



**Foundation Investigation and
Design Report**

Highway 24
CNR Overhead NYC Railway
Structure Removal
Station 19+100
Norfolk County

Site No. 20-145

G.W.P. 362-98-00

Geocres No. 40116-23

Project No. 165000787

April 2012

Table of Contents

1.0 INTRODUCTION	1
2.0 SITE DESCRIPTION AND GEOLOGY	1
3.0 INVESTIGATION PROCEDURES	2
3.1 REVIEW OF EXISTING GEOCRETS REPORT	2
3.2 FIELD INVESTIGATION	3
3.3 LOCATION AND ELEVATION SURVEY	3
3.4 LABORATORY TESTING	4

4.0 SUBSURFACE CONDITIONS	4
4.1 GENERAL	4
4.1.1 Topsoil	5
4.1.2 Pavement Structure	5
4.1.3 Fill	5
4.1.4 Sand with Silt to Silty Sand	6
4.1.5 Silty Clay Till	6
4.1.6 Silty Sand	7
4.2 CHEMICAL TEST RESULTS	7
4.3 GROUNDWATER	8

5.0 MISCELLANEOUS	8
6.0 CLOSURE	9
7.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS	10
7.1 GENERAL	10
7.2 GEOTECHNICAL DESIGN PARAMETERS	11
7.3 FROST PENETRATION DEPTH	12
7.4 SEISMIC DESIGN CONSIDERATIONS	12
7.4.1 General	12
7.4.2 Soil Profile Type	13
7.4.3 Zonal Acceleration Ratio	13
7.4.4 Liquefaction of Site Soils	13
7.5 EMBANKMENT DESIGN	13
7.5.1 General	13
7.5.2 Slope Stability Evaluation	13
7.5.3 Evaluation of Potential Ground Settlement due to Embankment	14

8.0 CONSTRUCTION CONSIDERATIONS	15
8.1 CONSTRUCTION STAGING	15
8.2 STRUCTURE REMOVAL	15
8.3 GRADING	15
8.4 UNWATERING	16
8.5 EROSION PROTECTION	16

Table of Contents

9.0 SPECIFICATIONS	16
10.0 REFERENCES	17
11.0 CLOSURE	18

List of Tables

Table 3.1: Borehole Information Summary	4
Table 4.1: Results of Chemical Analysis	8
Table 4.2: Groundwater Levels	8
Table 7.1: Geotechnical Model – location of existing Highway 24 embankment	12
Table 7.2: Representative Soil Parameters for Imported Materials	12
Table 7.3: Summary of Slope Stability Analysis Results	14
Table 9.1: Specifications Referenced in Report	16

List of Appendices

APPENDIX A	Drawing No. 1 and 2 Borehole Location Plan and Soil Strata Plot Site Photos Copy of Geocres 40I16-07 Boring Location and Soil Strata Plot
APPENDIX B	Symbols and Terms Used on Borehole Records Borehole Records
APPENDIX C	Laboratory Test Results
APPENDIX D	Characterization of Liquefaction Resistance Typical Slope Stability Evaluation Results (Slope/W) Typical Settlement Evaluation Results (Settle3D)

FOUNDATION INVESTIGATION REPORT

For
G.W.P 362-98-00

Highway 24 – CNR Overhead NYC Railway Structure Removal
Station 19+100
Site No. 20-145
Norfolk County

1.0 Introduction

Stantec Consulting Ltd. (Stantec) was retained by the Ministry of Transportation, Ontario (MTO) to undertake the Environmental Assessment and Detailed Design for the Pavement Rehabilitation of Highway 24, between Simcoe north limits and 1.7 km south of Brant Road 4. This project also includes the removal of the existing overhead bridge structure for the former CNR railway (Site No. 20-145) at approximate Station 19+100 on Highway 24, approximately 7 km north of Simcoe, in Norfolk County.

This Foundation Investigation Report has been prepared specifically and solely for the proposed structure removal.

Project Number: G.W.P.: 362-98-00

Project Location: Highway 24 CNR Overhead NYC Railway Structure Removal, Norfolk County

The work was carried out under MTO Agreement Number 3010-E-0013 with Stantec Consulting Ltd., the Detailed Design Consultant for this project.

2.0 Site Description and Geology

Site Location

The site is approximately 7 km north of Simcoe, Ontario. The site location is shown on the Key Plan inset to Drawing No. 1, provided in Appendix A. At the project site, Highway 24 passes over a former railway line (now removed) on a three-span bridge structure. The approximate Highway 24 station at the bridge structure is 19+100.

General Site Description

Highway 24 runs approximately north-south at the project location with chainage increasing from south to north. At the bridge location, Highway 24 has a two lane rural cross-section with

approximately 3 m wide shoulders. The roadway width is approximately 11.3 m. Photographs of the site are provided in Appendix A.

Existing Bridge Structure

The existing structure is a three-span bridge with precast concrete girders. The total span is approximately 43 m (one 15 m centre span and two 14 m end spans) (see Photographs 1 and 2). The bridge structure provides a roadway width of approximately 11.3 m, and accommodates two lanes of Highway 24 traffic and shoulders (see Photographs 3 and 4).

The approach ramps to the bridge on both sides are supported on approximately 8 m high embankment fills. The embankment has approximately 2H:1V side slopes.

The tracks of the former railway have been removed. The sand and gravel fill for the former railway track is still visible along the alignment of this former railway line.

Physiographic Description

The site is located within a physiographic region known as the Norfolk Sand Plain (Chapman and Putnam, 1984). The predominant soil types in this region are sands and silts. The sands and silts of this region were deposited as a delta in glacial Lakes Whittlesey and Warren. The moraines of this region are partly buried by sand.

The sand plain generally declines southward from an elevation of approximately 260 m to the level of Lake Erie (174 m). Drainage in the region is mainly through small rivers flowing directly to Lake Erie.

Review of the geologic map of the region suggests that undifferentiated limestone bedrock is approximately 40 m below existing ground surface.

3.0 Investigation Procedures

3.1 REVIEW OF EXISTING GEOCREC REPORT

Prior to carrying out the geotechnical investigation reported herein, Stantec reviewed Geocres Report 40I16-07 (1963). This report was prepared for the proposed crossing of Highway 24 over the CNR Track. A copy of the Borehole Location and Soil Strata Plot from this report has been reproduced in Appendix A.

Review of this Report indicates the following:

- Four boreholes were drilled and eight Dynamic Cone Penetration Tests were conducted during the investigation. The test holes were located in lines of four on either side of Highway 24 (offset approximately 7 m from CL) at a spacing of approximately 12 m to 15 m centered on the railway;

- The encountered subsoil generally consisted of a surficial layer of very loose to compact, fine to medium sand approximately 5 m in thickness, over a compact to very dense glacial till containing layers of very dense fine sand extending to 8.3 m to 9.1 m below ground surface, over a dense to very dense, fine to medium sand extending to the maximum depth of investigation of 18 m below ground surface. SPT Refusal was only noted in one borehole. Groundwater was observed approximately 1.5 m to 1.9 m below ground surface.
- The design recommendations included supporting the structure on large displacement end-bearing piles driven to refusal in the till or on treated timber piles driven to the glacial till. It was noted that stability of the approach fills would not be an issue. Dewatering was noted to be a potential problem for the pier pile caps.

3.2 FIELD INVESTIGATION

A field investigation consisting of eight boreholes was carried out for this assignment. The boreholes were designated BH11-1 through BH11-8 and their locations are shown on the Borehole Location Plan, Drawing No.1 in Appendix A.

Prior to carrying out the investigation, Stantec made arrangements to obtain clearance for the proposed borehole locations regarding underground utilities.

The field drilling program was carried out on between July 12 and July 19, 2011. All boreholes were advanced with hollow-stem augers and casing using a rubber track mounted CME 75 drill rig equipped for soil and bedrock sampling. In addition, Dynamic Cone Penetration (DCP) resistance testing was carried out in three boreholes (at lower depth) along with the drilling and sampling investigation.

Groundwater monitoring wells were installed in two boreholes (BH11-5 and BH11-6) at the time of drilling. The wells included 50 mm diameter perforated PVC screen and risers. The wells were provided with a flush mount well cover. The water level in both wells was measured on August 4, 2011, approximately two weeks after the completion of drilling.

The subsurface stratigraphy encountered in each borehole was recorded in the field by an experienced Stantec Field Technologist. Split spoon samples were collected at regularly spaced intervals (typically every 760 mm) during the course of Standard Penetration Testing (ASTM, 1999). Pocket penetration tests were carried out in the field on samples of soil collected from the split spoons. All samples recovered were returned to Stantec's Ottawa laboratory for detailed classification and testing. Boreholes were backfilled with auger cuttings mixed with bentonite and road holes were topped with cold patch asphalt.

3.3 LOCATION AND ELEVATION SURVEY

Elevation and location survey of the borehole locations was performed by professional land surveyors Callon Dietz, Inc. of London, Ontario. The ground surface elevation at each borehole location was surveyed with reference to a Geodetic Benchmark. Table 3.1 summarizes the location and elevation information for the boreholes included in this report.

Table 3.1: Borehole Information Summary

Borehole	MTM Zone 10 Coordinates		Ground Elevation (m)	Total Depth (m)	End of Borehole Elevation (m)	No. of Soil Samples Collected
	Northing (m)	Easting (m)				
BH11-1	4754285.6	236482.7	247.8	18.9	228.9	25
BH11-2	4754250.9	236480.9	239.1	9.8	229.3	13
BH11-3	4754268.3	236499.9	239.5	9.8	229.7	13
BH11-4	4754253.7	236502.1	239.5	18.3	221.2	20*
BH11-5	4754261.7	236480.2	239.5	18.3	221.2	20*
BH11-6	4754267.2	236517.5	239.3	9.8	229.5	13
BH11-7	4754252.3	236466.2	239.4	9.8	229.6	13
BH11-8	4754233.7	236500.4	248.3	18.3	230.0	21*

*Note: Dynamic Cone Penetration resistance testing was carried out to approximately 3 m past the last sample.

3.4 LABORATORY TESTING

All samples were taken to our Ottawa laboratory where they were subjected to a detailed visual examination by a Geotechnical Engineer. Moisture content test was carried out on all retrieved samples (138 samples). Gradation analysis test was carried on selected soil samples (35 samples). It is noted that three of these gradation tests were limited to wash sieve analysis. Four samples 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

4.1 GENERAL

The subsurface conditions observed in the boreholes 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 general, the subsurface stratigraphy consisted of sand to silty sand deposit over glacial till over silty sand. A pavement structure was encountered in two boreholes. The pavement structure was underlain by approximately 8 m thick roadway embankment fill over existing subsurface. A 200 to 500 mm thick topsoil layer was encountered in three of the eight boreholes. Crushed stone fill was observed on the surface at three boreholes advanced along the former railway alignment while topsoil was observed over the fill in the remaining three boreholes along the railway alignment. Only one borehole along the former railway alignment did not penetrate a fill layer.

Borehole location plans and stratigraphic sections of the soils encountered within the boreholes are provided on Drawing No. 1 and 2 in Appendix A.

4.1.1 Topsoil

Topsoil was encountered in Boreholes BH11-2, BH11-3 and BH11-4. The observed thickness of the topsoil ranged between approximately 200 and 500 mm. The moisture content of the topsoil ranged approximately between 2 and 16%.

4.1.2 Pavement Structure

The pavement structure observed in Boreholes BH11-1 and BH11-8 consisted of the following:

HM Asphalt	200 mm
Base Gravel/Sand	300 mm

The base layer consisted of brown sand with gravel.

It is noted that approximately 80 mm thick asphalt layer was encountered in both boreholes approximately 8.2 to 8.5 m below the existing pavement surface.

Standard Penetration Test (STP) N-values observed in the base gravel/sand layer was 30 and 45 blows per 0.3 m suggesting a dense state.

The measured moisture content in the base gravel/sand was 3 and 5%.

4.1.3 Fill

A fill layer of variable thickness was encountered in all boreholes except for BH11-4. In Boreholes BH11-1 and BH11-8 advanced in the approach fills of Highway 24, the fill extended to a depth of approximately 8.2 to 8.5 m below the road profile (to elevation 239.6 m and 239.8 m) and generally consisted of sand and silty sand with variable amounts of gravel. In Boreholes BH11-2, BH11-3, BH11-5, BH11-6 and BH11-7, the fill thickness varied between 0.4 and 2.0 m and consisted of gravel and sand with variable amounts of silt, with bottom elevations varying between 237.5 m and 238.9 m.

The SPT N-values observed within the fill layer ranged from 10 to 56 blows per 0.3 m suggesting a compact to very dense state.

Moisture content and grain size distribution tests carried out on representative samples of the fill layer yielded the following results:

- Gravel: 0 to 11%
- Sand: 79 to 89%
- Fines (silt & clay): 10 to 13%
- Moisture Content: 3 to 11%

The fill material can be classified as poorly graded sand with silt (SP-SM) to silty sand (SM). The grain size distribution curves are plotted on Figure 1 in Appendix C.

4.1.4 Sand with Silt to Silty Sand

This deposit was encountered in all boreholes immediately beneath the topsoil (BH11-4) or fill (in all other boreholes) described above. The thickness of this layer ranged between 2.9 and 6.8 m and extended to elevation of 235.6 m (BH11-6) to 232.8 m (BH11-8).

The SPT N-values for this deposit ranged between 5 and 51 blows per 0.3 m suggesting a loose to very dense state.

Moisture content and grain size distribution tests carried out on representative samples of the sand with silt layer yielded the following results:

- Gravel: 0 to 15%
- Sand: 58 to 89%
- Fines (silt & clay): 9 to 39%
- Moisture Content: 3 to 20%

This layer is classified as silty sand (SM) to poorly graded sand with silt (SP-SM) to well-graded sand with silt (SW-SM). Representative grain size distribution plots for the material of this layer are indicated on Figure 2 in Appendix C.

4.1.5 Silty Clay Till

This layer was encountered in all boreholes immediately beneath the sand with silt to silty sand deposit described above. It is noted that the presence of this layer was inferred from the DCP results in BH11-8. The deposit consisted of a heterogeneous mixture of fine-grained soils (silt and clay), sand and gravel of variable proportions throughout the deposit. The thickness of this deposit ranged approximately from 2.6 to 4.1 m and extended to elevation 230.0 m to 232.6 m.

The SPT N-values for this deposit ranged from 6 to greater than 100 blows per 0.3 m suggesting a firm to hard consistency; generally this deposit may be viewed as very stiff.

A Dynamic Cone Penetration (DCP) resistance test was advanced through this layer in one borehole. The resistance value ranged from 127 to 205 per 0.3 m penetration.

Pocket penetration tests on samples of the material from borehole BH 11-6 yielded undrained shear strength values between 38 and 125 kPa and within borehole BH11-1 undrained shear strength values between 38 kPa and 63 kPa.

Moisture content and grain size distribution tests carried out on representative samples retrieved from this deposit yielded the following results:

- Gravel: 2 to 24%
- Sand: 6 to 27%
- Fines (silt & clay): 56 to 92%
- Moisture Content: 5 to 19%

Representative grain size distribution plots for the material of this deposit are indicated on Figure 3 in Appendix C.

