Taken		

BH No	ELEVATION (mASL)	COORDINATES (NAD 83 Zone17)	
		NORTHING	EASTING
12-1	291.341	5395486.1	516043.6
12-2	291.312	5395485.5	516022.4
12-3	291.301	5395500.9	516022.4
12-4	291.193	5395501.0	516042.8
12-5	291.070	5395491.7	516032.6

- NOTE -

THE ACTUAL SOIL STRATIFICATION HAS BEEN VERIFIED FROM DATA OBTAINED AT THE BOREHOLE LOCATIONS ONLY. THE INFERRED CONTACTS SHOWN ARE BASED ON GEOLOGICAL EVIDENCE AND THESE MAY VARY FROM THOSE SHOWN BETWEEN BORINGS.

REVISIONS			
DATE	BY	DESCRIPTION	

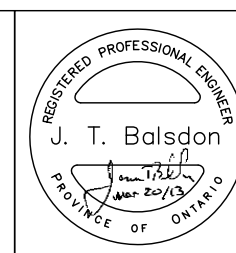
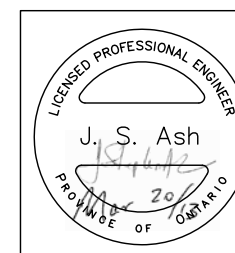
GEOCRES No. 42A-95

HWY No 67			DIST COCHRANE
SUBM'D --	CHECKED JSA	DATE MARCH 2013	SITE --
DRAWN PLB	CHECKED --	APPROVED --	DWG --

PROJECT: 121-17876-00 111-05



GENIVAR



SITE PLAN MAPPING REF. NO.:
MTO PLAN H-624-67-1 PATROL FACILITY SITE PLAN AND JAGGER
HIMS LIMITED FIGURE 2, SITE PLAN, PROJECT 011297.12, SEPT 2008.

Appendix A

Borehole Explanation Forms

Borehole Logs

BOREHOLE LOG EXPLANATION FORM

This explanatory section provides the background to assist in the use of the borehole logs. Each of the headings used on the borehole log, is briefly explained.

DEPTH

This column gives the depth of interpreted geologic contacts in metres below ground surface.

STRATIGRAPHIC DESCRIPTION

This column gives a description of the soil based on a tactile examination of the samples and/or laboratory test results. Each stratum is described according to the following classification and terminology.

<u>Soil Classification*</u>		<u>Terminology</u>	<u>Proportion</u>
Clay	<0.002 mm		
Silt	0.002 to 0.06 mm	"trace" (e.g. trace sand)	<10%
Sand	0.06 to 2 mm	"some" (e.g. some sand)	10% - 20%
Gravel	2 to 60 mm	adjective (e.g. sandy)	20% - 35%
Cobbles	60 to 200 mm	"and" (e.g. and sand)	35% - 50%
Boulders	>200 mm	noun (e.g. sand)	>50%

* Extension of MIT Classification system unless otherwise noted.

The use of the geologic term "till" implies that both disseminated coarser grained (sand, gravel, cobbles or boulders) particles and finer grained (silt and clay) particles may occur within the described matrix.

The compactness of cohesionless soils and the consistency of cohesive soils are defined by the following:

<u>COHESIONLESS SOIL</u>		<u>COHESIVE SOIL</u>		
Compactness	Standard Penetration Resistance "N", Blows / 0.3 m	Consistency	Standard Penetration Resistance "N", Blows / 0.3 m	Undrained Shear Strength (cu) (kPa)
Very Loose	0 to 4	Very Soft	0 to 2	0 to 12
Loose	4 to 10	Soft	2 to 4	12 to 25
Compact	10 to 30	Firm	4 to 8	25 to 50
Dense	30 to 50	Stiff	8 to 15	50 to 100
Very Dense	Over 50	Very Stiff	15 to 30	100 to 200
		Hard	Over 30	Over 200

The moisture conditions of cohesionless and cohesive soils are defined as follows.

COHESIONLESS SOILS

Dry
Moist
Wet
Saturated

COHESIVE SOILS











DTPL - Drier Than Plastic Limit
APL - About Plastic Limit
WTPL - Wetter Than Plastic Limit
MWTP - Much Wetter Than Plastic Limit

STRATIGRAPHY

Symbols may be used to pictorially identify the interpreted stratigraphy of the soil and rock strata.

MONITOR DETAILS

This column shows the position and designation of standpipe and/or piezometer ground water monitors installed in the borehole. Also the water level may be shown for the date indicated.

	Standpipe		Geotextile Material / Liner		Granular Backfill
	Piezometer		Borehole Seal (Bentonite Grout)		Granular (Filter) Pack
	Screened Interval		Cement Seal		Native Soil Backfill / Cave / Slough
	Borehole Seal (Peltonite, Bentonite or Hole Plug)				

Where monitors are placed in separate boreholes, these are shown individually in the "Monitor Details" column. Otherwise, monitors are in the same borehole. For further data regarding seals, screens, etc., the reader is referred to the summary of monitor details table.

