



**Foundation Investigation and
Design Report**

Highway 402, Sign Installations
City of Sarnia

G.W.P. 3038-09-00

Geocres No. 40J16-84

Job No. 165000607

August 2011

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FOUNDATION INVESTIGATION REPORT

For

G.W.P 3038-09-00

Highway 402, Steel Breakaway Sign Installations
City of Sarnia

1.0 Introduction

Stantec Consulting Ltd. (Stantec) was retained by the Ministry of Transportation, Ontario (MTO) to undertake the detailed design of the widening of Highway 402 in the City of Sarnia, Ontario. This report contains the results of the geotechnical investigation carried out at the proposed locations of three 'ground-mounted' steel breakaway signs along Highway 402 between Christina Street North and Murphy Road.

This Foundation Investigation Report has been prepared specifically and solely for the signs related to the proposed widening project.

Project Number: G.W.P.: 3038-09-00

Project Location: Highway 402 between Christina Street North and Murphy Road,
Sarnia, Ontario

The work was carried out for Contract Number 2009-3001 developed by Stantec Consulting Ltd., the Detailed Design Consultant for this project.

2.0 Site Description and Geology

Site Location

The site locations are shown on the Key Plan inset to Drawings No. 1, provided in Appendix A. It should be noted that for project orientation purposes, Highway 402 will be assumed to run east-west at the project location, with chainage increasing from west to east.

General Site Description

The locations for the proposed ground-mounted steel breakaway signs are between Christina Street North and Murphy Road. The signs are located approximately 160 m, 1.2 km and 2.5 km east of the Christina Street North underpass.

Drainage for the highway at the sign locations is through roadside ditching.

Physiographic Description

The site is located within a physiographic region known as the St. Clair Clay Plains more specifically the Lambton Clay Plain (Chapman and Putnam, 1984) which is described as a beveled till plain often having a shallow veneer of lacustrine clay over the underlying till. The two main soils found in the Lambton clay plain are Brooston clay and Caistor clay. There is a deep cover of overburden over the limestone bedrock.

In the vicinity of the project site the terrain is fairly flat with little topographical relief.

3.0 Method of Investigation

3.1 DRILLING INVESTIGATION

The geotechnical investigation for the proposed highway signs included three boreholes along Highway 402 in the immediate vicinity of the proposed signs. These boreholes are designated 11-1 through 11-3 and are shown on the Borehole Location Plan, Drawings No. 1 in Appendix A.

Prior to carrying out the investigation, Stantec contacted the public utility authorities to clear the borehole locations of both private and public utilities.

The field drilling program was carried out on May 4, 2011. The boreholes were advanced with continuous flight hollow stem augers using a D120 track-mounted drill rig equipped for soil and bedrock sampling.

The subsurface stratigraphy encountered in each borehole was recorded in the field by an experienced Stantec engineering technologist. Split spoon samples were collected at regularly spaced intervals (every 760 mm for up to 6 m below existing ground surface and every 1.5 m for deeper strata). All samples recovered were returned to Stantec's Ottawa laboratory for detailed classification and testing.

Groundwater levels were inferred in each borehole while drilling.

The boreholes were backfilled immediately after drilling with drill cuttings placed to match the observed stratigraphy and compacted in place. Where boreholes were advanced in the pavement, the boreholes were capped with 150 mm of cold patch asphalt.

3.2 LAYOUT AND SURVEY

The ground surface elevation along with the northing and easting at each borehole location was surveyed by BOT Construction Group of Oakville, Ontario, on May 24, 2011, with reference to a Geodetic Benchmark. Table 3.1 summarizes the information pertaining to the three boreholes included in this report.

Table 3.1: Borehole Information Summary

	Boreholes		
	11-3	11-1	11-2
MTM Zone 11 Coordinates Northing Easting	4760925 313255	4760828 314328	4760768 315559
Station	11+400	12+475	13+709
Offset (looking east on Hwy 402), m	16 Lt	20 Rt	19 Rt
Ground Surface Elevation, m	183.0	183.3	182.9
Total Depth Drilled, m	6.7	8.2	6.7
End of Borehole Elevation, m	176.3	175.1	176.2
Depth Augered, m	6.7	8.2	6.7
Number of Soil Samples	9	10	9

Notes: (1) Rt = right, and Lt = left of median centreline; stations and offsets refer to chainage on Highway 402.

3.3 LABORATORY TESTING

All samples were taken to Stantec's Ottawa laboratory where they were subjected to a detailed visual examination by a Geotechnical Engineer. Routine soil testing was carried out on selected soil samples. The tests carried out included grain size analysis (13 samples), Atterberg Limit Testing (4 samples) and moisture content testing (all 28 samples retrieved). Three samples, one from each borehole, were submitted to Parcel Laboratories of Ottawa for analysis of pH, soluble sulphate content, chloride content and resistivity.

Samples remaining after testing will be placed in storage for a period of one year after issuance of the final report. After the storage period, the samples will be discarded unless we are directed otherwise by MTO.

4.0 Subsurface Conditions

The subsurface conditions observed in the boreholes included in this report are presented in detail on the Borehole Records provided in Appendix B. An explanation of the symbols and terms used to describe the Borehole Records is also provided in Appendix B.

In general, the subsurface stratigraphy consisted of fill over sand over a sandy silty clay till.

As the three signs are spread over a distance of 2.3 km, the descriptions below are separated by location.

4.1 STATION 11+400, BH 11-3

Three soil strata were observed at this location.

A 1.5 m thick layer of silty sand with gravel fill was encountered at the surface and extended down to an elevation of 181.5 m. The Standard Penetration Test blow count (N-value) ranged from 16 to 30 blows per 0.3 m penetration suggesting a compact to dense state. The moisture content of this material ranged from 4% to 7%. Grain size distribution analysis carried out on one representative sample indicated 25% gravel, 61% sand and 14% fines (silt and clay). The grain size distribution plot of the sample obtained from this layer is provided on Figure 1 in Appendix C. The material can be classified silty sand with gravel (SM).

A 3.8 m thick layer of silty sand was observed beneath the fill layer and extended down to an elevation of 177.7 m. The N-value ranged from 21 to 29 blows per 0.3 m penetration suggesting a compact state. The moisture content of this material ranged from 4% to 23%. Grain size distribution analysis carried out on two representative samples indicated 0 to 1% gravel, 76 to 87% sand and 13 to 23% fines (silt and clay). The percentage of fines was noted to increase with depth. The grain size distribution results from this layer are provided on Figure 2 in Appendix C. The material can be classified as silty sand (SM).

