



January 2011

FOUNDATION INVESTIGATION AND DESIGN REPORT

**Canadian National Railway Overhead (Site No. 33-225)
Widening of Highway 7/8
From 1.9 Km West of Fischer-Hallman Road Interchange
Easterly to 0.8 Km East of Courtland Avenue Interchange
Kitchener
GWP 131-98-00, Purchase Order #3007-E-0024
Ministry of Transportation, Ontario - West Region**

Submitted to:

Mr. Jeff Matthews, P.Eng., Partner
Dillon Consulting Limited
1400-130 Dufferin Avenue
London, Ontario
N6A 5R2

REPORT



**A world of
capabilities
delivered locally**

Report Number: 08-1132-084-1-R05

Geocres No. 40P8-175

Distribution:

9 Copies - Dillon Consulting Limited

2 Copies - Golder Associates Ltd.





Table of Contents

PART A - FOUNDATION INVESTIGATION REPORT

1.0 INTRODUCTION	1
2.0 SITE DESCRIPTION	2
2.1 Site Geology.....	2
3.0 INVESTIGATION PROCEDURES.....	3
4.0 SUBSURFACE CONDITIONS.....	4
4.1 Site Stratigraphy	4
4.2 Soil Conditions.....	4
4.2.1 Pavement Structure.....	4
4.2.2 Topsoil and Fill	5
4.2.3 Silt	5
4.2.4 Clayey Silt.....	6
4.2.5 Sand	6
4.2.6 Sandy Silt.....	6
4.2.7 Silty Sand and Silty Fine Sand	7
4.2.8 Clayey Silt Till.....	7
4.2.9 Silty Sand and Gravel to Sand and Gravel.....	7
4.2.10 Silty Clay.....	8
4.2.11 Silty Clay Till	8
4.2.12 Sandy Silt Till	8
4.3 Groundwater Conditions.....	9
5.0 MISCELLANEOUS.....	10

PART B - FOUNDATION DESIGN REPORT

6.0 ENGINEERING RECOMMENDATIONS.....	11
6.1 General	11
6.2 Existing Structure.....	11
6.2.1 Geotechnical Resistances for Existing Foundations.....	12



FOUNDATION INVESTIGATION AND DESIGN REPORT CANADIAN NATIONAL RAILWAY OVERHEAD (SITE NO. 33-225)

6.3	Proposed Work.....	12
6.4	Foundations for Widened Bridge Sections	13
6.4.1	Geotechnical Axial Resistance – Deep Foundations	13
6.4.2	Resistance to Lateral Loads – Deep Foundations	15
6.4.3	Frost Protection.....	16
6.4.4	Monitoring of Existing Structure.....	17
6.4.5	Shallow Foundations	17
6.5	Liquefaction Potential and Seismic Analysis.....	17
6.5.1	Seismic Parameters	17
6.5.2	Seismic Hazard Assessment.....	18
6.6	Lateral Earth Pressures	18
6.7	Temporary Track Protection	19
6.7.1	Lateral Earth Pressures	21
6.7.2	Passive Toe Restraint.....	21
6.7.3	Other Design Considerations	22
6.7.4	Monitoring of Protection Systems.....	22
6.8	Embankments	22
6.8.1	Subgrade Preparation and Embankment Construction.....	22
6.8.2	Settlement.....	23
6.8.3	Stability	24
6.9	Excavations and Temporary Cut Slopes	24
7.0	MISCELLANEOUS.....	25

TABLE I - Comparison of Foundation Alternatives

LIST OF ABBREVIATIONS

LIST OF SYMBOLS

RECORD OF BOREHOLE SHEETS

FIGURE 1 - Key Plan

FIGURE 2 - Design Earth Pressures for Track Protection

DRAWING 1 - Borehole Locations and Soil Strata

DRAWING 2 - Soil Strata



FOUNDATION INVESTIGATION AND DESIGN REPORT CANADIAN NATIONAL RAILWAY OVERHEAD (SITE NO. 33-225)

APPENDICES

APPENDIX A

Laboratory Test Data

APPENDIX B

Site Photographs



**FOUNDATION INVESTIGATION AND DESIGN REPORT
CANADIAN NATIONAL RAILWAY OVERHEAD (SITE NO. 33-225)**

PART A

FOUNDATION INVESTIGATION REPORT

CANADIAN NATIONAL RAILWAY OVERHEAD (SITE NO. 33-225)

WIDENING OF HIGHWAY 7/8

FROM 1.9 KM WEST OF FISCHER-HALLMAN ROAD

INTERCHANGE EASTERLY TO 0.8 KM EAST OF

COURTLAND AVENUE INTERCHANGE, KITCHENER

GWP 131-98-00, PURCHASE ORDER NUMBER 3007-E-0024

MINISTRY OF TRANSPORTATION, ONTARIO - WEST REGION



1.0 INTRODUCTION

Golder Associates Ltd. (Golder Associates) has been retained by Dillon Consulting Limited (Dillon) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations as part of the detail design work for GWP 131-98-00. The project involves the detail design for the widening of Highway 7/8 (Conestoga Parkway) in Kitchener, Ontario from 1.9 kilometres west of Fisher-Hallman Road easterly 5.5 kilometres to Courtland Avenue.

This report addresses the proposed widening of the single-span overpass twin structures over the Canadian National Railway (CNR) tracks (Site 33-225) to provide an additional lane in each direction. The structures will also be rehabilitated. For the purposes of this report, the twin structures are considered to be a single structure.

The purpose of the foundation investigation is to determine the subsurface conditions at the location of the proposed structure widenings by drilling boreholes and carrying out in situ testing and laboratory testing on selected samples. The terms of reference for the scope of work are outlined in the MTO's Request for Proposal and in Golder Associates' proposal P81-3002 dated April 8, 2008 and our letters dated July 21 and 22, 2008 and February 23, 2009. The work was carried out in accordance with our Quality Control Plan for Foundation Engineering dated July 4, 2008.

Dillon provided Golder Associates with preliminary drawings for this project in digital format.



2.0 SITE DESCRIPTION

The subject site is situated in the south central area of Kitchener, Ontario. Highway 7/8 in the vicinity of the CNR overhead structure is currently a four lane divided highway with a concrete curb median within the structure area and a grassed median beyond the structure. The Highway 7/8 alignment is generally in an east-west orientation. The CNR tracks cross beneath Highway 7/8 in a north-south orientation with a skew angle of roughly 30 degrees. Schneider Creek is situated approximately 500 metres east of the CNR Overhead structure. The location of the project site is shown on the Key Plan, Figure 1.

The existing overpass consists of twin, reinforced, single-span, concrete rigid frame structures that were constructed in 1968. According to the Department of Highways Ontario (DHO) Drawing No. D-5637-1 entitled "General Arrangement Drawing, C.N.R. Overhead" dated June 1967, the approximate design grades for Highway 7/8 and the top of CNR rail elevation were 326.3 metres and 318.4 metres, respectively.

The topography of the lands surrounding the expressway slopes down from approximately elevation 326 metres west of the overpass to elevation 315 metres east of the overpass. Adjacent land use is typically urban residential and commercial to the north of the expressway and commercial and industrial to the south. The Rockway Municipal Golf Course is northwest of the overpass area.

2.1 Site Geology

This project lies within the physiographic region of southwestern Ontario known as the Waterloo Hills¹. The soils generally consist of sandy hills; some consist of sandy glacial till while others are kames or kame moraines, with outwash sands deposited in the valleys. Adjoining the sandy hills is the Grand River spillway system comprised of alluvial terraces of sand and gravel.

Based on the Ministry of Northern Development and Mines Map P.2604 entitled "Quaternary Geology, Cambridge Area", the site lies in an area of primarily ice contact sands. Adjacent to the site are areas of Port Stanley till, a silt to sandy silt till and the Maryhill clayey till.

The Geologic Survey of Canada Map 1263A entitled "Geology, Toronto-Windsor Area, Ontario" indicates that the subcropping bedrock in the area of site is dolomite and mudstone of the Salina formation of Upper Silurian age. Based on the Ontario Department of Mines Preliminary Map No. P.1985 "Bedrock Topography Series, Cambridge Area", the bedrock surface at the site is at about elevation 267 metres or some 48 to 59 metres below ground surface.

¹ L.J. Chapman and D.F. Putnam: The Physiography of Southern Ontario, Third Edition. Ontario Geological Survey, Special Volume 2, 1984.



3.0 INVESTIGATION PROCEDURES

The field work for the investigation was carried out between October 15 and December 2, 2008 and between March 26 and June 19, 2009, during which time eight boreholes were drilled at the locations shown on the Borehole Location Plan, Drawing 1. It should be noted that borehole 504 was deepened from elevation 299.5 metres to elevation 283.5 metres in June 2009. The table below summarizes the borehole locations, ground surface elevations at the borehole locations and borehole depths.

Borehole	Location (m)		Ground Surface Elevation	Borehole Depth
	Northing	Easting	(m)	(m)
501	4 810 485	225 972	326.49	44.26
502	4 810 488	225 983	326.23	21.79
503	4 810 477	225 941	326.75	18.75
504	4 810 440	225 985	318.68	35.14
505	4 810 451	225 951	326.53	20.27
506	4 810 456	225 966	326.32	41.39
507	4 810 466	226 013	325.80	21.79
508	4 810 505	225 954	317.92	30.14

The investigation was carried out using truck mounted CME 75 and all-terrain vehicle mounted CME 750 power augers and mud rotary drilling equipment supplied and operated by specialist drilling contractors. In the boreholes, samples of the overburden were obtained at suitable intervals of depth using 50 millimetre outside diameter split spoon sampling equipment in accordance with the standard penetration test (SPT) procedures (ASTM D1586). The boreholes were terminated between 18.75 and 44.26 metres below the exiting pavement or ground surface. Groundwater conditions in the boreholes were observed throughout the drilling operations and a standpipe and a piezometer were installed in borehole 504 as indicated on the corresponding Record of Borehole sheets. The boreholes were backfilled in accordance with the current MTO procedures and Ontario Regulation 372/07.

The field work was monitored on a full-time basis by experienced members of our engineering staff who located the boreholes in the field, monitored the drilling, sampling and in situ testing operations, logged the boreholes and surveyed their locations. The samples were identified in the field, placed in labeled containers and transported to our London laboratory for further examination and testing. Index and classification tests, consisting of water content determinations, grain size distribution analyses and Atterberg limits determinations, were carried out on selected samples. The samplers used in the investigations limit the maximum particle size that can be sampled and tested to about 40 millimetres. Therefore, particles or objects that may exist within the soils that are larger than this dimension will not be sampled or represented in the grain size distributions. Larger particle sizes, including cobbles and boulders, are known to be present in the glacial till deposits as discussed in the text of this report. The results of the testing are shown on the Record of Borehole sheets and in Appendix A. The ground surface elevations of the boreholes were determined by Golder Associates using benchmarks provided by Dillon that are understood to be referenced to geodetic datum.



4.0 SUBSURFACE CONDITIONS

4.1 Site Stratigraphy

The detailed subsurface soil and groundwater conditions encountered in the boreholes, together with the results of the in situ testing and the laboratory testing carried out on selected samples, are given on the attached Record of Borehole sheets following the text of this report and in Appendix A. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous samples and observations of drilling resistance and, therefore, may represent transitions between soil types rather than exact planes of geological change. Further, the subsurface conditions will vary between and beyond the borehole locations.

In summary, the soils encountered in the boreholes drilled at the site were highly variable and encountered the existing pavement structure or topsoil overlying fill materials which were underlain, in succession, by clayey silt to silt, clayey silt till, silty clay and sandy silt till. Relatively thin layers of granular soils varying in gradation from sand to sand and gravel were found above and below the silty clay stratum. These conditions are consistent with the summary of stratigraphy prepared for the original investigation at this site. The subsoils were described as an extremely interstratified and heterogenous deposit of sandy silt to clayey silt which contains several and irregular laminae of clay and sand (Geocres No. 40P08-036)². Reference should be made to the Records of Boreholes and stratigraphic profiles and sections for additional details.

The locations and elevations of the boreholes, together with the interpreted stratigraphic profiles and sections, are shown on the attached Drawings 1 and 2. The stratigraphic profile on Drawing 1 has been simplified for clarity. A detailed description of the subsurface conditions encountered in the boreholes is provided on the Record of Borehole sheets and is summarized in the following sections.

4.2 Soil Conditions

4.2.1 Pavement Structure

Asphalt was encountered at the pavement surface in boreholes 502, 503, 505, 506 and 507. The thickness of the asphalt ranged from 90 to 150 millimetres at the borehole locations. A layer of shallow buried asphalt approximately 90 millimetres thick was encountered beneath the sand fill in borehole 504.

Granular roadbase materials were encountered beneath the asphalt in boreholes 502, 503, 505, 506 and 507. The granulars were about 240 to 550 millimetres thick and consisted primarily of crushed sand and gravel. The surface of the granular roadbase varied between elevation 325.7 and 326.7 metres at the borehole locations. At borehole 504, the buried asphalt layer was underlain by about 510 millimetres of granular fill from approximately elevation 318.3 metres.

² E.M. Peto Associates Limited (February 1, 1965). Foundation Report for W.P. 625-64, Kitchener-Waterloo Expressway System (Geocres No. 40P08-036).



4.2.2 Topsoil and Fill

Topsoil layers 20 and 180 millimetres thick were encountered at the ground surface in boreholes 504 and 508. Layers of buried topsoil were encountered beneath cohesive fills in boreholes 502 and 503. The buried topsoil layer in borehole 502 was at about elevation 315.6 metres with a thickness of about 360 millimetres. This topsoil was peaty in composition and had a water content of about 74 per cent. In borehole 503, the buried topsoil layer was found at elevation 318.1 metres and had a thickness of about 220 millimetres. This silty topsoil had a water content of 26 per cent. Materials designated as topsoil in this report were classified solely based on visual and textural evidence. Testing of organic content or for other nutrients was not carried out. Therefore, the use of materials classified as topsoil cannot be relied upon for support and growth of landscaping vegetation.

Fill materials were encountered at the ground surface in borehole 501 and beneath the pavement structure or topsoil in all of the remaining boreholes. The fill surface varied between about elevations 317.7 and 326.4 metres. The fill, variable in nature and mostly cohesionless, consisted of sand, silty sand, sandy silt, sand and gravel to clayey silt or silty clay materials with the occasional presence of organics. The fill materials encountered in the boreholes, except 504 and 508, ranged in thickness from about 7.7 to 10.4 metres. Boreholes 504 and 508 had fill thickness of about 230 and 800 millimetres, respectively.

The loose to very dense cohesionless fill had SPT 'N' values of 4 to 94 blows per 0.3 metres and water contents of 4 to 17 per cent. The firm to hard cohesive fill had N values of 6 to 36 blows per 0.3 metres. The cohesive fill had plastic and liquid limits of 15 and 26 per cent, respectively, and a plasticity index of 11 per cent, based on a single Atterberg limits determination. These data are provided on the Plasticity Chart, Figure A-13.

Grain size distribution curves for samples of the fill recovered from the standard penetration testing are provided on Figures A-1 and A-2.

4.2.3 Silt

Silt interlayered with clayey silt was encountered in all of the boreholes. The uppermost silt layers were encountered beneath the clayey silt in boreholes 501, 503, 505, 506 and 508, beneath the buried topsoil in borehole 502, beneath the buried pavement structure in borehole 504 and beneath the fill in borehole 507. The silt was found to contain occasional clayey silt layers. The surface of the uppermost silt layers in each borehole was encountered between about elevation 310.1 and 317.8 metres. Where fully penetrated, the individual layers ranged from 0.3 to 4.9 metres in thickness. Borehole 502 was terminated in the silt after exploring it for about 3.1 metres.

The silt was compact to very dense with N values of 14 to 70 blows per 0.3 metres and water contents of 17 to 26 per cent.

Grain size distribution curves for samples of the silt recovered from the standard penetration testing are provided on Figure A-3.



4.2.4 Clayey Silt

Layers of clayey silt interlayered with silt were encountered in all of the boreholes. The clayey silt was also interlayered with silty sand and gravel in borehole 505, sandy silt in borehole 504 and silty fine sand in borehole 507. The uppermost clayey silt layer was encountered beneath the fill in boreholes 501, 505, 506 and 508, beneath the silt in boreholes 502, 504 and 507 and beneath the buried topsoil in borehole 503. The clayey silt was found to contain numerous partings, lenses and layers of silt. The surface of the uppermost clayey silt layer in each borehole was encountered between about elevation 312.7 and 318.3 metres. Where fully penetrated, the individual layers ranged from 0.4 to 8.2 metres in thickness. Boreholes 503 and 507 were terminated in the clayey silt after exploring it for about 5.0 and 0.2 metres, respectively.

The clayey silt was firm to hard with N values of 5 to 58 blows per 0.3 metres and had water contents of 15 to 23 per cent. The clayey silt had plastic limits of 11 to 16 per cent, liquid limits of 20 to 34 per cent and plasticity indices of 7 to 17 per cent based on fourteen Atterberg limits determinations. These data are provided on the Plasticity Chart, Figure A-13 which show the clayey silt to be of low plasticity.

Grain size distribution curves for samples of the clayey silt recovered from the standard penetration testing are provided on Figures A-4 and A-5.

4.2.5 Sand

An upper layer of sand was found within the clayey silt at elevation 307.4 metres in borehole 505. The upper sand was approximately 1 metre thick and was compact with an N value of 29 blows per 0.3 metres.

The middle sand deposit was encountered between the clayey silt till and silty clay deposits in boreholes 501 and 504 from elevations 296.6 and 294.9 metres, respectively. The middle sand layer was approximately 1.5 metres thick. The middle sand is very dense with N values of 58 and 92 blows per 0.3 metres and a water content of 12 per cent.

The lower sand deposit was encountered below the silty clay in boreholes 501 and 508 from elevation 289.0 and 290.8 metres, respectively, and below the silty clay till in borehole 508 from elevation 288.7 metres. The lower sand layers were 0.6 to 3.2 metres thick where fully penetrated. Borehole 508 was terminated in the lower sand layer after exploring it for some 0.9 metres. The lower sand is very dense with N values of 55 to over 100 blows per 0.3 metres and a water content of 29 per cent.

Grain size distribution curves for two samples of the sand recovered from the standard penetration testing are provided on Figure A-6.

4.2.6 Sandy Silt

Layers of compact to very dense sandy silt were encountered beneath the clayey silt in borehole 504 and beneath the silty clay in borehole 506 at elevations 307.7 and 288.8 metres, respectively. The upper and lower layers of sandy silt had thicknesses of about 2.1 and 1.5 metres, respectively. The upper sandy silt had an N value of 28 blows per 0.3 metres and the lower sandy silt had an N value over 100 blows per 0.3 metres. The water content obtained from a single test was about 18 per cent.



A grain size distribution curve for the sandy silt sample recovered from the standard penetration testing in borehole 506 is provided on Figure A-7.

4.2.7 Silty Sand and Silty Fine Sand

The clayey silt to silt deposit was interlayered with a 2.4 metre thick layer of upper silty fine sand from elevation 306.6 metres at borehole 507. The upper silty fine sand was loose to compact with N values of 8 and 12 blows per 0.3 metres.

Layers of lower silty sand 1.4 to 1.5 metres thick were encountered below the sand in borehole 501 from elevation 285.8 metres and below the silty clay from elevation 288.8 metres in borehole 504 and below the silt in borehole 506 from elevation 299.5 metres. The lower silty sand is dense to very dense with N values ranging from 33 to 44 blows above the silty clay layer and to over 100 blows per 0.3 metres below the silty clay layer. The lower silty sand to silty fine sand had water contents of 12 to 20 per cent.

Grain size distribution curves for samples of the silty sand recovered from the standard penetration testing are provided on Figure A-8.

4.2.8 Clayey Silt Till

Very stiff to hard clayey silt till was encountered beneath the clayey silt in boreholes 501, 504 and 508. The surface of the clayey silt till was encountered between about elevations 299.5 and 300.9 metres and the thickness of the layers ranged from about 3.1 to 7.6 metres. The clayey silt till had N values of 16 to 66 blows per 0.3 metres. The natural water content was about 16 to 17 per cent, the plastic limit was 13 per cent, liquid limits were 25 and 33 per cent and the plasticity indices were 12 and 20 per cent. These data are provided on the Plasticity Chart, Figure A-13.

Grain size distribution curves for samples of the clayey silt till recovered from the standard penetration testing are provided on Figure A-9.

Although not specifically encountered in the boreholes, the presence of cobbles and boulders should be expected in the till.

4.2.9 Silty Sand and Gravel to Sand and Gravel

A layer of compact silty sand and gravel was encountered at about elevation 306.4 metres beneath the sand in borehole 505. The borehole was terminated in the silty sand and gravel after exploring it for about 0.2 metres. It had an N value of 29 blows per 0.3 metres. A 1.5 metre thick layer of very dense sand and gravel with an N value of 75 blows per 0.3 metres was encountered at about elevation 298.0 metres beneath the lower silty sand in borehole 506.