Atterberg limits tests were carried out on five till samples which all produced low plastic results (see Fig. 5 in Appendix C). The classification of silty clay till samples from this layer ranges from CL-ML to CL.

4.1.6 Silty Sand

This layer was encountered in Boreholes BH11-1 through BH11-7 immediately beneath the silty clay till. This layer consisted predominantly of silty sand and was encountered to elevation ranging from 229.7 m (BH11-3) to 221.2 m (BH11-4). In all boreholes, drilling was terminated within this layer and hence, the actual thickness of this layer was not confirmed.

The SPT N-values for this deposit ranged from 15 to greater than 50 blows per 0.3 m suggesting a compact to very dense state.

Dynamic Cone Penetration resistance testing was carried out in two boreholes through this layer. The resistance values ranged from 24 to 178 blows per 0.3 m.

Moisture content and grain size distribution tests carried out on representative samples of this layer yielded the following results:

- Gravel: 0 to 8%
- Sand: 53 to 87%
- Fines (silt & clay): 13 to 44%
- Moisture Content: 9 to 19%

The sand layer is classified as silty sand (SM). Representative grain size distribution plots are indicated on Figure 4 in Appendix C.

4.2 CHEMICAL TEST RESULTS

Four samples retrieved from the sand with silt to silty sand deposit were submitted to Paracel Laboratories in Ottawa, Ontario, for analysis of pH, water soluble sulphate and chloride concentrations, and resistivity. The analysis results are provided in Table 4.1.

Table 4.1: Results of Chemical Analysis

Borehole No	Sample No.	Depth (m)	pH	Chloride (µg/g)	Sulphate (µg/g)	Resistivity (Ohm-m)
BH11-2	SS-3	1.5 to 2.1	7.5	14	18	123
BH11-3	SS-3	1.5 to 2.1	7.8	40	41	68
BH11-5	SS-5	3.0 to 3.6	7.9	91	8	42
BH11-6	SS-4	2.3 to 2.9	7.9	25	8	86

4.3 GROUNDWATER

Groundwater was encountered in all eight boreholes at the time of drilling from July 12 and 19, 2011. Groundwater monitoring wells were installed in BH11-5 and BH11-6. Groundwater was measured in these wells on August 4, 2011. Groundwater level was also inferred in the open boreholes prior to backfilling. The measured and inferred (i.e., at the time of drilling) groundwater levels are summarized in Table 4.2.

Table 4.2: Groundwater Levels

Borehole No	Ground Surface Elevation (m)	Groundwater	
		Depth (m)	Elevation (m)
Measured August 4, 2011			
BH11-5	239.5	2.3	237.2
BH11-6	239.3	2.2	237.1
Inferred (time of drilling)			
BH11-1	247.8	10.7	237.1
BH11-2	239.1	3.1	236.0
BH11-3	239.5	3.4	236.1
BH11-4	239.5	3.4	236.1
BH11-7	239.4	3.4	236.0
BH11-8	248.3	12.5	235.8

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

5.0 Miscellaneous

The field work was carried out under the supervision of Mr. Dan Stunden, Geotechnical Engineering Technologist under the direction of Mr. Chris McGrath, P.Eng.

The CME 75 drilling equipment was supplied and operated by Pontil Drilling Ltd of Mount Albert, Ontario.

MultiVIEW Locates Inc. of Mississauga, Ontario, carried out the private and public utility locates for the boreholes.

Geotechnical laboratory testing was carried out at Stantec's Ottawa laboratory.

Chemical testing on soil samples was carried out by Paracel Laboratories in Ottawa.

This report was prepared by Simon Gudina and Chris McGrath and Reviewed by Raymond Haché.

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. 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.

Respectfully Submitted;

STANTEC CONSULTING LTD.

Simon Gudina, Ph.D., P.Eng.
Geotechnical Engineer



Chris McGrath, P.Eng.
Associate, Geotechnical Engineer



Raymond Haché, M.Sc., P.Eng.
Designated Principal MTO Foundation Contact



FOUNDATION DESIGN REPORT

For

G.W.P 362-98-00

Highway 24 – CNR Overhead NYC Railway Structure Removal

Station 19+100

Site No. 20-145

Norfolk County

7.0 Discussion and Engineering Recommendations

7.1 GENERAL

Project Purpose/Justification

The CNR railway at the site has been abandoned and subsequently decommissioned. The existing three-span bridge structure over the abandoned CNR railway is to be removed. This bridge carries Highway 24 traffic over the decommissioned railway.

The existing structure is a three-span bridge with precast concrete girders (prestressed concrete post-tensioned concrete continuous beams bridge). The bridge is supported on pile foundations. The materials and the depth of the piles are unknown. It is understood that the bridge was built before or around 1965. This bridge has been identified as being in poor condition. The vertical curve for Highway 24 at the site has been identified as sub-standard hence requiring improvement to achieve a better vertical alignment (sight distance). Improving Highway 24 profile is anticipated to involve reconstructing Highway 24 at the bridge location.

Proposed Reconstruction

It is understood that the existing bridge structure will be removed and Highway 24 reconstructed. Two alternatives considered for the reconstruction of the Highway 24 embankment included:

- Alternative 1: Removal of the bridge structure and building up the embankment between the existing abutment locations with mostly imported fill. As part of this alternative, improvement to the vertical alignment would be achieved by lowering the profile grades of the existing embankment.
- Alternative 2: Removal of the existing bridge structure, placement of a culvert structure (pedestrian crossing), and building up the embankment between the existing abutment locations with mostly imported fill. The vertical alignment improvement would be achieved by lowering the profile grades of the existing embankments.

The preferred alternative selected for design is Alternative 1, namely, filling the location of the existing bridge structure and the abandoned railway with imported and site generated fill

material. The vertical profile of Highway 24 will be slightly modified to improve the vertical site distance.

Key elevations associated with the proposed bridge removal and Highway 24 reconstruction are as follows:

Pavement Elevation (Existing):	248.3 m (near C/L of existing bridge)
Bottom of Bridge Deck	247.0 m (south pier) 246.8 m (north pier)
Elevation of abandoned CNR:	239.5 m (near C/L of Highway 24)
Groundwater Elevation:	237.2 m at time of Foundation Investigation (August 4, 2011)
Proposed Top of Pavement:	247.2 m (at CL of existing CNR Bridge)
Proposed Pavement Bottom Elevation:	246.2 m (at CL of existing CNR Bridge)
Proposed Top of Embankment Fill:	246.2 m (at CL of existing CNR Bridge)

The proposed fill is anticipated to be highest near the centerline of the abandoned CNR alignment and is anticipated to be approximately 7.7 m.

Construction Staging & Detours

This section of Highway 24 is to be closed during the construction period required to remove the existing bridge structure and to reshape the existing embankment. Traffic is to be managed by using existing roads as traffic detours. Therefore, construction staging and associated temporary roadway protection are not required for this project.

For the proposed bridge structure removal, consideration was also given to the option of staged construction. This would involve reducing the traffic on Highway 24 to a single lane during the proposed bridge removal and Highway 24 reconstruction by using temporary traffic signals. This option would have potentially induced settlement of the existing piles supporting half of the Highway 24 traffic during the staged removal and reconstruction. This option was deemed unfavourable.

7.2 GEOTECHNICAL DESIGN PARAMETERS

The soil conditions at this site generally consist of fill over loose to very dense sand over firm to hard till consisting heterogeneous mixture of sand, silt, clay and gravel underlain by a compact to very dense deposit of silty sand.

For design purposes, the following soils profile will be used:

Table 7.1: Geotechnical Model – location of existing Highway 24 embankment

Elevation (m)		Soil Type	Design Properties*			
From	To		γ	C_u	ϕ'	E
247.8	239.5	FILL: Sand (SP-SM to SM), compact to very dense	21	-	32	35
239.5	235.0	Sand (SP-SM, SW-SM, SM), loose to very dense	21	-	33	20
235.0	231.0	Firm to hard silty clay till (CL to CL-ML)	19	150 kPa	30	50
231	<221.2	Compact to very dense silty sand (SM)	22	-	35	75

*Note: γ = total unit weight (kN/m^3), ϕ' = effective friction angle ($^\circ$), E= soil Young's modulus (MPa)

A typical groundwater level elevation of 237.2 m can be used for analysis. For drained or effective stress analysis, the submerged unit weight is calculated as $\gamma' = \gamma - \gamma_w$ below the water table, where γ_w is the unit weight of water.

The parameters in Table 7.2 below are applicable to fill materials imported to the site.

Table 7.2: Representative Soil Parameters for Imported Materials

Material	Design Parameter	
	γ (kN/m^3)	ϕ ($^\circ$)
Earth Borrow	20.0	29
Select Subgrade Material (SSM)	21.0	32
OPSS Granular B Type I	21.2	32
OPSS Granular B Type II	22.8	35
OPSS Granular A	22.8	35

7.3 FROST PENETRATION DEPTH

OPSD 3090.101 indicates that the frost penetration depth at the project site is 1.2 m.

Foundation units are not proposed as part of the construction and therefore soil cover or foundation isolation requirements do not apply.

7.4 SEISMIC DESIGN CONSIDERATIONS

7.4.1 General

The design recommendations presented in the following sections have been developed in accordance with the requirements and methods described in the Canadian Highway Bridge Design Code (CHBDC, 2006).

7.4.2 Soil Profile Type

7.4.3 Zonal Acceleration Ratio

Table A3.1.1 of the CHBDC indicates that the Zonal Acceleration Ratio (ZAR) for Simcoe, approximately 7 km south of the site, is 0.05. Hence, a ZAR of 0.05 is appropriate for this site.

7.4.4 Liquefaction of Site Soils

The potential for liquefaction of the foundation soils was evaluated for a typical borehole at the site. The evaluation result is provided in Appendix D. This evaluation indicates that the factor of safety against potential liquefaction is in excess of unity and thus liquefaction of the site soil is not a concern for this project. In addition, confinement by the proposed reconstruction of Highway 24 embankment within the abandoned CNR railway will further reduce the potential for liquefaction.

7.5 EMBANKMENT DESIGN

7.5.1 General

It is understood that after the removal of the existing CNR Bridge, Highway 24 will be reconstructed by placing embankment fill material. The fill extent is anticipated to be between the north and south abutments of the existing bridge. The approximate dimensions of the proposed embankment are as follows:

- The distance between the north and south abutments is approximately 55.2 m. This dimension indicates the length of the proposed embankment along the Highway 24 profile.
- The width of the abandoned railway platform is approximately 15.2 m. This dimension indicates the length of infilling at the base of the embankment.
- The top width of Highway 24 embankment is approximately 13.65 m.
- The proposed new profile of Highway 24 is approximately 7.7 m above the former railway platform.

7.5.2 Slope Stability Evaluation

Stability of the proposed high-fill embankment was evaluated. The stability evaluation was carried out using a commercial software Slope/W (Geo-Slope, 2010). The following assumptions were made in carrying out the stability evaluations:

- Available soils to be imported to the site for embankment construction include Earth Borrow or better fill materials provided in Table 7.2 above;
- The soil parameters listed in Table 7.1 are considered representative of the site soil;
- The soil parameters indicated in Table 7.2 will be used for soils imported to the site; and
- The side slope of the embankment will be 2H:1V.

Both static (short- and long-term) and seismic (short-term) stability evaluations were carried out. For the seismic slope stability evaluation, seismic loading was applied using one-half of the

ZAR. Typical slope stability evaluations are presented in Figures 6a through 6c in Appendix D. Table 7.3 below summarizes the slope stability analysis results:

Table 7.3: Summary of Slope Stability Analysis Results

Case	Calculated Factor of Safety	Required Factor of Safety	comment
Long-term Static	1.4	1.3	Stable
Short-term Static	1.3	1.3	Stable
Short-term Seismic	1.2	1.1	Stable

The slope stability evaluation results indicate that an embankment constructed from Earth Borrow would be stable with a side slope of 2H:1V under the long and short-term conditions.

All other soils listed in Table 7.2 would also be suitable with a side slope of 2H:1V for the proposed Highway 24 reconstruction. These soils are expected to enable steeper embankment side slopes. Additional evaluation is required to establish the steepest possible embankment side slopes for a specific soil type.

7.5.3 Evaluation of Potential Ground Settlement due to Embankment

Settlement of the underlying soil due to the new embankment fill was evaluated. The following assumptions were made in evaluating the potential settlement of the site soil due to the reconstruction of Highway 24 at the location of the former CNR alignment:

- Settlement caused only by the additional fill at the location of the bridge structure will be considered;
- Most of the area at the project site has already been subjected to existing Highway 24 embankment and hence the associated settlement has been completed;
- The typical soil profile given in Table 7.1 is considered representative;
- Only immediate (elastic) settlement is considered due to the presence of predominantly non-cohesive soils and a very stiff silty clay till layer at the site;
- A representative Poisson's ratio of 0.3 is used for all soil types;
- A maximum fill height of 7.7 m near the centerline of the former railway alignment;
- Groundwater is approximately 2.3 m below the level of the rail bed (approximate elevation of 237.2 m);
- The original Highway 24 embankment at the CNR bridge extends approximately from Station 18+713 to 19+490 giving a total embankment length of 777 m;
- The top width of the Highway 24 embankment is approximately 13.65 m;
- Highway 24 embankment is constructed with a side slope of 2H:1V as required by the slope stability evaluation presented above for Earth Borrow; and
- The self-weight settlement of the new embankment fill will be negligible and will be completed by the end of construction.

Evaluation of the anticipated soil settlement was carried out using a commercial computer program Settle3D (Rocscience, 2009). It is a three-dimensional computer program for the analysis of the immediate vertical settlement and consolidation of soil under surface loads such as embankments.

Typical plots of the settlement contours from typical Settle3D analyses are provided in Figures 7a and 7b of Appendix D. Figure 7a shows the settlement profile caused by the existing Highway 24 embankment while Figure 7b shows the settlement profile caused by the existing Hwy 24 profile and fill material placed within the region occupied by the existing CNR Bridge. Since Highway 24 was built more than 40 years ago, the settlement shown in Figure 7a has already been completed. The difference in the amount of settlement in Figures 7a and 7b provides an estimate of the expected net settlement caused by fill material within the region of the existing CNR Bridge of the removal of the latter. Comparison of Figures 7a and 7b indicates that this settlement is largest near the centerline of the abandoned railway. The amount of this settlement is approximately 10 mm. This settlement will take place rapidly and is expected to be completed during construction of the embankment.

Settlement is not considered to be an issue of significance to this project.

8.0 Construction Considerations

8.1 CONSTRUCTION STAGING

An off-site detour is planned during the removal of the bridge and fill placement. Construction staging is not anticipated for the removal of the bridge structure and for the construction of Highway 24 embankment at the site.

8.2 STRUCTURE REMOVAL

This project involves the removal of a bridge structure over the former CNR railway. Removal of bridge structure should be carried out in accordance with OPSS 510 Construction Specification for Removal. Any exposed side slopes resulting from the structure removal or related excavation should conform to the current Occupational Health and Safety Act (OHSA) regulations for Construction Projects. The soils encountered at the site may be classified in accordance to the OHSA as Type 2 Soil.