A sandy silty clay till was observed beneath the silty sand stratum and extended down 1.4 m to borehole termination at elevation 176.3 m. The N-value recorded was 12 blows per 0.3 m penetration. The undrained shear strength of this stratum was estimated using a field pocket penetrometer. The measured undrained shear strengths ranged from 54 kPa to 67 kPa also indicating a stiff consistency. The moisture content of this material ranged from 15% to 19%. Grain size distribution analysis carried out on one representative sample indicated 1% gravel, 21% sand, 48% silt size and 30% clay size particles. The grain size distribution plot of the sample obtained from this layer is provided on Figure 3 in Appendix C. Atterberg Limit testing carried out on one sample of this material revealed a liquid limit of 28 a plastic limit of 14 and plasticity index of 14. The Atterberg Limit test result is plotted on Figure 4 in Appendix C. The soil can be classified as a sandy silty clay of low plasticity (CL).

4.2 STATION 12+475, BH 11-1

Three soil strata were observed at this location.

A 1.5 m thick layer of silty sand fill was encountered at the surface and extended down to an elevation of 181.8 m. The N-value recorded of 11 blows per 0.3 m penetration suggests a compact state. The moisture content of this material ranged from 7% to 19%. Grain size distribution analysis carried out on one representative sample indicated 1% gravel, 76% sand and 23% fines (silt and clay). The grain size distribution plot of the sample obtained from this layer is provided on Figure 1 in Appendix C. The material can be classified as a silty sand (SM).

A 3.8 m thick layer of sand with silt and gravel to poorly graded sand with silt was observed beneath the fill layer and extended down to an elevation of 178.0 m. The N-value ranged from 19 to 35 blows per 0.3 m penetration suggesting a compact to dense state. The moisture content of this material ranged from 5% to 21%. Grain size distribution analysis carried out on

two representative samples indicated 0 to 19% gravel, 70 to 90% sand and 10 to 11% fines (silt and clay). The percentage of gravel was noted to decrease with depth. The grain size distribution results for the samples obtained from this layer are provided on Figure 2 in Appendix C. The material can be classified as a well graded sand with silt and gravel (SW-SM) to a poorly graded sand with silt (SP-SM).

Sandy silty clay till was observed beneath the sand stratum and extended down 2.9 m to borehole termination at elevation 175.1 m. The N-values recorded ranged from 8 to 15 blows per 0.3 m penetration. The undrained shear strength of this stratum was estimated using a field pocket penetrometer. The measured undrained shear strengths ranged from 50 kPa to 62 kPa indicating a stiff consistency. The moisture content of this material ranged from 10% to 20%. Grain size distribution analysis carried out on two representative samples indicated 2 to 4% gravel 20 to 34% sand 43 to 44% silt size and 19 to 34% clay size particles. The grain size distribution results for the samples obtained from this layer are provided on Figure 3 in Appendix C. Atterberg Limit testing carried out on two samples of this material revealed liquid limits of 17 and 27, plastic limits of 11 and 14, and plasticity indices of 8 and 13. The Atterberg Limit test results are plotted on Figure 4 in Appendix C. This material can generally be classified as a sandy silty clay of low plasticity (CL).

4.3 STATION 13+709, BH 11-2

Four strata were observed at this location.

A 110 mm thick layer of asphalt was encountered at the surface and extended down to an elevation of 182.8 m.

A 1.4 m thick layer of silty sand with gravel fill was encountered beneath the asphalt and extended down to an elevation of 181.4 m. The N-values recorded were 33 and 34 blows for 0.3 m of penetration suggesting a dense state. The moisture content of this material ranged from 5% to 6%. Grain size distribution analysis carried out on one representative sample indicated 37% gravel, 49% sand and 14% fines (silt and clay). The grain size distribution plot of the sample obtained from this layer is provided on Figure 1 in Appendix C. The material can be classified as a silty sand with gravel (SM).

A 3.4 m thick layer of poorly graded sand with silt to silty sand was observed beneath the fill layer and extended down to an elevation of 178.1 m. The N-values recorded ranged from 7 to 16 blows per 0.3 m penetration suggesting a loose to compact state. The moisture content of this material ranged from 7% to 23%. Grain size distribution analysis carried out on two representative samples indicated 1 to 3% gravel, 84 to 91% sand and 6 to 15% fines (silt and clay). The percentage of fines was noted to increase with depth. The results of the gradation analyses of the tested samples from this material are plotted on Figure 2 in Appendix C. The material can be classified as a poorly graded sand with silt (SP-SM) to a silty sand (SM).

A sandy silty clay till was observed beneath the sand stratum and extended 1.8 m down to borehole termination at elevation 176.2 m. The N-value recorded ranged from 13 to 15 blows per 0.3 m penetration. The undrained shear strength of this stratum was estimated using a field

pocket penetrometer. The measured undrained shear strengths ranged from 56 kPa to 67 kPa indicating a stiff consistency. The moisture content of this material ranged from 17% to 19%. Grain size distribution analysis carried out on one representative sample indicated 1% gravel, 26% sand, 41% silt size and 32% clay size particles. The grain size distribution plot of the sample obtained from this layer is provided on Figure 3 in Appendix C. Atterberg Limit testing carried out on one sample of this material revealed a liquid limit of 28, plastic limit of 14, and plasticity index of 14. The Atterberg Limit test results are plotted on Figure 4 in Appendix C. The material can be classified as a sandy silty clay of low plasticity (CL).

4.4 BEDROCK

Bedrock was not encountered within the depth of exploration of the boreholes advanced during this investigation.

4.5 GROUNDWATER

Groundwater observations were made during drilling in all the boreholes. The observed groundwater elevations were not confirmed as stabilized, and hence, were designated as 'inferred'. These inferred groundwater level readings are summarized in Table 4.1

Table 4.1: Inferred Groundwater Level Readings (time of drilling)

Borehole No	Ground Surface Elevation (m)	Groundwater	
		Depth (m)	Elevation (m)
11-1	183.3	2.3	181.0
11-2	182.9	2.2	180.7
11-3	183.0	3.8	179.2

Fluctuations in the groundwater level due to seasonal variations or in response to a particular precipitation event should be anticipated.

4.6 CHEMICAL TEST RESULTS

Three samples were submitted to Paracel Laboratories in Ottawa, Ontario, for analysis of pH, water soluble sulphates and chloride concentrations, and resistivity. The analysis results are provided in Table 4.2.

Table 4.2: Results of Chemical Analysis

Borehole No	Sample No.	Depth (m)	pH	Chloride (µg/g)	Sulphate (µg/g)	Resistivity (Ohm-m)
11-1	SS-4	2.3 – 3.1	7.6	217	22	11
11-2	SS-5	3.0 – 3.7	7.8	353	63	8
11-3	SS-3	1.5 – 2.2	7.9	11	<5	77

5.0 Miscellaneous

The field work was carried out under the supervision of Mr. Dan Stunden, CET, Senior Technologist, under the direction of Kenton Power, M.Eng., P.Eng., Geotechnical Engineer.