4.2.10 Silty Clay

Very stiff to hard silty clay was encountered beneath the middle sand in boreholes 501 and 504, beneath the sand and gravel in borehole 506 and beneath the silty fine sand in borehole 508. The surface of the silty clay was encountered between about elevations 292.4 and 296.5 metres and the thickness of the layer ranged from about 1.6 to 7.6 metres. The silty clay had N values of 27 blows per 0.3 metres to over 100 blows per 0.3 metres with natural water contents of about 17 to 27 per cent. The silty clay is of intermediate plasticity with plastic limits of 17 to 20 per cent, liquid limits of 40 to 47 per cent and plasticity indices of 20 to 27 per cent as shown on the Plasticity Chart, Figure A-13.

Grain size distribution curves for samples of the silty clay recovered from the standard penetration testing are provided on Figure A-10.

4.2.11 Silty Clay Till

A 1.5 metre thick layer of hard silty clay till was encountered beneath the lower sand in borehole 508 from about elevation 290.2 metres. The silty clay till had a N value of over 100 blows per 0.3 metres of penetration. The water content was about 21 per cent, based on a single sample retrieved from the standard penetration testing.

The grain size distribution curve for the silty clay till sample recovered from the standard penetration testing in borehole 508 is provided on Figure A-11.

Although not specifically encountered in the boreholes, the presence of cobbles and boulders should be expected in the till.

There was insufficient sample to conduct an Atterberg limits determination.

4.2.12 Sandy Silt Till

Very dense sandy silt till was encountered beneath the lower silty sand in boreholes 501 and 504 and beneath the lower sandy silt in borehole 506. The surface of this deposit was encountered between about elevations 284.4 and 287.3 metres. Each of the three boreholes was terminated in the sandy silt till after exploring it for about 2.2 to 3.7 metres. The sandy silt till had N values of over 100 blows per 0.3 metres. The water content ranged from 11 to 12 per cent.

The grain size distribution curve for a single sandy silt till sample recovered from the standard penetration testing in borehole 501 is provided on Figure A-12.

Although not specifically encountered in the boreholes, the presence of cobbles and boulders should be expected in the till.



4.3 Groundwater Conditions

Groundwater conditions were observed during and on completion of drilling and sampling and a standpipe and a piezometer were installed in borehole 504. Installation details are provided on Record of Borehole 504 following the text of this report. Groundwater was encountered in the boreholes between elevations 313.1 and 317.3 metres.

A shallow standpipe and a deep piezometer were installed near the top and bottom, respectively, of the clayey silt to silt deposits. On June 18, 2009, the water level in the shallow standpipe was about 2.5 metres below ground surface or at about elevation 316.2 metres. The water level in the deep piezometer was about 1.2 metres below ground surface or at about elevation 317.5 metres. The June 18, 2009 water level measurements suggest an upward vertical hydraulic gradient. On August 25, 2009, the installations were found to be destroyed, likely due to recent watermain repairs in the area. According to Geocres No. 40P08-036, the historical groundwater levels encountered in boreholes advanced in September and October 1964 in the abutment area of the CNR Overhead structure ranged between elevation 316.1 and 317.8 metres.

A summary of the encountered and measured groundwater levels is provided in the following table:

Borehole	Ground Surface Elevation (m)	Encountered Groundwater Elevation (m)	Installation	Measured Groundwater Elevation (m)	
				Nov. 13, 2008	June 18, 2009
501	326.49	313.9 311.9 296.6	-	-	-
502	326.23	313.1 306.8	-	-	-
503	326.75	316.8	-	-	-
504	318.68	316.6	Shallow Standpipe Deep Piezometer	315.50 312.10	316.17 317.49
505	326.53	316.8 310.1	-	-	-
506	326.32	318.1 308.6	-	-	-
507	325.80	317.3 315.1 306.6	-	-	-
508	317.92	316.5	-	-	-

Based on the encountered and measured groundwater levels, the inferred groundwater level is at elevation 317 metres. The groundwater levels are expected to fluctuate seasonally and are expected to be higher during periods of sustained precipitation or during spring melt conditions.



5.0 MISCELLANEOUS

The investigation was carried out using equipment supplied and operated by Aardvark Drilling Inc. and Lantech Drilling Services Inc., both of which are Ontario Ministry of Environment licensed well contractors. The field operations were supervised by Mr. Michael Arthur and Mr. Daniel Babcock under the direction of Mr. David J. Mitchell. The laboratory testing was carried out at Golder Associates' London laboratory under the direction of Mr. Chris M. Sewell. The laboratory is an accredited participant in the MTO Soil and Aggregate Proficiency Program and is certified by the Canadian Council of Independent Laboratories for testing Types C and D aggregates. This report was prepared by Ms. Dirka U. Prout, P. Eng. under the direction of the Team Leader, Mr. Philip R. Bedell, P. Eng. This report was reviewed by Mr. Fintan J. Heffernan, P. Eng., the Designated MTO Contact and Quality Control Auditor for this assignment.

GOLDER ASSOCIATES LTD.

ORIGINAL SIGNED

Dirka U. Prout, P.Eng.

ORIGINAL SIGNED

Philip R. Bedell, P.Eng.
Senior Consultant

ORIGINAL SIGNED

Fintan J. Heffernan, P.Eng.
MTO Designated Contact

DUP/PRB/FJH/ly

n:\active\2008\1132 - geotechnical\1132-000-0\08-1132-084-1 dillon - gwp 131-98-00 fdns - hwy 7-8\reports\0811320841-r05 - cnr\0811320841-r05 jan 5 11 - (final) fdns - cnr.doc



**FOUNDATION INVESTIGATION AND DESIGN REPORT
CANADIAN NATIONAL RAILWAY OVERHEAD (SITE NO. 33-225)**

PART B

FOUNDATION DESIGN REPORT

CANADIAN NATIONAL RAILWAY OVERHEAD (SITE NO. 33-225)

WIDENING OF HIGHWAY 7/8

FROM 1.9 KM WEST OF FISCHER-HALLMAN ROAD

INTERCHANGE EASTERLY TO 0.8 KM EAST OF

COURTLAND AVENUE INTERCHANGE, KITCHENER

GWP 131-98-00, PURCHASE ORDER NUMBER 3007-E-0024

MINISTRY OF TRANSPORTATION, ONTARIO - WEST REGION



6.0 ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides our recommendations on the foundation aspects of the design of the proposed CNR overhead widening and rehabilitation based on our interpretation of the factual information obtained during the investigation. It should be noted that the interpretation and recommendations are intended for use only by the design engineer. Where comments are made on construction they are provided only in order to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

6.2 Existing Structure

The CNR twin overhead structures were built in 1968. Information on the existing structures was obtained from a review of the Department of Highways Ontario (DHO) Drawing No. D-5637-1 entitled "General Arrangement: Kitchener-Waterloo Expressway, C.N.R. Overhead" dated June 1967, DHO Drawing No. D-5637-4 entitled "Footing Layout & Reinforcing" dated June 1967 and Geocres Report No. 40P08-036. For the purposes of this report the CNR overhead is considered to be one single-span reinforced concrete rigid frame structure that is approximately 25.3 metres long and 34.5 metres wide.

The original design information indicates that the rigid frame structure is founded on concrete filled steel tube piles having a nominal diameter of 324 millimetres and wall thickness of 6.3 millimetres. The piles were designed to be approximately 17.37 metres long with a centre to centre spacing of about 1.24 metres. The piles had a working stress design load of 534 kilonewtons (60 tons) and were to be driven to approximately elevation 299.3 metres. The top and bottom elevations of the pile caps were 317.1 and 316.4 metres, respectively. Concrete filled reinforced horizontal steel tube struts 8.07 metres long and 324 millimetres in diameter and spaced at 3.96 to 5.18 metres were placed underneath the tracks and connected to the pile caps to provide additional stiffness to the structure. The centreline elevation of the streets is at approximately elevation 316.76 metres or 1.59 metres below the top of rail elevation. The struts were embedded about 0.3 metres into the pile caps.

The original 1967 general arrangement drawing indicates a 600 millimetre buried watermain, roughly aligned with the Highway 7/8 median, crossing the site at approximately elevation 315 metres. Other buried pipelines shown in the original design drawing include a 600 millimetre storm sewer, a 300 millimetre sanitary sewer and another 200 millimetre watermain. These pipelines pass within the extent of the existing structure near the south end and are located between about elevation 317 and 315 metres. There was also a buried Bell telephone cable located parallel to the east abutment and approximately 12 metres behind the face of the abutment. It should be confirmed that all of these utilities were removed or abandoned during the original construction. If they remain active, special procedures may be required for the new construction. A Non-Standard Special Provision (NSSP) should be added to the contract documents to address confirmation of the location of active and abandoned utilities and for protection of existing utilities.



6.2.1 Geotechnical Resistances for Existing Foundations

The following factored geotechnical resistances at Ultimate Limit States (ULS) and geotechnical resistances at Serviceability Limit States (SLS) can be utilized for a structural assessment of the existing structure:

Location	Foundation Type	Cut-Off Elevation (m)	Tip Elevation (m)	Pile Length (m)	Founding Strata	Geotechnical Resistances	
						Factored ULS (kN)	SLS (kN)
West abutment	Tube Pile	316.69	299.31	17.37	Very stiff clayey silt till to dense to very dense silty sand to sand and gravel	900	600
East abutment	Tube Pile	316.69	299.31	17.37	Very stiff to hard clayey silt till	900	600

It should be noted that the pile tip and underside of footing elevations as well as the pile lengths are based only on the design drawings as no as-built information or construction records were available.

Lateral resistances for a single existing pile, based on an LPILE analysis as discussed in Section 6.4.2, can be taken as 150 kilonewtons at factored ULS and 100 kilonewtons at SLS. The SLS value assumes a maximum 10 millimetre deflection at the ground surface.

6.3 Proposed Work

The overhead structure at the CNR will be widened in the north and south directions by about 4.8 and 5.5 metres, respectively and the existing retaining wall 'D' in the southwest quadrant of the structure will be rehabilitated and/or modified, where necessary. The existing CNR Overhead Retaining Wall D is addressed under separate cover in Geocres No. 40P8-193. No grade raise is proposed in the vicinity of the CNR Overhead structure. However, due to property limitations in this area, the road widenings will be created with Retained Soil System (RSS) retaining walls. Recommendations specific to these RSS retaining walls were provided in Geocres No. 40P8-191 issued on October 21, 2010. A geotechnical report for the retaining walls will be issued under separate cover.



6.4 Foundations for Widened Bridge Sections

The subsoils encountered in the boreholes advanced during the investigation typically consist of surficial fills over a complex and variable sequence of silt, clayey silt, silty clay and glacial till interlayered with sand, sand and gravel, sandy silt and silty sand. The groundwater level is inferred to be at approximately elevation 317 metres.

The existing rigid frame structure is founded on concrete filled steel tube piles having a nominal diameter of 324 millimetres and wall thickness of 6.3 millimetres. Based on the results of the boreholes and the existing bridge foundations, it is recommended that deep foundations be used for the widened structure. This option should reduce the magnitude of differential settlement between the existing and proposed structures and facilitate construction. Two pile types have been considered for the proposed structure widenings: driven HP 310 x 110 steel H-piles or 324 millimetre outer diameter concrete filled steel tube piles with a nominal 9.5 millimetre wall thickness. The preferred technical alternative for the abutment foundations is tube piles driven closed ended. If Retained Soil System (RSS) walls are to be considered beyond the structure limits, shallow foundations may be considered for the support of the retaining walls.

6.4.1 Geotechnical Axial Resistance – Deep Foundations

For design, the factored axial geotechnical resistances at ULS for steel H-piles and tube piles driven to refusal into the dense to very dense or very stiff to hard deposits at or below the elevations shown in the following table are presented in this section. The SLS values assume 25 millimetres of settlement. For the purposes of detail design, it was assumed that the cut-off elevations will be similar to those used for the existing structure.

Location	Pile Type	Cut-Off Elevation (m)	Approximate Tip Elevation (m)	Approximate Pile Length (m)	Founding Strata	Geotechnical Resistances	
						Factored ULS (kN)	SLS (kN)
Northerly Widenings/ Retaining Walls	HP 310x110 Pile	316.69	288	28.7	Very dense sand to sandy silt till	1400	1100
	324x9.5 Steel Tube Pile (Concrete Filled)	316.69	295	21.7	Very dense silty sand to sandy silt till	1400	1100
	324x9.5 Steel Tube Pile (Concrete Filled)	316.69	299	17.7	Very stiff to hard clayey silt till	900	600



FOUNDATION INVESTIGATION AND DESIGN REPORT CANADIAN NATIONAL RAILWAY OVERHEAD (SITE NO. 33-225)

Location	Pile Type	Cut-Off Elevation (m)	Approximate Tip Elevation (m)	Approximate Pile Length (m)	Founding Strata	Geotechnical Resistances	
						Factored ULS (kN)	SLS (kN)
Southerly Widenings/ Retaining Walls	HP 310x110 Pile	316.69	287	30.0	Very dense sandy silt to sandy silt till	1400	1100
	324x9.5 Steel Tube Pile (Concrete Filled)	316.69	294	12.7	Very dense sand to very stiff to hard silty clay	1400	1100
	324x9.5 Steel Tube Pile (Concrete Filled)	316.69	299	17.7	Dense sand to very stiff clayey silt till	900	600

The piles should be installed and monitored in accordance with OPSD 3000.150 or OPSD 3001.150 and SP903S01, as applicable.

In accordance with Special Provision 903S01, provision should be made to re-tap the piles to confirm the set after adjacent piles have been driven.

A pile note is to be added to the foundation drawing that states that piles are to be driven in accordance with Standard SS 103-11 using a maximum ultimate resistance of two times the factored ULS value shown in the above table and must be driven below the elevations shown in the above table. The wording of the pile note should match Note 2 of Section 3.3.3 of the MTO Structural Manual.

Construction Considerations

It should be noted that cobbles and boulders may be present in the till soils and may impact pile driving operations. The piles will be driven through primarily firm to very stiff cohesive deposits and compact granular deposits which represent moderate driving. However, since the tips will be founded at several locations in very dense/stiff to hard till materials containing cobbles and boulders all piles are to be equipped with Type I driving shoes in accordance with OPSD 3000.100 or 3001.100, as applicable. Splicing of steel tub piles should be in accordance with OPSD 3001.150.

Downdrag Load (Negative Skin Friction)

There will be no additional grade raise at this location. The proposed widening of the Highway 7/8 corridor will entail placement of small fills and RSS walls. Considering the presence of compact to dense silts and firm to hard clayey silt immediately underlying the embankments, no significant negative skin friction is expected to develop on the existing and new piles at the abutments.



6.4.2 Resistance to Lateral Loads – Deep Foundations

The lateral loading could be resisted fully or partially by the use of battered piles. The stratigraphy presented in the table below has been simplified for the purposes of this report. The horizontal reaction to the pile can be estimated using the following equation and ranges in subgrade reaction coefficient where:

$$\begin{aligned}
 k_s &= \text{coefficient of horizontal subgrade reaction (MPa/m)} &= n_h (z/d) &\text{for cohesionless soils} \\
 & &= \frac{67S_u}{d} &\text{for cohesive soils} \\
 d &= \text{pile width or diameter (m)} \\
 n_h &= \text{constant of horizontal subgrade reaction (MPa/m)} \\
 z &= \text{depth below ground surface grade (m)}
 \end{aligned}$$

Soil Type	Elevation (m)		n _h	S _u
	From	To	(MPa/m)	(MPa)
West abutment				
Compact to dense cohesionless fill (sand, sandy silt, sand and gravel)	Surface	315	-	-
Stiff to very stiff clayey silt interlayered with compact to very dense silt, occasional compact sandy silt	315	300	- 2-12	0.08-0.19 -
Very stiff clayey silt till	300	296	-	0.11-0.19
Very dense sand and gravel/very dense sand, some gravel	296	294	9-12	-
Very stiff to hard silty clay	294	288	-	0.18-0.54
Very dense sandy silt/dense silty sand	288	287	6-12	-
Very dense sandy silt till	287	284	9-12	-

East abutment				
Loose to very dense cohesionless fill (sand and gravel, sand, silty sand, sandy silt)	Surface	316	-	-
Firm to hard clayey silt interlayered with compact to very dense silt	316	300	- 2-12	0.05-0.39 -
Very stiff clayey silt till	300	297	-	0.17-0.29
Very dense sand	297	295	9-12	-
Hard silty clay	295	289	-	0.34-0.67
Very dense sand	289	286	9-12	-
Very dense silty sand	286	284	9-12	-
Very dense sandy silt till	284	282	9-12	-



FOUNDATION INVESTIGATION AND DESIGN REPORT CANADIAN NATIONAL RAILWAY OVERHEAD (SITE NO. 33-225)

Group action for lateral loading should be considered when the pile spacing in the direction of the loading is less than six to eight pile diameters. Group action can be evaluated by reducing the coefficient of horizontal subgrade reaction in the direction of loading by a reduction factor R as follows:

<i>Pile Spacing in Direction of Loading, d = Pile Diameter</i>	<i>Subgrade Reaction Reduction Factor R</i>
8d	1.00
6d	0.70
4d	0.40
3d	0.25

For the purposes of design, LPILE analyses were carried out to compute the lateral response of the HP 310 x 110 steel H-piles and 324 x 9.5 steel tube piles filled with concrete. The strength of the upper 1.5 metres of soil was reduced to account for frost effects. Fixed pile head conditions were modelled for both sizes of the piles. The effect of the horizontal pipe struts was ignored in the analyses. The resistances given are therefore considered to be conservative. For the SLS condition, a lateral deflection of 10 millimetres at pile head was considered. The results of the analyses in terms of the lateral loads at factored ULS and unfactored SLS are provided in the following table:

Location	Pile Type	Factored Lateral Load at ULS (kN)	Lateral Load at SLS (kN)
Northerly Widening	HP 310x110 Pile	200	120
	324x9.5 Steel Tube Pile (Concrete Filled)	150	100
Southerly Widening	HP 310x110 Pile	200	120
	324x9.5 Steel Tube Pile (Concrete Filled)	150	100

6.4.3 Frost Protection

The pile caps should be provided with a minimum of 1.4 metres of soil cover for frost protection or thermal equivalent.



6.4.4 Monitoring of Existing Structure

The process of installing the new piles will produce ground vibrations in the surrounding soils. It is anticipated that structures more than one pile length³ away from the areas where the new piles are constructed are not likely to be affected. The overpass structure will be widened by approximately 5.5 metres at both ends of each abutment. Assuming that the pile spacing will be similar to that of the existing structure, a small number of piles will be installed. Therefore, vibration and settlement monitoring in conjunction with the pile driving operations is not considered warranted.

6.4.5 Shallow Foundations

Shallow foundations are considered a feasible but not an optimal option from a foundations engineering perspective. There is a potential for differential settlement between the existing and widened portions of the structure if the widenings are supported on spread/strip footings. In addition, excavations for the footings will extend to or just above the groundwater level. Furthermore, the stiff to very stiff clayey silt and compact to dense silts at the founding level will provide limited geotechnical resistance.

Based on the borehole investigation results and existing foundation type, shallow foundations are not considered suitable for the abutments. If RSS walls are to be considered beyond the structure limits, shallow foundations may be considered as discussed in separate reports, Geocres Nos. 40P8-191 and 40P8-193.

6.5 Liquefaction Potential and Seismic Analysis

6.5.1 Seismic Parameters

The site is located in Kitchener, in southwestern Ontario. According to Table A.3.1.1 of the CHBDC, the zonal acceleration ratio, A , applicable to this site is 0.05. The corresponding acceleration related seismic zone, Z_a is 1. The following seismic performance zones (SPZ) are applicable to the proposed structure based on the assigned importance category:

Importance Category	Seismic Performance Zone
Lifeline bridge	2
Emergency route and other bridges	1

We have been informed by Dillon that the structure is not a lifeline bridge. Single-span bridges of construction other than a truss, such as the subject structure, need not be analyzed for seismic loads regardless of seismic performance zone. However, design forces for restraining elements and bridge support lengths must meet the minimum requirements as outlined in CHBDC Clause 4.4.5.1.

The effects of site conditions on the bridge response are to be included in the determination of the seismic loads. The stratigraphy generally consists of the existing pavement structure or topsoil overlying compact to very dense

³ Woods, R.D. (1997). Dynamic Effects of Pile Installations on Adjacent Structures. NCHRP Synthesis 253. National Cooperative Highway Research Program, Transportation Research Board, Washington D.C.



or stiff to hard fill materials, underlain by a variable sequence of compact to very dense cohesionless soils and firm to hard cohesive deposits. The density/consistency of the deposits ranges from very stiff to hard and dense to very dense below approximately elevation 300 metres. Clayey silt till, silty clay till and sandy silt till were encountered generally at about elevations 300, 290 and 287 metres, respectively, in different boreholes. None of the boreholes advanced for the current investigation at this site encountered bedrock. The available mapping indicates that dolomite and mudstone bedrock of the Salina formation is present at depths of about 48 to 59 metres, or below approximately elevation 267 metres. Based on the site stratigraphy, the soil profile type is categorized as Type I with a seismic site response coefficient, S , of 1.0 based on the CHBDC criteria.