SAMPLE

These columns describe the sample type and number, the "N" value, the water content, the percentage recovery, and Rock Quality Designation (RQD), of each sample obtained from the borehole where applicable. The information is recorded at the approximate depth at which the sample was obtained. The legend for sample type is explained below.

SS = Split Spoon	GS = Grab Sample
TW = Thin Walled Shelby Tube	CS = Channel Sample
AS = Auger Flight Sample	WS = Wash Sample
CC = Continuous Core	RC = Rock Core
PH = TW Advanced Hydraulically	TRC = Total Core Recovery

$$\% \text{ Recovery} = \frac{\text{Length of Core Recovered Per Run}}{\text{Total Length of Run}} \times 100$$

Where rock drilling was carried out, the term RQD (Rock Quality Designation) is used. The RQD is an indirect measure of the number of fractures and soundness of the rock mass. It is obtained from the rock cores by summing the length of core recovered, counting only those pieces of sound core that are 100 mm or more in length. The RQD value is expressed as a percentage and is the ratio of the summed core lengths to the total length of core run. The classification based on the RQD value is given below.

RQD ClassificationRQD (%)

Very poor quality	< 25
Poor quality	25 - 50
Fair quality	50 - 75
Good quality	75 - 90
Excellent quality	90 - 100

TEST DATA

The central section of the log provides graphs which are used to plot selected field and laboratory test results at the depth at which they were carried out. The plotting scales are shown at the head of the column.

Dynamic Penetration Resistance - The number of blows required to advance a 51 mm diameter, 60° steel cone fitted to the end of 45 mm OD drill rods, 0.3 m into the subsoil. The cone is driven with a 63.5 kg hammer over a fall of 750 mm.

Standard Penetration Resistance - Standard Penetration Test (SPT) "N" Value - The number of blows required to advance a 51 mm diameter standard split-spoon sampler 300 mm into the subsoil, driven by means of a 63.5 kg hammer falling freely a distance of 750 mm. In cases where the split spoon does not penetrate 300 mm, the number of blows over the distance of actual penetration in millimetres is shown as $\frac{x\text{Blows}}{\text{mm}}$

Water Content - The ratio of the mass of water to the mass of oven-dry solids in the soil expressed as a percentage.

W_P - Plastic Limit of a fine-grained soil expressed as a percentage as determined from the Atterberg Limit Test.

W_L - Liquid Limit of a fine-grained soil expressed as a percentage as determined from the Atterberg Limit Test.

REMARKS

The last column describes pertinent drilling details, field observations and/or provides an indication of other field or laboratory tests that were performed.

RECORD OF BOREHOLE No BH12-1

1 OF 2

METRIC

LOCATION PORQUIS JUNCTION PATROL YARD N 5395486 1: E 516043.6

ORIGINATED BY DCL

BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGERS WITH SPT AND DCPT

COMPILED BY JW/BDL

DATUM GEODETTIC DATE 9.13.12 - 9.13.12

CHECKED BY RK

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 (%)				
								20 40 60 80 100		10 20 30				
291.3														
290.9	75 mm ASPHALT:		1	AS			291							18 74 (8)
	GRANULAR FILL:													
290.6	FINE SAND FILL, SOME GRAVEL													
0.8	BROWN, MOIST TO WET		2	SS	4									
	SILTY CLAY:		3	SS	7									
	SILTY CLAY, TRACE SAND													
	BROWN TO GREY, STIFF TO VERY		4	SS	7									
	STIFF, MOIST TO WET													
			5	SS	5									
			6	SS	9									
286.9														
4.4	SILT:		7	SS	13									
	SILT, TRACE TO SOME CLAY													
	GREY, STIFF TO HARD, WET													
			8	SS	33									
284.8														
6.5	SILTY SAND:													
	SILTY FINE SAND, TRACE TO													
	SOME CLAY, TRACE GRAVEL		9	SS	13									
	GREY, DENSE TO LOOSE, WET													
			10	SS	2									
			11	SS	5									
			12	SS	8									
			13	SS	2									