The truck mounted drilling equipment was supplied and operated by Walker Drilling of Utopia, Ontario.

Geotechnical laboratory testing was carried out at the Stantec Ottawa laboratory. Chemical testing on soil samples was carried out by Paracel Laboratories in Ottawa.

This report was prepared by Kenton Power, M.Eng., P.Eng., and reviewed by Fred Griffiths, Ph.D., P.Eng., and Raymond Haché, M.Sc., P.Eng., MTO Designated Principal Contact.

6.0 Closure

A subsurface investigation is a limited sampling of a site. The subsurface conditions given herein are based on information gathered at the specific borehole locations and timeframe described herein. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information.

Respectively Submitted;

STANTEC CONSULTING LTD.

7. JMS
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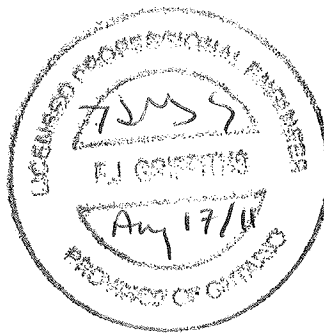
Kenton C. Power, M.A.Sc., P.Eng
Geotechnical Engineer

7. JMS

Fred J. Griffiths, Ph.D., P.Eng.
Principal and Senior Geotechnical Engineer

Raymond Haché

Raymond Haché, M.Sc., P.Eng.
Central Canada Practice Lead and
Designated Principal MTO Foundation Contact



FOUNDATION DESIGN REPORT

For

G.W.P. 3038-09-00

Highway 402, Steel Breakaway Sign Installations
City of Sarnia

7.0 Discussion

7.1 PROJECT DESCRIPTION & BACKGROUND

Three 'ground-mounted' steel breakaway signs are being installed along Highway 402 as part of the widening of Highway 402 in Sarnia, Ontario. The signs are being installed between Christina Street North and Murphy Road.

This section presents the geotechnical recommendations for the design and construction of the three proposed sign foundations along Highway 402.

It is assumed that the signs will have steel column breakaway supports in accordance with the MTO Sign Support Manual, 2004.

7.2 RECOMMENDATIONS FOR FOUNDATIONS

The frost penetration depth based on OPSD 3090.101 is 1.1 m. A minimum design frost depth for foundation design of 1.1 m is recommended.

The MTO Sign Support Manual is applicable to this site since the following conditions were not observed:

- Bedrock at or near the surface;
- Footing located in rock fill; and
- Soil exceptionally soft or loose.

The proposed footing depths and the post sizes have not been finalized yet, however, it is noted that at the frost penetration depth, the site soil can provide the minimum required passive earth pressure of 68 kPa according to MTO Sign Support Manual 2004. Footings could therefore be designed using the standard details shown on Drawing SS118-30. A copy is provided in Appendix D.

Should a more site specific design be required, the recommended design parameters for the proposed sign support foundations are provided in Table 1 in Appendix D. For design purposes, the groundwater level should be assumed to be at 1.5 m below ground surface.

7.3 UNWATERING

Groundwater levels were inferred while drilling in all boreholes advanced for this project (see Table 4.1). The groundwater level in Boreholes 11-1, 11-2, and 11-3 were 2.3 m, 2.2 m and 3.8 m below the existing ground surface respectively.

The three sign support locations each include a sand deposit which is generally poorly graded and with generally 6 to 13% fines. The coefficient of permeability for the sand deposit is estimated to range between 1×10^{-2} and 6×10^{-3} cm/sec.

It is anticipated that the footing depth will be between 2 and 3 m below ground surface. Therefore, depending on the actual footing depth unwatering may be required. Alternatively, a tremie approach using a concrete pump truck could easily be used within a temporary lined hole to displace water from the footing location.

7.4 CONSTRUCTION RECOMMENDATIONS

In all the three boreholes, the soil conditions encountered within the anticipated footing depths consist of sand with varying amount of gravel and silt with no cohesion over a clay till material.

Depending on their design depth it is possible that the footings will extend below the water table. Should this be the case; the holes will not be capable of remaining open for any significant period of time and therefore the use of a temporary casing or liner is anticipated to be required during construction. It is recommended that an NSSP be included in the contract advising the contractor that the footing holes may not be capable of remaining open for any significant period of time and that the use of a temporary liner or casing may be required during construction.

Footings for the proposed sign support should be installed in accordance with SS118-30.

7.5 CEMENT TYPE AND CORROSION PROTECTION

Three samples of the soil in the vicinity of the anticipated footings for the sign support were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate and chloride concentrations, and resistivity. The analysis results are summarized in Table 4.2.

The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected on concrete, if any, in contact with soil and groundwater at the site. The maximum concentration of soluble sulphate was 63 µg/g. Soluble sulphate concentrations less than 1000 µg/g generally indicate that a low degree of sulphate attack is expected on concrete in contact with soil and groundwater. If needed, Type GU (General Use) Portland Cement should therefore be suitable for use in concrete at this site.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The soil pH test results are within what is considered the normal range for soil pH of 5.5 to 9.0. The pH levels of the tested soil do not indicate a highly corrosive environment. The test results provided in the Table 4.2 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects.

8.0 References

Chapman, L.J., and Putnam, D.F. 1984. The physiography of Southern Ontario, Ontario Geological Survey Special Volume 2. Ontario Research Foundation, Toronto, Ontario.

Ontario Ministry of Transportation (MTO). 2004. Sign Support Manual. Engineering Standards Branch, Bridge Office, Toronto, Ontario. August 2004.

9.0 Closure

The recommendations made in this report are in accordance with our present understanding of the project. We request that we be permitted to review our recommendations when the drawings and specifications are complete.

A soil investigation is a limited sampling of a site. The conclusions given herein are based on information gathered at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information and its effects on the above recommendations.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

This report has been prepared by Kenton Power. Technical review was carried out by Fed Griffiths. A Quality Audit was carried out by Raymond Haché.

Respectfully submitted,

STANTEC CONSULTING LTD.