6.5.2 Seismic Hazard Assessment

The site location has historically been considered to be in an area of low seismicity with peak ground acceleration (PGA) values between 0.04 and 0.08g from an earthquake with a 10 per cent probability of exceedance in 50 years. A preliminary screening of the soil stratigraphy was conducted using the procedure outlined in the Federal Highway Administration recommended procedures⁴. Although granular layers with fines contents less than 15 per cent by mass passing 0.005 millimetres are present below the groundwater table, these layers generally were found to have a normalized N value of greater than 30 blows per 0.3 metres and often greater than 50 blows per 0.3 metres. These deposits also date to the Pleistocene era. Deposits from the Pleistocene era historically have a very low to low susceptibility to liquefaction upon strong ground shaking. Therefore the liquefaction potential is considered to be relatively low based on the soil profile type, age of the deposits, relative density and the historically low seismicity. Therefore, a detailed evaluation of the liquefaction potential of the foundation soils, impact of liquefaction on the bridge foundations and the effect of seismic forces on embankment stability is not considered warranted unless the structure is deemed to be a lifeline bridge.

6.6 Lateral Earth Pressures

The lateral pressures acting on the bridge abutments and associated retaining walls will depend on the type and method of placement of the backfill materials, on the nature of the soils behind the backfill, on the freedom of lateral movement of the structure and on the drainage conditions behind the walls. The following recommendations are made concerning the design of the abutments in accordance with the CHBDC:

- Select, free-draining granular fill meeting the specifications of Ontario Provincial Standard Specifications (OPSS) Granular A or Granular B but with less than 5 per cent passing the No. 200 sieve should be used as backfill behind the abutments and walls. This fill should be compacted in loose lifts not greater than 200 millimetres in thickness in accordance with SP 105S10. Longitudinal drains and weep holes should be installed to provide positive drainage of the granular backfill. Other aspects of the abutment granular backfill requirements with respect to subdrains and frost taper should be in accordance with Ontario Provincial Standard Drawings (OPSD) 3101.150 and 3190.100.
- A compaction surcharge equal to 12 kilopascals should be included in the lateral earth pressures for the structural design of the abutment wall in accordance with CHBDC, Figure 6.6. Compaction equipment should be used in accordance with SP 105S10.

⁴ Federal Highway Administration (FHWA). (1997). "Design Guidance: Geotechnical Earthquake Engineering For Highways. Volume I – Design Principles." *Geotechnical Engineering Circular No. 3: FHWA-SA-97-076*, Washington, D.C.



- The granular fill may be placed either in a zone with a width equal to at least 1.4 metres behind the back of the stem (Case (a) from Commentary on CHBDC, Figure C6.20) or within the wedge-shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical extending up and back from the rear face of the footing (Case (b) from Commentary on CHBDC, Figure C6.20).
- For Case (a), the pressures are based on the proposed embankment fill materials and the following parameters (unfactored) may be assumed:

Soil unit weight:	21 kN/m ³
Coefficients of lateral earth pressure:	
Active, K_a	0.33
At rest, K_o	0.50

- For Case (b), the pressures are based on the granular fill as placed and the following parameters (unfactored) may be assumed:

	<u>GRANULAR A</u>	<u>GRANULAR B</u> (Type III)
Soil unit weight:	22 kN/m ³	21 kN/m ³
Coefficients of lateral earth pressure:		
Active, K_a	0.27	0.31
At rest, K_o	0.43	0.47

- If the wall support and superstructure allow lateral yielding of the stem, active earth pressures may be used in the geotechnical design of the structure. If the wall support does not allow lateral yielding, at-rest earth pressures should be assumed for geotechnical design.

It should be noted that the above design parameters assume level backfill and ground surface behind the wall. For sloping backfill/ground surface, these parameters should be adjusted as indicated in Section C6.9.1(e) of CHBDC.

6.7 Temporary Track Protection

It is anticipated that the design of the pile caps for the widened bridge foundations will incorporate horizontal steel tube struts connecting the pile caps for the east and west abutments as was done for the original design. Considering the relatively shallow cover, less than 1.5 metres, it is considered that these struts could be installed after installation of temporary steel sheet piling and prior to forming the pile caps by jacking or by using open cut techniques. All work of this nature must be done with the consent of the CNR. The construction procedures used to install the temporary track protection and construct foundation elements for the widenings must consider the presence of any existing buried utilities (sewers, Bell telephone cable and watermain).

A temporary track protection system is required to facilitate excavation for construction of new pile caps for the abutment widening. Similar to the existing foundations, as shown in DHO Drawing No. D-5637-4, the new pile cap excavations are assumed to extend to approximately elevation 315.2 metres or about 2.0 metres below the top of the adjacent pile caps. The design batter of the piles is 1 horizontal to 6 vertical.



Although active earth pressure coefficients have been developed based on the borehole data, it is also understood that design of any retaining structures adjacent to rail tracks is also governed by the requirements of the track owner, CNR, and the American Railway Engineering and Maintenance Association (AREMA) design manual.

The CNR design manual (Section 19.2, pages 3 to 6) requires that: "Active pressure coefficients shall be used for the design of abutments and other permanent earth retaining structures unless its stiffness prevents mobilization of active pressure. The active pressure coefficient is to be determined by the Geotechnical Engineer but shall not be less than 0.33." Therefore, if the requirements of this design manual are to govern the design, K_a for all soils shall be taken as 0.33 as this results in a greater design load.

The adjacent railway tracks will impart loads on the retaining structures whenever a train passes over them. These loads may be represented by a uniformly loaded, long rectangular strip, subject to a surcharge, $\sigma_{\text{surcharge}}$, acting over a width, $2b$, equivalent to the length of the railway ties. The degree to which the vertical load is translated into horizontal pressure depends on the distance of the load away from the wall. For calculating the lateral loading due to a long strip load at any point z down from the top of the wall at a distance x from the centre of the loading, the following equation may be used:

$$\sigma_{hz} = \sigma_{\text{surcharge}} [\alpha - \sin \alpha \cos (\alpha + 2\beta)] / \pi$$

Where

σ_{hz} = horizontal stress at depth z from the top of wall;

$\sigma_{\text{surcharge}}$ = uniform vertical surcharge pressure;

= internal angle formed by apex at point of depth z , and the two edges of the surcharge load (radians)

note that $\alpha = \tan^{-1}[(x+b)/z] - \beta$; and

β = internal angle formed by the apex at point of depth z , the top of the wall and the closest edge of the surcharge load (radians) with $\beta = \tan^{-1}[(x-b)/z]$

The track protection is to be designed to AREMA guidelines. AREMA (Sections 5.3.1b and 5.3.1d) provides the following guidance for determining the uniform vertical surcharge pressure from track loads: "In calculating the surcharge due to track loading on an abutment and on wingwalls that are in line with the abutment backwalls, the entire load shall be taken as distributed uniformly on the surface of the ballast immediately below the tie, over a width equal to the length of the tie. With increased depth, the width for distribution can be increased on slopes of 1 horizontal to 2 vertical, with surcharge loads from the adjacent tracks not being permitted to overlap. In calculating the surcharge due to track loading above a wall and parallel, or roughly parallel to the wall, the entire load shall be taken as distributed uniformly over a width equal to the length of the tie". Using this approach, the E-90 railway loading produces a vertical surcharge pressure of 103.8 kilopascals. It is recommended that this approach be used for calculation of the vertical surcharge pressures induced by the railway tracks.

AREMA Section 20.3.2.2 8-20-5 and Figure 8-20-2 provide guidance for determining lateral loads from the vertical surcharges as described above. While the relationships provided by AREMA are similar to the equation provided above, the AREMA method results in design pressures that are double those given by the equation above. A discussion of the reasons for this difference is provided by J. Bowles (Foundation Engineering Design, Fifth Edition, 1983). It is recommended that, for this project, the equation provided above be used, rather than the AREMA guidelines.



6.7.1 Lateral Earth Pressures

The arrangement of the temporary track protection shown in DHO Drawing No. D-5637-4 has been adopted here for the calculation of the lateral earth pressures. It involves installation of sheet piling around the excavation for the new pile caps. The sheet pile wall will be offset 3.1 metres from the centerline of the tracks on both the east and west sides.

Shoring walls should be designed to resist a triangular earth pressure distribution. The unfactored triangular earth pressure distribution (p' in kilonewtons per square metres (kN/m^2), increasing with depth), can be calculated as follows:

$$p' = K_a [\gamma (H - h_w) + (\gamma - \gamma_w) h_w]$$

where

K_a = 0.33 for level ground behind the wall; K_a must be adjusted if there is sloping ground behind the wall;

γ = soil unit weight as stated in table below;

H = height of the excavation at any point in metres; and

h_w = height of the groundwater level above the base of the excavation (water level to be taken as elevation 317 metres for design purposes).

The following table provides bulk and effective unit weights to be used in the above lateral earth pressure equations.

Soil Unit	Bulk Unit Weight, γ (kN/m^3)	Effective Unit Weight, γ' (kN/m^3)
Fill (ballast) to approx. elevation 317.9 m	22	12
Native silt/ clayey silt	20	10

Water pressure and surcharge loading from the Cooper E-90 live loading should be added to the earth pressure calculation. Typical distributions of horizontal pressures are shown on Figure 2.

6.7.2 Passive Toe Restraint

Passive toe restraint to the protection system may be determined using a triangular distribution. The coefficient of passive lateral earth pressure, K_p , and the effective unit weight, γ' , for the soil in front of the piles may be taken as follows:

Soil Unit	K_p	Effective Unit Weight, γ' (kN/m^3)
Native silt/ clayey silt	3.0	10



6.7.3 Other Design Considerations

Assuming a typical depth of excavation of approximately 2.0 metres, the factor of safety against base heave is greater than 1.5 for the stiff clayey silt to compact to dense silt soils at this site. Therefore, a minimum depth of penetration for the resistance to base heave has not been specified. Track protection is to be designed, constructed, maintained and monitored in accordance with OPSS 539. The track protection should be designed to limit lateral movements due to the sensitivity of the railway tracks to differential settlements.

Assuming the pile spacing and configuration will be similar to the original design, a maximum batter of 1 horizontal to 6 vertical should be used for the design of piles inclined towards the CNR tracks.

6.7.4 Monitoring of Protection Systems

The Contract Documents are to include an NSSP which outlines the requirements for monitoring of the shoring. Monitoring of the track protection system should be carried out during and following installation using targets installed at the top of the shoring system. Measurement of the vertical and horizontal displacement of the targets should be taken twice daily during installation of the protection system and excavation for construction of the new pile caps. Measurements should be taken twice weekly upon completion of the pile cap construction and decommissioning of the track protection system. The monitoring results should promptly be reported to the Contract Administrator following each event.

It is recommended that a pre-construction survey of the existing CNR Overhead structure be carried out prior to commencement of the proposed works.

6.8 Embankments

It is understood that embankment fills will be placed up to a height of about 8 metres in conjunction with the widening of the existing overhead structure. The width of the crest widening will be approximately 4.8 metres on the north side and 5.5 metres on the south side. The fill materials are to consist of well compacted on site borrow materials or imported granular fills. For embankment heights of 8 metres or greater, a mid height bench of 2 metres should be provided.

6.8.1 Subgrade Preparation and Embankment Construction

All surficial topsoil, organic, loose, soft and/or otherwise deleterious materials should be stripped from areas of proposed embankment widening. It is not considered necessary to remove the buried topsoil in existing embankment areas. The exposed subgrade should be proofrolled prior to fill placement under the direction of qualified geotechnical personnel. Grading and embankment construction should be conducted in accordance with MTO Special Provision 206S03.

Except for the top 0.5 metres, where Granular B Type III should be placed, the embankment fills should consist of an approved granular borrow such as SSM or Granular B Type I. Embankment fill materials should be placed in maximum 300 millimetre thick loose lifts and properly benched into the existing embankments in accordance with Ontario Provincial Standard Drawing (OPSD) 208.010 and compacted. Upon completion of filling to the



pavement subgrade level, the embankment side slopes should be trimmed to a final inclination of two horizontal to one vertical or flatter.

6.8.2 Settlement

Settlement of the proposed embankment widening was modelled using Settle^{3D}, a three-dimensional program for the analysis of consolidation and settlement. The widening was modelled using the proposed dimensions of the widening. An infinite embankment was assumed for the model. A post-construction settlement criterion recommended by MTO of an allowable settlement of up to 25 millimetres within 30 metres of an abutment was used to assess post-construction settlement performance of the modified approach embankments.

Settlements in the order of 25 millimetres or less are expected for the widenings in all quadrants, as shown in the following table. Noting the absence of a grade raise, limited width of the widening areas and presence of relatively deep deposits of compact to very dense granular and very stiff to hard cohesive foundation soils, the settlements are expected to occur mainly during construction and will be complete at the end of the construction period.

Location	Estimated Total Settlement (mm)		
	Crest of widened embankment	Toe of existing embankment	Toe of widening embankment
Northwest widening – abutment	12	12	6
Northwest widening – 20m behind abutment	20	22	10
Southwest widening – abutment	14	14	7
Southwest widening – 20m behind abutment	20	25	10
Northeast widening – abutment	11	14	6
Northeast widening – 20m behind abutment	16	23	10
Southeast widening – abutment	6	16	6
Southeast widening – 20m behind abutment	20	25	10

Post-construction and post paving settlements in these areas are expected to be minimal and within the MTO's settlement criteria.



6.8.3 Stability

Embankment side slopes formed no steeper than 2 horizontal to 1 vertical are considered suitable for this site. A Factor of Safety against deep seated failure of greater than 1.3 is available for embankments constructed with the native materials founded on the surficial compact to very dense silt interlayered with generally stiff to very hard clayey silt foundation soils.

6.9 Excavations and Temporary Cut Slopes

Excavations for construction of the pile caps will extend primarily through fill materials and may penetrate into the underlying clayey silt and silt. Temporary open cut slopes within the fill materials should be maintained no steeper than 1 horizontal to 1 vertical. Groundwater control such as pumping from properly constructed and filtered sumps may be required based on timing of construction and prevailing weather conditions.

Water seepage into the excavations at the pile cap locations should be expected and will be heavier during periods of sustained precipitation. The groundwater level is inferred to be at approximately elevation 317 metres. As such, pumping from filtered sumps located at the base of the excavations will also be required. Sumps should be maintained outside of the actual footing limits. Surface water runoff should be directed away from the excavations at all times. The appropriate Non Standard Special Provision (NSSP) should be included in the contract documents to alert contractors that excavation below the groundwater level is required and that excavations must be protected from influxes of surface water.

Where space is restricted and will not permit open cuts, a temporary roadway protection support system should be installed to support the sides of the excavation and permit the use of vertical cuts. Comments specific to temporary protection of the CNR tracks are provided in Section 6.7. The temporary roadway support system could consist of soldier piles and lagging where the H-piles would be driven to a suitable depth and horizontal lagging installed as the excavation proceeds or driven steel sheet piling. Support to the system could be in the form of struts and walers in the case of footing excavations or rakers and anchors in the case of roadway protection.

The raker/anchor support must be designed to accommodate the loads applied from earth pressures and surcharge pressures from area, line or point loads as well as the impact of sloping ground behind the system.

The temporary excavation support system should be designed and constructed and maintained in accordance with OPSS 539 as stated in Section 6.7.3.

All excavations should be carried out in accordance with the guidelines outlined in the latest edition of the Ontario Occupational Health and Safety Act and Regulations For Construction Projects. The fill materials at this site would be classified as Type 3 soils as would any cohesionless materials below the groundwater level. The native clayey materials, properly dewatered cohesionless materials and glacial tills would be classified as Type 2 soils.



7.0 MISCELLANEOUS

This report was prepared by Ms. Dirka U. Prout, P. Eng. under the direction of the Project Manager, Mr. Philip R. Bedell, P. Eng. This report was reviewed by Mr. Fintan J. Heffernan, P. Eng., the Designated MTO Contact and Quality Control Auditor for this assignment.

GOLDER ASSOCIATES LTD.

ORIGINAL SIGNED

Dirka U. Prout, P.Eng.

ORIGINAL SIGNED

Philip R. Bedell, P.Eng.
Senior Consultant

ORIGINAL SIGNED

Fintan J. Heffernan, P.Eng.
MTO Designated Contact

DUP/PRB/FJH/ly

n:\active\2008\1132 - geotechnical\1132-000-0\08-1132-084-1 dillon - gwp 131-98-00 fdns - hwy 7-8\reports\0811320841-r05 - cnr\0811320841-r05 jan 5 11 - (final) fdns - cnr.doc

TABLE I

COMPARISON OF FOUNDATION ALTERNATIVES

CNR Overhead (Site 33-225)
 Widening of Highway 7/8
 GWP 131-98-00

FOUNDATION OPTION	FEASIBILITY	ADVANTAGES	DISADVANTAGES	ESTIMATED COSTS	RISKS/ CONSEQUENCES
Shallow foundation	<ul style="list-style-type: none"> • Not feasible 	<ul style="list-style-type: none"> • Lower cost 	<ul style="list-style-type: none"> • Lowest geotechnical resistance • Not compatible with existing pile foundations from a geotechnical perspective due to the potential for differential settlement between the widened and existing sections 	-	<ul style="list-style-type: none"> • Bearing materials will provide limited geotechnical resistance • Excessive differential settlement
End bearing or friction concrete filled steel tube piles driven into native very dense granular materials or very stiff to hard cohesive materials	<ul style="list-style-type: none"> • Feasible • Preferred technical option 	<ul style="list-style-type: none"> • High bearing resistance • Negligible settlement 	<ul style="list-style-type: none"> • Higher potential vibration related damage compared to H-pile 	<ul style="list-style-type: none"> • Estimated cost \$57,000 to \$86,000 per abutment, depending on pile length and design capacity chosen • More expensive than H-piles if the longer length is chosen 	<ul style="list-style-type: none"> • Possible pile tip damage if piles are not adequately protected while driving through very dense/hard soils

COMPARISON OF FOUNDATION ALTERNATIVES

FOUNDATION OPTION	FEASIBILITY	ADVANTAGES	DISADVANTAGES	ESTIMATED COSTS	RISKS/ CONSEQUENCES
End bearing steel H-pile foundations driven to refusal into very dense native granular materials	<ul style="list-style-type: none">• Feasible	<ul style="list-style-type: none">• High bearing resistance• Negligible settlement• Less potential vibration related damage compared to steel tube piles	<ul style="list-style-type: none">• Differential performance from existing tube piles	<ul style="list-style-type: none">• Estimated cost \$84,500 per abutment• Cost competitive with tube piles	<ul style="list-style-type: none">• Possible pile tip damage if piles are not adequately protected while driving through very dense/hard soils

- NOTES: 1. Costs are very preliminary estimates and are intended to provide a comparison between alternatives rather than actual construction costs.
2. Table to be read in conjunction with accompanying report.

Prepared By: DUP

Checked By: PRB

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split spoon sampler for a distance of 300 mm (12 in.)