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

METRIC

ORIGINATED BY DCL

COMPILED BY JW/BDL

CHECKED BY RK

+³, X³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

METRIC

ORIGINATED BY DCL

COMPILED BY JW/BDL

CHECKED BY RK

ONTARIO MOT PORQUIS JUNCTION BH LOGS GPJ ONTARIO MOT GDT 2/13/13

+³, X³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

METRIC

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

RECORD OF BOREHOLE No BH12-3

1 OF 2

METRIC

LOCATION PORQUIS JUNCTION PATROL YARD N 5395500.9, E 516022.4

ORIGINATED BY DCL

BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGERS WITH SPT AND DCPT

COMPILED BY JWBDL

DATUM GEODETIC DATE 9.13.12 - 9.14.12

CHECKED BY RK

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						
291.3								20 40 60 80 100						
290.4	75 mm ASPHALT:		1				291							
	GRANULAR FILL:		2	SS	18									
289.9	GRAVELLY SAND FILL						290							
1.4	BROWN, COMPACT, MOIST TO WET													
	SILTY CLAY:		3	SS	7		289							
	SILTY CLAY, TRACE GRAVEL,		4	SS	4									
	TRACE SAND													
	BROWN TO GREY, STIFF TO VERY		5	SS	12		288							
	STIFF, MOIST TO WET													
287.6														
3.7	SILT:		6	SS	9		287							
	SILT, SOME CLAY, TRACE FINE		7	SS	13									
	SAND						286							
	BROWN, LOOSE TO COMPACT,													
	DILATENT, SATURATED						285							
285.7														
5.6	SILTY SAND:		8	SS	16		284							
	SILTY FINE SAND, TRACE													
	GRAVEL, TRACE CLAY		9	SS	10		283							
	GREY, STIFF, WET													
							282							
			10	SS	4		281							
	- SOME GRAVEL, TRACE CLAY,													
	COMPACT		11	SS	15		280							
							279							
	- TRACE GRAVEL, TRACE CLAY,		12	SS	8		278							
	DILATENT, LOOSE													
			13	SS	4		277							

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH12-3

2 OF 2

METRIC

LOCATION PORQUIS JUNCTION PATROL YARD N 5395500 9; E 516022 4

ORIGINATED BY DCL

BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGERS WITH SPT AND DCPT

COMPILED BY JW/BDL

DATUM GEODETTIC DATE 9.13.12 - 9.14.12

CHECKED BY RK

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W _p	W		
275.6			14	SS	62	276										
15.7	END OF BOREHOLE BOREHOLE CAVED AT 10.7 m DEPTH															

ONTARIO MOT PORQUIS JUNCTION BH LOGS GPJ ONTARIO MOT GDT 2/13/13

RECORD OF BOREHOLE No BH12-4

1 OF 1

METRIC

LOCATION PORQUIS JUNCTION PATROL YARD N 5395501.0; E 516042.8



ORIGINATED BY DCL

BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGERS WITH SPT AND DCPT

COMPILED BY JW/BDL

DATUM GEODETIC DATE 9.14.12 - 9.14.12

CHECKED BY RK

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
291.2							20	40	60	80	100				
290.9	75 mm ASPHALT: GRANULAR FILL: GRAVELLY FINE SAND FILL BROWN, MOIST TO WET STAINED AND STRONG PHC ODOUR BELOW 0.76 m DEPTH		1	AS											
290.0			2	SS	5										
289.7	SILTY CLAY: SILTY CLAY, TRACE SAND GREY, STIFF, MOIST														
1.5	END OF BOREHOLE BOREHOLE TERMINATED AT 1.5 m DEPTH AS INSTRUCTED BY MTO STAFF DUE TO RISK OF CONTAMINATION OF UNDERLYING SOILS.														

RECORD OF BOREHOLE No BH12-5

1 OF 2

METRIC

LOCATION PORQUIS JUNCTION PATROL YARD N 5395491 7; E 516032 6

ORIGINATED BY DCL

BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGERS WITH SPT AND DCPT

COMPILED BY JW/BDL

DATUM GEODETTIC DATE 9.14.12 - 9.14.12

CHECKED BY RK

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			20 40 60 80 100	20 40 60 80 100					
291.1														
290.9	75 mm ASPHALT; GRANULAR FILL; GRAVELLY SAND TO SAND TRACE GRAVEL BROWN, LOOSE, MOIST TO SATURATED		1	AS										
289.7			2	SS	6		290							
1.4	SILTY CLAY; SILTY CLAY, TRACE GRAVEL, TRACE CLAY BROWN TO GREY, STIFF TO VERY STIFF, MOIST		3	SS	6		289							1 8 37 54
			4	ST										
			5	SS	7		288							
287.4														
3.7	SILT; SILT, SOME CLAY, TRACE SAND GREY, STIFF, WET		6	SS	9		287							0 3 83 14
286.7														
4.4	SILTY SAND; SILTY FINE SAND, TRACE GRAVEL, TRACE CLAY GREY, COMPACT, WET		7	SS	10		286							
			8	SS	13		285							
284.0							284							
7.1	CONTINUOUS DYNAMIC CONE PENETRATION TEST BELOW 7.08 m DEPTH.						283							
							282							
							281							
							280							
							279							
							278							
							277							