K. Power

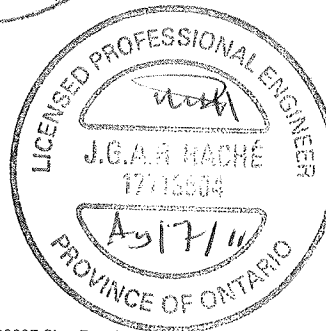
Kenton C. Power, M.A.Sc., P.Eng
Geotechnical Engineer

F. Griffiths

Fred J. Griffiths, Ph.D., P.Eng.
Principal and Group Leader

R. Haché

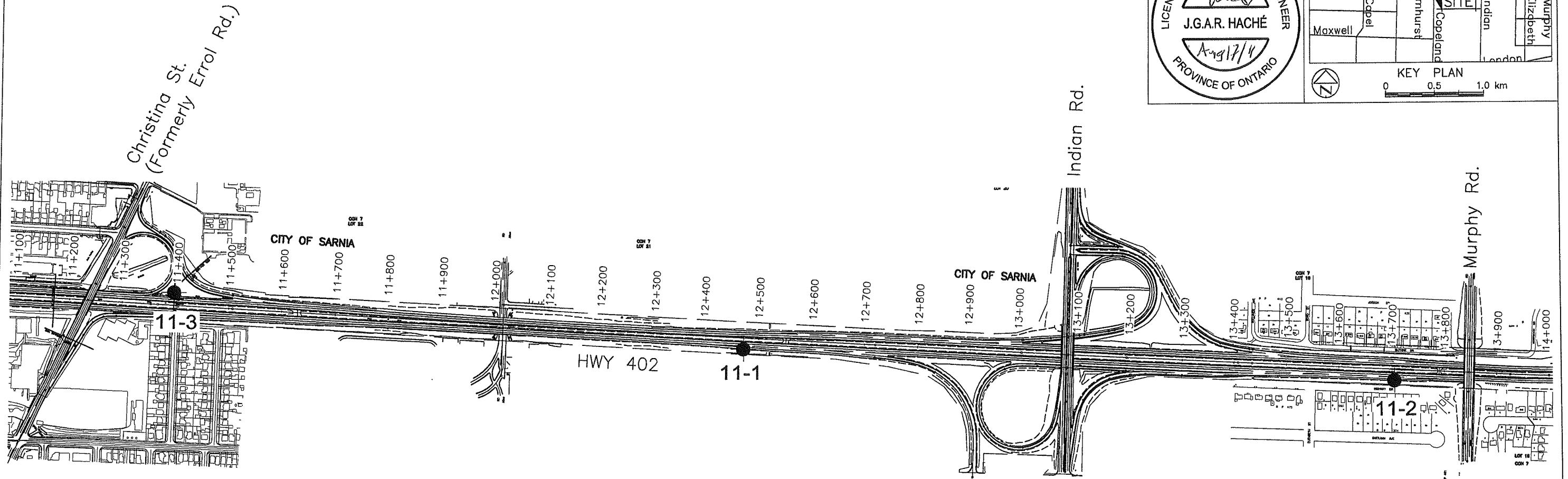
Raymond Haché, M.Sc., P.Eng.
Central Canada Practice Lead and
Designated Principal MTO Foundation Contact



APPENDIX A

Drawing No. 1 – Borehole Location Plan

DRAWING NAME: 165000607-1.DWG
CREATED BY: GBB
MODIFIED: 11/06/16
T:\Autocad\Drawings\Project Drawings\2011\165000607\June 21\165000607-1.dwg (HWY 402) Printed: Aug 16, 2011



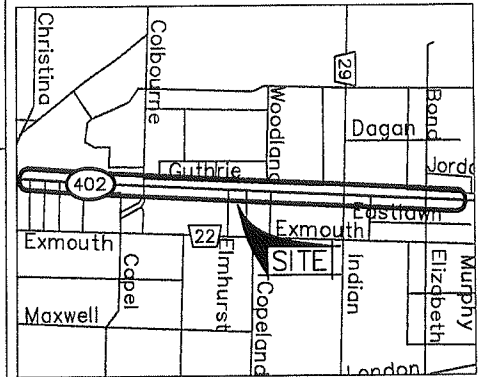
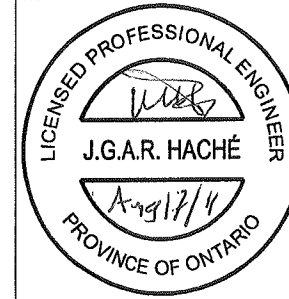
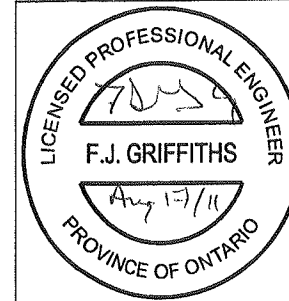
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

PLATE No
CONT 2009-3001
WP 3038-09-00



HIGHWAY 402
FROM STA 11+400 TO STA 13+709
BOREHOLE LOCATION

SHEET



KEY PLAN
0 0.5 1.0 km

SCALE
50 0 100 m
Horizontal

LEGEND			
Bore Hole			
No	ELEVATION	MTM ZONE 11 COORDINATES NORTH	EAST
11-1	183.3	4 760 827.9	314 327.5
11-2	182.9	4 760 768.0	315 559.2
11-3	183.0	4 760 925.3	313 254.7

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REVISIONS			
DATE		BY	DESCRIPTION
GEOCRES No 40J16-84			
HWY No 402			DIST
SUBM'D KP		CHECKED	SITE
DRAWN GBB		CHECKED	DWG 1
		APPROVED	

APPENDIX B

Symbols and Terms Used on Borehole Records

Borehole Records

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

<i>Topsoil</i>	- mixture of soil and humus capable of supporting vegetative growth
<i>Peat</i>	- mixture of visible and invisible fragments of decayed organic matter
<i>Till</i>	- unstratified glacial deposit which may range from clay to boulders
<i>Fill</i>	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

<i>Desiccated</i>	- having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
<i>Fissured</i>	- having cracks, and hence a blocky structure
<i>Varved</i>	- composed of regular alternating layers of silt and clay
<i>Stratified</i>	- composed of alternating successions of different soil types, e.g. silt and sand
<i>Layer</i>	- > 75 mm in thickness
<i>Seam</i>	- 2 mm to 75 mm in thickness
<i>Parting</i>	- < 2 mm in thickness

Terminology describing soil types:

The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488). The classification excludes particles larger than 76 mm (3 inches). The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):

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:

<i>Trace, or occasional</i>	Less than 10%
<i>Some</i>	10-20%
<i>Frequent</i>	> 20%

Terminology describing compactness of cohesionless soils:

The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test N-Value (also known as N-Index). A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
<i>Very Loose</i>	<4
<i>Loose</i>	4-10
<i>Compact</i>	10-30
<i>Dense</i>	30-50
<i>Very Dense</i>	>50

Terminology describing consistency of cohesive soils:

The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests.