(b) Cohesive Soils

Consistency	c_u, s_u	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

Dynamic Cone Penetration Resistance; N_d :

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. General

π	3.1416
$\ln x$,	natural logarithm of x
\log_{10}	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
F	factor of safety
V	volume
W	weight

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ϵ	linear strain
ϵ_v	volumetric strain
η	coefficient of viscosity
ν	poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(a) Index Properties (continued)

w	water content
w_l	liquid limit
w_p	plastic limit
I_p	plasticity index $= (w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p) / I_p$
I_C	consistency index $= (w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_a	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 + \sigma_3)/2$ or $(\sigma'_1 + \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 + \sigma_3)$
S_t	sensitivity

- Notes:** 1 $\tau = c' + \sigma' \tan \phi'$
 2 shear strength = (compressive strength)/2
 * density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

PROJECT <u>08-1132-084-1</u>		RECORD OF BOREHOLE No 501		1 OF 3		METRIC	
W.P. <u>131-98-00</u>		LOCATION <u>N 4810484.7 ; E 225971.9</u>		ORIGINATED BY <u>MA</u>			
DIST <u> </u> HWY <u>7/8</u>		BOREHOLE TYPE <u>POWER AUGER / ROTARY DRILLING</u>		COMPILED BY <u>LMK</u>			
DATUM <u>GEODETIC</u>		DATE <u>October 15, 2008 - October 29, 2008</u>		CHECKED BY <u> </u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								20	40	60	80	100	W _p	W	W _L					
326.49	ROAD SURFACE																			
0.00	FILL, sand and gravel, trace silt Very dense Brown																			
			1	SS	51															
325.12	FILL, fine to coarse sand, some gravel, trace silt Dense to very dense Brown		2	SS	39															
1.37			3	SS	54															
			4	SS	41															
322.83	FILL, sand, some silt Dense Brown		5	SS	44															
3.66																				
322.07	FILL, silty sand, with clayey silt lumps Loose to compact Brown		6	SS	15															
4.42			7	SS	4															
			8	SS	5															
319.78	FILL, clayey silt, some sand Firm Brown		9	SS	6															
6.71																				
319.02	FILL, sandy silt, some clay, trace gravel, with wood pieces Loose to compact Brown		10	SS	25															
7.47																				
			11	SS	7															
316.13	CLAYEY SILT, trace sand Stiff to very stiff Brown		12	SS	8															
10.36																				
313.93	SILT, trace sand Compact Brown		13	SS	23															
12.56																				
313.23	CLAYEY SILT, trace sand, silt partings Firm Grey		14	SS	8															
13.26																				
311.86																				
14.63																				

LDN_MTO_06_08-1132-084-1.GPJ LDN_MTO.GDT 06/01/11

Continued Next Page

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

PROJECT <u>08-1132-084-1</u>		RECORD OF BOREHOLE No 501		2 OF 3		METRIC	
W.P. <u>131-98-00</u>		LOCATION <u>N 4810484.7 ; E 225971.9</u>		ORIGINATED BY <u>MA</u>			
DIST <u> </u> HWY <u>7/8</u>		BOREHOLE TYPE <u>POWER AUGER / ROTARY DRILLING</u>		COMPILED BY <u>LMK</u>			
DATUM <u>GEODETIC</u>		DATE <u>October 15, 2008 - October 29, 2008</u>		CHECKED BY <u> </u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								20	40	60	80	100	W _P	W	W _L					
	SILT, some clay, trace sand, with silt and fine sand partings Compact Grey		15	SS	18											0	1	85	14	
			16	SS	23															
308.51																				
17.98	CLAYEY SILT Very stiff Grey																			
308.05																				
18.44	SILT, trace clay, some sand Compact to very dense Grey		17	SS	39															
			18	SS	56															
304.79			19	SS	58															
21.70	CLAYEY SILT Hard Grey																			
304.24																				
22.25	SILT, trace clay, with clayey silt layers Compact Grey																			
			20	SS	28															
302.72																				
23.77	CLAYEY SILT, with silt partings and lenses Very stiff Grey		21	SS	17															
			22	SS	16															
299.67																				
26.82	CLAYEY SILT TILL, some sand, trace gravel Very stiff Grey		23	SS	25															
			24	SS	43															
296.62																				

LDN_MTO_06_08-1132-084-1.GPJ LDN_MTO.GDT 06/01/11

Continued Next Page

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

RECORD OF BOREHOLE No 501

3 OF 3

METRIC

PROJECT 08-1132-084-1
W.P. 131-98-00 LOCATION N 4810484.7 ; E 225971.9 ORIGINATED BY MA
DIST HWY 7/8 BOREHOLE TYPE POWER AUGER / ROTARY DRILLING COMPILED BY LMK
DATUM GEODETIC DATE October 15, 2008 - October 29, 2008 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								20	40	60	80	100			W _P	W	W _L
29.87	SAND, fine, some silt Very dense Grey					296											
			25	SS	92												
295.10							295										
31.39	SILTY CLAY, trace sand, with silt layers Hard Grey		26	SS	87		294										
							293										
			27	SS	76		292										
							291										
			28	SS	50		290										
							289										
289.00							288										
37.49	SAND, fine, trace silt, trace gravel Very dense Grey	30	SS	55		287											
						286											
		31	SS	116		285											
285.80						284											
40.69	SILTY SAND, trace clay, trace gravel Very dense Grey	32	SS	101/ 225mm		283											
284.43																	
42.06	SANDY SILT TILL, some clay, trace gravel Very dense Grey	33	SS	102/ 75mm													
282.23																	
44.26	END OF BOREHOLE Groundwater encountered at about elev. 313.9m, elev. 311.9m, and elev. 296.6m during drilling.	34	SS	117/ 50mm													

LDN_MTO_06 08-1132-084-1.GPJ LDN_MTO_GDT 06/01/11

RECORD OF BOREHOLE No 502

1 OF 2

METRIC

PROJECT 08-1132-084-1

W.P. 131-98-00

LOCATION N 4810488.1 ; E 225983.2

ORIGINATED BY MA

DIST HWY 7/8

BOREHOLE TYPE POWER AUGER

COMPILED BY LMK

DATUM GEODETIC

DATE October 20, 2008

CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							W _P W W _L			
326.23	ROAD SURFACE							20	40	60	80	100						
0.00	ASPHALT																	
0.15	FILL, sand and gravel, crushed						326											
325.77																		
0.46	FILL, sandy silt, trace clay, trace gravel, clayey silt pockets Loose to dense Brown		1	SS	25		325											
			2	SS	9													
			3	SS	44		324											
			4	SS	36		323											
322.57																		
3.66	FILL, silty clay, trace sand Hard Grey		5	SS	30		322											
321.81																		
4.42	FILL, silty sand, fine to medium, trace clay, trace to some gravel, asphalt fragments Compact to very dense Brown		6	SS	23		321											
			7	SS	21													
			8	SS	21		320											
			9	SS	50													
318.37			10	SS	30		319											
7.86	FILL, sandy silt, trace clay, trace gravel Dense Brown																	
318.00							318											
8.23	FILL, sand, fine to medium, trace silt, trace gravel, with silt layers Compact to very dense Brown		11	SS	60													
316.90							317											
9.33	FILL, clayey silt, trace to some sand, trace topsoil Stiff Brown		12	SS	13													
			13	SS	14		316											
315.56																		
10.67	TOPSOIL, peaty Very stiff Black		14	SS	26		315											
315.20																		
11.03	SILT, trace topsoil, trace clay Compact Brown		15	SS	13													
11.28	CLAYEY SILT, trace sand Stiff Brown		16	SS	15		314											
312.98							313											
13.25	SILT, trace clay, trace sand Compact Brown		17	SS	23													
312.09							312											
14.14	CLAYEY SILT, trace sand, with silt layers Stiff to very stiff Grey																	

Continued Next Page

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

LDN_MTO_06 08-1132-084-1.GPJ LDN_MTO.GDT 06/01/11

PROJECT <u>08-1132-084-1</u>		RECORD OF BOREHOLE No 502		2 OF 2		METRIC	
W.P. <u>131-98-00</u>		LOCATION <u>N 4810488.1 ; E 225983.2</u>		ORIGINATED BY <u>MA</u>			
DIST <u> </u> HWY <u>7/8</u>		BOREHOLE TYPE <u>POWER AUGER</u>		COMPILED BY <u>LMK</u>			
DATUM <u>GEODETIC</u>		DATE <u>October 20, 2008</u>		CHECKED BY <u> </u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								20	40	60	80	100	W _p	W	W _L						
																				</	

RECORD OF BOREHOLE No 503

1 OF 2

METRIC

PROJECT 08-1132-084-1
W.P. 131-98-00 LOCATION N 4810477.1 ; E 225940.5 ORIGINATED BY MA
DIST HWY 7/8 BOREHOLE TYPE POWER AUGER COMPILED BY LMK
DATUM GEODETIC DATE October 21, 2008 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20	40	60	80	100	10	20	30		
326.75	ROAD SURFACE																
0.10	ASPHALT																
0.34	FILL, sand and gravel, crushed Brown																
	FILL, sandy silt, some clay, trace gravel Compact to dense Brown		1	SS	16												
			2	SS	14												
			3	SS	26											0 42 45 13	
			4	SS	24												
			5	SS	40												
322.33			6	SS	16												
4.42	FILL, clayey silt, some sand, trace gravel Stiff to very stiff Brown		7	SS	10												
320.81			8	SS	19											0 69 27 4	
5.94	FILL, silty sand, trace clay Compact Brown		9	SS	12											0 74 20 6	
319.28			10	SS	36												
318.07			11	SS	14												
8.68	TOPSOIL, silty Compact Black		12	SS	16												
8.90	CLAYEY SILT, trace sand, with silt layers Very stiff Brown		13	SS	26												
316.72			14	SS	23											0 5 78 17	
10.03	SILT, some clay, trace sand Compact Brown to grey at about elev. 316.3m		15	SS	16												
313.00			16	SS	12												
13.75	CLAYEY SILT, trace to some sand, trace gravel, with silt layers Stiff to hard Grey																

Continued Next Page

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

LDN_MTO_06 08-1132-084-1.GPJ LDN_MTO.GDT 06/01/11

PROJECT <u>08-1132-084-1</u>		RECORD OF BOREHOLE No 503		2 OF 2		METRIC	
W.P. <u>131-98-00</u>		LOCATION <u>N 4810477.1 ; E 225940.5</u>		ORIGINATED BY <u>MA</u>			
DIST <u> </u> HWY <u>7/8</u>		BOREHOLE TYPE <u>POWER AUGER</u>		COMPILED BY <u>LMK</u>			
DATUM <u>GEODETIC</u>		DATE <u>October 21, 2008</u>		CHECKED BY <u> </u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					w _p	w	w _L		GR	SA	SI	CL		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE													WATER CONTENT (%)	
							20	40	60	80	100											
	CLAYEY SILT, trace to some sand, trace gravel, with silt layers Stiff to hard Grey		17	SS	15																	
					18	SS	19															
308.00																						
18.75	END OF BOREHOLE																					
	Groundwater encountered at about elev. 316.8m during drilling on October 21, 2008.																					

LDN_MTO_06 08-1132-084-1.GPJ LDN_MTO.GDT 06/01/11

RECORD OF BOREHOLE No 504

1 OF 3

METRIC

PROJECT 08-1132-084-1
W.P. 131-98-00 LOCATION N 4810439.8 ; E 225985.2 ORIGINATED BY MA
DIST HWY 7/8 BOREHOLE TYPE POWER AUGER / TRICONE COMPILED BY LMK
DATUM GEODETIC DATE November 13, 2008 and Borehole Deepened June 18 & 19, 2009 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								20 40 60 80 100							W _P W W _L		
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
318.68	GROUND SURFACE																
0.02	TOPSOIL, sandy Brown						Concrete										
0.34	FILL, sand Brown																
317.83	ASPHALT																
0.85	FILL, sand and gravel Compact Brown		1	SS	20		Holeplug										
317.31	SILT, trace sand, trace clay Compact Brown		2	SS	12												
1.37	CLAYEY SILT, with silt layers Stiff Brown		3	SS	29												
316.55	SILT, some sand, trace clay Compact Brown																
2.13	CLAYEY SILT, with silt layers Stiff Brown																
315.27	CLAYEY SILT, with silt layers Stiff Brown to grey at about elev. 315.0m		4	SS	15												
3.41	SILT, trace sand, trace clay Compact Grey		5	SS	26		Cuttings										
314.78			6	SS	17									0 4 87 9			
3.90			7	SS	18												
			8	SS	19												
312.19	CLAYEY SILT, trace sand Stiff to very stiff Grey		9	SS	14		Standpipe										
6.49	SILT, trace sand, trace clay, with clayey silt layers Compact Grey		10	SS	24												
311.61			11	SS	20												
7.07	CLAYEY SILT, trace sand Very stiff Grey		12	SS	15									0 1 79 20			
309.69																	
8.99																	
307.68	SANDY SILT, trace clay Compact Grey		13	SS	16		Holeplug										
11.00			14	SS	28		Caved Material										
305.57																	
13.11	SILT, trace clay, with clayey silt layers Dense Grey		15	SS	43									0 0 93 7			
304.05							Filter sand										
14.63																	

Continued Next Page

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

PROJECT <u>08-1132-084-1</u>		RECORD OF BOREHOLE No 504		2 OF 3	METRIC
W.P. <u>131-98-00</u>	LOCATION <u>N 4810439.8 ;E 225985.2</u>			ORIGINATED BY <u>MA</u>	
DIST <u></u> HWY <u>7/8</u>	BOREHOLE TYPE <u>POWER AUGER / TRICONE</u>			COMPILED BY <u>LMK</u>	
DATUM <u>GEODETIC</u>	DATE <u>November 13, 2008 and Borehole Deepened June 18 & 19, 2009</u>			CHECKED BY <u></u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	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		ELEVATION SCALE	SHEAR STRENGTH kPa								WATER CONTENT (%)	
								○ UNCONFINED	+	FIELD VANE							
								● QUICK TRIAXIAL	×	LAB VANE							
	CLAYEY SILT, with silt partings Very stiff Grey		16	SS	21		Filter sand										
301.01							Piezometer										
17.67	CLAYEY SILT, with silt lenses Stiff Grey		17	SS	16												
299.48																	
19.20	CLAYEY SILT TILL, trace sand and gravel Very stiff Grey		18	SS	12										0 0 56 44		
			19	SS	16												
			20	SS	29												
			21	SS	26												
294.91																	
23.77	SAND, some gravel, some silt, trace clay Very dense Grey		22	SS	58										15 66 16 3		
293.38																	
25.30	SILTY CLAY, with silt layers Hard Grey		23	SS	63												
			24	SS	60												
			25	SS	33												
288.78																	

Continued Next Page

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

PROJECT <u>08-1132-084-1</u>		RECORD OF BOREHOLE No 504		3 OF 3	METRIC
W.P. <u>131-98-00</u>	LOCATION <u>N 4810439.8 ; E 225985.2</u>	ORIGINATED BY <u>MA</u>			
DIST <u> </u> HWY <u>7/8</u>	BOREHOLE TYPE <u>POWER AUGER / TRICONE</u>	COMPILED BY <u>LMK</u>			
DATUM <u>GEODETIC</u>	DATE <u>November 13, 2008 and Borehole Deepened June 18 & 19, 2009</u>	CHECKED BY <u> </u>			

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 (%)		
												20						40	60	80
29.90	SILTY SAND, fine, trace clay Dense Grey																			
			26	SS	33															
287.28	SANDY SILT TILL, some clay, trace to some gravel Very dense Grey																			
31.40			27	SS	100/ 100mm															
			28	SS	100/ 100mm															
283.54	END OF BOREHOLE		29	SS	100/ 100mm															
35.14	Groundwater encountered at about elev. 316.6m during drilling on November 13, 2008. Water level measured in piezometer at elev. 312.10m on November 13, 2008. Water level measured in standpipe at elev. 315.51m on November 13, 2008. Water level measured in piezometer at elev. 317.49m on June 18, 2009. Water level measured in standpipe at elev. 316.17m on June 18, 2009. Standpipe and piezometer found to be destroyed on August 25, 2009.																			

PROJECT 08-1132-084-1		RECORD OF BOREHOLE No 505		2 OF 2		METRIC	
W.P. 131-98-00		LOCATION N 4810451.2 ; E 225950.6		ORIGINATED BY MA			
DIST _____ HWY 7/8		BOREHOLE TYPE POWER AUGER / HOLLOW STEM		COMPILED BY LMK			
DATUM GEODETIC		DATE November 18, 23 and 24, 2008		CHECKED BY _____			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	20	40	60	80	100	w _p	w		w _L				
	CLAYEY SILT, trace sand, with silt layers Firm to very stiff Brown to grey at about elev. 316.0m		17	SS	15													0	1	77	22
310.07																					
16.46	SILT, trace clay, trace sand Compact Grey		18	SS	26																
308.70																					
17.83	CLAYEY SILT, trace sand, trace gravel, with silt layers Very stiff Grey		19	SS	27																
307.43																					
19.10	SAND, fine to medium, trace silt Compact Grey																				
306.41			20	SS	29																
20.12	SILTY SAND AND GRAVEL Compact Grey																				
20.27	END OF BOREHOLE Groundwater encountered at about elev. 316.8m and elev. 310.1m during drilling on November 18 and 24, 2008, respectively.																				

LDN_MTO_06 08-1132-084-1.GPJ LDN_MTO.GDT 06/01/11

PROJECT		<u>08-1132-084-1</u>		RECORD OF BOREHOLE No 506	1 OF 3	METRIC
W.P.	<u>131-98-00</u>	LOCATION	<u>N 4810455.9 ;E 225966.2</u>	ORIGINATED BY		<u>MA</u>
DIST	<u> </u>	HWY	<u>7/8</u>	BOREHOLE TYPE	<u>POWER AUGER / TRICONE</u>	COMPILED BY <u>DMB</u>
DATUM	<u>GEODETTIC</u>	DATE	<u>November 24, 2008, May 31 and June 1, 2009.</u>	CHECKED BY		<u> </u>

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						
326.32	GROUND SURFACE																
0.00	ASPHALT																
0.15																	
325.86	FILL, sand and gravel, crushed Brown																
0.46																	
0.70	FILL, sand and gravel Brown																
	FILL, sand, fine to medium, trace to some gravel, sandy silt pockets Compact to very dense Brown		1	SS	22						○						
			2	SS	41						○						
			3	SS	49						○						
			4	SS	44						○						
			5	SS	59						○						
			6	SS	46						○						
			7	SS	33						○						
320.38																	
5.94	FILL, sandy silt, trace to some clay, trace gravel Compact to dense Brown		8	SS	24						○						
			9	SS	31						○						
318.49																	
7.83	FILL, sand and gravel, with wood Compact Brown		10	SS	27						○		○				
318.09																	
8.23	FILL, sand, fine to medium, trace silt, trace gravel Compact Brown		11	SS	23						○						
			12	SS	16						○						
316.82																	
9.50	FILL, clayey silt, trace sand, some topsoil Very stiff Brown and black		13	SS	14						—○—			0 2 70 28			
9.75	CLAYEY SILT, trace sand, with silt layers Stiff Brown		14	SS	13						○						
314.74																	
11.58	SILT, trace clay, trace sand Dense Grey		15	SS	33						○			0 1 98 1			
313.21																	
13.11	CLAYEY SILT, trace sand, with silt layers Very stiff Grey		16	SS	22						—○—			0 2 75 23			

Continued Next Page

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

PROJECT <u>08-1132-084-1</u>		RECORD OF BOREHOLE No 506		2 OF 3		METRIC	
W.P. <u>131-98-00</u>		LOCATION <u>N 4810455.9 ; E 225966.2</u>		ORIGINATED BY <u>MA</u>			
DIST <u> </u> HWY <u>7/8</u>		BOREHOLE TYPE <u>POWER AUGER / TRICONE</u>		COMPILED BY <u>DMB</u>			
DATUM <u>GEODETIC</u>		DATE <u>November 24, 2008, May 31 and June 1, 2009.</u>		CHECKED BY <u> </u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)			GR	SA	SI	CL	
								20 40 60 80 100					10 20 30							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
308.64 17.68	CLAYEY SILT, trace sand, with silt layers Very stiff Grey		17	SS	29	▽	311													
							310													
			18	SS	15		309													
	SILT, some clay, some sand Very dense Grey		19	SS	50		308						○				0	20	68	12
							307													
			20	SS	70		306													
							305													
			21	SS	67		304													
304.07 22.25	CLAYEY SILT, trace sand, with silt layers Very stiff Grey		22	SS	15		303													
							302													
			23	SS	21		301													
	SILT, some clay Dense Grey		24	SS	31		300													
299.50 26.82	SILTY SAND, some gravel, trace clay Dense Grey		25	SS	44	299						○				10	64	23	3	
297.97 28.35	SAND AND GRAVEL, trace silt Very dense Grey		26	SS	75	298														
296.45						297														

LDN_MTO_06_08-1132-084-1.GPJ LDN_MTO.GDT 06/01/11

Continued Next Page

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

PROJECT <u>08-1132-084-1</u>		RECORD OF BOREHOLE No 506		3 OF 3	METRIC
W.P. <u>131-98-00</u>	LOCATION <u>N 4810455.9 ; E 225966.2</u>	ORIGINATED BY <u>MA</u>			
DIST <u> </u> HWY <u>7/8</u>	BOREHOLE TYPE <u>POWER AUGER / TRICONE</u>	COMPILED BY <u>DMB</u>			
DATUM <u>GEODETIC</u>	DATE <u>November 24, 2008, May 31 and June 1, 2009.</u>	CHECKED BY <u> </u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								W _p	W	W _L																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
								○ UNCONFINED	+	FIELD VANE									● QUICK TRIAXIAL	×	LAB VANE	WATER CONTENT (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
							20	40	60	80	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				

LDN_MTO_06 08-1132-084-1.GPJ LDN_MTO.GDT 06/01/11

RECORD OF BOREHOLE No 507

1 OF 2

METRIC

PROJECT 08-1132-084-1

W.P. 131-98-00

LOCATION N 4810466.3 ; E 226013.0

ORIGINATED BY MA

DIST HWY 7/8

BOREHOLE TYPE POWER AUGER / HOLLOW STEM

COMPILED BY LMK

DATUM GEODETIC

DATE December 2, 2008

CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
325.80	ROAD SURFACE																
0.00	ASPHALT																
0.15	FILL, sand and gravel, trace silt, crushed																
325.34	Brown																
0.46	FILL, sandy silt, trace clay, trace gravel		1	SS	18		325										
	Compact		2	SS	24		324										
	Brown		3	SS	23		323										
			4	SS	17												
322.14																	
3.66	FILL, sand, fine, trace to some silt, trace gravel		5	SS	22		322										
	Compact to dense		6	SS	31		321										
	Brown		7	SS	33												
319.86							320										
5.94	FILL, silty sand, trace to some clay, trace gravel		8	SS	21												
	Compact to dense		9	SS	64		319										
	Grey		10	SS	94		318										
			11	SS	16		317										
316.81																	
8.99	FILL, sandy silt, trace clay, trace topsoil, trace gravel		12	SS	30		316										
	Compact to dense		13	SS	26												
	Brown and grey																
315.07																	
10.73	SILT, trace sand, trace clay		14	SS	30		315										
	Dense						314										
	Brown to grey at about elev. 314.2m		15	SS	34												
							313										
312.69																	
13.11	CLAYEY SILT, trace sand, with silt layers		16	SS	14		312										
	Stiff																
	Grey						311										

Continued Next Page

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

LDN_MTO_06 08-1132-084-1 GPJ LDN_MTO_GDT 06/01/11

PROJECT <u>08-1132-084-1</u>		RECORD OF BOREHOLE No 507		2 OF 2	METRIC
W.P. <u>131-98-00</u>	LOCATION <u>N 4810466.3 ; E 226013.0</u>	ORIGINATED BY <u>MA</u>			
DIST <u> </u> HWY <u>7/8</u>	BOREHOLE TYPE <u>POWER AUGER / HOLLOW STEM</u>	COMPILED BY <u>LMK</u>			
DATUM <u>GEODETIC</u>	DATE <u>December 2, 2008</u>	CHECKED BY <u> </u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								20	40	60	80	100	W _p	W	W _L					
	CLAYEY SILT, trace sand, with silt layers Stiff Grey		17	SS	12	▽	310									0	1	63	36	
							309													
			18	SS	14															
308.12																				
17.68	SILT, trace clay, trace sand Compact Grey		19	SS	17		308													
306.60																				
19.20	SILTY FINE SAND Loose to compact Grey		20	SS	8	306														
							305													
304.16			21	SS	12															
21.64	CLAYEY SILT, with silt layers Stiff Grey																			
21.79	END OF BOREHOLE																			
	Groundwater encountered at about elev. 317.3m, elev. 315.1m, and elev. 306.6m during drilling on December 2, 2008.																			