Continued Next Page

+ 3, X 3

Numbers refer to
Sensitivity

○ 3% STRAIN AT FAILURE

METRIC

CHECKED BY RK

+3, X3 Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

Appendix B

Summary of Particle Size Distribution
Results (Table B1)

Particle Size Distribution Analyses
(Figures B1 to B4)

Plasticity Chart
(Figure B5)

Table B1: Summary of Grain Size Distribution

Borehole No.	Sample ID	Soil Description	Percentage Retained (%)			
			Gravel	Sand	Silt	Clay
BH12-1	AS1	Sand, some gravel, trace silt	18	74	8	
BH12-1	SS4	Silty clay, trace sand	0	2	35	63
BH12-1	SS8	Silt, trace sand, trace clay	0	1	93	6
BH12-1	SS12	Silty sand, trace clay, trace gravel	4	54	34	8
BH12-2	SS5	Silty clay, trace sand	0	2	31	67
BH12-2	SS9	Silt, some clay, trace sand	0	1	86	11
BH12-2	SS12	Silty sand, trace clay, trace gravel	6	51	36	7
BH12-3	SS4	Silty clay, trace sand, trace gravel	3	5	35	57
BH12-3	SS7	Silt, some clay, trace gravel	0	1	88	11
BH12-3	SS10	Silty sand, trace clay, trace gravel	6	52	34	8
BH12-5	SS3	Clay and silt, trace sand, trace gravel	1	8	37	54
BH12-5	SS6	Silt, some clay, trace gravel	0	3	83	14

Terminology	Proportion
--------------------	-------------------

“trace” (e.g. trace sand)	< 10%
“some” (e.g. some sand)	10% to 20%
adjective (e.g. sandy)	20% to 35%
“and” (e.g. and sand)	35% to 50%
Noun (e.g. sand)	> 50%

NOTE:

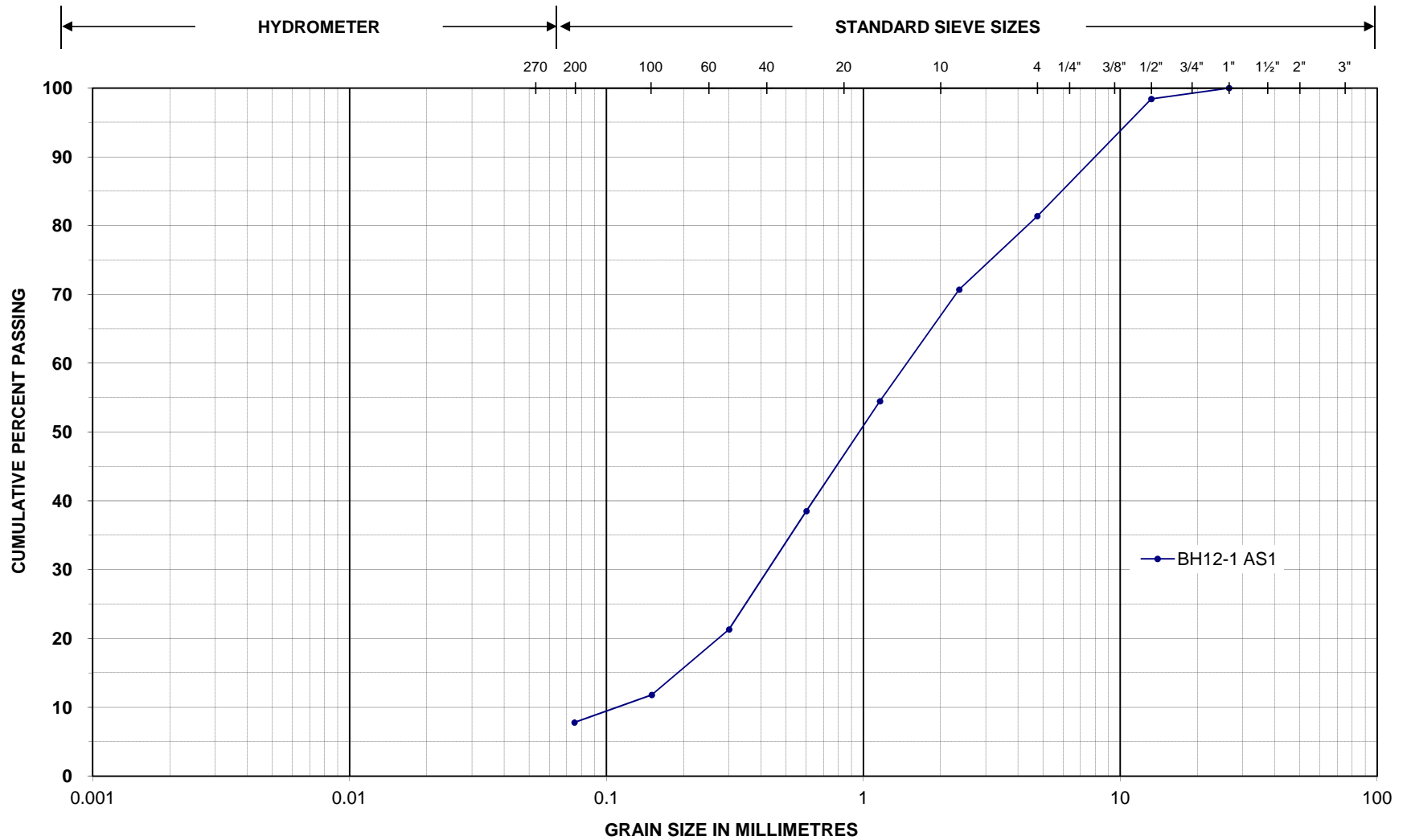
Division of Particle Sizes (USCS except clay based on MIT division)