Consistency	Undrained Shear Strength	
	kips/sq.ft.	kPa
<i>Very Soft</i>	<0.25	<12.5
<i>Soft</i>	0.25 - 0.5	12.5 - 25
<i>Firm</i>	0.5 - 1.0	25 - 50
<i>Stiff</i>	1.0 - 2.0	50 - 100
<i>Very Stiff</i>	2.0 - 4.0	100 - 200
<i>Hard</i>	>4.0	>200



ROCK DESCRIPTION

Terminology describing rock quality:

RQD	Rock Mass Quality
0-25	<i>Very Poor</i>
25-50	<i>Poor</i>
50-75	<i>Fair</i>
75-90	<i>Good</i>
90-100	<i>Excellent</i>

Rock quality classification is based on a modified core recovery percentage (RQD) in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be due to close shearing, jointing, faulting, or weathering in the rock mass and are not counted. RQD was originally intended to be done on NW core; however, it can be used on different core sizes if the bulk of the fractures caused by drilling stresses are easily distinguishable from *in situ* fractures. The terminology describing rock mass quality based on RQD is subjective and is underlain by the presumption that sound strong rock is of higher engineering value than fractured weak rock.

Terminology describing rock mass:

Spacing (mm)	Joint Classification	Bedding, Laminations, Bands
> 6000	<i>Extremely Wide</i>	-
2000-6000	<i>Very Wide</i>	<i>Very Thick</i>
600-2000	<i>Wide</i>	<i>Thick</i>
200-600	<i>Moderate</i>	<i>Medium</i>
60-200	<i>Close</i>	<i>Thin</i>
20-60	<i>Very Close</i>	<i>Very Thin</i>
<20	<i>Extremely Close</i>	<i>Laminated</i>
<6	-	<i>Thinly Laminated</i>

Terminology describing rock strength:

Strength Classification	Unconfined Compressive Strength (MPa)
<i>Extremely Weak</i>	< 1
<i>Very Weak</i>	1 – 5
<i>Weak</i>	5 – 25
<i>Medium Strong</i>	25 – 50
<i>Strong</i>	50 – 100
<i>Very Strong</i>	100 – 250
<i>Extremely Strong</i>	> 250

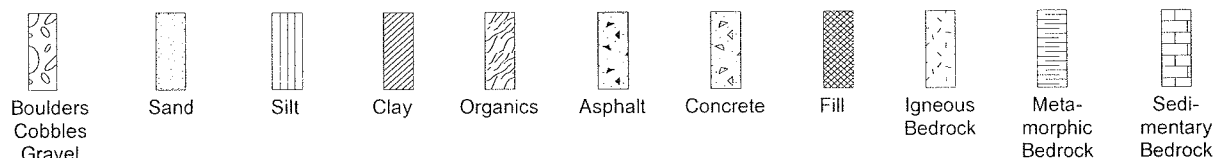
Terminology describing rock weathering:

Term	Description
<i>Fresh</i>	No visible signs of rock weathering. Slight discolouration along major discontinuities
<i>Slightly Weathered</i>	Discolouration indicates weathering of rock on discontinuity surfaces. All the rock material may be discoloured.
<i>Moderately Weathered</i>	Less than half the rock is decomposed and/or disintegrated into soil.
<i>Highly Weathered</i>	More than half the rock is decomposed and/or disintegrated into soil.
<i>Completely Weathered</i>	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.



STRATA PLOT

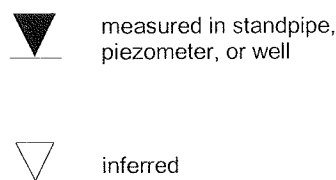
Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

WATER LEVEL MEASUREMENT



RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

N-VALUE

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (64 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (305 mm) into the soil. For split spoon samples where insufficient penetration was achieved and N-values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N value corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to A size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (305 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
γ	Unit weight
G_s	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
Q_u	Unconfined compression
I_p	Point Load Index (I_p on Borehole Record equals $I_{p(50)}$ in which the index is corrected to a reference diameter of 50 mm)

	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer







RECORD OF BOREHOLE No 11-1

1 OF 1

METRIC

W.P. 3038-09-00 LOCATION Station 12+475 Eastbound Shoulder N: 4 760 828 E: 314 328 ORIGINATED BY DS
DIST Samia HWY 402 BOREHOLE TYPE Splitspoon, Hollow Stem COMPILED BY KCP
DATUM Geodetic DATE 2011 05 04 - 2011 05 04 CHECKED BY RH

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							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	✕ FIELD VANE ✕ LAB VANE						
183.3 0.0	Silty sand Brown FILL		1	SS	11		183								1 76 (23)
			2	SS	11		182								
181.8 1.5	SAND (SW-SM to SP-SM) with silt Brown Compact to dense - with gravel to 2.1 m		3	SS	22		181								19 70 (11)
			4	SS	19		180								
	- grey below 3.3 m		5	SS	29		179								0 90 (10)
			6	SS	35		178								
			7	SS	20		177								
178.0 5.3	Sandy silty clay (CL-ML to CL) Brown Stiff TILL		8	SS	15		176								4 34 43 19 PP = 62 kPa
			9	SS	11										PP = 58 kPa
			10	SS	8										2 20 44 34 PP = 50 kPa
175.1 8.2	End of Borehole Groundwater level inferred while drilling													PP = Pocket Penetrometer	

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RECORD OF BOREHOLE No 11-2

1 OF 1

METRIC

W.P. 3038-09-00 LOCATION Station 13+709 Eastbound Shoulder N: 4 760 768 E: 315 559 ORIGINATED BY DS
DIST Samia HWY 402 BOREHOLE TYPE Splittspoon, Hollow Stem COMPILED BY KCP
DATUM Geodetic DATE 2011 05 04 - 2011 05 04 CHECKED BY RH




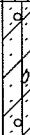

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)	
								○ UNCONFINED	✕ FIELD VANE	● QUICK TRIAXIAL	✕ LAB VANE							
182.9							20	40	60	80	100							
180.9	110 mm ASPHALT		1	SS	34											37 49 (14)		
	Silty sand with gravel		2	SS	33													
	Brown FILL																	
181.4			3	SS	16													
1.5	SAND (SP-SM to SM) with silt																	
	Brown		4	SS	9											3 91 (6)		
	Loose to compact																	
	- silty and grey below 3.4 m		5	SS	8													
			6	SS	8											1 84 (15)		
			7	SS	7													
178.1	Sandy silty clay (CL)		8	SS	13											PP = 67 kPa		
4.9	Grey																	
	Stiff		9	SS	15											PP = 56 kPa		
	TILL															1 26 41 32		
176.2	End of Borehole															PP = Pocket Penetrometer		
6.7	Groundwater level inferred while drilling																	