RECORD OF BOREHOLE No 508

1 OF 3

METRIC

PROJECT 08-1132-084-1

W.P. 131-98-00

LOCATION N 4810505.3 ; E 225954.1

ORIGINATED BY DB

DIST HWY 7/8

BOREHOLE TYPE POWER AUGER / ROTARY DRILLING / NW CASING

COMPILED BY LMK

DATUM GEODETIC

DATE March 26, 2009 - March 30, 2009

CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								20 40 60 80 100		10 20 30				
								○ UNCONFINED + FIELD VANE						
								● QUICK TRIAXIAL × LAB VANE						
317.92	GROUND SURFACE							20 40 60 80 100					kN/m ³	GR SA SI CL
0.00	TOPSOIL, silty													
0.18	Brown													
	FILL, silty fine sand, trace topsoil, trace gravel													
316.94	Compact		1	SS	17		317							
0.98	Brown													
316.55	CLAYEY SILT, trace sand													
1.37	Very stiff													
	Brown													
	SILT, trace sand, trace clay		2	SS	21		316							
	Compact to dense													
	Brown													
			3	SS	18		315							
			4	SS	31		314							
314.26														
3.66	CLAYEY SILT, with silt layers		5	SS	8		313							
	Stiff													
	Brown to grey below about elev. 314.0m													0 4 64 32
313.10			6	SS	28		312							
4.82	SILT, trace sand, trace gravel, with clayey silt layers													
312.74	Dense													
5.18	Grey		7	SS	9		311							
	CLAYEY SILT, trace sand, trace gravel, silt layers		8	SS	7		310							
	Firm to stiff													
	Grey		9	SS	11		309							
			10	SS	11		308							
309.69														
8.23	SILT, some clay, trace sand, with clayey silt layers		11	SS	24		307							
	Compact to dense													
	Grey													
			12	SS	43		306							
306.87							305							
11.05	CLAYEY SILT, with silt layers		13	SS	39		304							
	Very stiff to hard													
	Grey													
			14	SS	37		303							
			15	SS	26									

Continued Next Page

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

LDN_MTO_06 08-1132-084-1.GPJ LDN_MTO.GDT 06/01/11

RECORD OF BOREHOLE No 508

2 OF 3

METRIC

PROJECT 08-1132-084-1

W.P. 131-98-00

LOCATION N 4810505.3 ; E 225954.1

ORIGINATED BY DB

DIST HWY 7/8

BOREHOLE TYPE POWER AUGER / ROTARY DRILLING / NW CASING

COMPILED BY LMK

DATUM GEODETIC

DATE March 26, 2009 - March 30, 2009

CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
							20 40 60 80 100			10 20 30				

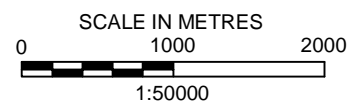
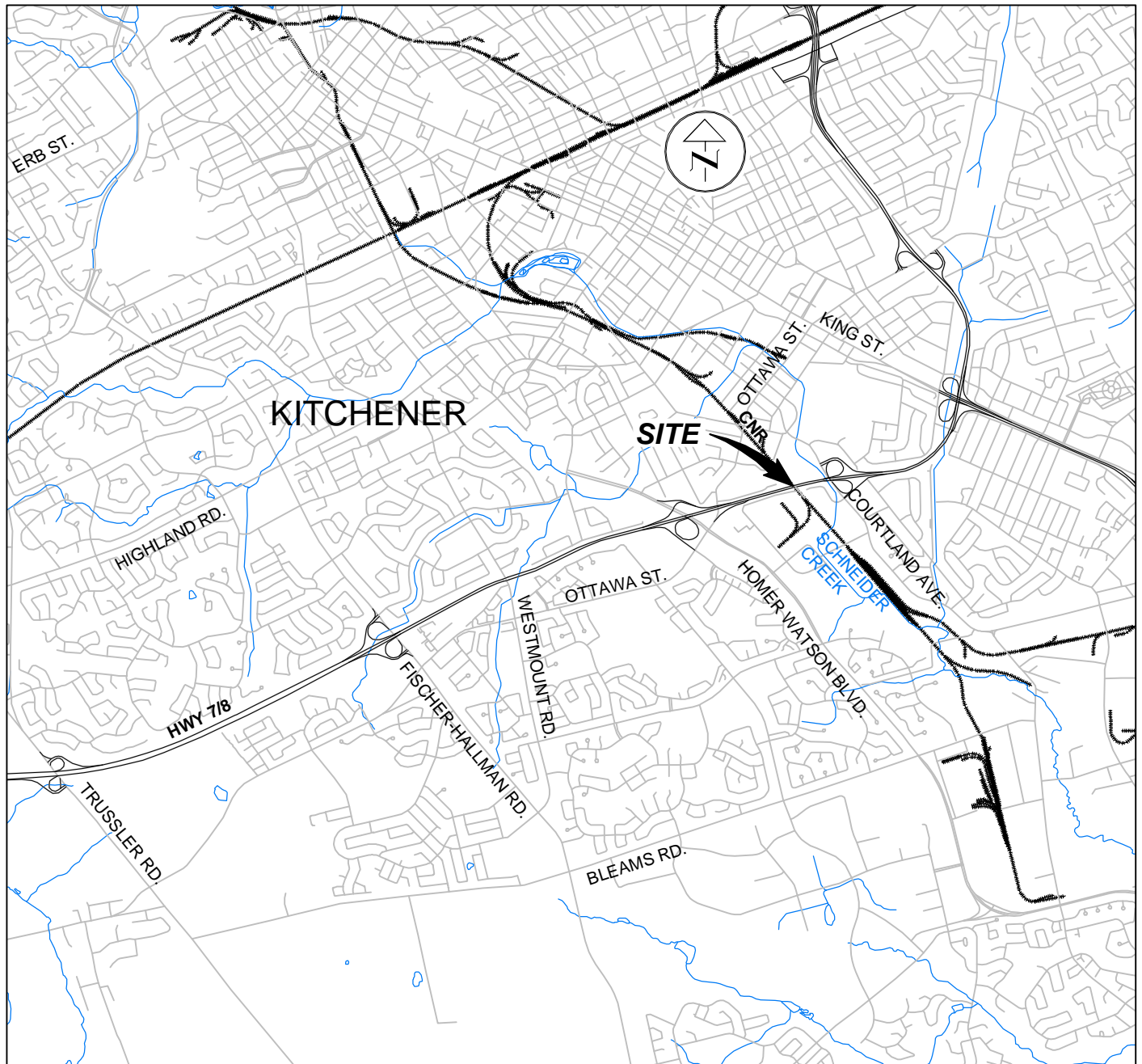
Continued Next Page

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

PROJECT <u>08-1132-084-1</u>		RECORD OF BOREHOLE No 508		3 OF 3	METRIC
W.P. <u>131-98-00</u>	LOCATION <u>N 4810505.3 ; E 225954.1</u>	ORIGINATED BY <u>DB</u>			
DIST <u> </u> HWY <u>7/8</u>	BOREHOLE TYPE <u>POWER AUGER / ROTARY DRILLING / NW CASING</u>	COMPILED BY <u>LMK</u>			
DATUM <u>GEODETIC</u>	DATE <u>March 26, 2009 - March 30, 2009</u>	CHECKED BY <u> </u>			

SOIL PROFILE		SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W _p	W	W _L		
287.78 30.14	END OF BOREHOLE Groundwater encountered at about elev. 316.5m during drilling on March 26, 2009.	N	3	25	SS	100/ 125mm											

LDN_MTO_06 08-1132-084-1.GPJ LDN_MTO.GDT 06/01/11



REFERENCE

DRAWING BASED ON CANMAP STREETFILES V2005.4.

NOTE

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

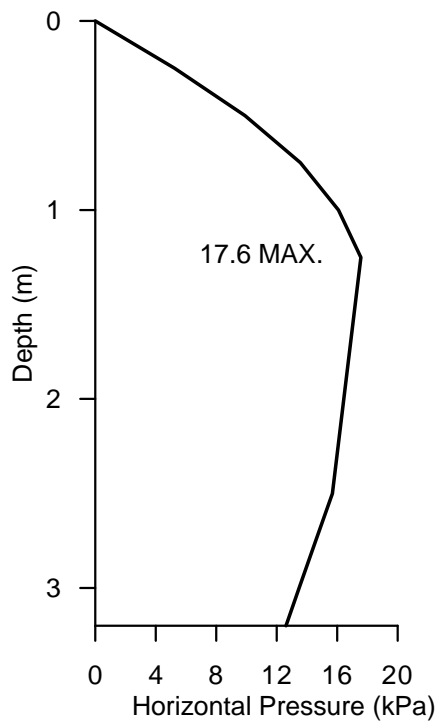
PROJECT
CANADIAN NATIONAL RAILWAY OVERHEAD (SITE 33-225)
WIDENING OF HIGHWAY 7/8
GWP 131-98-00

TITLE

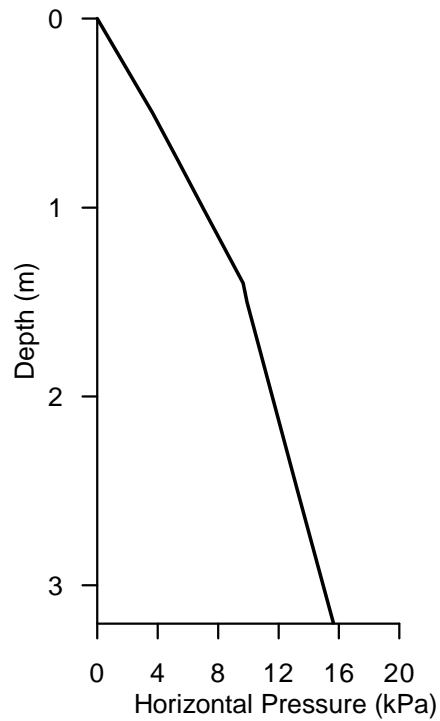
KEY PLAN



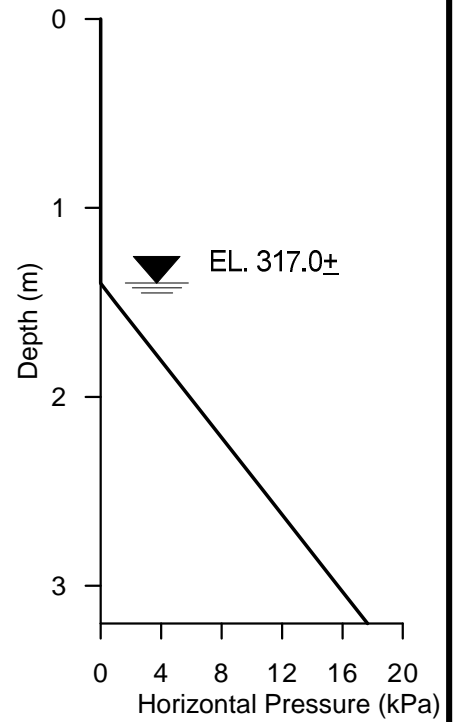
PROJECT No.		08-1132-084-1	FILE No.		0811320841-F05001
CADD	WDF/LMK	Sept. 23/09	SCALE	AS SHOWN	REV.
CHECK			FIGURE 1		




COOPER E-90 LIVE LOAD

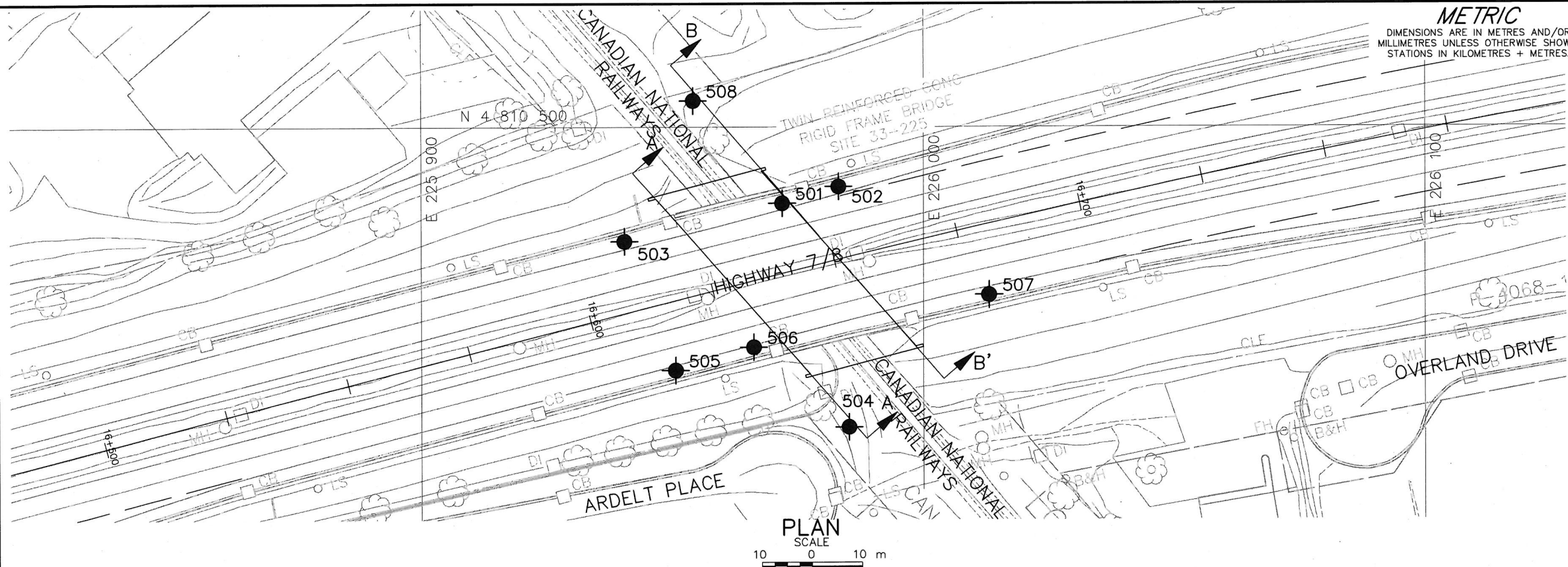


FILL & NATIVE SOILS



GROUNDWATER

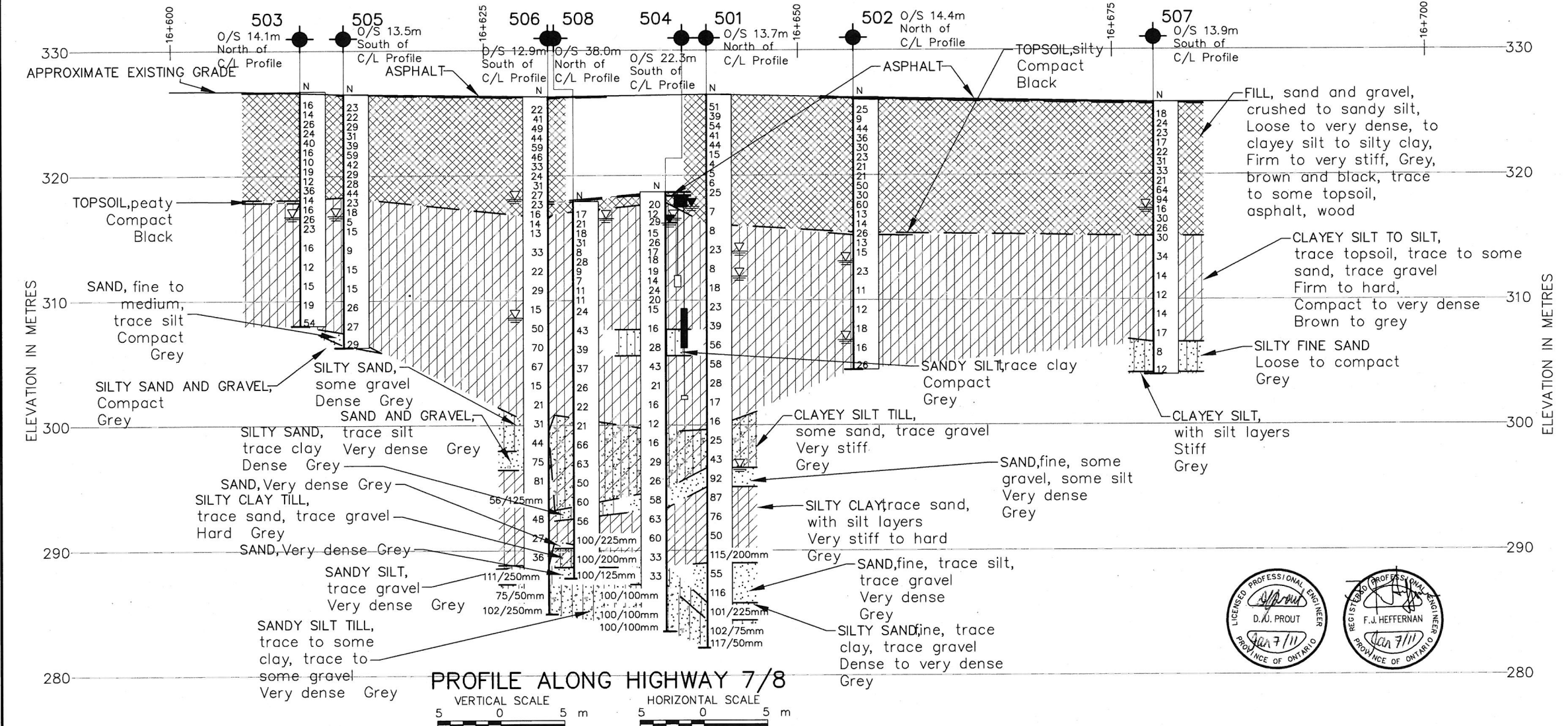
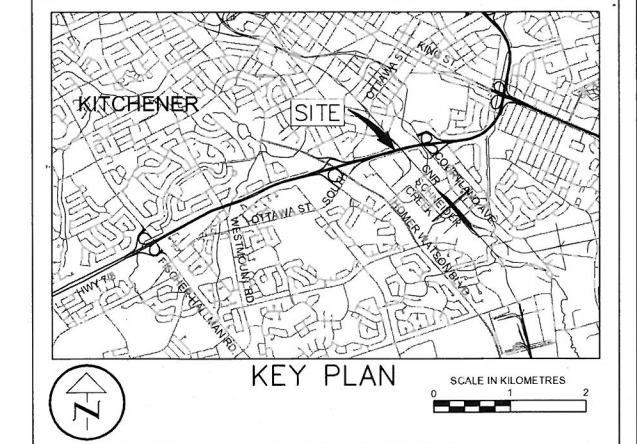
PROJECT CANADIAN NATIONAL RAILWAY OVERHEAD (SITE 33-225) WIDENING OF HIGHWAY 7/8 GWP 131-98-00			
TITLE DESIGN EARTH PRESSURES FOR TRACK PROTECTION			
	PROJECT No.	08-1132-084-1	FILE No. 0811320841-F05002
	DRAWN	MK	Aug. 27/09
	CHECK		
			SCALE AS SHOWN REV. 0
FIGURE 2			



CONT No.
 WP No. 131-98-00

CANADIAN NATIONAL RAILWAY
 OVERHEAD
 HIGHWAY 7/8 WIDENING
 BOREHOLE LOCATIONS & SOIL STRATA

SHEET



LEGEND

- Borehole - Current Investigation
- ⊥ Seal
- ⊥ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- DRY Borehole dry during drilling
- ≡ WL upon completion of drilling
- ≡ WL in piezometer (June 18, 2009)

No.	ELEVATION	CO-ORDINATES (MTM ZONE 10)	
		NORTHING	EASTING
501	326.49	4 810 484.7	225 971.9
502	326.23	4 810 488.1	225 983.2
503	326.75	4 810 477.1	225 940.5
504	318.68	4 810 439.8	225 985.2
505	326.53	4 810 451.2	225 950.6
506	326.32	4 810 455.9	225 966.2
507	325.80	4 810 466.3	226 013.0
508	317.92	4 810 505.3	225 954.1

NOTES

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

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

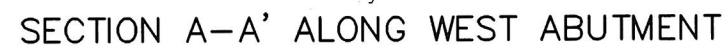
Stratigraphy has been simplified for clarity. Please refer to Record of Boreholes and Sections for further detail.