- Gravel > 4.75 mm
- Sand 0.075 mm to 4.75 mm
- Silt 0.002 mm to 0.075 mm
- Clay < 0.002 mm



GENIVAR

PARTICLE SIZE DISTRIBUTION



Unified Classification System

SILT AND CLAY	SAND	GRAVEL
---------------	------	--------

Project Name: MTO Agreement #5011-E-0010 - Porquis Junction

Project No.: 121-17876-00

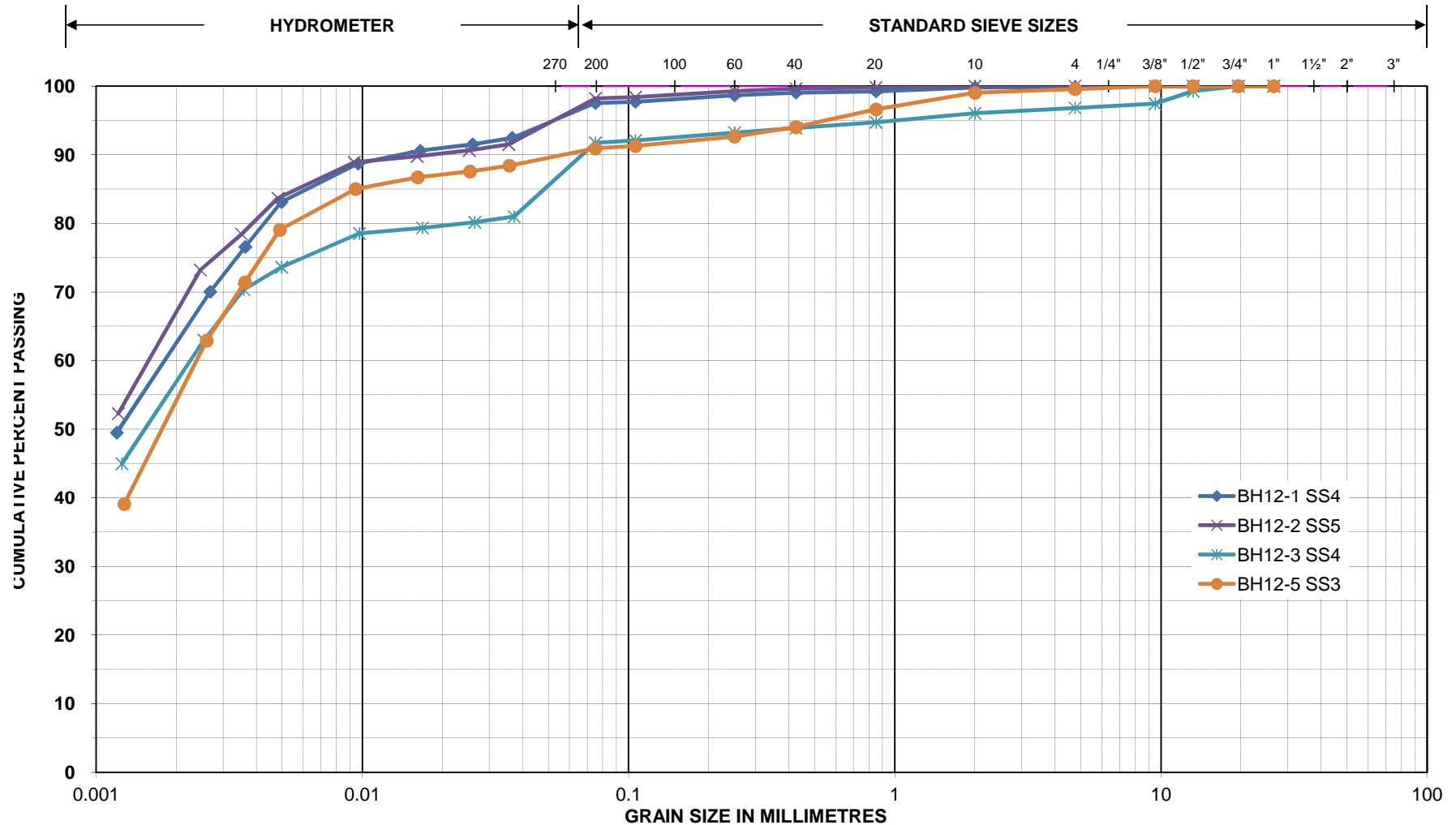
Figure No.: B1

Remarks: Sand, some gravel, trace silt



GENIVAR

PARTICLE SIZE DISTRIBUTION ASTM D422



Unified Classification System

SILT AND CLAY	SAND	GRAVEL