RECORD OF BOREHOLE No 11-3

1 OF 1

METRIC

W.P. 3038-09-00 LOCATION Station 11+400 Westbound N: 4 760 925 E: 313 255 ORIGINATED BY DS
DIST Sarnia HWY 402 BOREHOLE TYPE Splitspoon, Hollow Stem COMPILED BY KCP
DATUM Geodetic DATE 2011 05 04 - 2011 05 04 CHECKED BY RH

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 ○ UNCONFINED × FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
183.0								20	40	60	80	100						
0.0	Silty sand with gravel, trace topsoil Brown FILL		1	SS	16		182								○			25 61 (14)
			2	SS	30		181								○			0 87 (13)
181.5	Silty SAND (SM) Brown Compact		3	SS	21		180								○			
1.5			4	SS	27		179								○			
			5	SS	29		178									○		1 76 (23)
	- grey below 3.8 m		6	SS	26		177									○		PP = 67 kPa
			7	SS	23													PP = 54 kPa
177.7	Sandy silty clay (CL) Grey Stiff TILL		8	SS	12													1 21 48 30
5.3			9	SS	12													
176.3																		
6.7	End of Borehole Groundwater level inferred while drilling																PP = Pocket Penetrometer	

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APPENDIX C

Laboratory Test Results

Figures 1 – 4: Grain Size Distribution Plots and Plasticity Chart

Unified Soil Classification System

CLAY & SILT		SAND				Gravel	
		Fine	Medium	Coarse	Coarse	Fine	Coarse

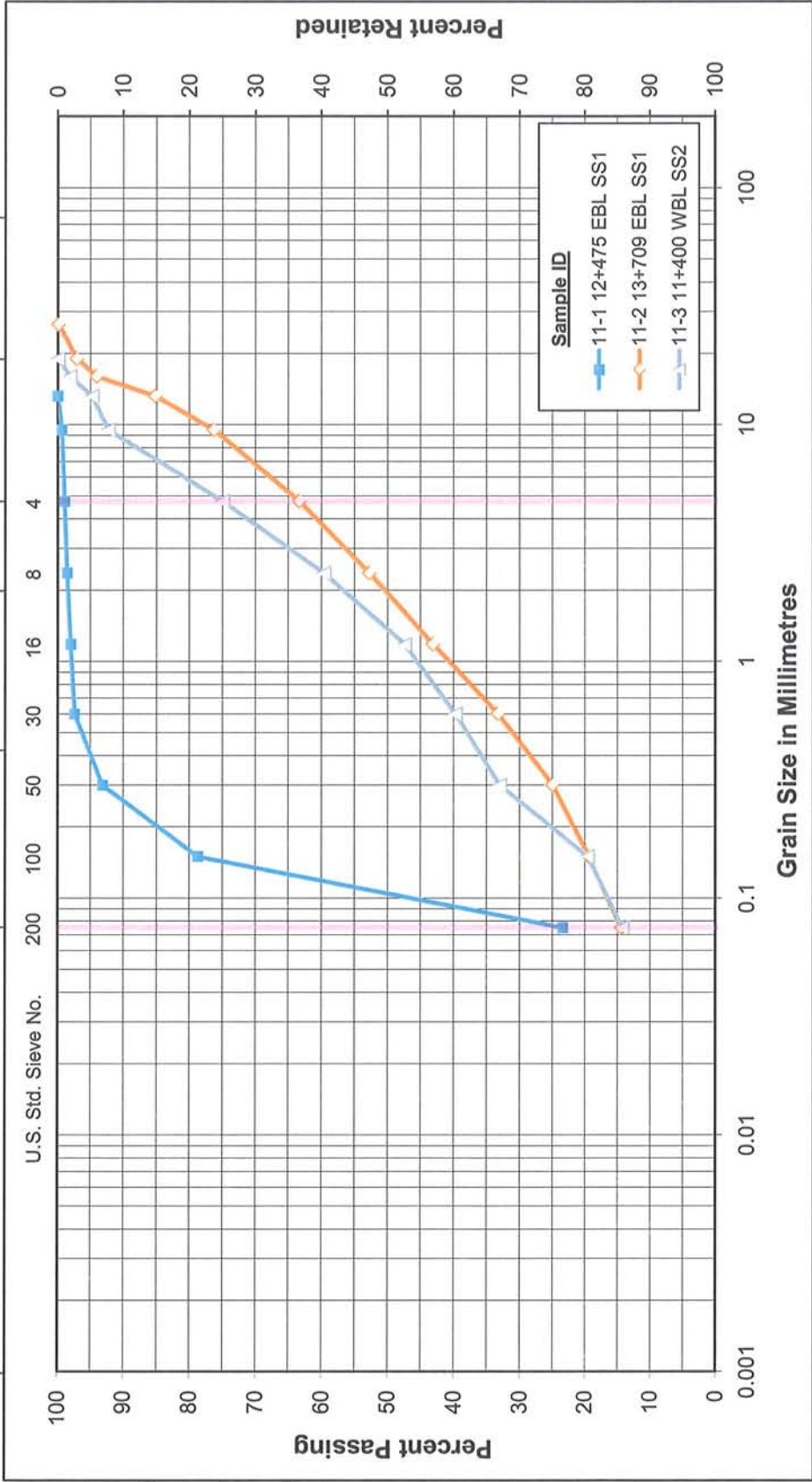


Figure No. 1

GRAIN SIZE DISTRIBUTION

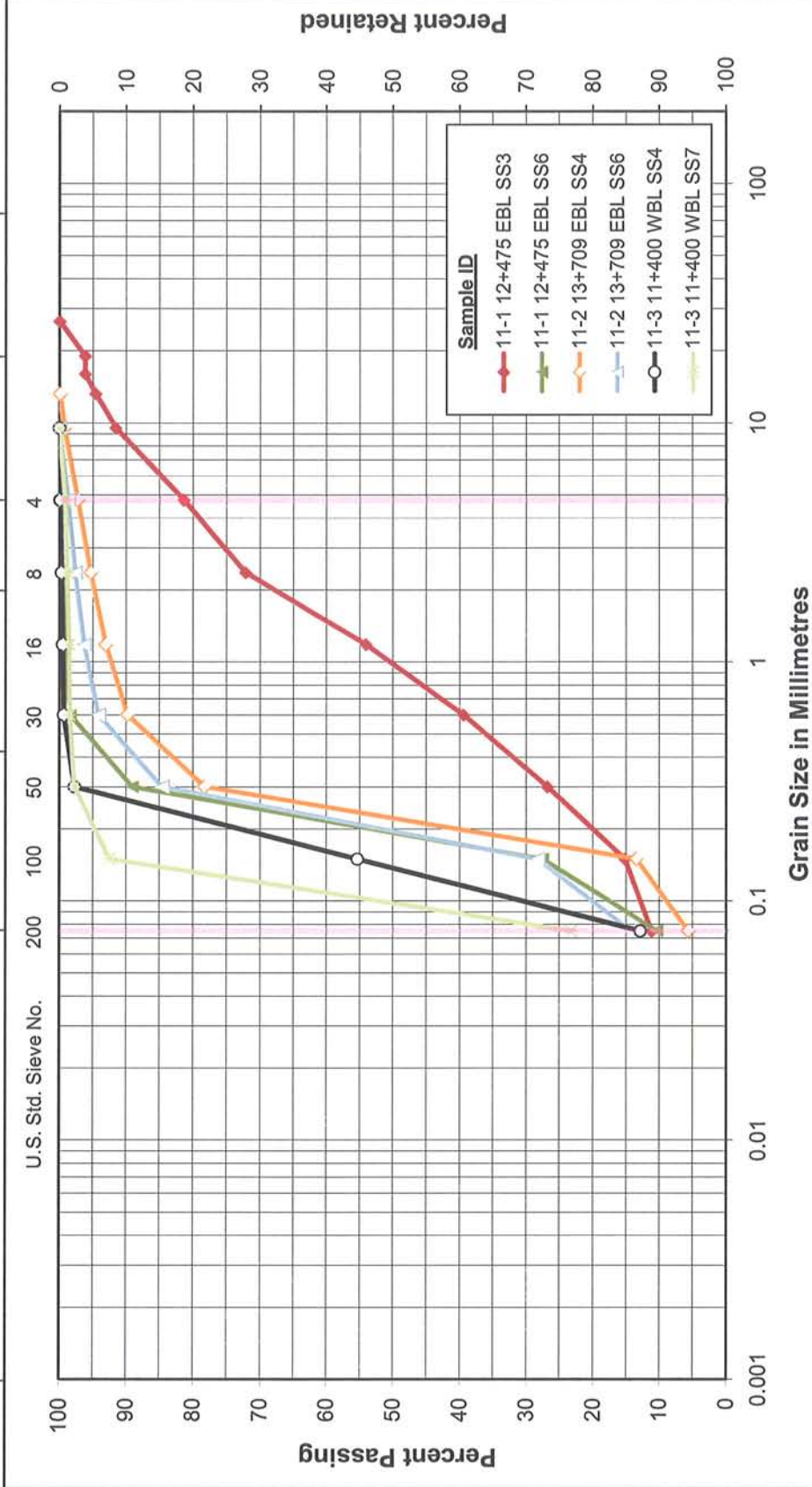
FILL: Silty Sand (SM) to Silty Sand with Gravel (SM)

Project No. 165000607



Unified Soil Classification System

CLAY & SILT		SAND				Gravel	
		Fine	Medium	Coarse	Fine		



GRAIN SIZE DISTRIBUTION

Sitly Sand (SM) to Well-graded Sand with Gravel and Silt (SW-SM)