REFERENCE

Base plans provided in digital format by Dillon Consulting.

NO.	DATE	BY	REVISION
1	7/8	LMK	PROJECT NO. 08-1132-084-1 DIST.
2	7/8	LMK	DATE: Sept. 28/09 SITE: 33-225
3	7/8	LMK	APPD. 7/11 DWG. 1





VERTICAL SCALE HORIZONTAL SCALE

5 0 5 m 5 0 5 m

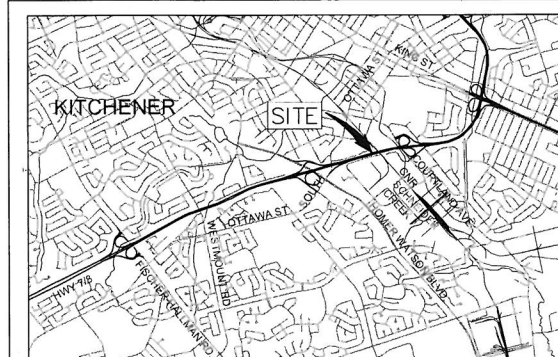
CONT No.
WP No. 131-98-00

CANADIAN NATIONAL RAILWAY
OVERHEAD
HIGHWAY 7/8 WIDENING
SOIL STRATA

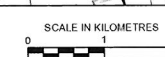
SHEET








Golder Associates Ltd.
LONDON, ONTARIO, CANADA



KEY PLAN



LEGEND

- | | |
|---|--|
|  | Borehole – Current Investigation |
|  | Seal |
|  | Piezometer |
| N | Standard Penetration Test Value |
| 16 | Blows/0.3m unless otherwise stated
(Std. Pen. Test, 475 j/blow) |
| DRY | Borehole dry during drilling |
|  | WL upon completion of drilling |
|  | WL in piezometer (June 18, 2009) |

No.	ELEVATION	CO—ORDINATES (MTM ZONE 10)	
		NORTHING	EASTING
501	326.49	4 810 484.7	225 971.9
502	326.23	4 810 488.1	225 983.2
504	318.68	4 810 439.8	225 985.2
506	326.32	4 810 455.9	225 966.2
507	325.80	4 810 466.3	226 013.0
508	317.92	4 810 505.3	225 954.1

NOTES

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

REFERENCE

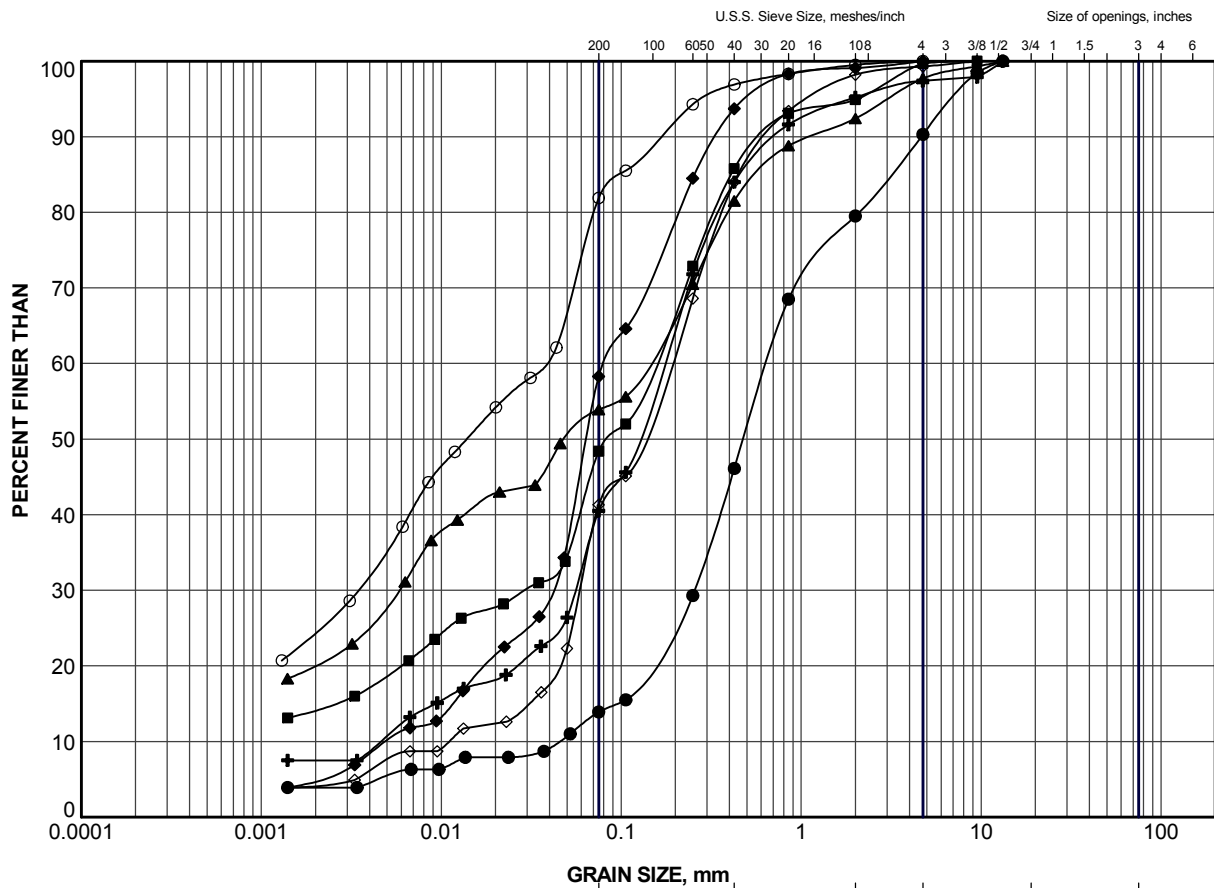
Base plans provided in digital format by Dillon Consulting.

NO.	DATE	BY	REVISION
Geocres No. 40P8-175			
HWY. 7/8		PROJECT NO. 08-1132-084-1	DIST.
SUBM'D. DUP	CHKD.	DATE: Sept. 25/09	SITE: 33-225
DRAWN: LMK	CHKD.	APPD. <i>gar</i> 7/11	DWG. 2



APPENDIX A

Laboratory Test Data



CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	501	3	324.0
■	501	7	320.9
▲	501	10	318.6
+	502	3	323.7
◆	502	4	323.0
◇	502	9	319.1
○	502	13	316.1

PROJECT
CANADIAN NATIONAL RAILWAY OVERHEAD (SITE 33-225)
WIDENING OF HIGHWAY 7/8
GWP 131-98-00

TITLE

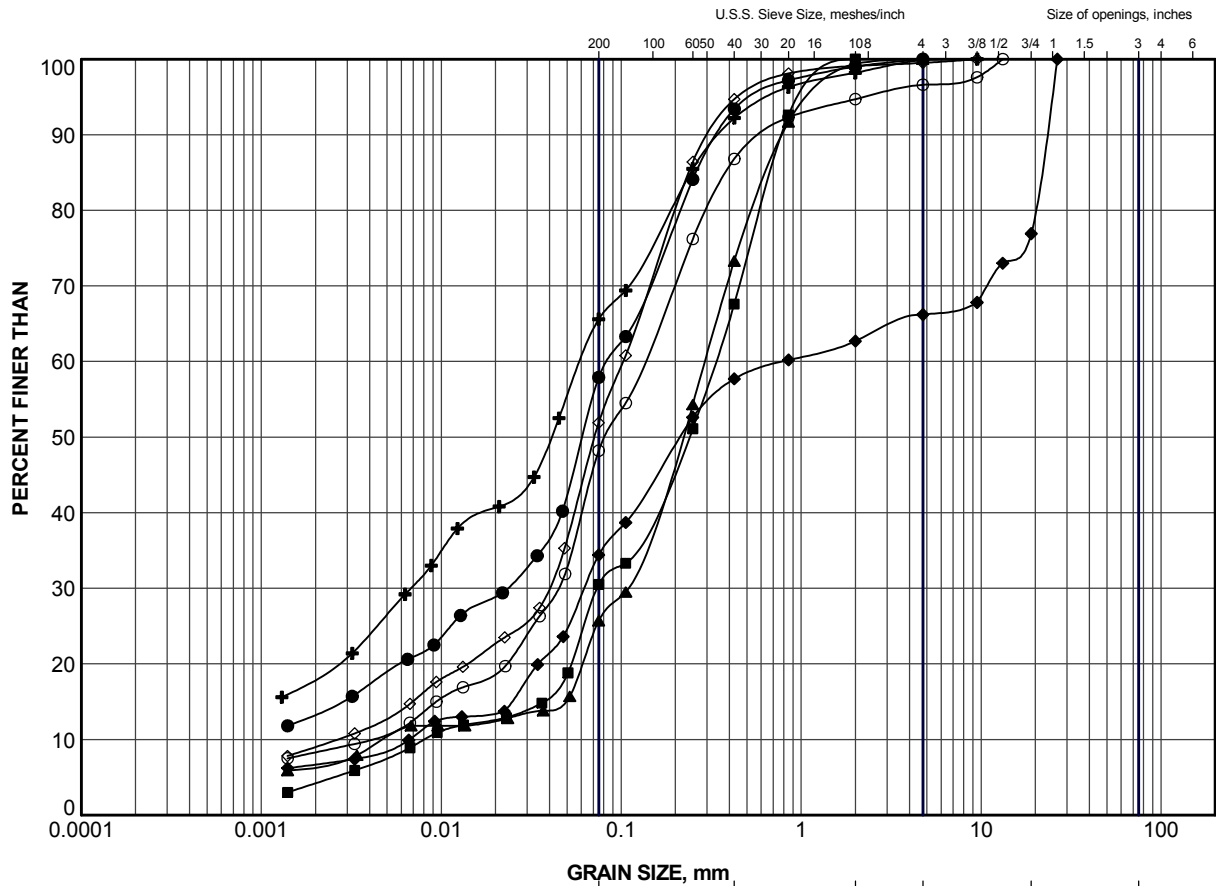
GRAIN SIZE DISTRIBUTION FILL



**Golder
Associates**
LONDON, ONTARIO

PROJECT No.	08-1132-084-1	FILE No.	0811320841-R050A1
DRAWN	LMK	Sep 23/09	SCALE N/A REV.
CHECK			

FIGURE A-1



CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	503	3	324.2
■	503	8	320.4
▲	503	9	319.7
+	505	2	324.8
◆	505	7	321.0
◇	507	3	323.3
○	507	11	317.2

PROJECT
CANADIAN NATIONAL RAILWAY OVERHEAD (SITE 33-225)
WIDENING OF HIGHWAY 7/8
GWP 131-98-00

TITLE

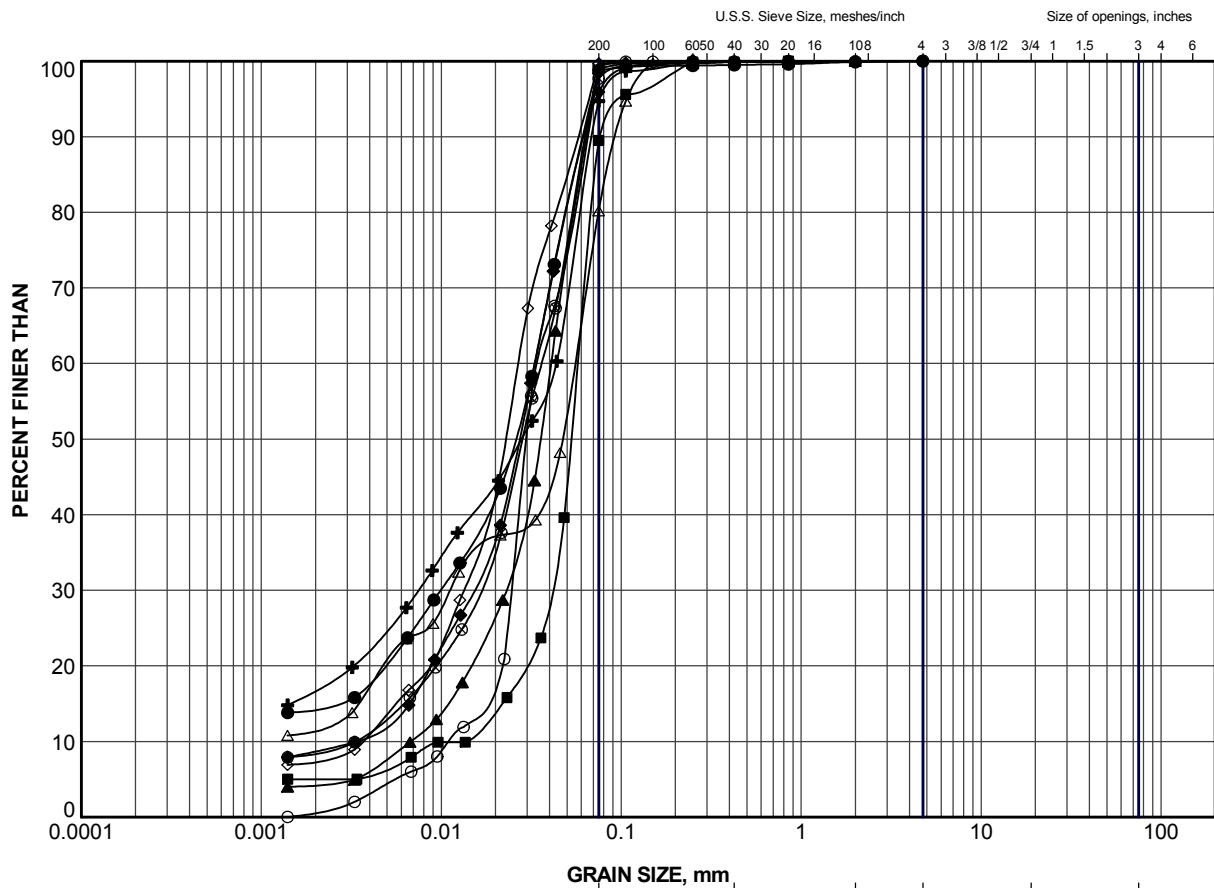
GRAIN SIZE DISTRIBUTION FILL



**Golder
Associates**
LONDON, ONTARIO

PROJECT No.	08-1132-084-1	FILE No.	0811320841-R050A2
DRAWN	LMK	Sep 23/09	SCALE N/A REV.
CHECK			

FIGURE A-2



GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	501	15	311.0
■	501	18	306.5
▲	502	17	312.3
+	503	14	315.9
◆	504	6	313.9
◇	504	15	304.7
○	506	15	313.9
△	506	19	307.8
⊗	507	15	313.4

PROJECT
CANADIAN NATIONAL RAILWAY OVERHEAD (SITE 33-225)
WIDENING OF HIGHWAY 7/8
GWP 131-98-00

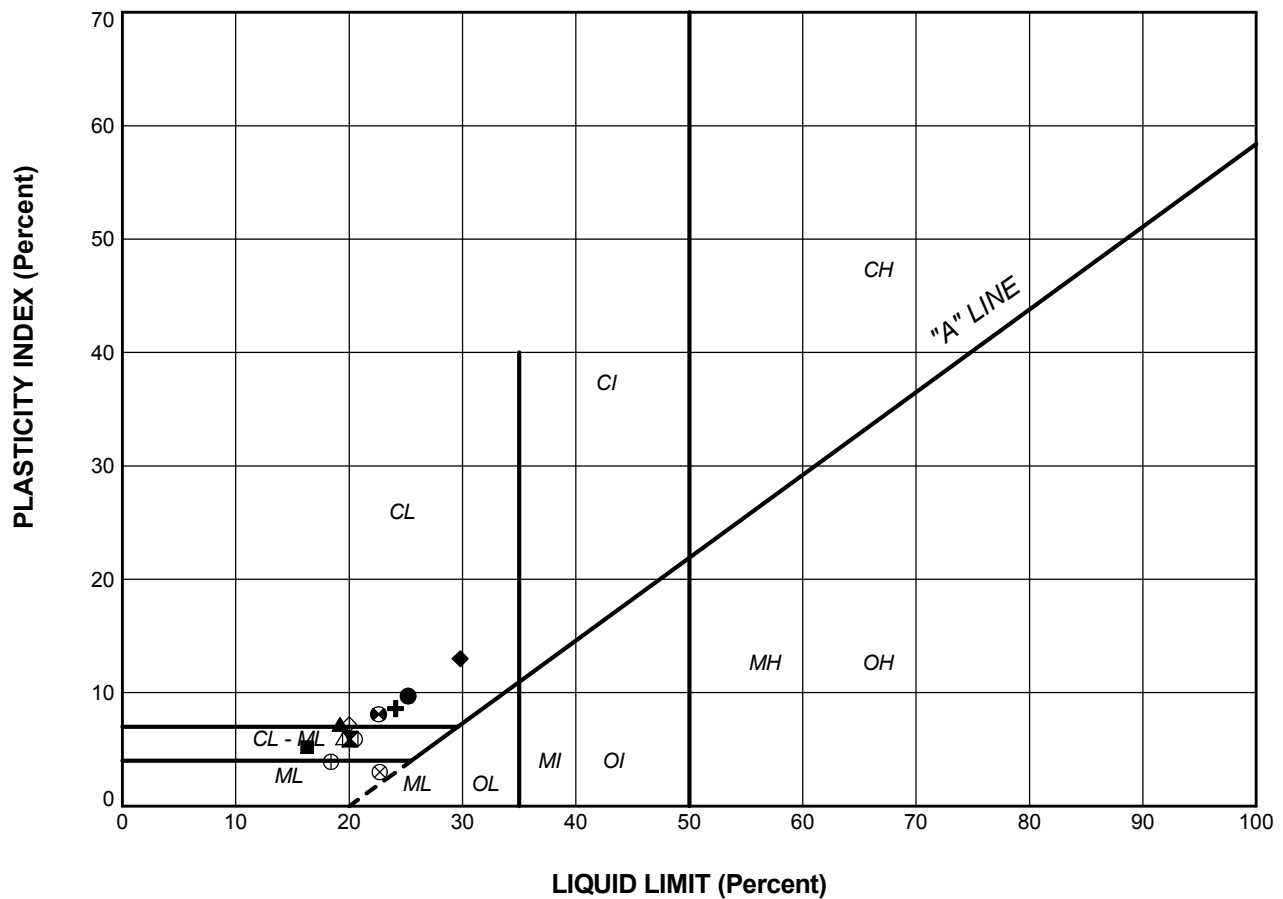
TITLE

GRAIN SIZE DISTRIBUTION SILT



PROJECT No.	08-1132-084-1	FILE No.	0811320841-R050A3
DRAWN	LMK	Sep 14/09	SCALE N/A REV.
CHECK			

FIGURE A-3



LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
FILL					
◇	409	8	20.0	12.8	7.2
SILT					
■	402	11	16.3	11.1	5.2
△	411	11	19.5	13.5	6.0
CLAYEY SILT					
●	401	9	25.2	15.5	9.7
▲	403	8	19.2	12.0	7.2
+	405	15	24.1	15.5	8.6
◆	406	18	29.8	16.8	13.0
○	409	15	20.5	14.6	5.9
⊗	411	13	22.7	19.7	3.0
⊠	411	14	20.1	14.2	5.9
⊕	412	6	18.4	14.5	3.9
⊙	413	6	22.6	14.5	8.1