---------------	------	--------

Project Name: MTO Agreement #5011-E-0010 - Porquis Junction

Project No.: 121-17876-00

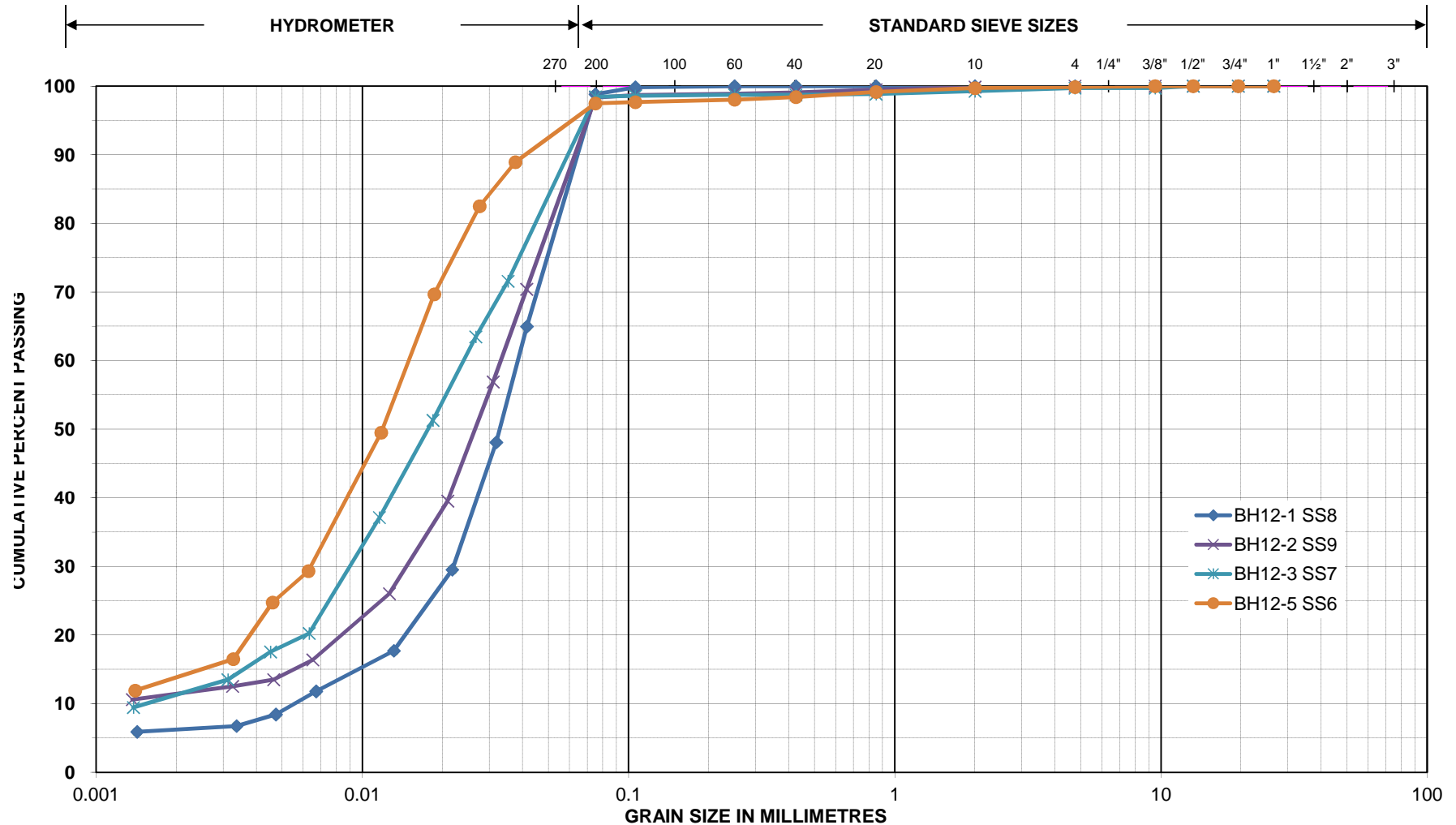
Figure No.: B2

Remarks: Silty clay to clay and silt, trace sand, trace gravel



GENIVAR

PARTICLE SIZE DISTRIBUTION ASTM D422



Unified Classification System

SILT AND CLAY	SAND	GRAVEL
---------------	------	--------

Project Name: MTO Agreement #5011-E-0010 - Porquis Junction

Project No.: 121-17876-00

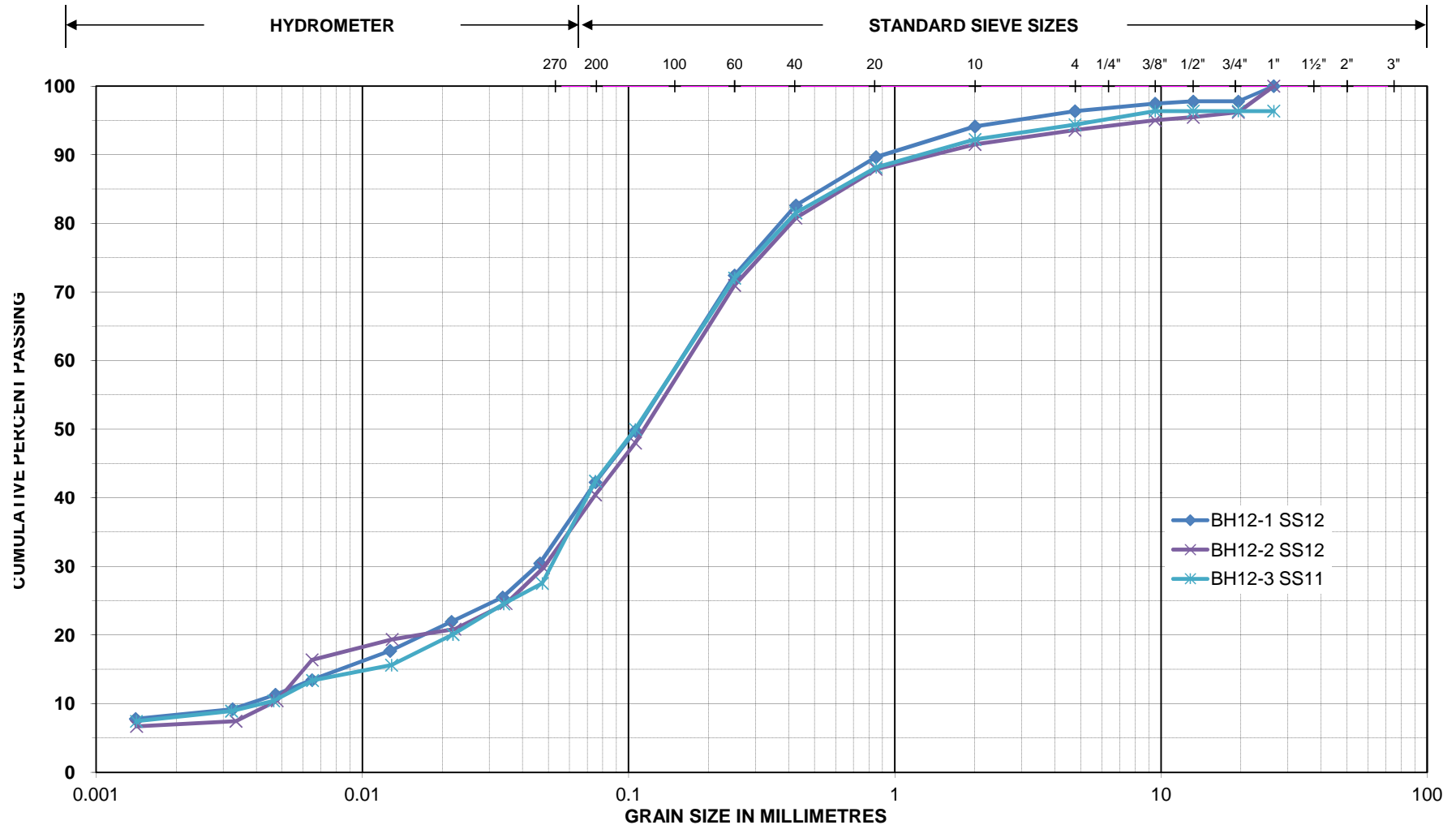
Figure No.: B3