8.3 GRADING

A limited amount of excavation is anticipated for Highway 24 profile adjustment. At the location of the existing bridge structure the proposed final grade of Highway 24 is anticipated to be approximately 1 m below the existing pavement elevation. This requires regrading of existing Highway 24 embankment on both sides of the existing bridge.

Grading work for reinstatement of the Highway 24 embankment should be carried out in accordance with OPSS SP 206S03. The existing embankment should be benched where new fill is placed adjacent to existing fill as per OPSD 208.010 Benching of Earth Slopes.

8.4 UNWATERING

Unwatering is not anticipated for the reconstruction of the Highway 24 embankment. However, groundwater control may need to be in place during the excavation for the removal of the structure foundations.

The native soils within the anticipated depth of excavation have a low to moderate hydraulic conductivity. The estimated hydraulic conductivity for the native soil at the site is expected to range from 1×10^{-7} to 1×10^{-4} m/s. Unwatering of the structure excavation using conventional sump and pump techniques should be adequate.

8.5 EROSION PROTECTION

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the reconstructed Highway 24 embankment slopes. Where embankment construction includes earth fill, normal slope vegetation should be established as soon as possible after completion of the embankment fills in order to control surficial erosion.

The contractor should provide silt fences and erosion control blankets, as required, throughout the duration of the construction to prevent silt/sediments from running off the site.

9.0 Specifications

The following specifications are referenced in this report:

Table 9.1: Specifications Referenced in Report

Document	Title
SP 206S03	Earth Excavation, Grading
OPSS 501	Construction Specification for Compacting
OPSS 510	Construction Specification for Removal
OPSD 208.010	Benching of Earth Slopes

10.0 References

ASTM. 1999. Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils (ASTM D1586). ASTM International, West Conshohocken, PA.

ASTM. 2000. Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) (ASTM D2487). ASTM International, West Conshohocken, PA.

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

CHBDC. 2006. Canadian Highway Bridge Design Code. Canadian Standards Association, Mississauga, Ontario.

Geo-Slope International, Ltd. 2010. GeoStudio 2007 (Slope/W 2007), Calgary, Alberta.

Rocscience, 2009. Settle3D Settlement and Consolidation Analysis: Theory Manual, Rocscience, Inc.

11.0 Closure

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 Simon Gudina and Chris McGrath. Technical review was carried out by Raymond Haché.

Respectfully submitted,

STANTEC CONSULTING LTD.

Simon Gudina, Ph.D., P.Eng.
Geotechnical Engineer



Chris McGrath, P.Eng.
Associate, Geotechnical Engineer



Raymond Haché, M.Sc., P.Eng.
Designated Principal MTO Foundation Contact



APPENDIX A

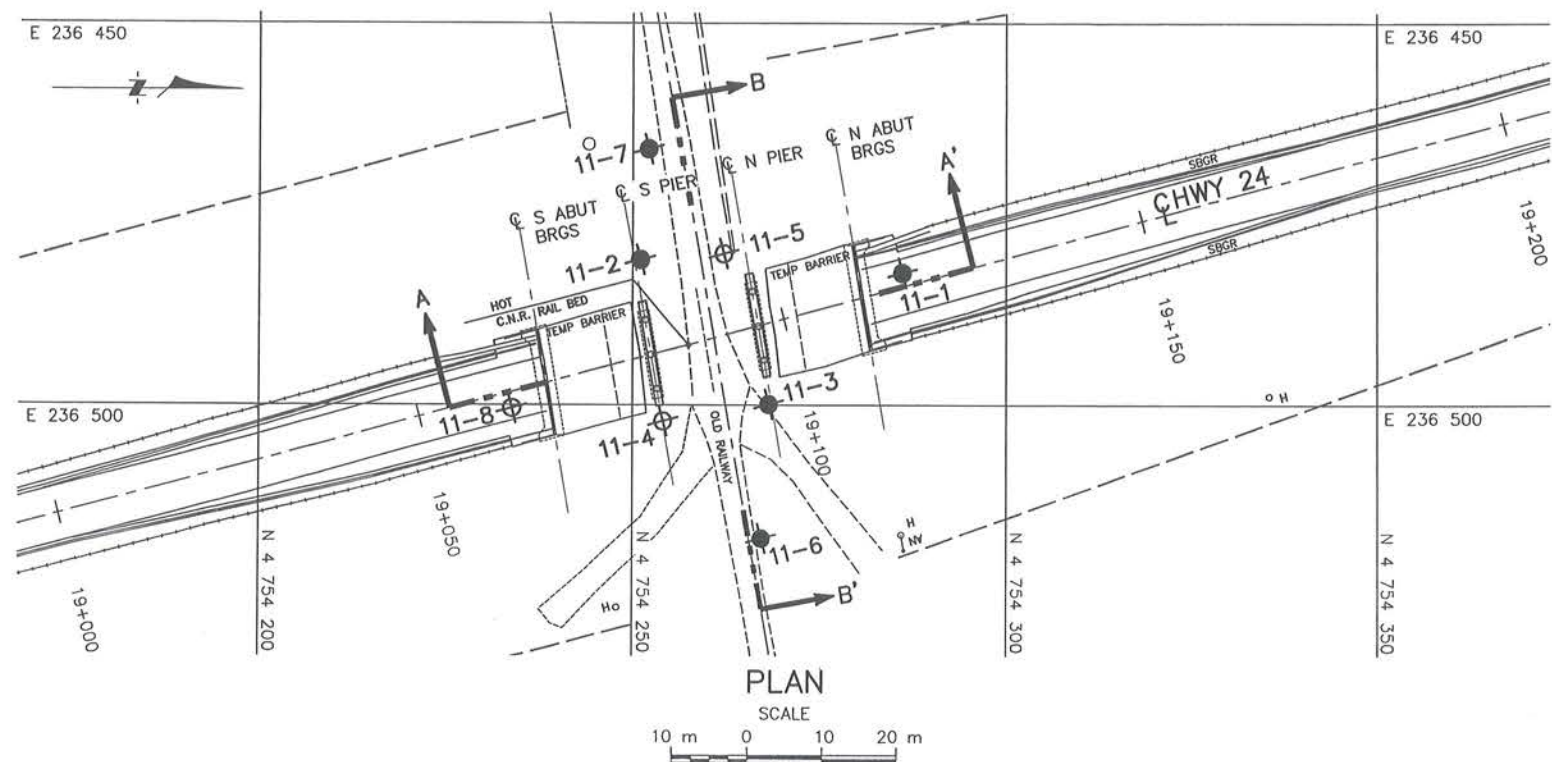
Drawing No. 1 and 2 – Borehole Location Plan and Soil Strata

Site Photos

Copy of Geocres 40I16-7 Boring Location and Soil Strata Plot

DRAWING NAME: 185000787-1_CNR Site 20-145
CREATED BY: GBB
T: Autocad Drawings\Project Drawings\2012\185000787\CNR Structure Plan & XS\185000787-1_CNR SITE 20-145.dwg (CNR - PLAN AND XS)
12/04/25
Printed: Apr 25, 2012

MINISTRY OF TRANSPORTATION, ONTARIO
PR-01-707
08-00



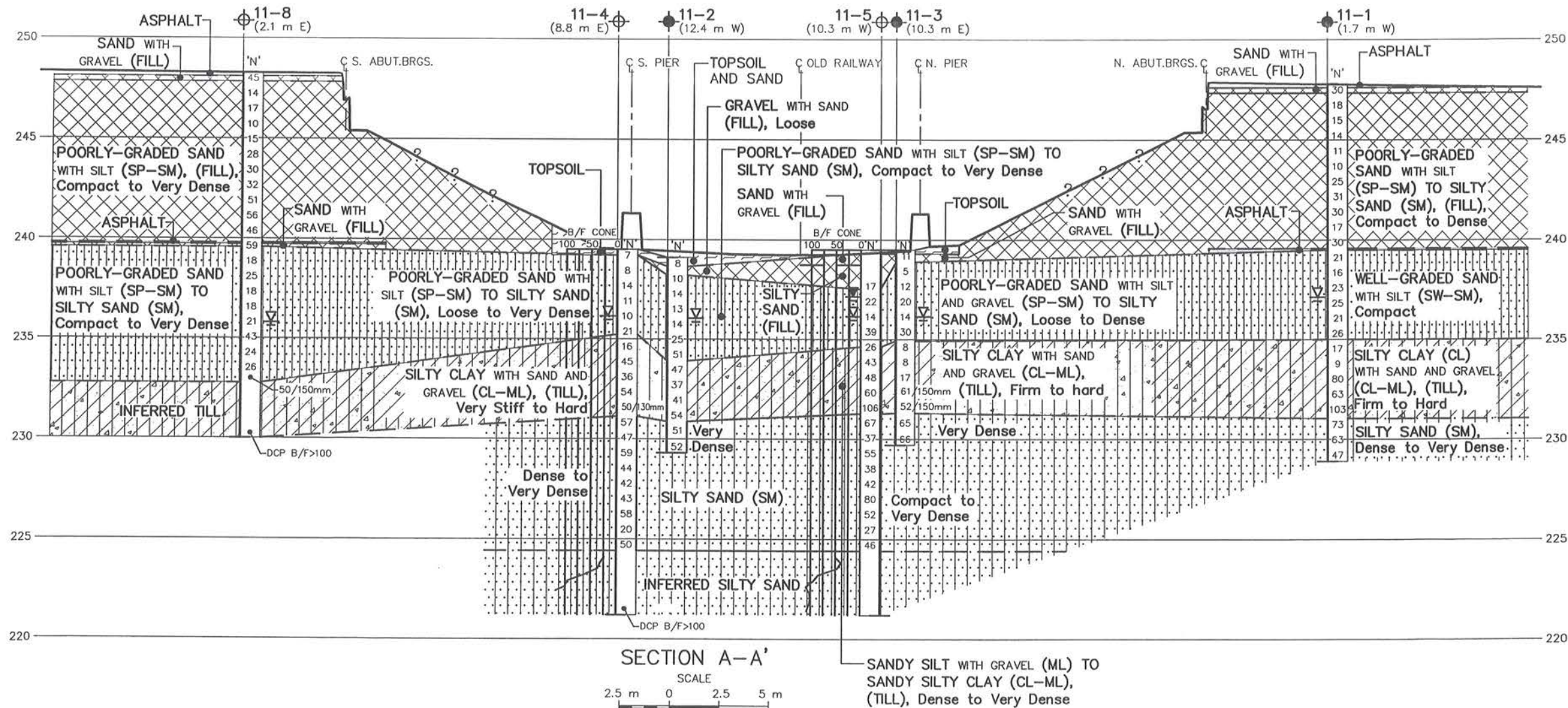
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



PLATE No
CONT
WP 362-98-00
HIGHWAY 24
CNR OVERHEAD NYC RAILWAY BRIDGE
BOREHOLE LOCATIONS & SOIL STRATA



KEY PLAN
1 km 0 1 2 km



LEGEND

- Borehole
- Borehole with Dynamic Cone Penetration Test (Cone)
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- WL (July 2011)
- WL (August 4, 2011)
- (1.7 m W) Offset from Hwy 24 centreline in meters

No	ELEVATION	MTM ZONE 10 COORDINATES NORTH	COORDINATES EAST
11-1	247.8	4 754 285.6	236 482.7
11-2	239.1	4 754 250.9	236 480.9
11-3	239.5	4 754 268.3	236 499.9
11-4	239.5	4 754 253.7	236 502.1
11-5	239.5	4 754 261.7	236 480.2
11-6	239.3	4 754 267.2	236 517.5
11-7	239.4	4 754 252.3	236 466.2
11-8	248.3	4 754 233.7	236 500.4

NOTES

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

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
12/04/25	CM	GEOCRES NUMBER ADDED	
DATE	BY	DESCRIPTION	
GEOCRES No	40116-23		
HWY No 24		DIST	
SUBM'D SG	CHECKED	DATE 2011-12-07	SITE 20-145
DRAWN GBB	CHECKED	APPROVED	DWG 1