Figure No. 2

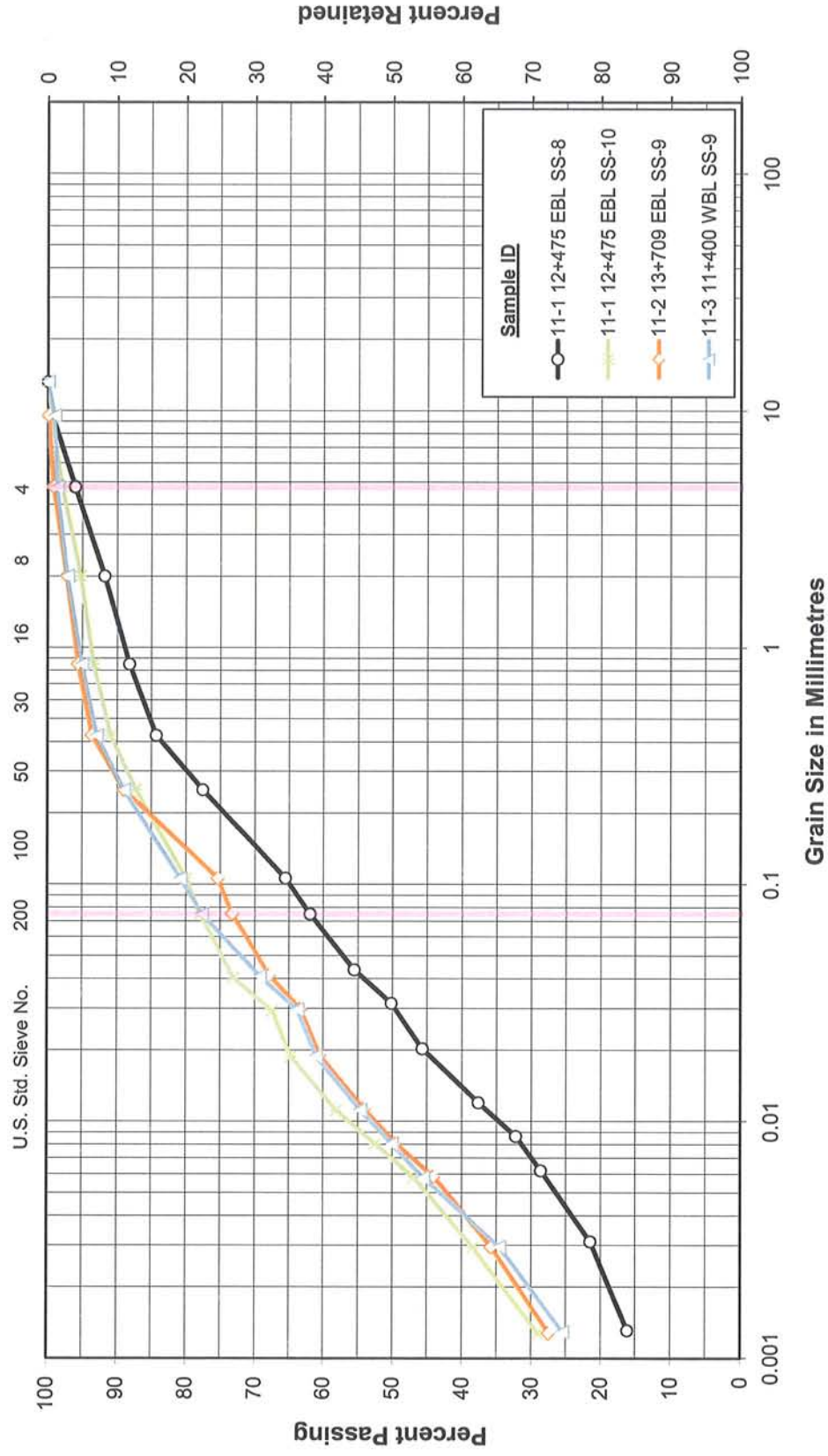
Project No. 165000607



Stantec

Unified Soil Classification System

CLAY & SILT	SAND				Gravel	
	Fine	Medium	Coarse		Fine	Coarse



GRAIN SIZE DISTRIBUTION

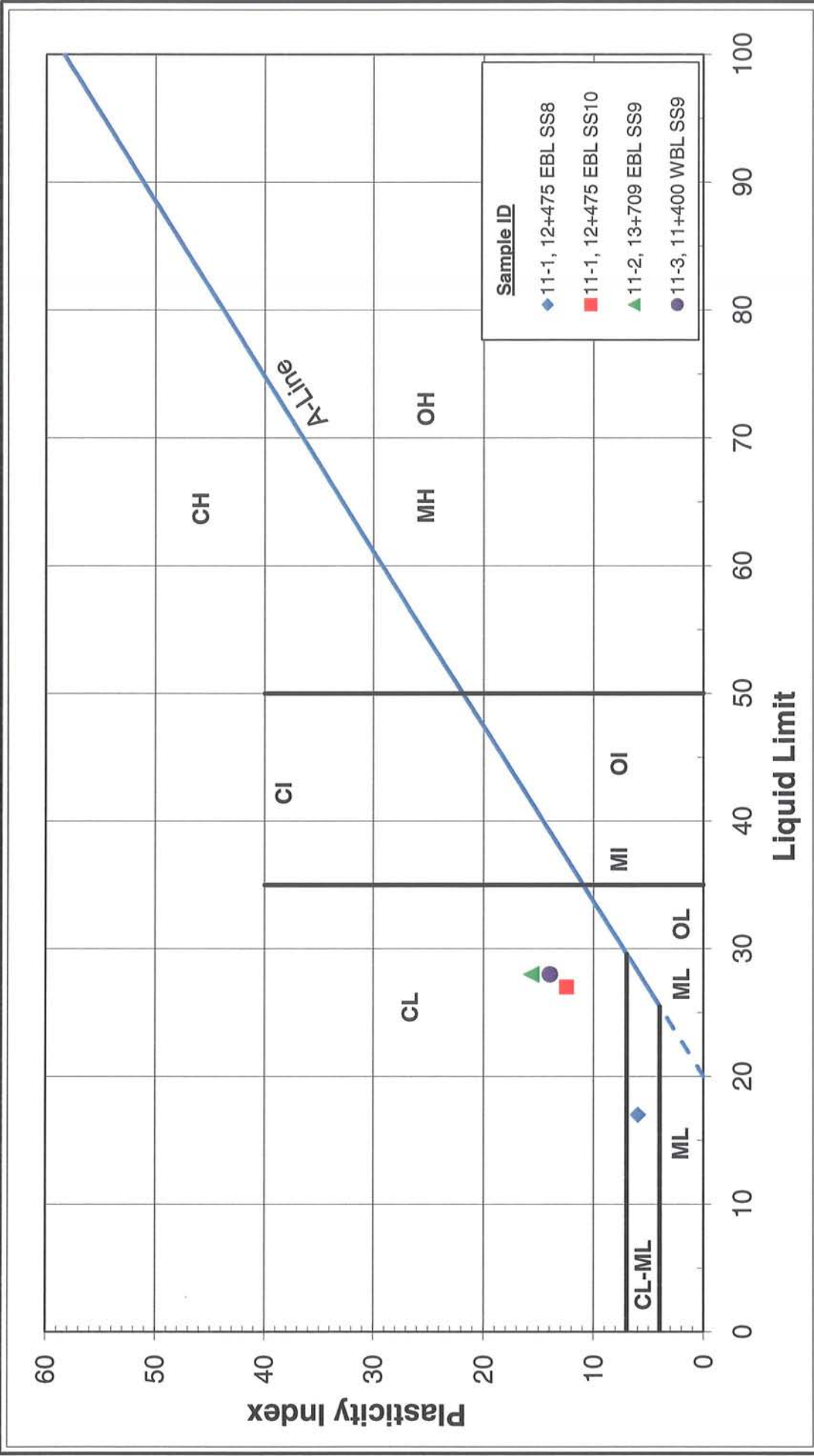
TILL: Sandy Silty Clay (CL-ML to CL)

Figure No. 3

Project No. 165000607



Stantec



PLASTICITY CHART

Figure No. 4

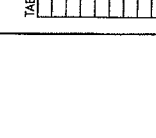
Project No. 165000607

APPENDIX D

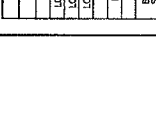
SS118-30 Steel Column Breakaway Sign Supports

Table 1: Recommended Design Parameters

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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
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DATE: _____
DRAWING NAME: _____

Table 1: Recommended Design Parameters at Proposed Sign Support Foundations

Borehole	Location (Station)	Soil Layer	Geodetic Elevation of Layer (m)		Average N Per 0.3 m	Average Shear Strength kPa	Unit Weight (kN/m ³)	Angle of Internal Friction ϕ (°)	K_a	K_o	K_p
			Start	End							
BH11-1	12+475	Silty Sand Fill Sand with Silt Sandy Silty Clay TILL	183.3	181.8	11	-	19	30	0.33	0.50	3.00