Remarks: Silt, trace gravel, trace sand, some to trace clay



GENIVAR

PARTICLE SIZE DISTRIBUTION ASTM D422



Unified Classification System

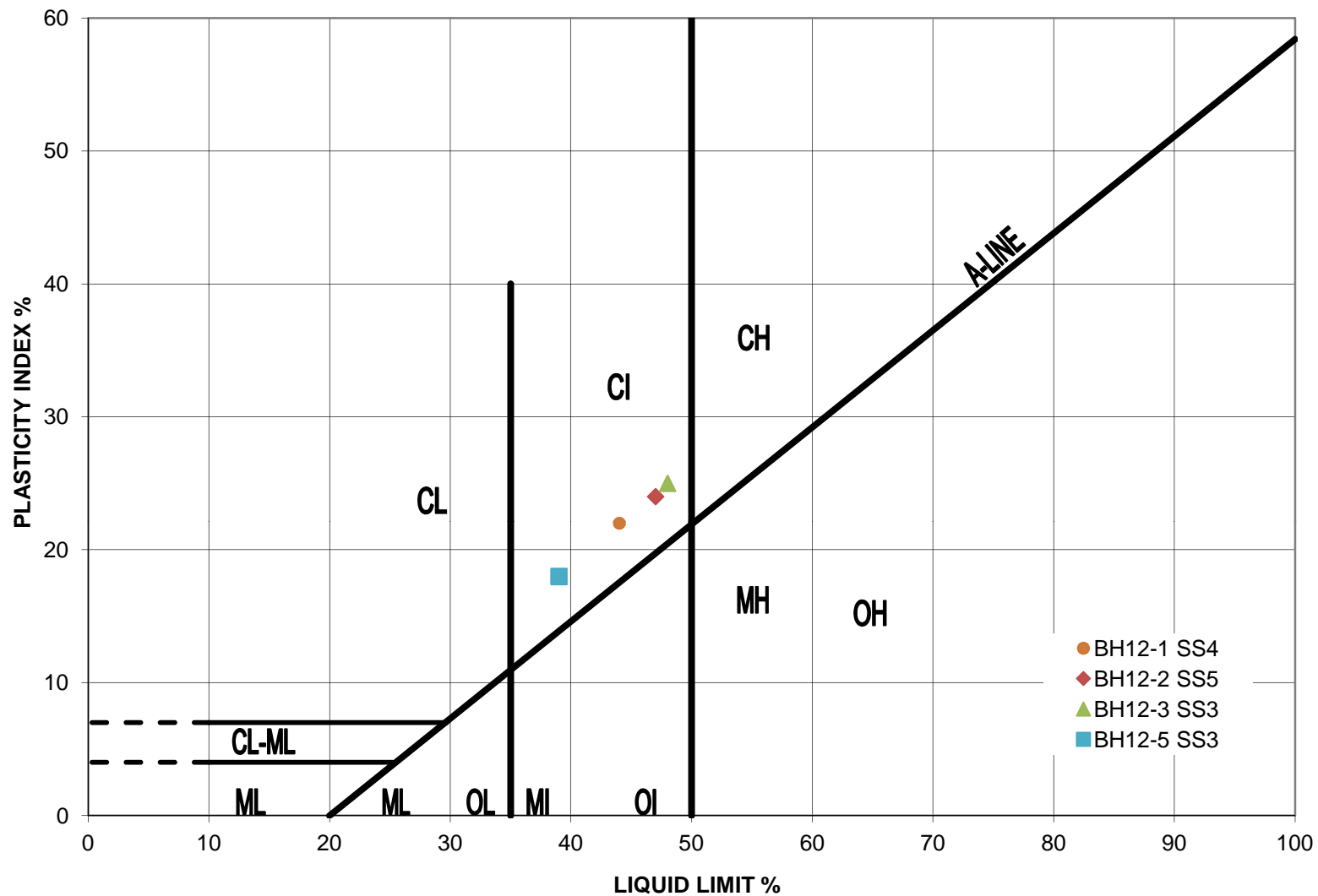
SILT AND CLAY	SAND	GRAVEL
---------------	------	--------

Project Name: MTO Agreement #5011-E-0010 - Porquis Junction

Project No.: 121-17876-00

Figure No.: B4

Remarks: Silty sand, trace gravel, trace clay



PLASTICITY CHART

Appendix C

Site Photographs

**MTO AGREEMENT #5011-E-0010
PORQUIS JUNCTION PATROL YARD**



Photograph 1: Borehole BH12-1 with existing sand dome in background. Looking east.



Photograph 2: Borehole BH12-2 with existing sand dome in background. Looking east.

**MTO AGREEMENT #5011-E-0010
PORQUIS JUNCTION PATROL YARD**



Photograph 3: Borehole BH12-4. Looking west.



Photograph 4: Borehole BH12-5 with view of proposed location for new structure. Facing west.

**MTO AGREEMENT #5011-E-0010
PORQUIS JUNCTION PATROL YARD**



Photograph 5: 9 bay garage / office. Facing northeast.



Photograph 6: View of storage sheds. Looking north.