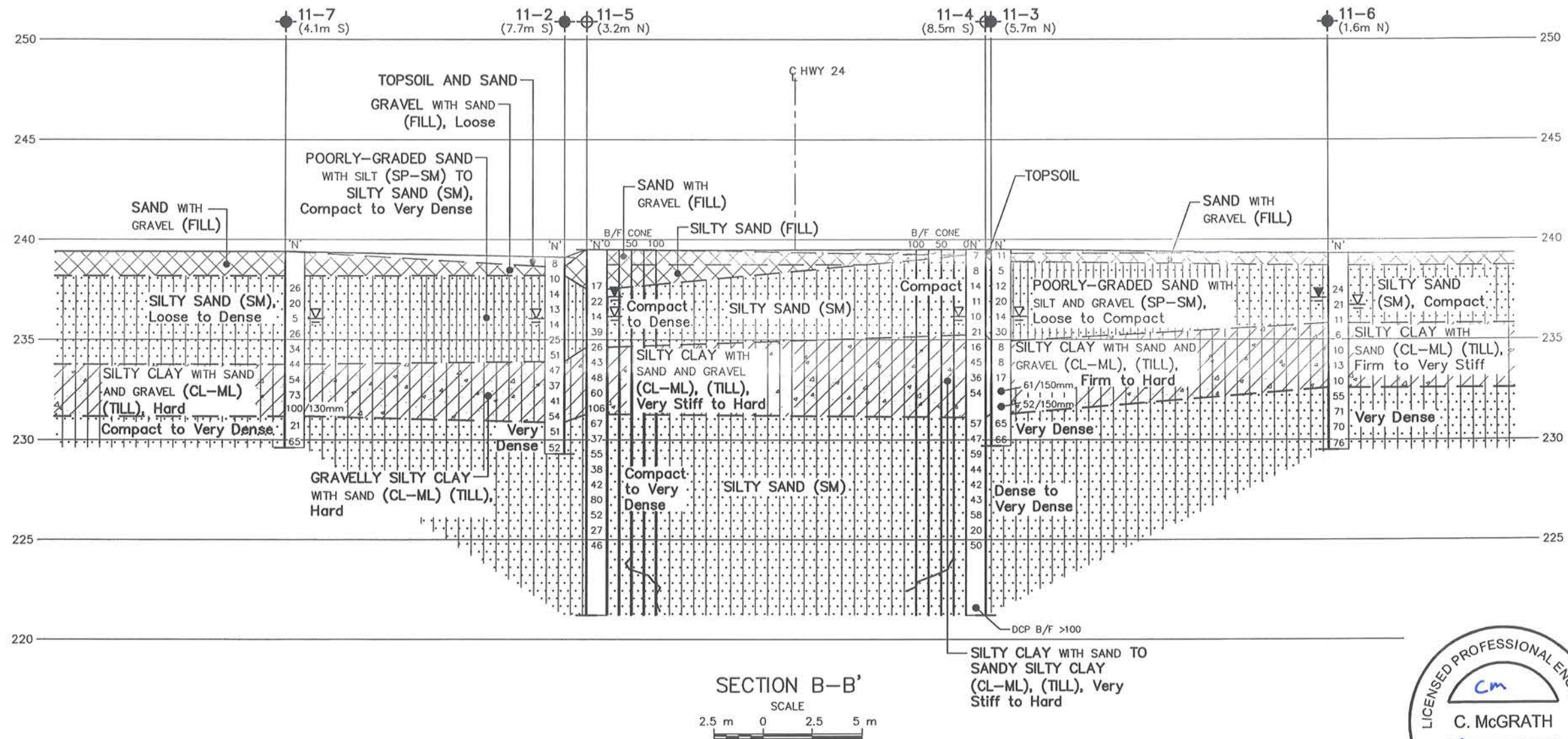




Photo No. 1: C.N.R. Bridge looking east along former railway



Photo No. 2: C.N.R. Bridge looking west along former railway

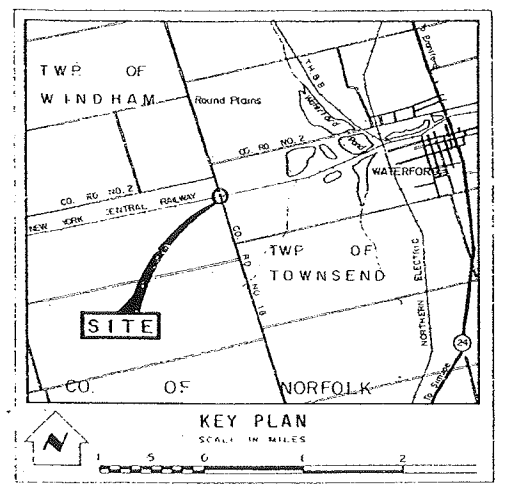
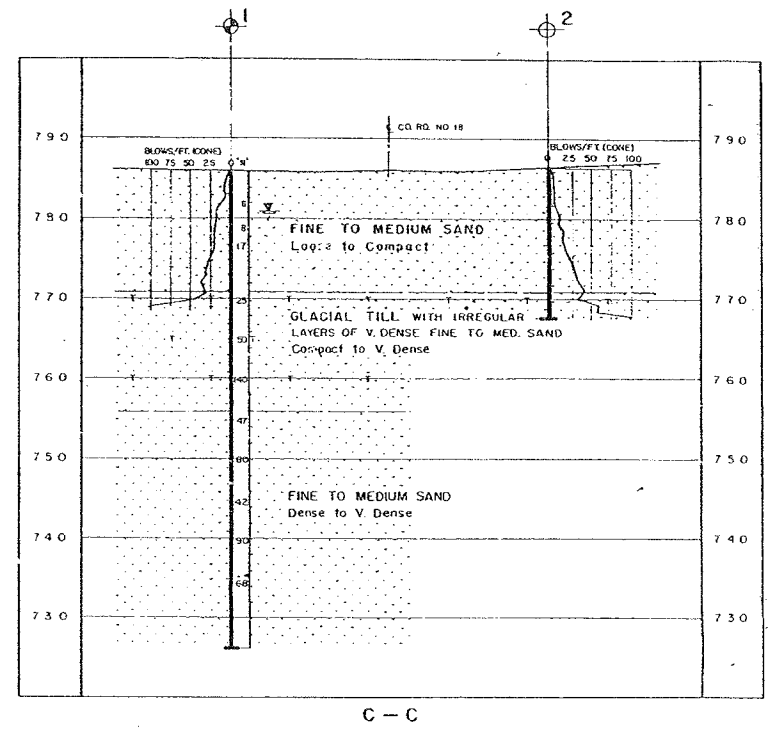
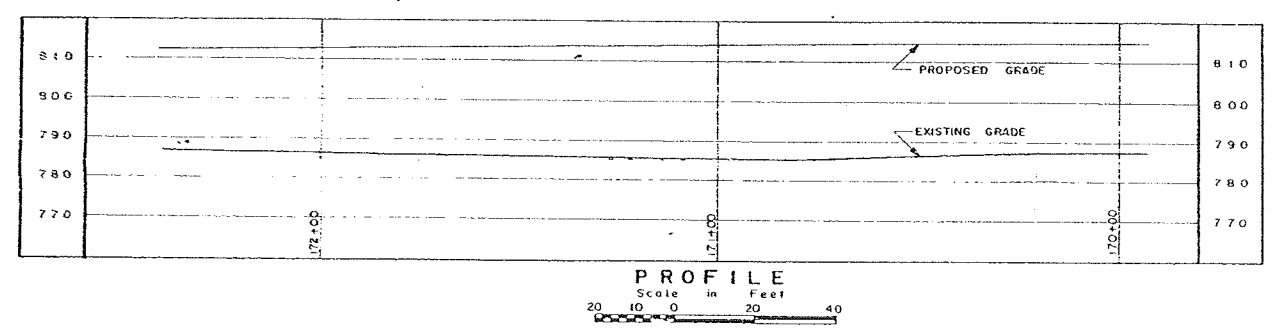
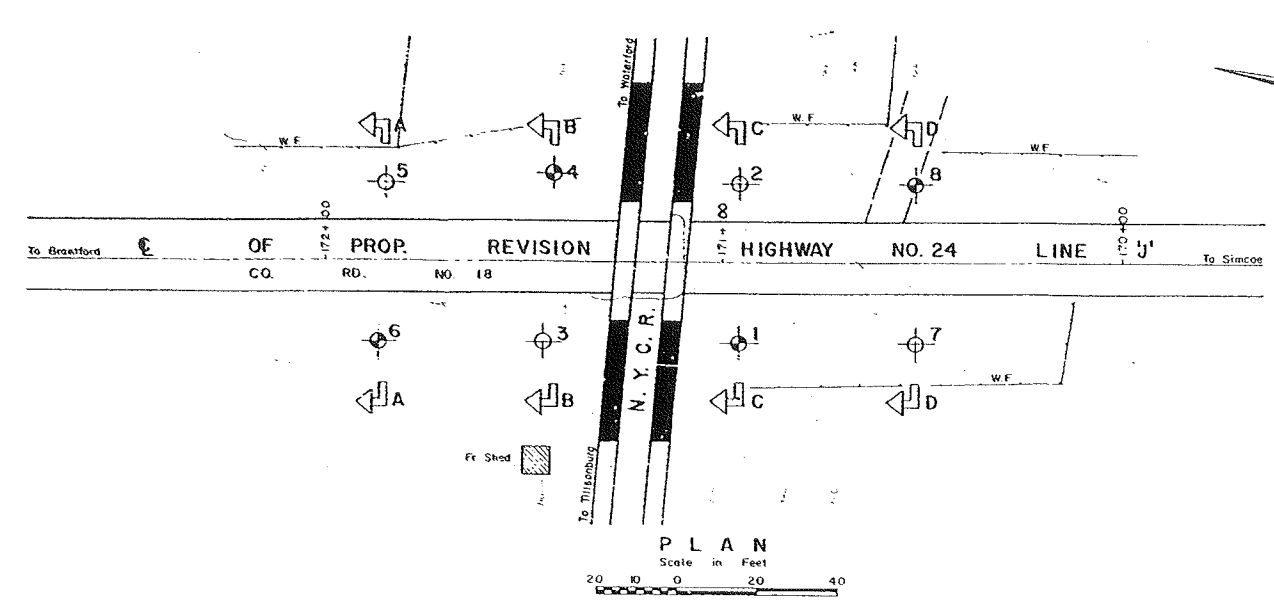


Photo No. 3: C.N.R. Bridge looking north along Highway 24



Photo No. 4: C.N.R. Bridge looking south along Highway 24

V:\01224\Active\Other_Pc_Projects\165000787\Reports\CNR Structure\Site Photo Pages.Doc



LEGEND

- Bore Hole
- Cone Penetration Hole
- Bore & Cone Penetration Hole
- Water Levels established at time of field investigation (April 1963)

NO.	ELEVATION	STATION	OFFSET
1	786.0	170+95	20' LT
2	786.5	170+96	20' RT
3	788.0	171+45	21' LT
4	787.0	171+42	22' RT
5	787.5	171+85	20' RT
6	786.5	171+87	20' LT
7	785.0	170+52	20' LT
8	786.5	170+52	20' RT

NOTE
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

REVISIONS

NO.	DATE	BY	DESCRIPTION

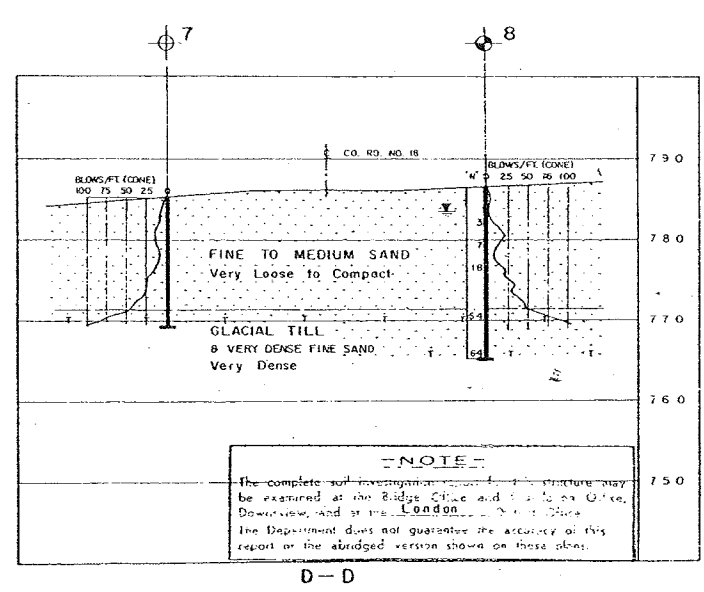
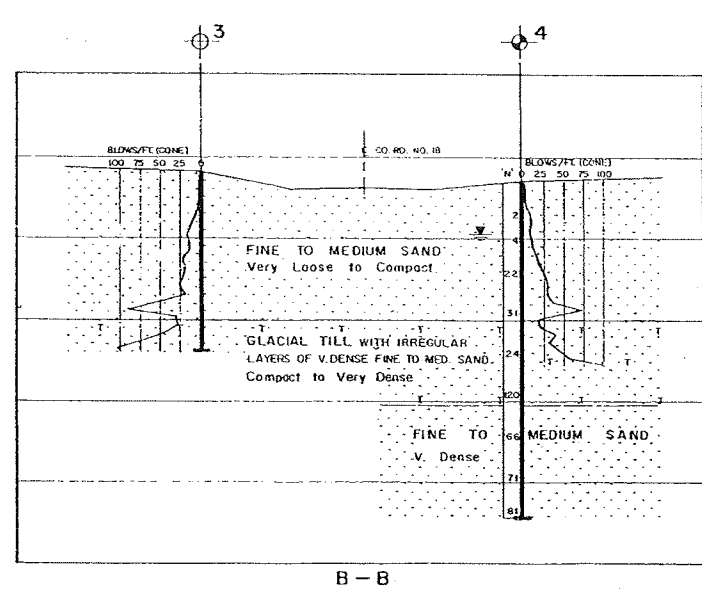
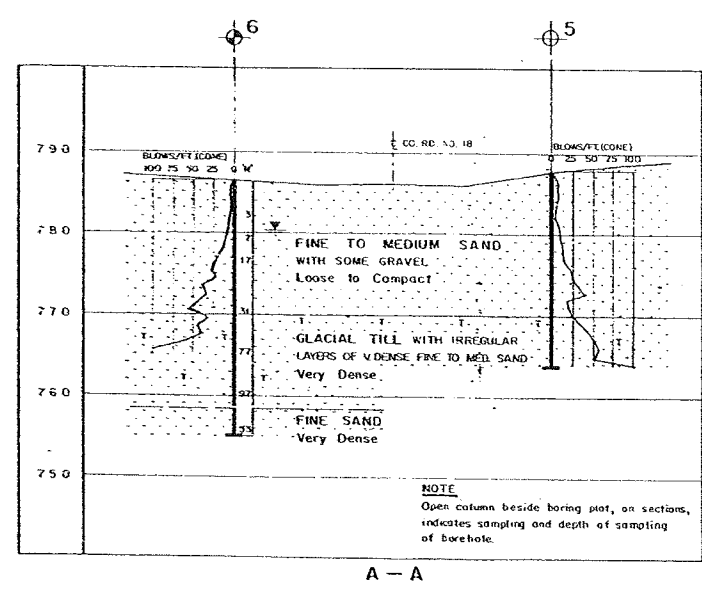
DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION - FOUNDATION SECTION

NEW YORK CENTRAL RAILWAY

KING'S HIGHWAY NO. 24 PROP. REV. LINE 'J' DIST. NO. 2
CO. NORFOLK
TWP. WINDHAM & TOWNSEND LOT 1 CON. VIII

BORE HOLE LOCATIONS & SOIL STRATA

SUB'D T.W.	CHECKED	W.P. NO.	34-62	M.B.R. DRAWING NO.
DRAWN D.M.	CHECKED	JOB NO.	63-F-40	63-F-40 A
DATE	31 MAY 1963	SITE NO.		BRIDGE DRAWING NO.
APPROVED				



SECTIONS
Scale in Feet
10 0 10 20

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.