PROJECT **COURTLAND AVENUE OVERPASS (SITE 33-224)**
WIDENING OF HIGHWAY 7/8
GWP 131-98-00

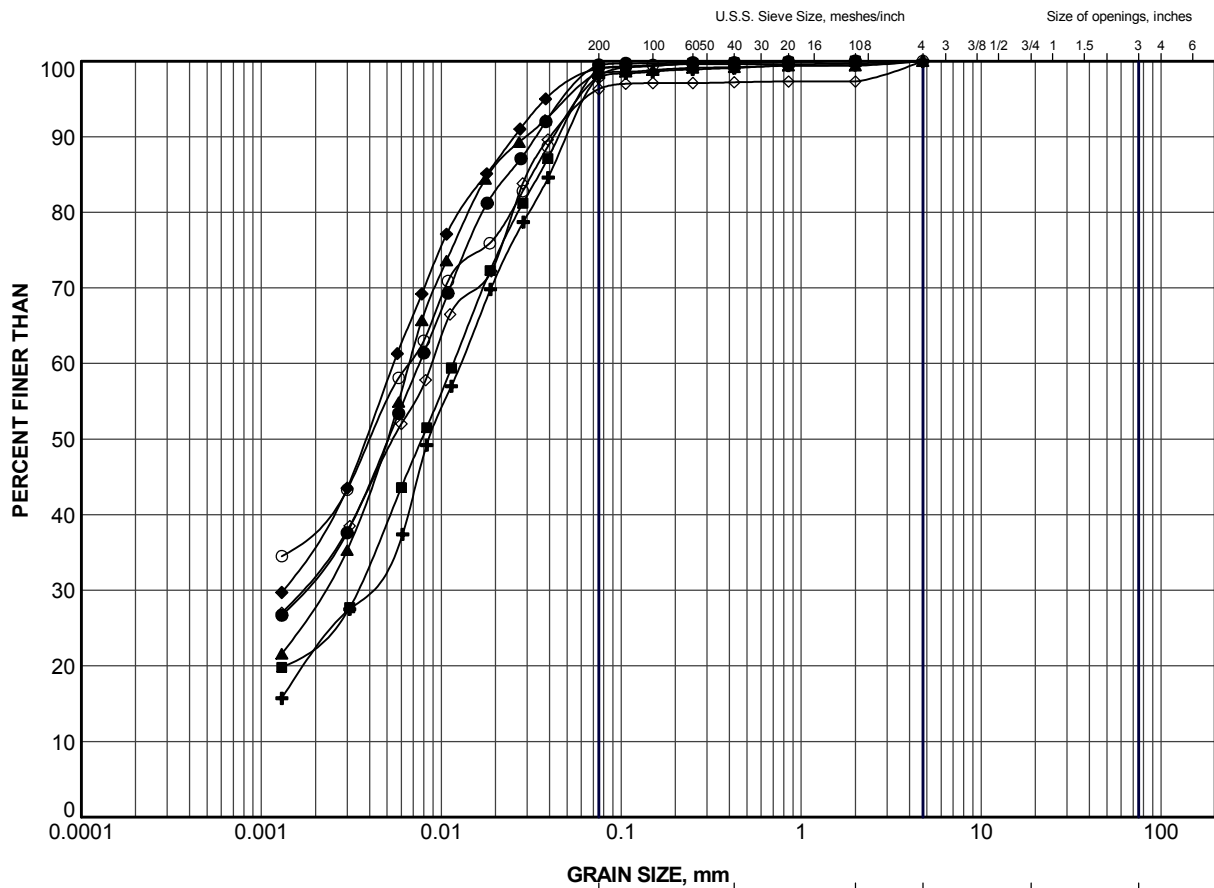
TITLE

PLASTICITY CHART



PROJECT No.	08-1132-084-1	FILE No.	0811320841-R040A4
DRAWN	DCH	Aug 24/09	SCALE N/A REV.
CHECK			

FIGURE A-4



CLAY AND SILT	GRAVEL SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	505	14	315.6
■	505	17	311.1
▲	506	13	316.2
+	506	16	312.4
◆	507	18	308.8
◇	508	5	313.9
○	508	13	306.1

PROJECT
CANADIAN NATIONAL RAILWAY OVERHEAD (SITE 33-225)
WIDENING OF HIGHWAY 7/8
GWP 131-98-00

TITLE

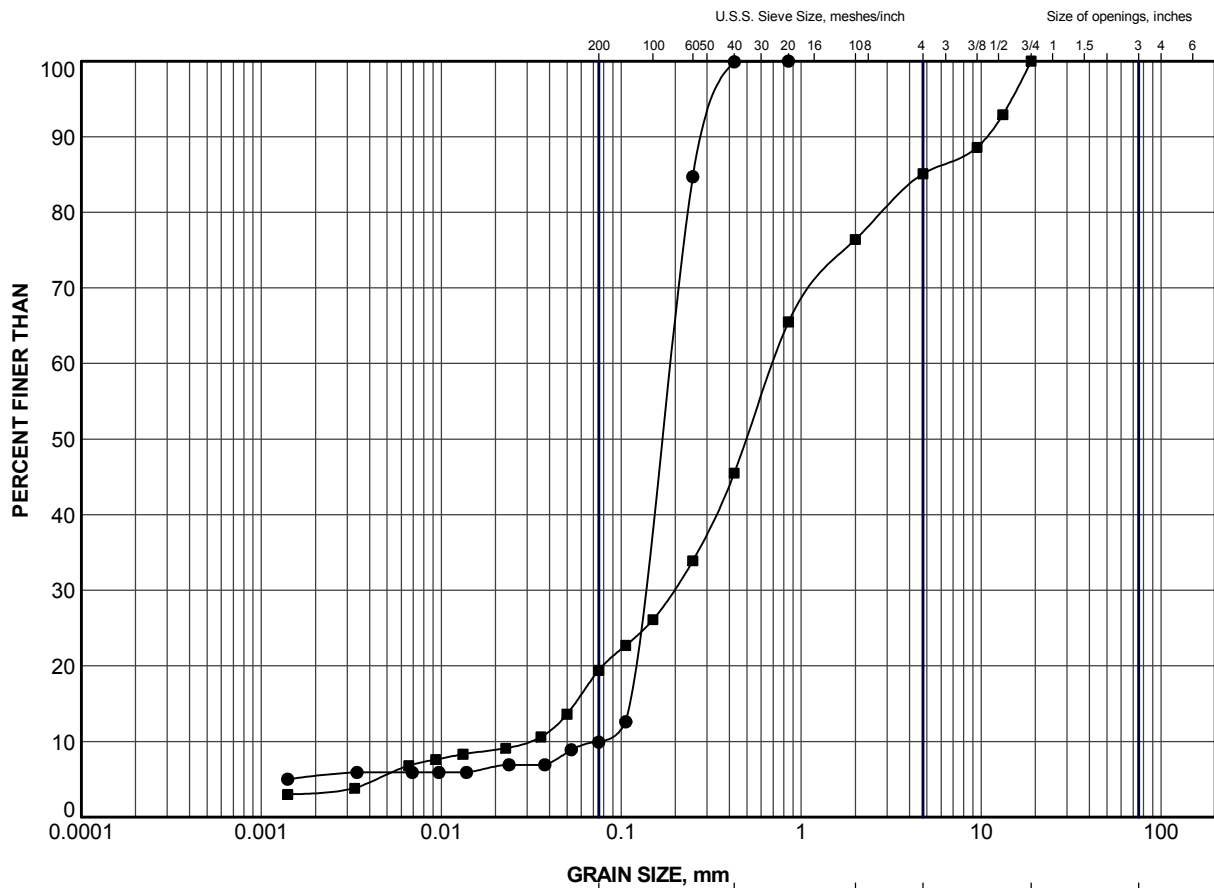
GRAIN SIZE DISTRIBUTION CLAYEY SILT



**Golder
Associates**
LONDON, ONTARIO

PROJECT No.	08-1132-084-1	FILE No.	0811320841-R050A5
DRAWN	LMK	Sep 14/09	SCALE N/A REV.
CHECK			


FIGURE A-5

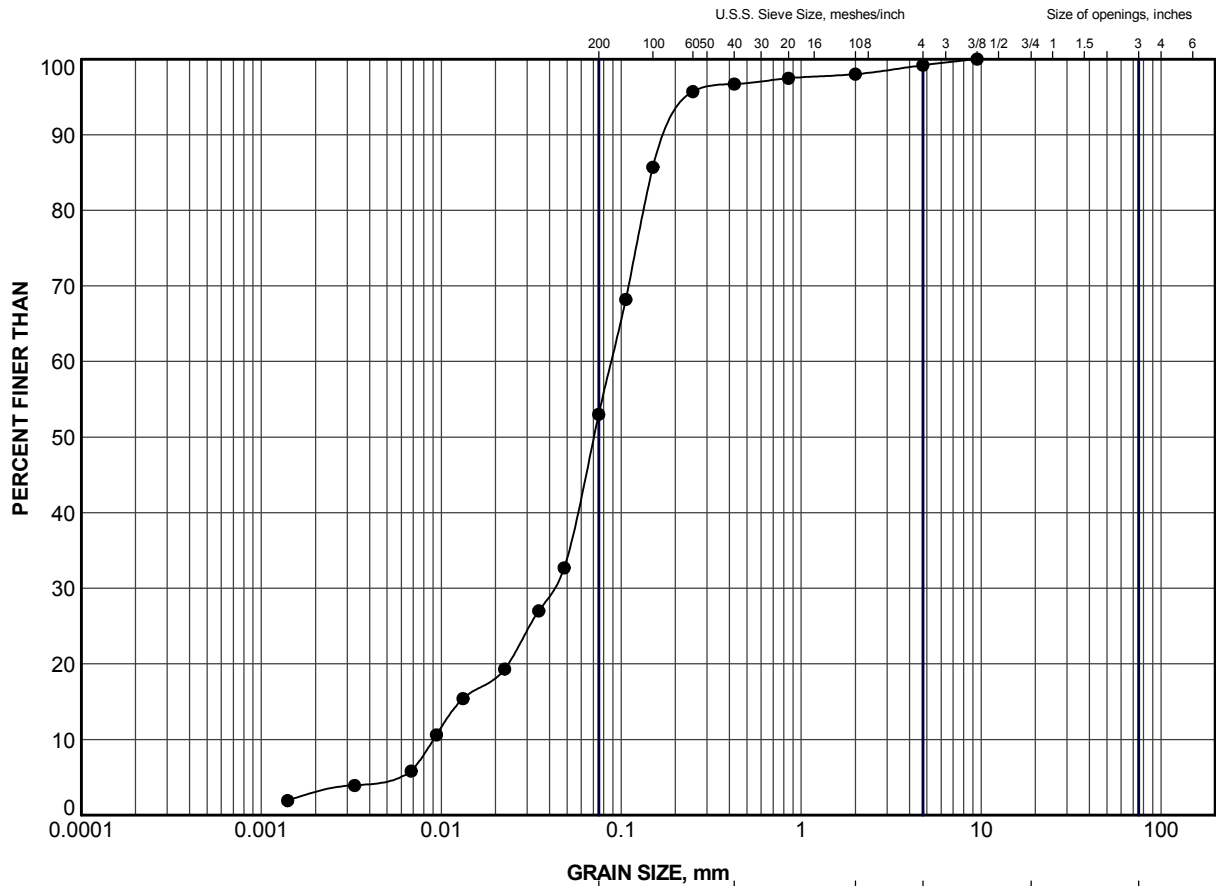


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	501	30	288.2
■	504	22	294.1

PROJECT CANADIAN NATIONAL RAILWAY OVERHEAD (SITE 33-225) WIDENING OF HIGHWAY 7/8 GWP 131-98-00				
TITLE GRAIN SIZE DISTRIBUTION SAND				
PROJECT No. 08-1132-084-1		FILE No. 0811320841-R050A6		
DRAWN	LMK	Jul 24/09	SCALE	N/A
CHECK			REV.	
 Golder Associates LONDON, ONTARIO			FIGURE A-6	

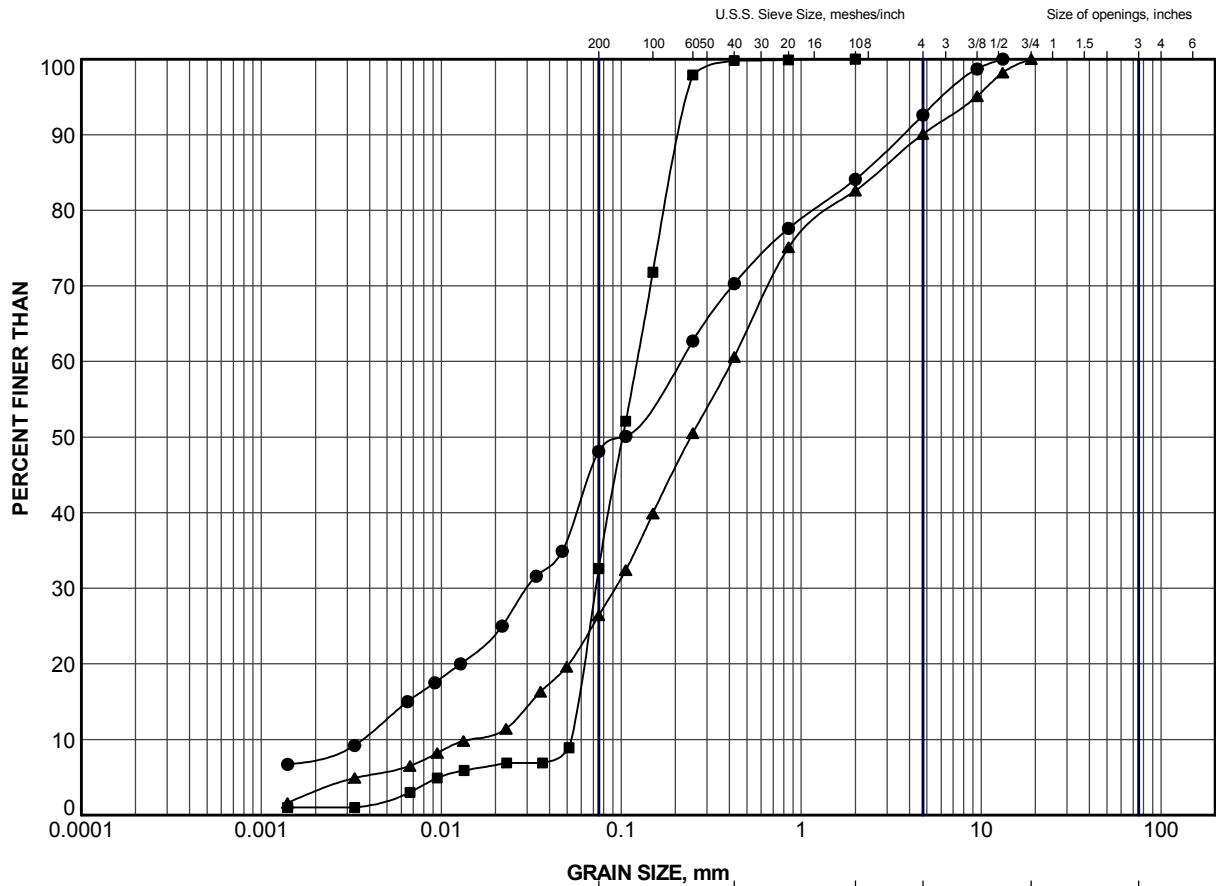


CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	506	32	288.0

PROJECT CANADIAN NATIONAL RAILWAY OVERHEAD (SITE 33-225) WIDENING OF HIGHWAY 7/8 GWP 131-98-00			
TITLE GRAIN SIZE DISTRIBUTION SANDY SILT			
 Golder Associates LONDON, ONTARIO	PROJECT No. 08-1132-084-1		FILE No. 0811320841-R050A7
	DRAWN LMK	Jul 20/09	SCALE N/A REV.
	CHECK		FIGURE A-7


LDN_MTO_NEW_GLDR_LDN.GDT

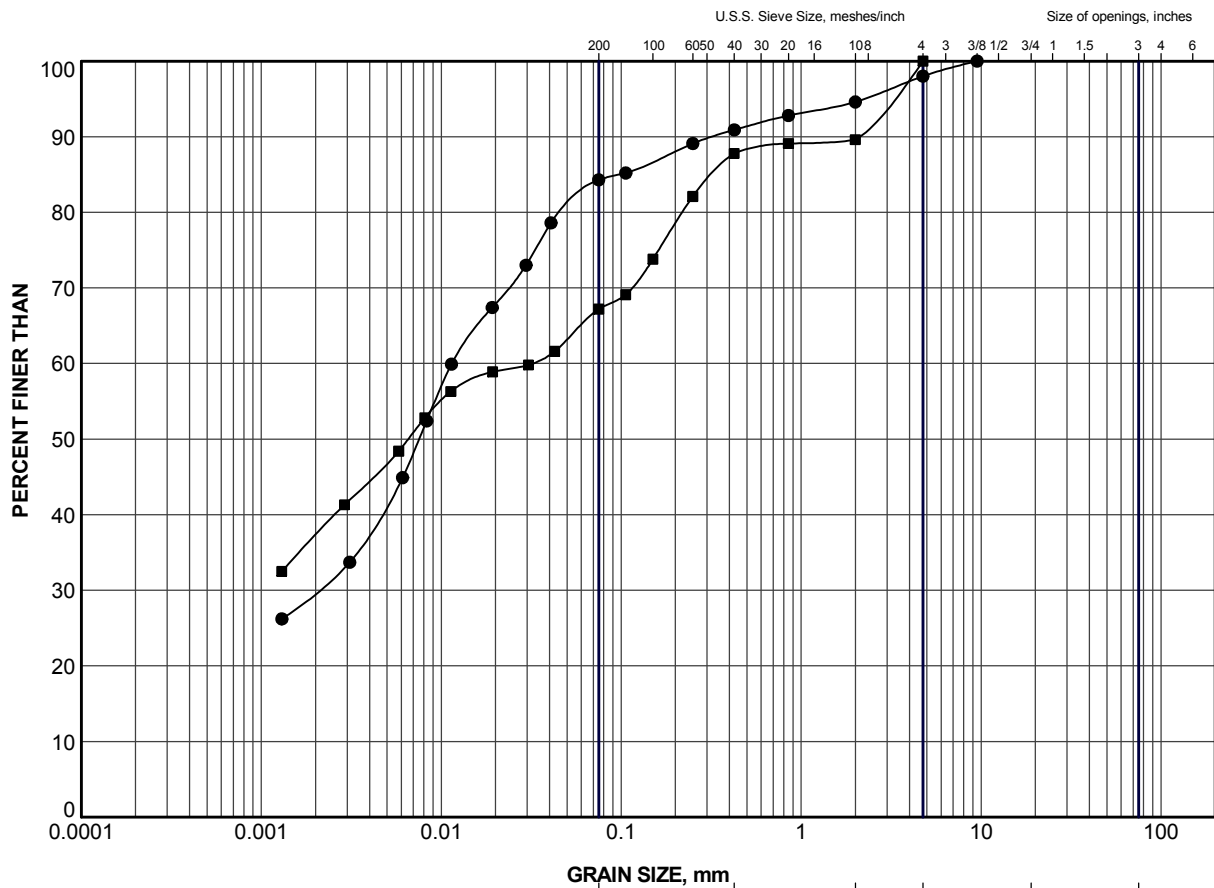


CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	501	32	285.2
■	504	26	288.0
▲	506	25	298.7


PROJECT				
CANADIAN NATIONAL RAILWAY OVERHEAD (SITE 33-225)				
WIDENING OF HIGHWAY 7/8				
GWP 131-98-00				
TITLE				
GRAIN SIZE DISTRIBUTION				
SILTY SAND				
PROJECT No.		08-1132-084-1		FILE No.
				0811320841-R050A8
DRAWN	LMK	Jul 24/09	SCALE	N/A
CHECK			REV.	
 Golder Associates LONDON, ONTARIO			FIGURE A-8	