			181.8	178.0	25	-	20	32	0.31	0.47	3.25
			178.0	175.1	11	57	22				
BH11-2	13+709	Silty Sand with Gravel Fill Sand with Silt/Silty Sand Sandy Silty Clay TILL	182.8	181.4	34	-	19	30	0.33	0.50	3.00
			181.4	178.1	10	-	20	32	0.31	0.47	3.25
			178.1	176.2	12	62	22				
BH11-3	11+400	Silty Sand with Gravel Fill Silty Sand Sandy Silty Clay TILL	183.0	181.5	23	-	19	30	0.33	0.50	3.00
			181.5	177.7	25	-	20	32	0.31	0.47	3.25
			177.7	176.3	12	61	22				

Notes:

Design frost penetration depth, $f = 1.1$ m

Soils above the frost penetration depth of 1.1 m should not be relied upon for lateral resistance.

K_a = Coefficient of Active Earth Pressure

K_o = Coefficient of Earth Pressure at Rest

K_p = Coefficient of Passive Earth Pressure

A maximum angle of internal friction (ϕ) of 32° was used to account for soil loosening anticipated as a result of construction augering.

Stations are measured along Highway 402 median centreline and increase going east.

The submerged unit weight for use below the ground water level can be calculated by subtracting 10 kN/m³ from the unit weight values provided in the table.

For design purposes groundwater should be assumed to be at a depth of 1.5 m.