Boulders Cobbles Gravel	Sand	Silt	Clay	Organics	Asphalt	Concrete	Fill	Igneous Bedrock	Meta- morphic Bedrock	Sedi- mentary Bedrock

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

measured in standpipe, piezometer, or well

inferred

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 BH 11-1

1 OF 2

METRIC

W.P. 362-98-00 LOCATION CNR Structure, Hwy 24, Simcoe, ON N: 4 754 286 E: 236 483 ORIGINATED BY DS
 DIST HWY 24 BOREHOLE TYPE Hollow Stem Augers, Splitspoon Sampler COMPILED BY JF
 DATUM Geodetic DATE 2011 07 13 - 2011 07 13 CHECKED BY CM

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	WATER CONTENT (%)
247.8	Asphalt						20	40	60	80	100						
0.0 247.8	200 mm ASPHALT																
0.2 247.3	FILL: Sand with gravel, brown		1	SS	30												
0.5	FILL: Poorly graded sand with silt (SP-SM) to Silty Sand (SM)																
	Compact to dense																
	Brown		2	SS	18												
			3	SS	15									11 79 (10)			
			4	SS	14												
			5	SS	11												
			6	SS	10												
			7	SS	25									0 87 (13)			
			8	SS	31												
			9	SS	30												
			10	SS	17												
			11	SS	30												
239.6 239.5 8.3	80 mm ASPHALT																
	Well-graded SAND with SILT (SW-SM)																
	Compact		12	SS	21									1 87 (12)			
	Brown, moist																
			13	SS	16												
			14	SS	23												

Continued Next Page

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

RECORD OF BOREHOLE No BH 11-1

2 OF 2

METRIC

W.P. 362-98-00 LOCATION CNR Structure, Hwy 24, Simcoe, ON N: 4 754 286 E: 236 483 ORIGINATED BY DS
 DIST HWY 24 BOREHOLE TYPE Hollow Stem Augers, Splitspoon Sampler COMPILED BY JF
 DATUM Geodetic DATE 2011 07 13 - 2011 07 13 CHECKED BY CM

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	×	LAB VANE								
								● QUICK TRIAXIAL	×	LAB VANE										
							20	40	60	80	100									
								20	40	60	80	100								
												</								





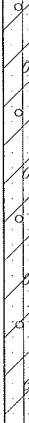
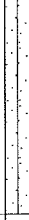
ONTARIO MTO STANTEC 165000787 - HWY 24 SIMCOE GPJ ONTARIO MOT GDT 30/3/12

RECORD OF BOREHOLE No BH 11-2

1 OF 1

METRIC

W.P. 362-98-00 LOCATION CNR Structure, Hwy 24, Simcoe, ON N: 4 754 251 E: 236 481 ORIGINATED BY DS
DIST HWY 24 BOREHOLE TYPE Hollow Stem Augers, Spitspoon Sampler COMPILED BY JF
DATUM Geodetic DATE 2011 07 18 - 2011 07 18 CHECKED BY CM

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/m³	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											
							20 40 60 80 100					WATER CONTENT (%)							
239.1	Topsoil																		
0.0	Topsoil and sand		1	SS	8		239										0 89 (11)		
238.6																			
0.5	FILL: Gravel with sand, black, loose																		
238.2																			
0.9	Poorly graded SAND with SILT (SP-SM) to SILTY SAND (SM)		2	SS	10		238												
	Compact to very dense																		
	Brown, moist																		
				3	SS		14	237											
				4	SS		13	236											
				5	SS		14	235											
				6	SS	25	234												
				7	SS	51	233												
233.9																			
5.2	Silty Clay with sand and gravel (CL-ML), TILL					232													
	Hard		8	SS	47	231													
	Brown, wet																		
			9	SS	37	230													
			10	SS	41														
			11	SS	54														
230.9																			
8.2	SILTY SAND (SM)																		
	Very dense		12	SS	51														
	Grey																		
			13	SS	52														
229.3																			
9.8	End of Borehole																		
	Groundwater level inferred during drilling.																		













































ONTARIO MTO STANTEC 165000787 - HWY 24 SIMCOE GPJ ONTARIO MOT GDT 29/3/12

RECORD OF BOREHOLE No BH 11-3

1 OF 1

METRIC

W.P. 362-98-00 LOCATION CNR Structure, Hwy 24, Simcoe, ON N: 4 754 268 E: 236 500 ORIGINATED BY DS
DIST HWY 24 BOREHOLE TYPE Hollow Stem Augers, Spitspoon Sampler COMPILED BY JF
DATUM Geodetic DATE 2011 07 18 - 2011 07 18 CHECKED BY CM

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED	× FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	20						40	60	80
239.5	Topsoil																			
0.0 239.3	TOPSOIL																			
0.2	FILL: Sand with gravel, compact, brown, moist		1	SS	11								○							
238.9	Poorly graded SAND with SILT (SP-SM)																			
0.6	Loose to compact												○				4 87 (9)			
	Brown		2	SS	5															
																				
													○							
			3	SS	12															
																				
																				
			4	SS	20									○						
																				
														○						
			5	SS	14															
																				
														○						
			6	SS	30												15 76 (9)			
	- poorly graded SAND with SILT and gravel (SP-SM) below 4.1 m																			
234.9	Silty Clay with sand and gravel (CL-ML), TILL																			
4.6	Firm to hard												○							
	Grey, wet		7	SS	8															
																				
														○						
			8	SS	8															
																				
														○						
			9	SS	17												6 22 (72)			
																				
														○						
			10	SS	61/ 150mm									○	○		23 21 47 9			
																				
																				
			11	SS	52/ 150mm									○						
																				
231.4	SILTY SAND (SM)																			
8.1	Very dense																			
	Grey, wet																			
			12	SS	65									○			0 56 (44)			
																				
																				
			13	SS	66										○					
229.7	End of Borehole																			
9.8	Groundwater level inferred during drilling																			

ONTARIO MTO STANTEC 16500787 - HWY 24 SIMCOE GPJ ONTARIO MOT GDT 29/3/12

RECORD OF BOREHOLE No BH 11-4

1 OF 2

METRIC

W.P. 362-98-00 LOCATION CNR Structure, Hwy 24, Simcoe, ON N: 4 754 254 E: 236 502 ORIGINATED BY DS
 DIST HWY 24 BOREHOLE TYPE Hollow Stem Augers, Splitspoon Sampler COMPILED BY JF
 DATUM Geodetic DATE 2011 07 19 - 2011 07 19 CHECKED BY CM

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
239.5	Topsoil						20	40	60	80	100							
0.0	TOPSOIL																	
239.2			1	SS	7													
0.3	SILTY SAND (SM)																	
	Loose to compact		2	SS	8													
	Brown, moist to wet																	
			3	SS	14													
			4	SS	11													
			5	SS	10													
			6	SS	21													
235.2																		
4.3	Silty Clay with sand and gravel (CL-ML), TILL																	
	Very stiff to hard		7	SS	16													
	Brown to grey, wet		8	SS	45													
			9	SS	36													
			10	SS	54													
			11	SS	50/ 130mm													
231.1																		
8.4	SILTY SAND (SM)		12	SS	57													
	Dense to very dense																	
	Grey, wet		13	SS	47													
			14	SS	59													

Continued Next Page

× 3, × 3

Numbers refer to
Sensitivity

○ 3%

STRAIN AT FAILURE

RECORD OF BOREHOLE No BH 11-5

1 OF 2

METRIC

W.P. 362-98-00 LOCATION CNR Structure, Hwy 24, Simcoe, ON N: 4 754 262 E: 236 480 ORIGINATED BY DS
 DIST HWY 24 BOREHOLE TYPE Hollow Stem Augers, Splitspoon Sampler COMPILED BY JF
 DATUM Geodetic DATE 2011 07 14 - 2011 07 14 CHECKED BY CM

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
239.5	Crushed stone							20 40 60 80 100	20 40 60 80 100	10 20 30				
0.0	FILL: Sand with gravel, black, moist		1	BS			239							
238.7	FILL: silty sand, black, moist		2	BS			238							
237.5			3	SS	17									
2.0	SILTY SAND (SM) Compact to dense Brown, moist to wet		4	SS	22		237							0 87 (13)
			5	SS	14		236							
			6	SS	39		235							
234.6			7	SS	26		234							
4.9	Silty Clay with sand and gravel (CL-ML), TILL Very stiff to hard Grey, moist to wet		8	SS	43		233							15 27 46 12
			9	SS	48		232							
			10	SS	60		231							
			11	SS	106		230							
231.3	SILTY SAND (SM) Compact to very dense Grey, wet to very wet		12	SS	67									
8.2			13	SS	37									0 73 (27)
			14	SS	55									

ONTARIO MTO STANTEC 165000787 - HWY 24 SIMCOE GPJ ONTARIO MOT GDT 29/3/12

Continued Next Page

× 3 × 3 Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH 11-6

1 OF 1

METRIC

W.P. 362-98-00 LOCATION CNR Structure, Hwy 24, Simcoe, ON N: 4 754 267 E: 236 518 ORIGINATED BY DS
 DIST HWY 24 BOREHOLE TYPE Hollow Stem Augers, Splitspoon Sampler COMPILED BY JF
 DATUM Geodetic DATE 2011 07 18 - 2011 07 18 CHECKED BY CM

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
239.3 0.0	Crushed stone FILL: Sand with gravel, black		1	BS			239							
238.7 0.6	SILTY SAND (SM) Compact Dark brown		2	BS			238							
			3	SS	24		237							
			4	SS	21		236							1 81 (18)
			5	SS	11		235							
235.6 3.7	Silty Clay with sand (CL-ML), TILL -trace gravel Firm to very stiff Grey, wet		6	SS	6		234							
			7	SS	10		233							
			8	SS	13		232							2 6 67 25 S _{upp} = 125 kPa
			9	SS	10		231							3 24 60 13 S _{upp} = 88 kPa
232.6 6.7	SILTY SAND (SM) Very dense Grey, wet		10	SS	55		230							
			11	SS	71									
			12	SS	70									
			13	SS	76									2 53 (45)
229.5 9.8	End of Borehole Groundwater measured in monitoring well on 2011/08/04 S _{upp} = Undrained shear strength from Pocket Penetrometer													

ONTARIO MTO STANTEC 165000787 - HWY 24 SIMCOE GPJ ONTARIO MOT GDT 29/3/12

RECORD OF BOREHOLE No BH 11-7

1 OF 1

METRIC

W.P. 362-98-00 LOCATION CNR Structure, Hwy 24, Simcoe, ON N: 4 754 252 E: 236 466 ORIGINATED BY DS
 DIST HWY 24 BOREHOLE TYPE Hollow Stem Augers, Splitspoon Sampler COMPILED BY JF
 DATUM Geodetic DATE 2011 07 15 - 2011 07 15 CHECKED BY CM

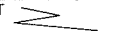
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%) w _p w w _L				
								○ UNCONFINED	× FIELD VANE	● QUICK TRIAXIAL	× LAB VANE								
239.4 0.0	Crushed stone FILL: Sand with gravel, brown		1	BS			239												
			2	BS															
238.2 1.2	SAND with SILT (SP-SM) to SILTY SAND (SM) Loose to dense Brown, moist to wet		3	SS	26			238											
			4	SS	20			237											
			5	SS	5			236											
			6	SS	26			235											
			7	SS	34			234											
233.8 5.6	Silty Clay with sand and gravel (CL-ML), TILL Hard Grey, wet			8	SS		44		233										
				9	SS		54		232										
		10		SS	73			231											
		11	SS	100/ 130mm			230												
231.2 8.2	SILTY SAND (SM) Compact to very dense Grey, wet		12	SS	21														
			13	SS	65														
229.6 9.8	End of Borehole Groundwater level inferred during drilling.																		

RECORD OF BOREHOLE No BH 11-8

1 OF 2

METRIC

W.P. 362-98-00 LOCATION CNR Structure, Hwy 24, Simcoe, ON N: 4 754 234 E: 236 500 ORIGINATED BY DS
 DIST HWY 24 BOREHOLE TYPE Hollow Stem Augers, Splitspoon Sampler COMPILED BY JF
 DATUM Geodetic DATE 2011 07 12 - 2011 07 12 CHECKED BY CM

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									
																	
248.3	Asphalt																
248.0	200 mm ASPHALT																
248.0	FILL: Sand with gravel, brown		1	SS	45		248										
247.8	FILL: Poorly graded sand with silt (SP-SM)																
247.8	Compact to very dense																
	Brown, moist		2	SS	14		247										
			3	SS	17									7 83 (10)			
			4	SS	10		246										
			5	SS	15		245										
			6	SS	28		244										
			7	SS	30		243							0 89 (11)			
			8	SS	32												
			9	SS	51		242										
			10	SS	56		241										
			11	SS	46		240										
239.8	80 mm ASPHALT						239							0 89 (11)			
239.8	FILL: Sand with gravel, brown		12	SS	59												
239.8	Poorly graded SAND with SILT (SP-SM) to SILTY SAND (SM)																
239.8	Compact to very dense																
239.8	Brown		13	SS	18												
			14	SS	25		238										

Continued Next Page

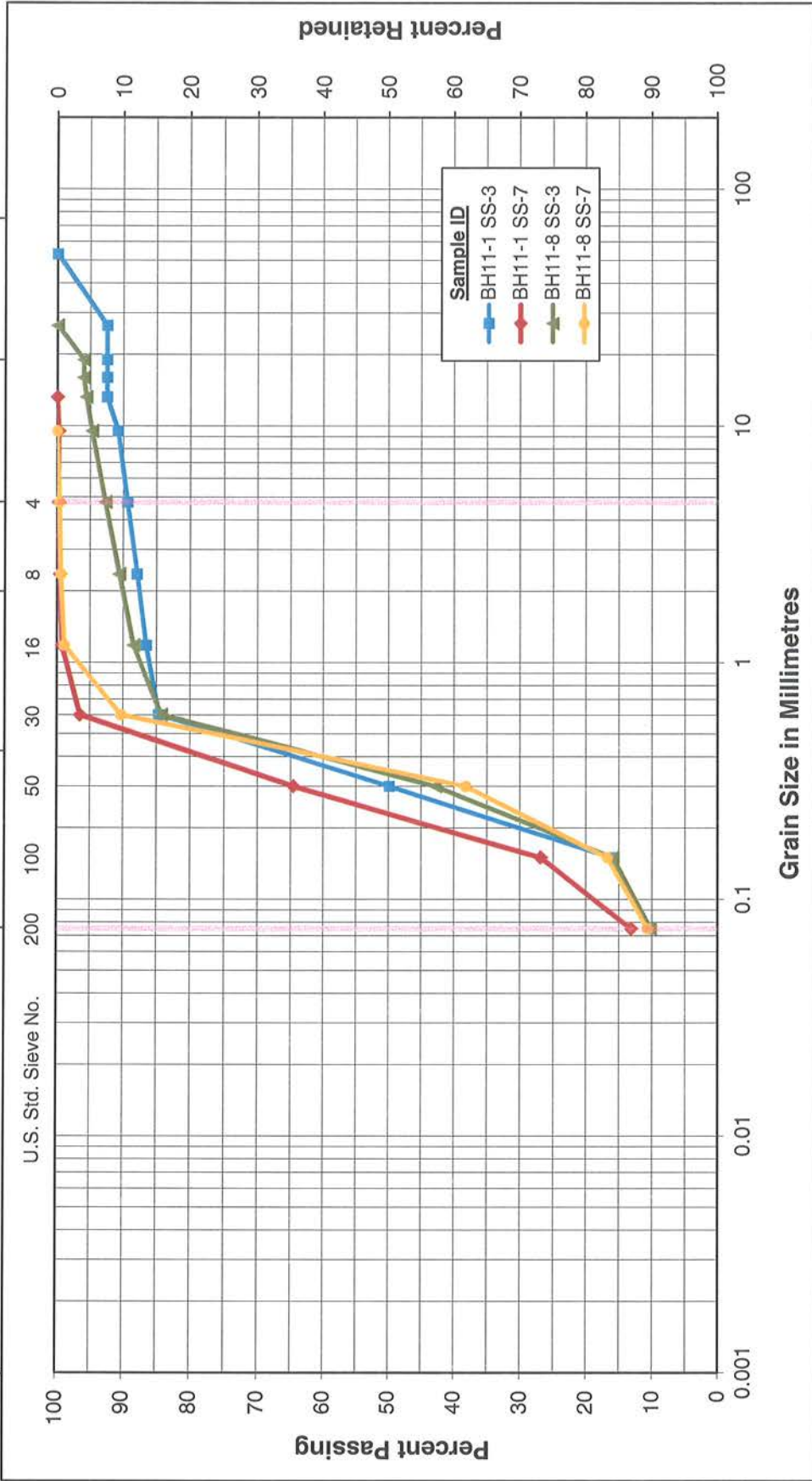
Numbers refer to Sensitivity $\times 3, \times 3$ \circ 3% STRAIN AT FAILURE