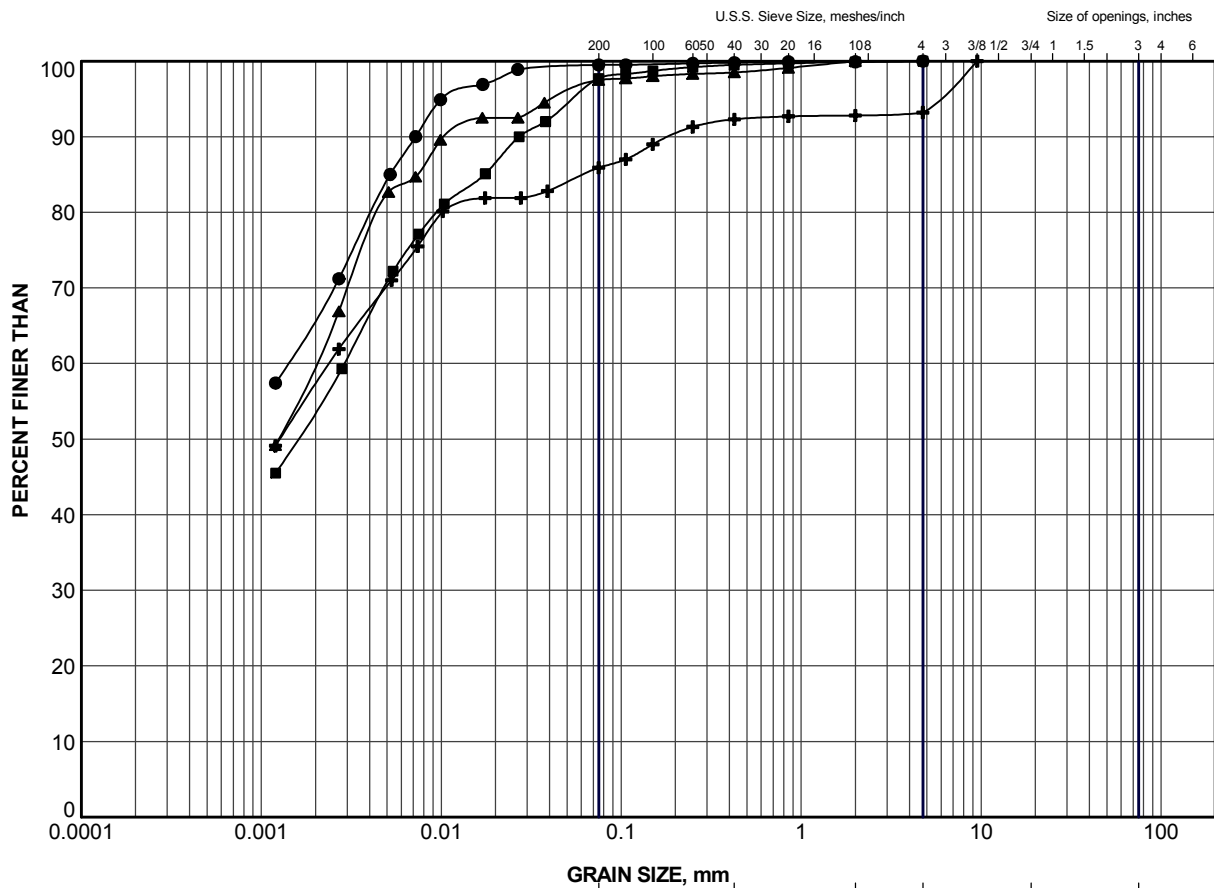


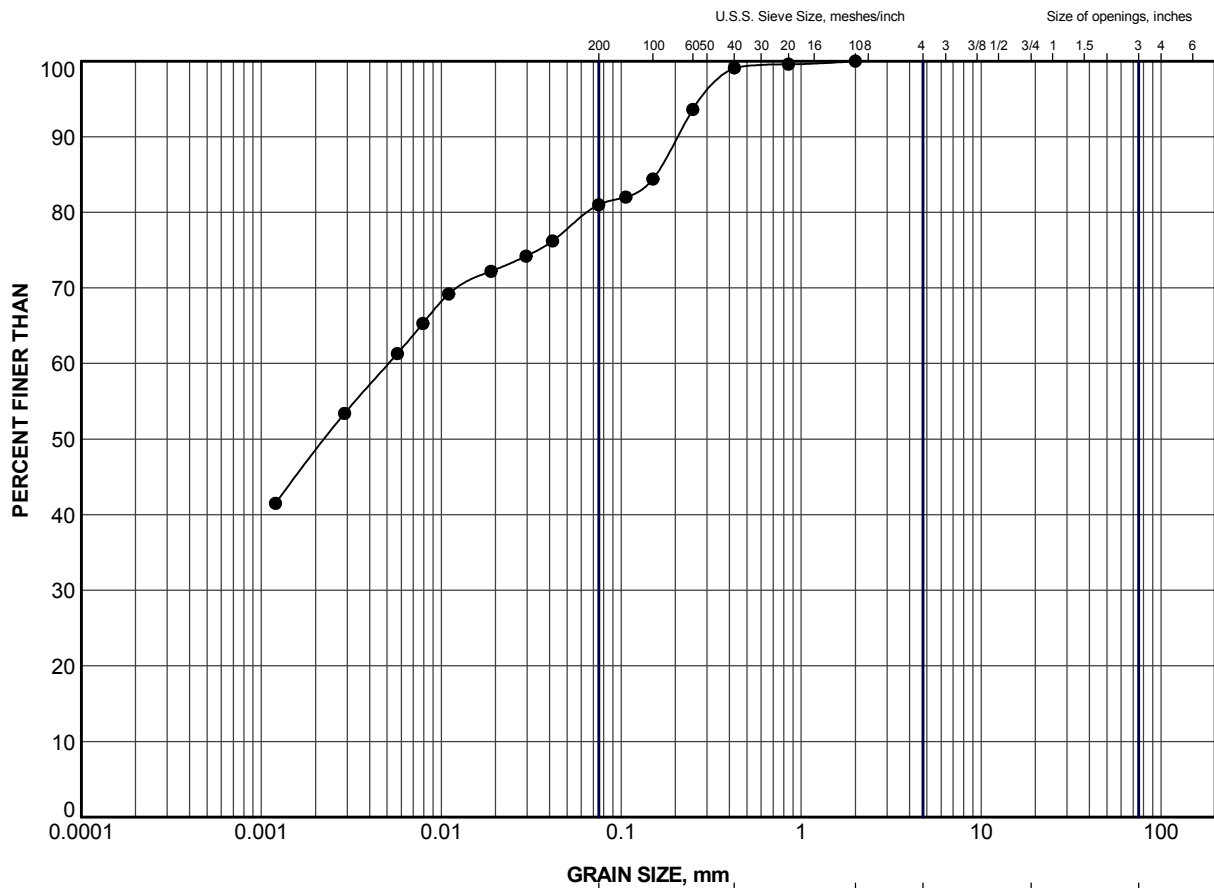
GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	501	23	298.8
■	508	19	297.0

PROJECT CANADIAN NATIONAL RAILWAY OVERHEAD (SITE 33-225) WIDENING OF HIGHWAY 7/8 GWP 131-98-00					
TITLE GRAIN SIZE DISTRIBUTION CLAYEY SILT TILL					
 Golder Associates LONDON, ONTARIO	PROJECT No.	08-1132-084-1	FILE No.	0811320841-R050A9	
	DRAWN	LMK	Jul 20/09	SCALE	N/A
	CHECK			REV.	
			FIGURE A-9		




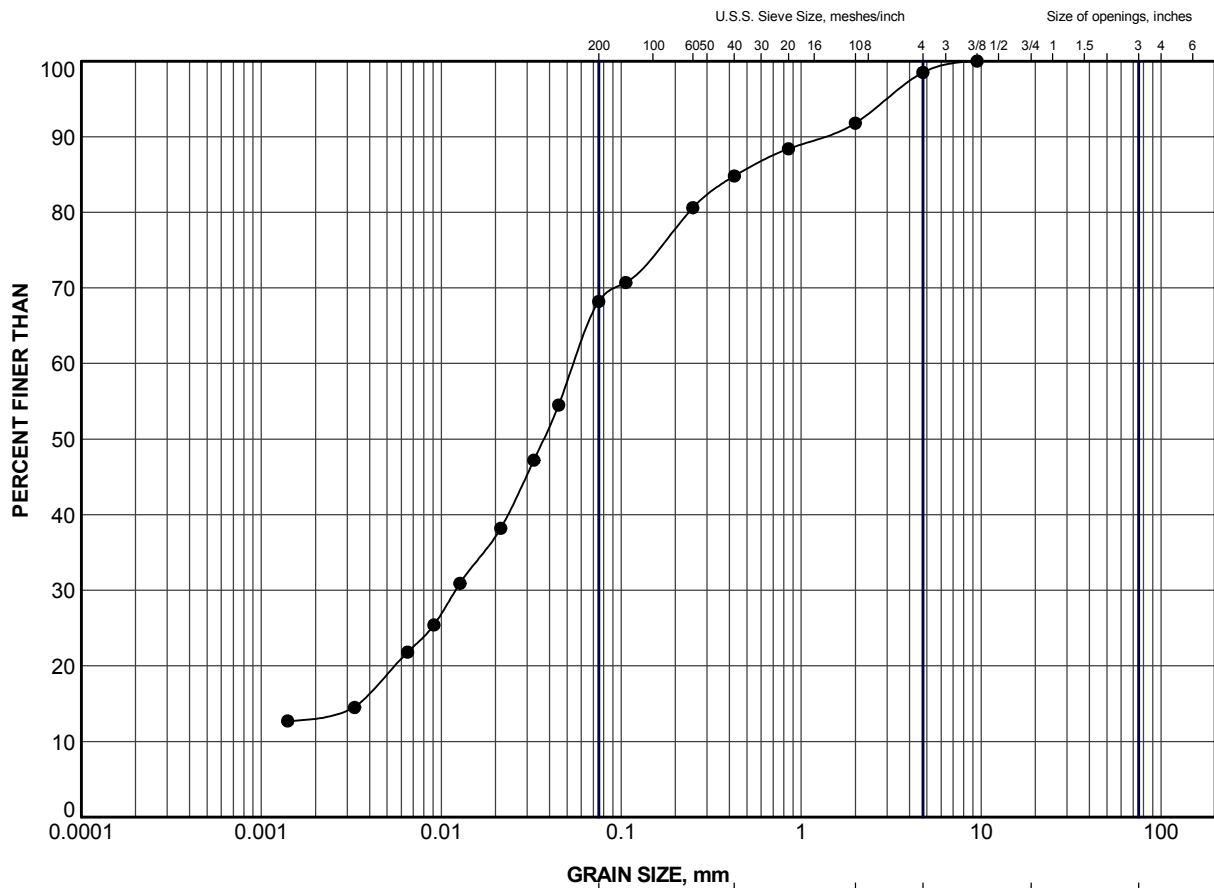


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	508	24	289.4

PROJECT				CANADIAN NATIONAL RAILWAY OVERHEAD (SITE 33-225)			
				WIDENING OF HIGHWAY 7/8			
				GWP 131-98-00			
TITLE							
GRAIN SIZE DISTRIBUTION							
SILTY CLAY TILL							
 Golder Associates LONDON, ONTARIO		PROJECT No.		08-1132-084-1		FILE No. 0811320841-R050A11	
		DRAWN		LMK		Jul 20/09	
		CHECK					
				SCALE		N/A	
				REV.			
FIGURE A-11							



CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	501	33	283.8

PROJECT

CANADIAN NATIONAL RAILWAY OVERHEAD (SITE 33-225)
WIDENING OF HIGHWAY 7/8
GWP 131-98-00

TITLE

GRAIN SIZE DISTRIBUTION
SANDY SILT TILL

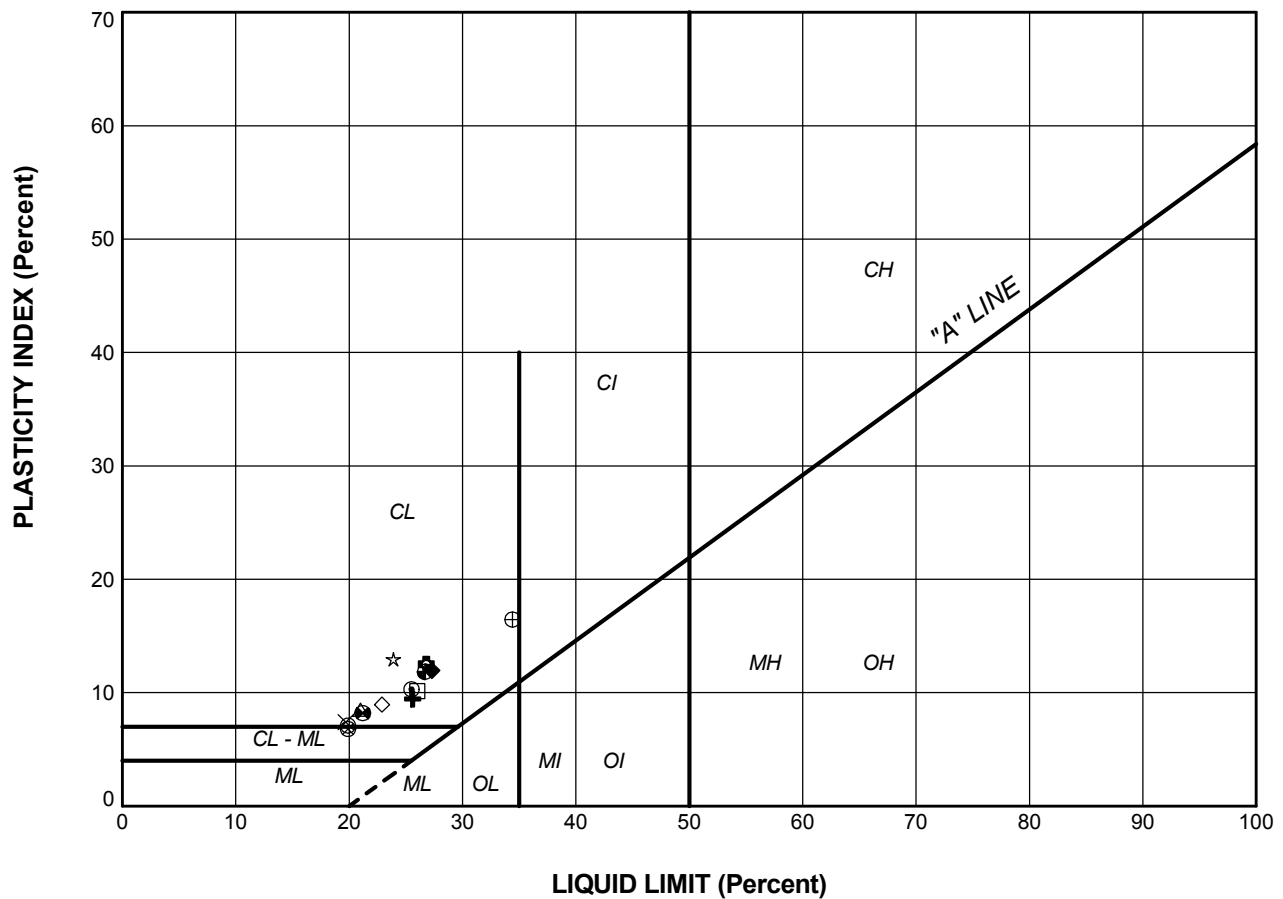
Golder

Associates

LONDON, ONTARIO


PROJECT No.	08-1132-084-1	FILE No.	0811320841-R050A12
DRAWN	LMK	Jul 24/09	SCALE N/A REV.
CHECK			

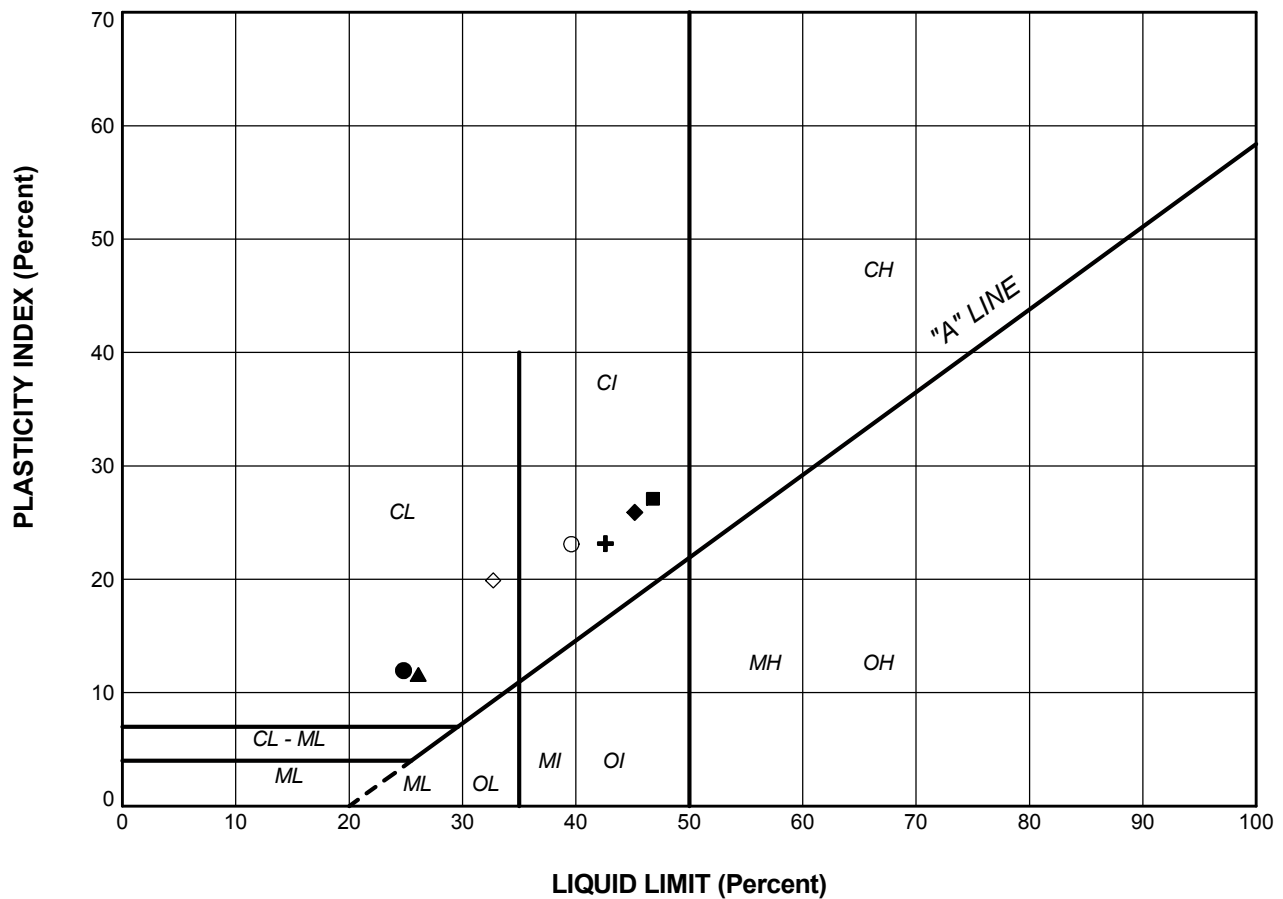
FIGURE A-12



LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
CLAYEY SILT					
+	502	15	25.6	16.2	9.5
◆	502	16	27.3	15.4	12.0
◇	502	19	22.9	14.0	9.0
○	503	17	19.9	12.8	7.1
△	503	18	21.0	12.5	8.5
⊗	504	12	19.9	13.1	6.8
⊕	504	18	34.4	18.0	16.5
□	505	14	26.0	15.9	10.2
⊙	505	17	21.2	13.0	8.2
⊗	506	13	26.7	14.9	11.9
☆	506	16	23.9	11.0	13.0
⊙	507	18	25.5	15.2	10.3
⊕	508	5	26.8	14.3	12.5
×	508	13	19.7	12.3	7.4

PROJECT			
CANADIAN NATIONAL RAILWAY OVERHEAD (SITE 33-225) WIDENING OF HIGHWAY 7/8 GWP 131-98-00			
TITLE			
PLASTICITY CHART (CLAYEY SILT)			
PROJECT No. 08-1132-084-1		FILE No. 0811320841-R050A13	
DRAWN	LMK	Sep 23/09	SCALE N/A REV.
CHECK			
 Golder Associates LONDON, ONTARIO			FIGURE A-13



LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
CLAYEY SILT TILL					
●	501	23	24.8	12.9	12.0
◇	508	19	32.7	12.8	19.9
SILTY CLAY					
■	501	27	46.8	19.7	27.1
+	506	28	42.6	19.5	23.2
◆	506	31	45.2	19.3	25.9
○	508	23	39.6	16.5	23.1
FILL					
▲	502	13	26.1	14.5	11.6

PROJECT
 CANADIAN NATIONAL RAILWAY OVERHEAD (SITE 33-225)
 WIDENING OF HIGHWAY 7/8
 GWP 131-98-00

TITLE

PLASTICITY CHART



PROJECT No.	08-1132-084-1	FILE No.	0811320841-R050A14
DRAWN	LMK	SCALE	N/A
CHECK		REV.	

FIGURE A-14



APPENDIX B

Site Photographs



APPENDIX B SITE PHOTOGRAPHS



Photograph 1: Highway 7/8 CNR overhead. View of deck EBL looking east.



Photograph 2: Highway 7/8 CNR overhead deck, westbound lanes looking northeast from median.



APPENDIX B SITE PHOTOGRAPHS



Photograph 3: South elevation CNR overhead (EBL).



Photograph 4: North elevation CNR overhead (WBL).



APPENDIX B SITE PHOTOGRAPHS



Photograph 5: Movement of joint of retaining wall 'D' at southwest corner of CNR overhead structure.

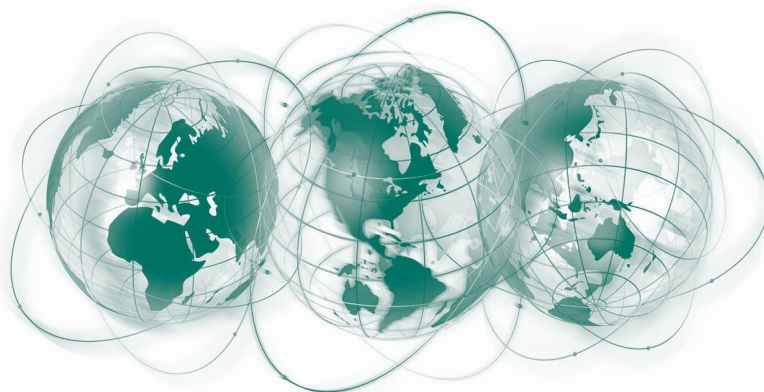


Photograph 6: Rotation of segment of retaining wall 'D'.

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com



Golder Associates Ltd.
309 Exeter Road, Unit #1
London, Ontario, N6L 1C1
Canada
[+1] (519) 652 0099
[+1] (519) 652 6299
T: [+1] (519) 652 0099