APPENDIX C

Figures 1 through 5 - Laboratory Test Results

Unified Soil Classification System

CLAY & SILT	SAND				Gravel	
	Fine	Medium	Coarse		Fine	Coarse



Unified Soil Classification System

CLAY & SILT	SAND				Gravel	
	Fine	Medium	Coarse	Fine	Coarse	

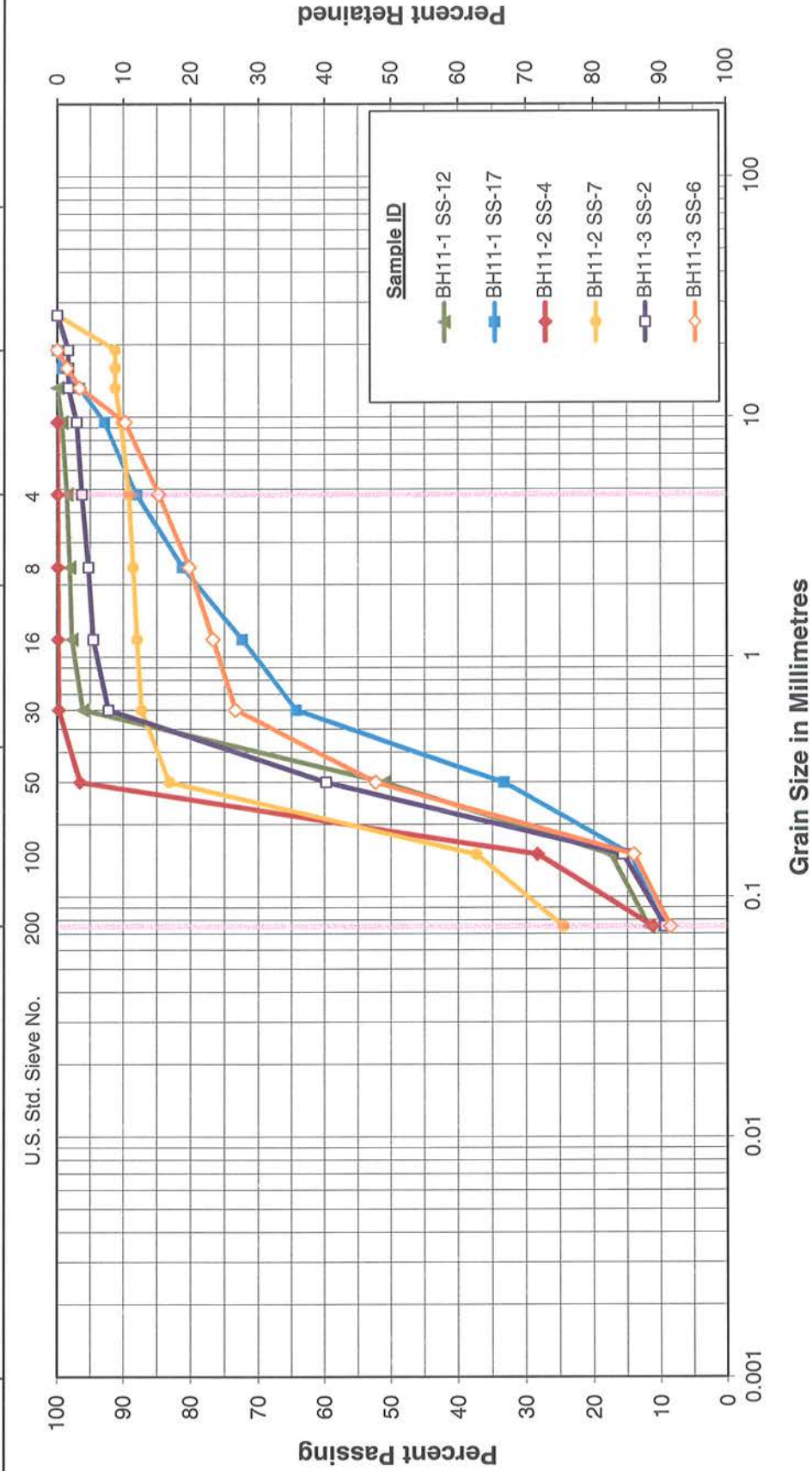


Figure No. 2a

GRAIN SIZE DISTRIBUTION
Silty Sand (SM) to Sand with Silt (SW-SM/SP-SM)

Project No. 165000787
GWP No. 362-98-00



Stantec

Unified Soil Classification System

CLAY & SILT	SAND			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

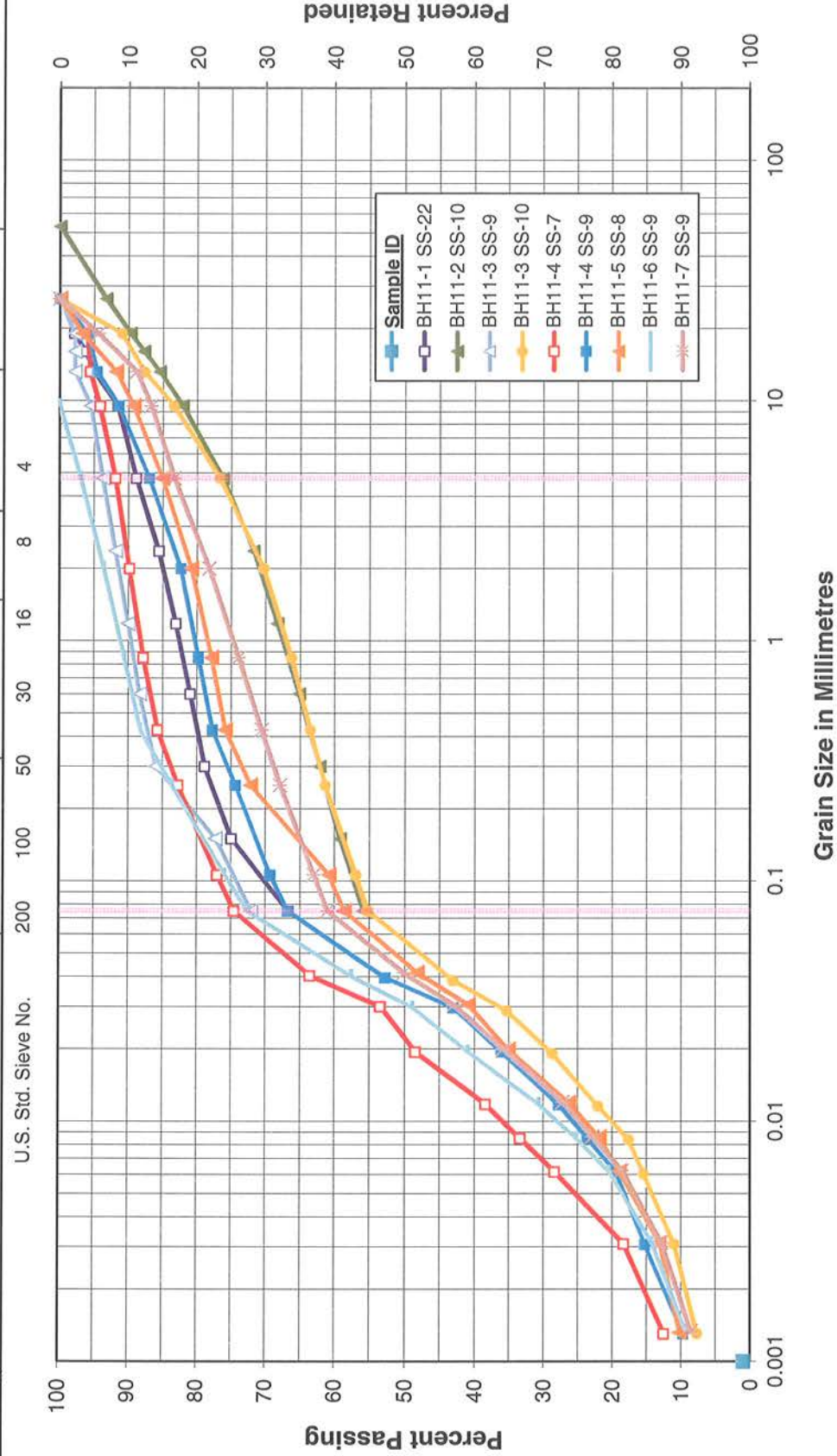


Figure No. 3a

GRAIN SIZE DISTRIBUTION

Silty Clay with Various Amounts of Sand and Gravel (CL-ML),
TILL

Project No. 165000787

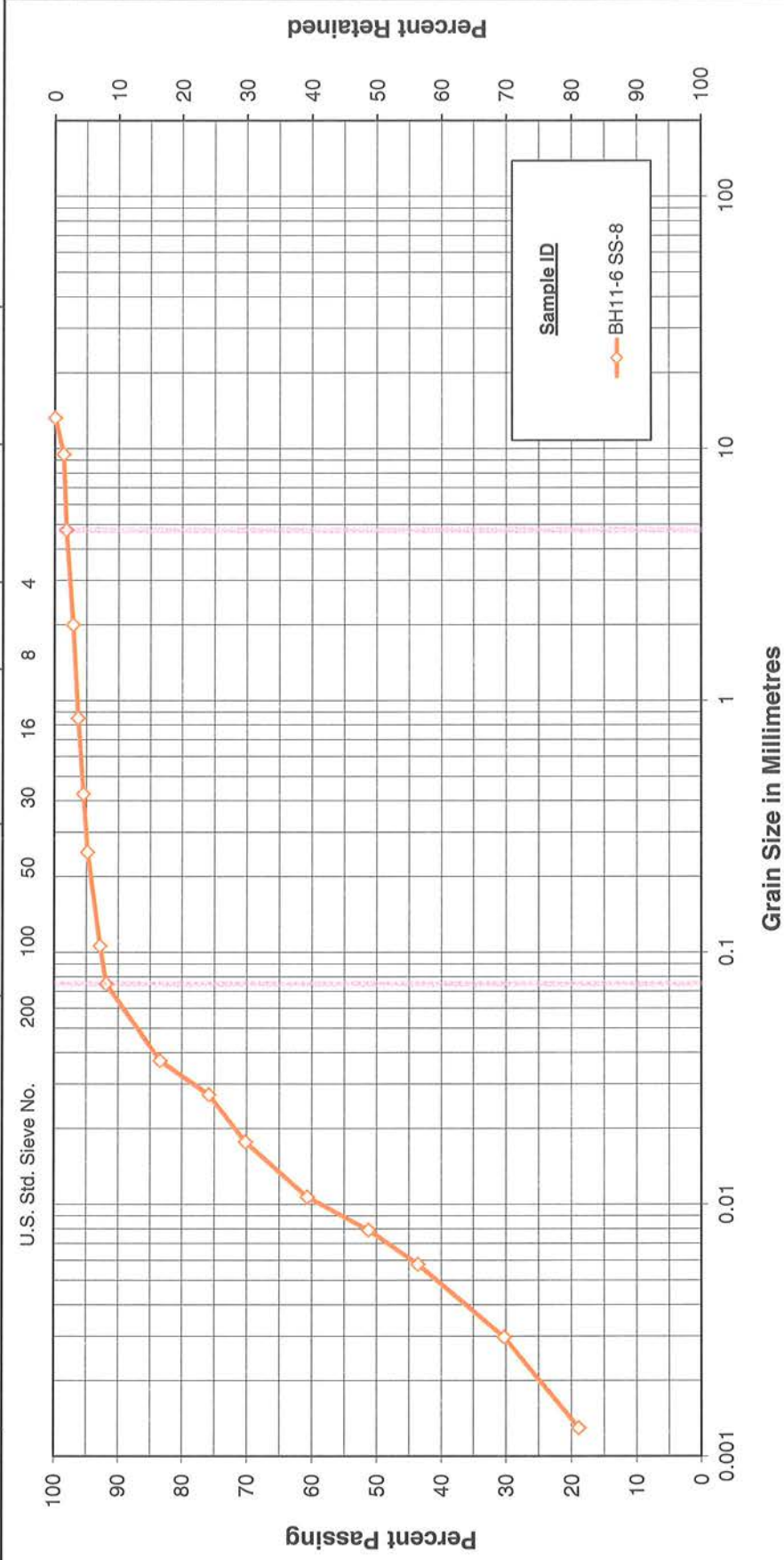
GWP No. 362-98-00



Stantec

Unified Soil Classification System

CLAY & SILT		SAND				GRAVEL	
		Fine	Medium	Coarse	Fine	Coarse	



GRAIN SIZE DISTRIBUTION

Silty Clay with Sand (CL-ML) , TILL

Figure No. 3b

Project No. 165000787

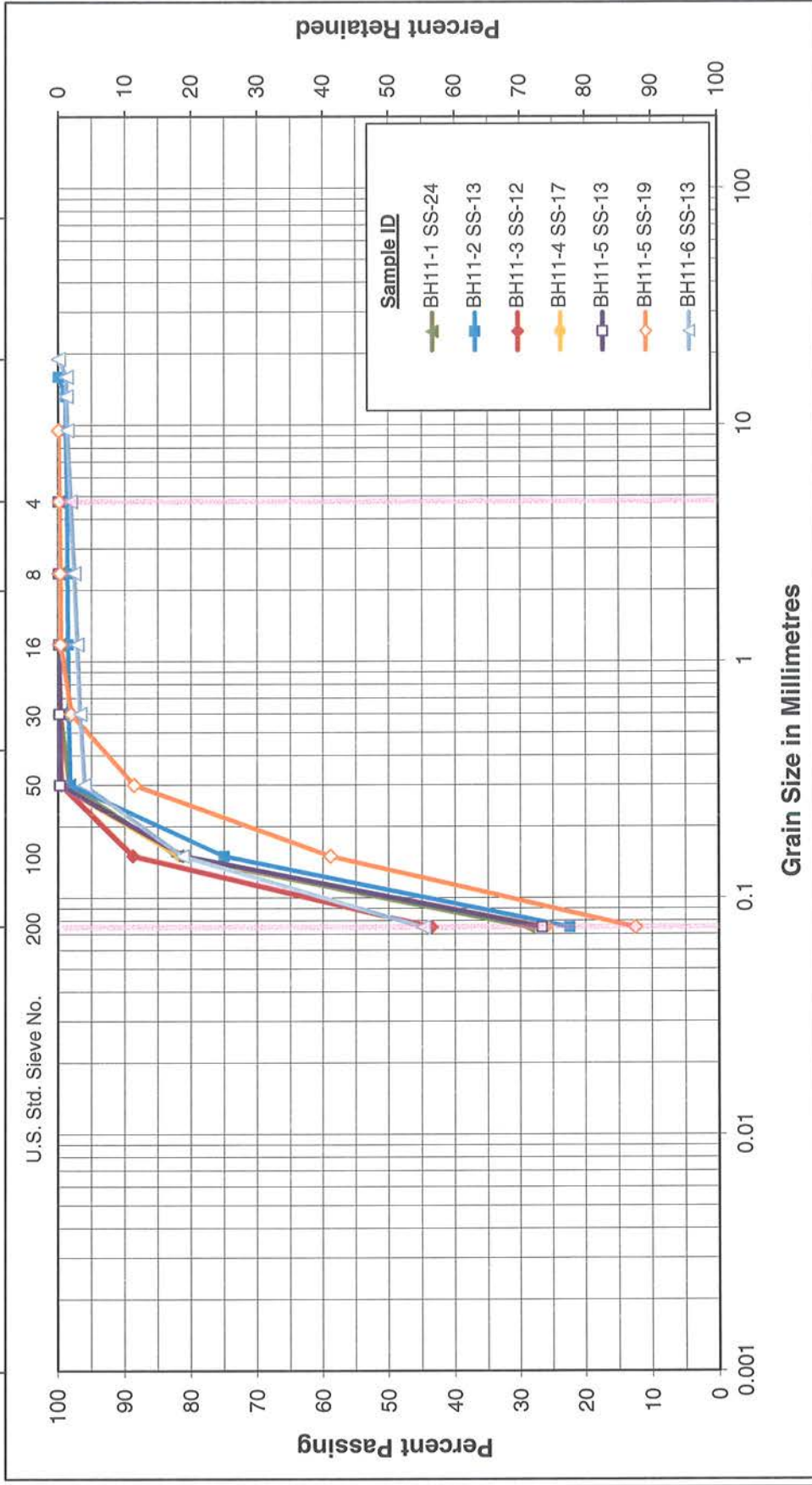
GWP No. 362-98-00



Stantec

Unified Soil Classification System

CLAY & SILT		SAND			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



GRAIN SIZE DISTRIBUTION

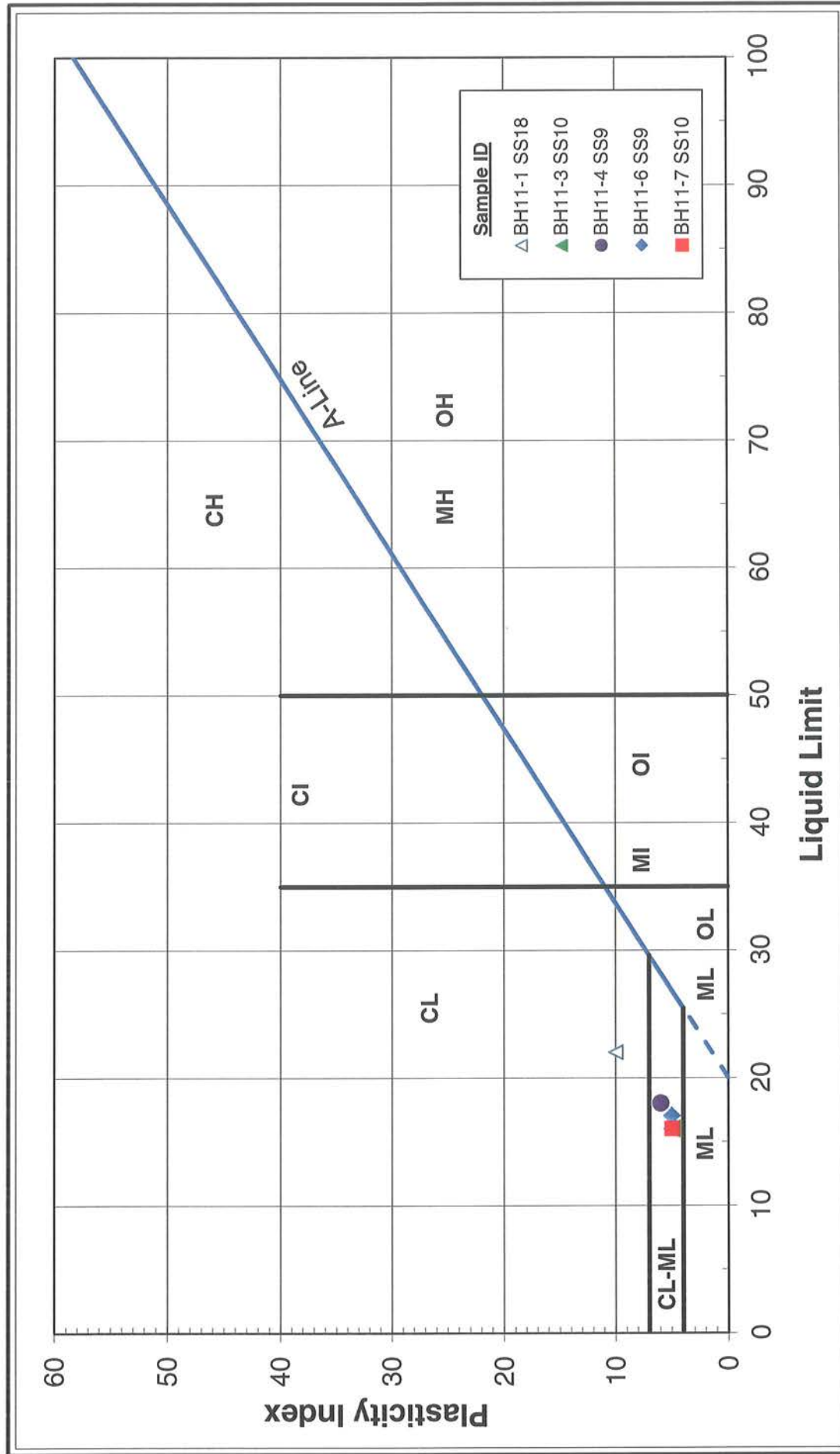
Silty Sand (SM)

Figure No. 4

Project No. 165000787
GWP No. 362-98-00



Stantec





Stantec

PLASTICITY CHART

Figure No. 5

Project No. 165000787

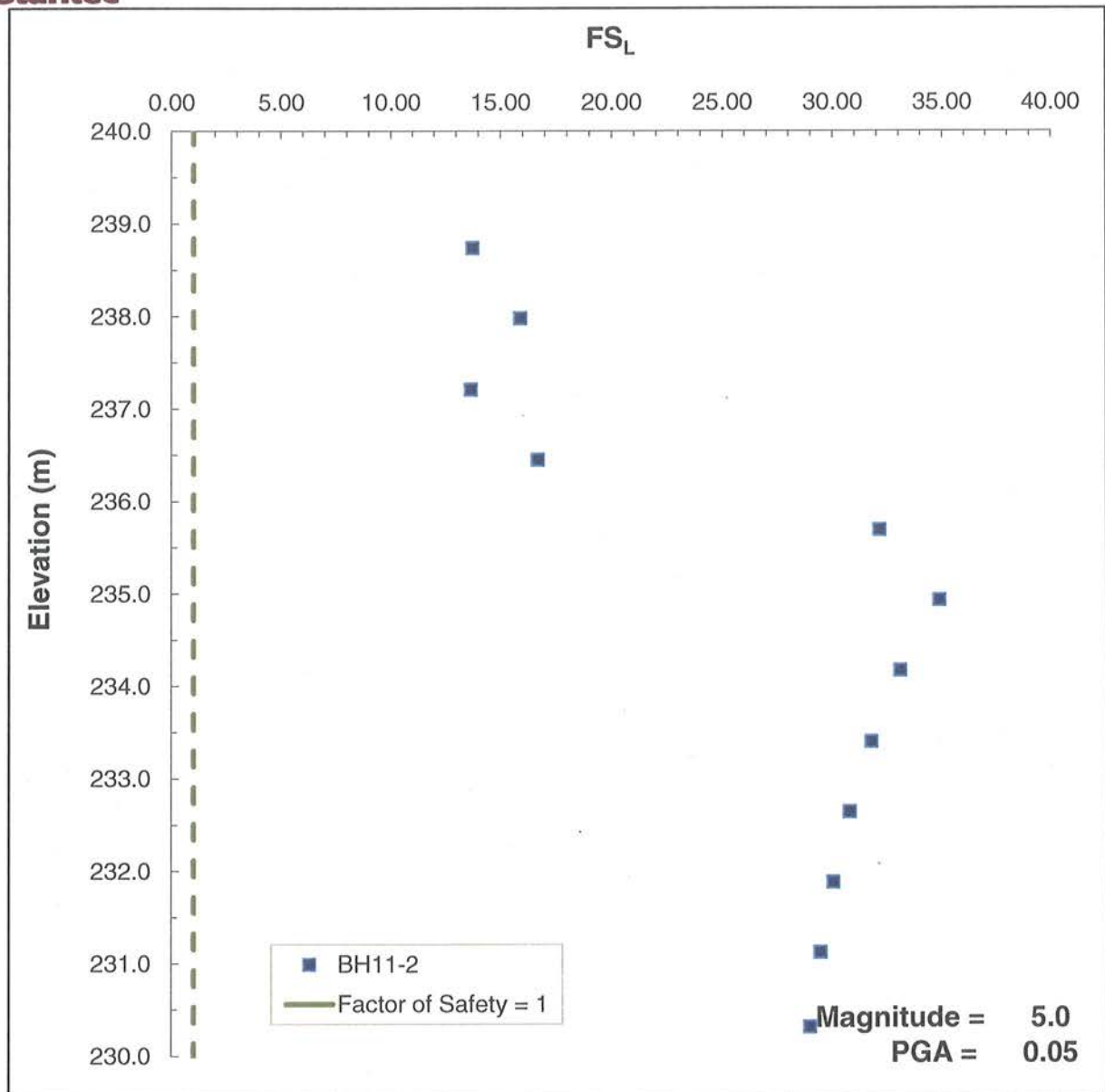
GWP No. 362-98-00

APPENDIX D

Characterization of Liquefaction Resistance

Figures 6a through 6c - Typical Slope Stability Evaluation Results (Slope/W)

Figures 7a & 7b - Typical Settlement Evaluation Results (Settle3D)



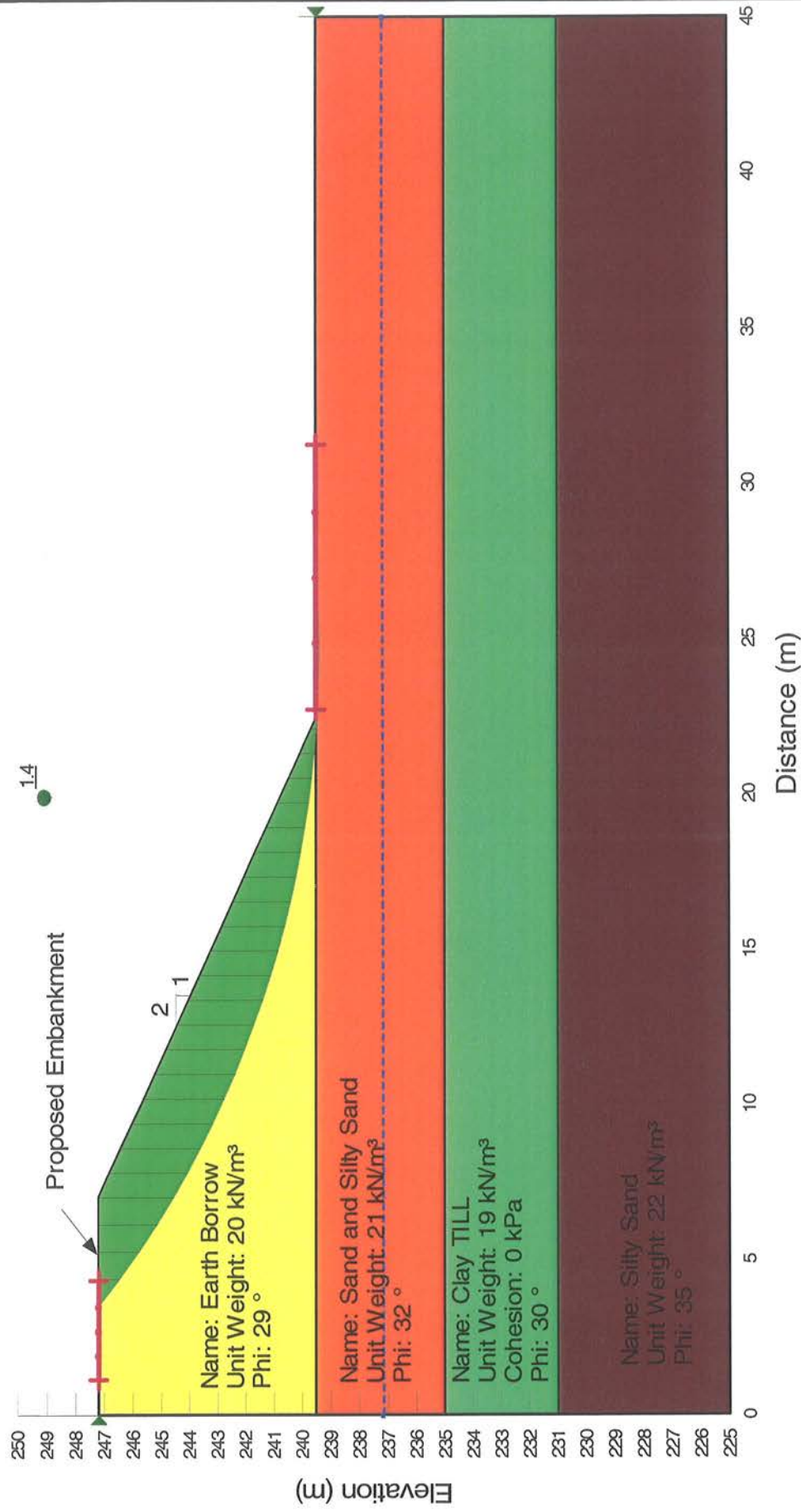
FS_L = Factor of Safety against Liquefaction

The Canadian Foundation Engineering Manual defines FS_L as the "soil deposit's cyclic resistance ratio (CRR)" divided by the "earthquake induced cyclic stress ratio (CSR)"

Assessment Method based on the Summary Report from the 1996 and 1998
NCEER/NSF Workshop on Evaluation of Liquefaction Resistance of Soils

Project No.

165000787



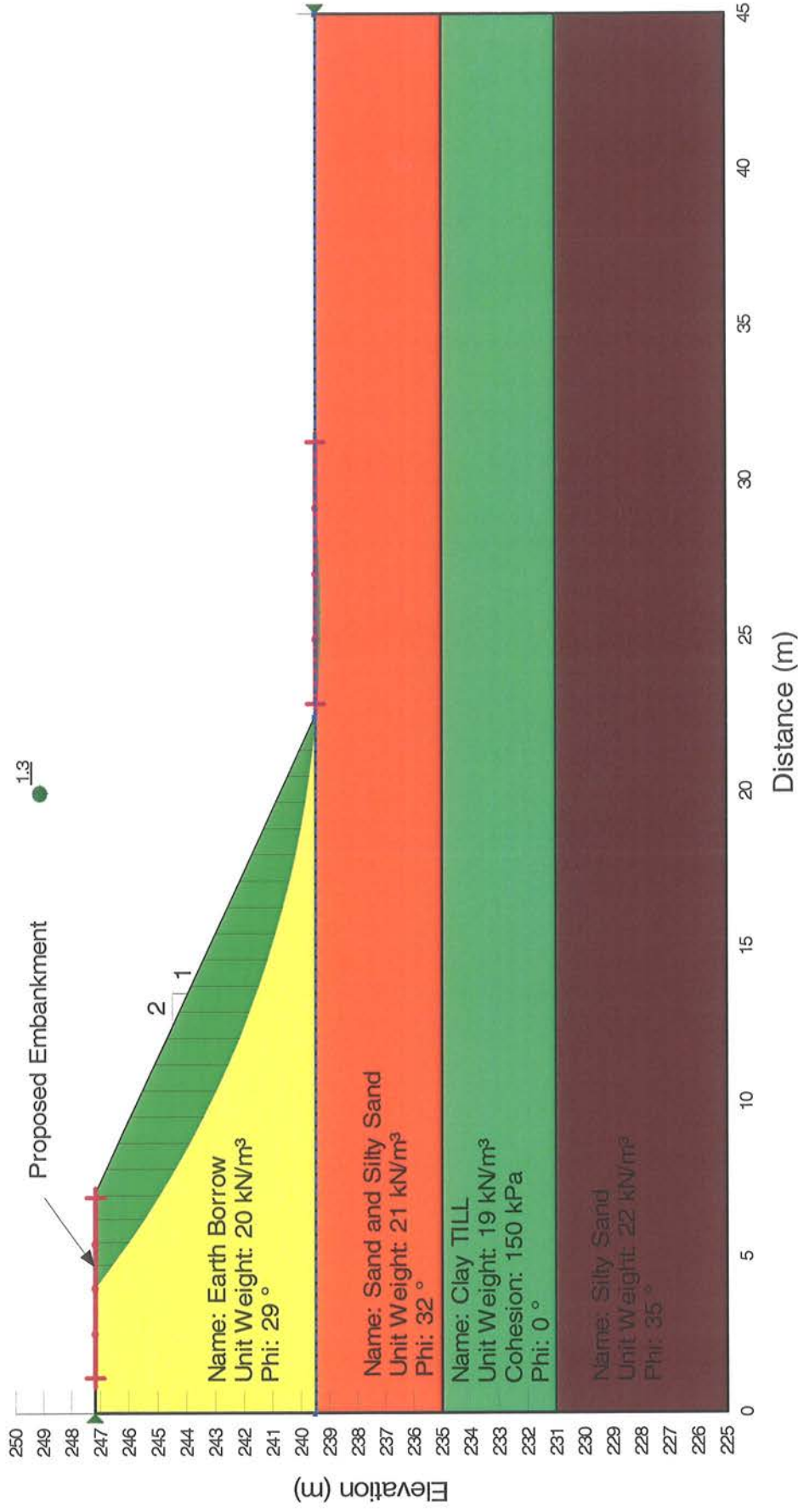
Stantec

Long-Term Static Slope Stability Analysis

C.N.R. Structure Removal
Highway 24 - Earth Borrow

Figure 6a

Project No. 165000787



Short-Term Static Slope Stability Analysis

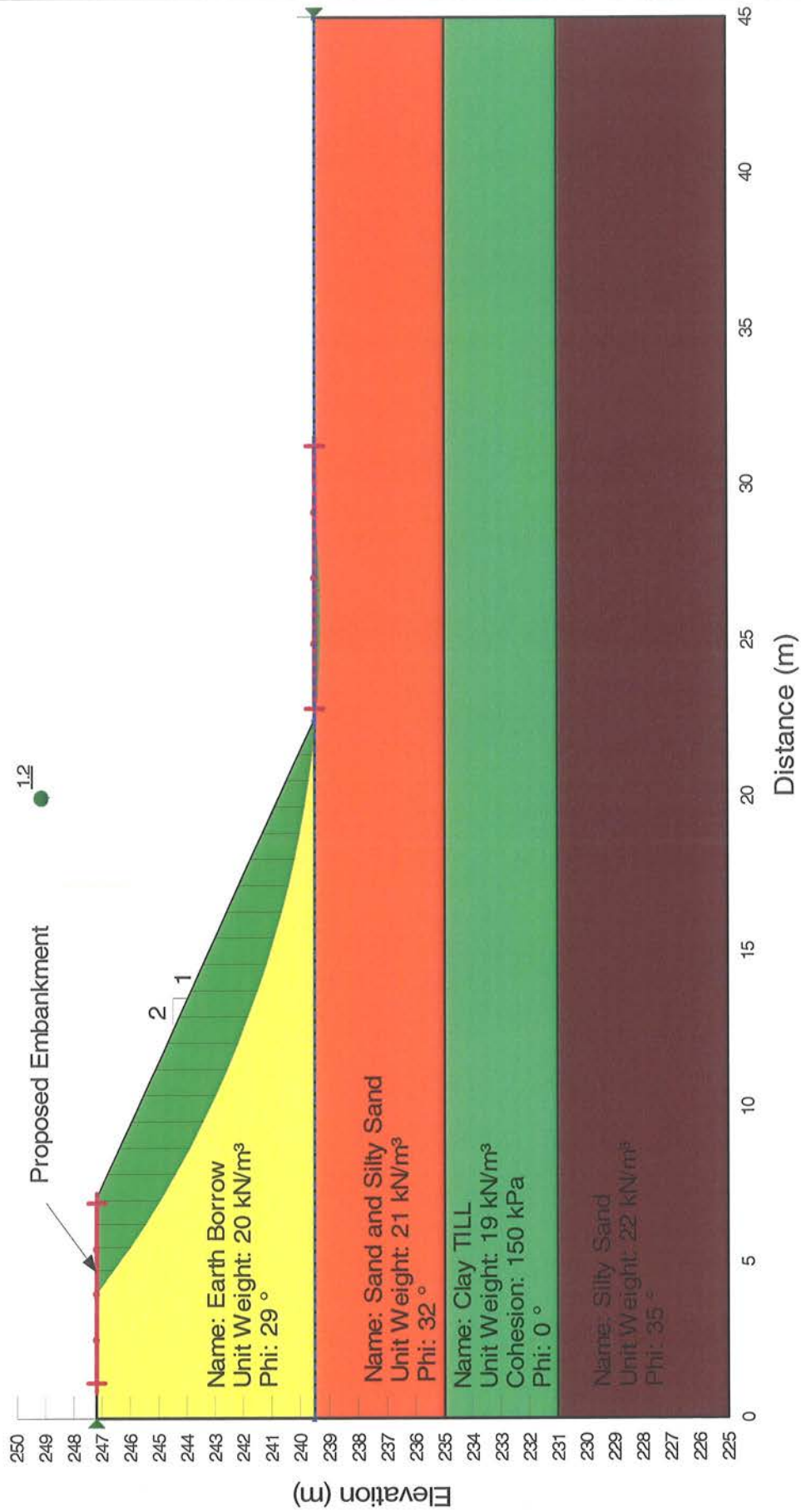
C.N.R. Structure Removal
Highway 24 - Earth Borrow

Figure 6b

Project No. 165000787



Stantec



Stantec

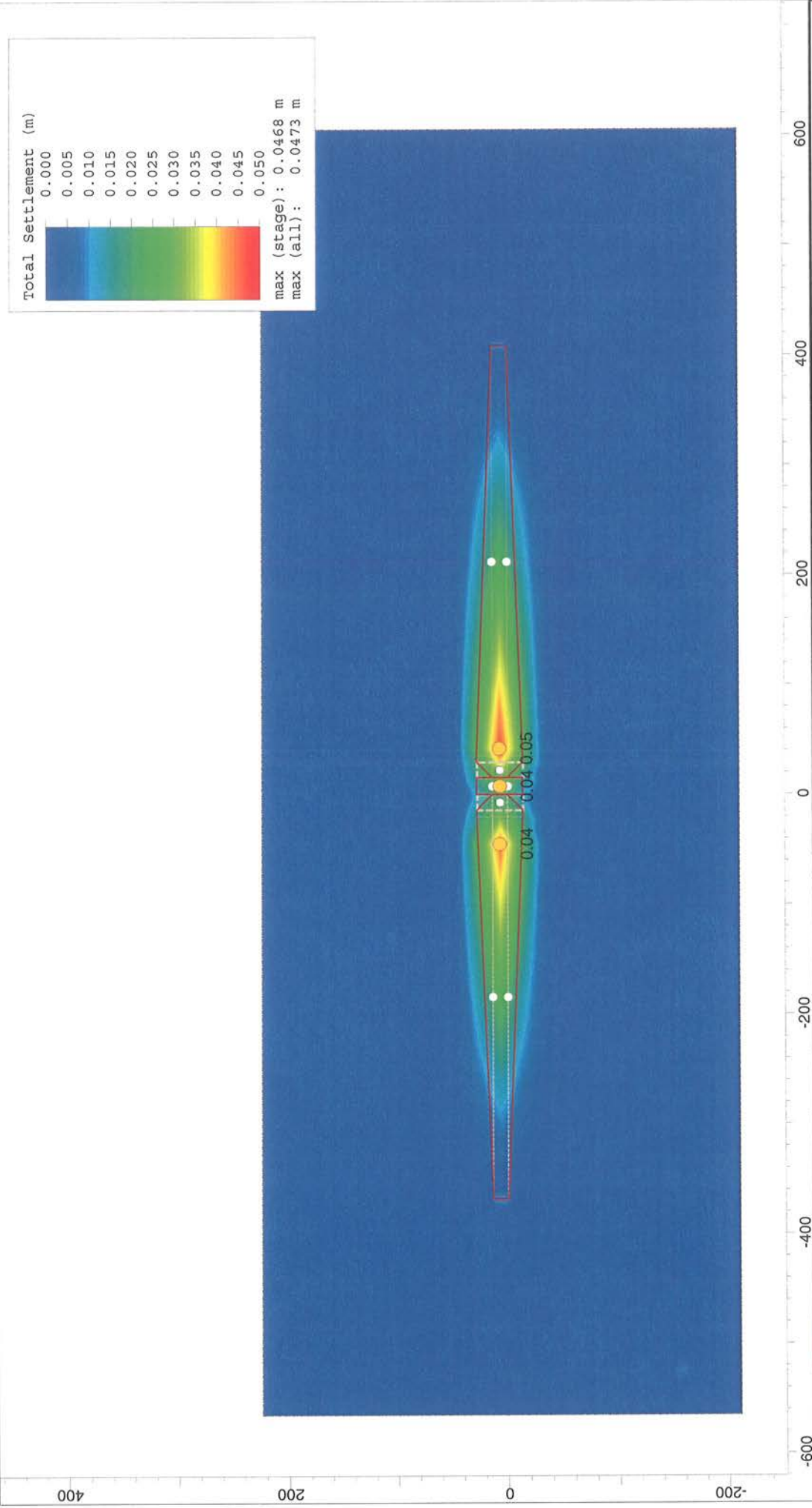
Short-Term Seismic Slope Stability Analysis

C.N.R. Structure Removal
Highway 24 - Earth Borrow

Figure 6c

Project No. 165000787

Figure 7a - Settlement Caused by Existing Hwy 24 Embankment




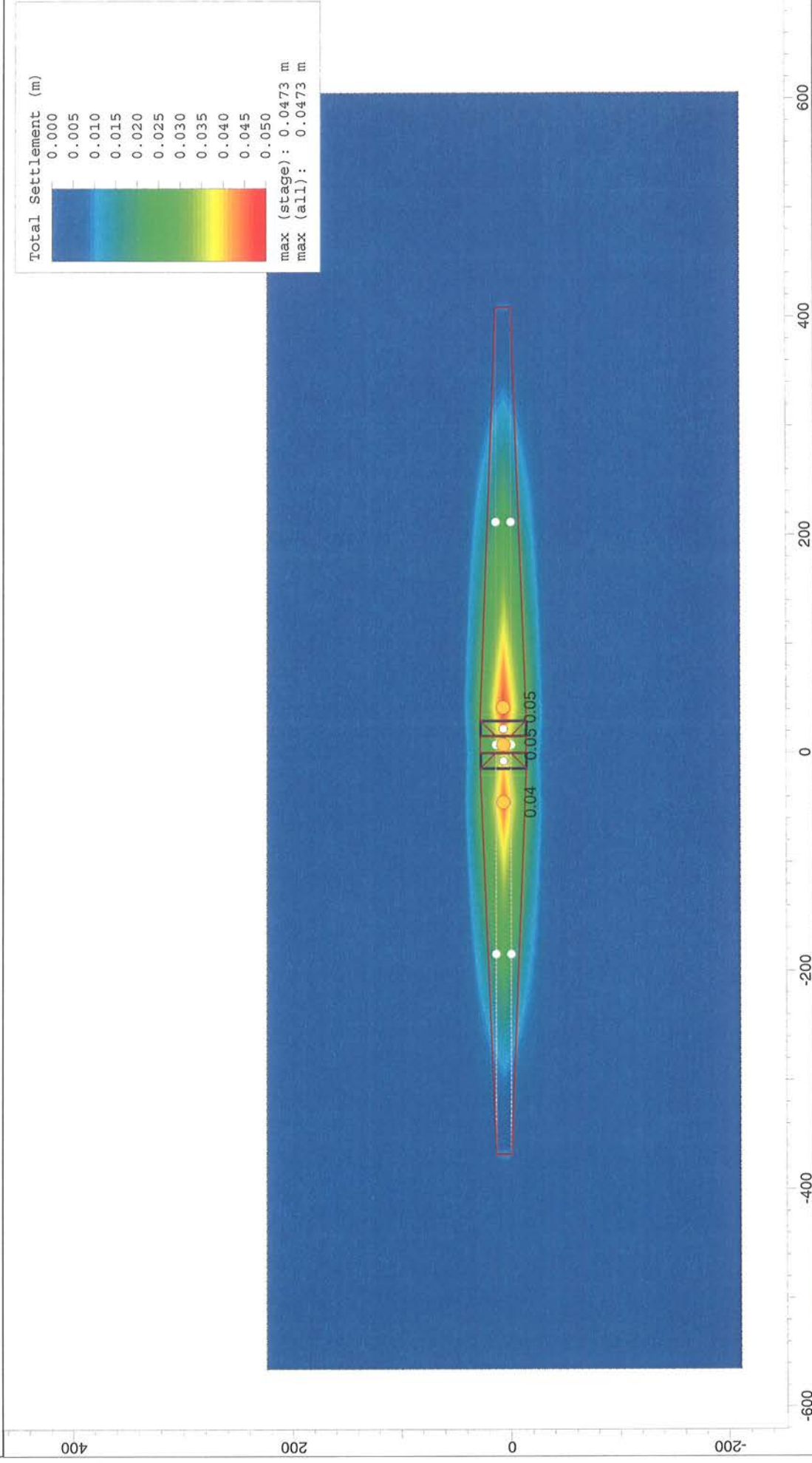

 Stantec	Project	CNR Structure Removal and Hwy 24 Reconstruction	
	Analysis Description	Settlement Caused by Existing Hwy 24 Embankment	
	Drawn By	SG	Company Stantec
	Date	1/26/2012, 3:34:44 PM	File Name Fill_Orig-Hwy24_Emb-NewFill.s3z

Figure 7b - Settlement Caused by Existing Hwy 24 Embankment and Fill in the Area of CNR Bridge



 Stantec	<i>Project</i>	CNR Structure Removal and Hwy 24 Reconstruction		
	<i>Analysis Description</i>	Settlement Caused by Existing Hwy 24 Embankment and Fill in the Area of CNR Bridge		
	<i>Drawn By</i>	SG	<i>Company</i>	Stantec
	<i>Date</i>	1/26/2012, 3:34:44 PM	<i>File Name</i>	Fill_Orig-Hwy24_Emb-NewFill.s3z

SETTLED 2.011