



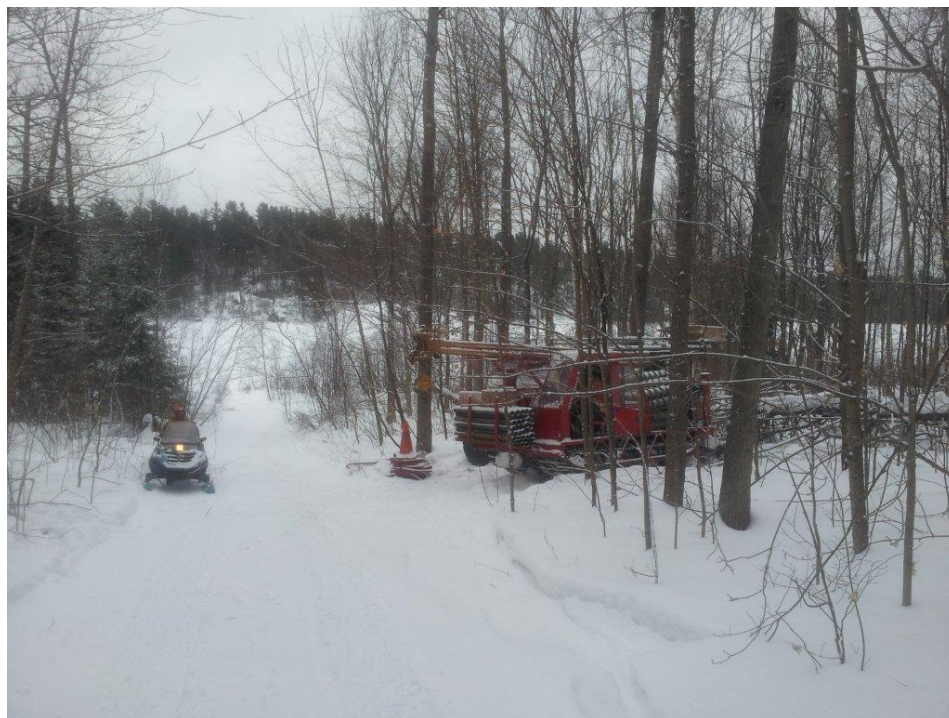
July 27, 2016

FOUNDATION INVESTIGATION AND DESIGN REPORT

**SWAMP CROSSING, HIGH FILL AREAS AND DEEP CUT– CONTRACT 5
HIGHWAY 69 FOUR-LANING FROM 1.7 KM NORTH OF HIGHWAY 529
NORTHERLY TO 3.9 KM NORTH OF HIGHWAY 522
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5347-08-00; WP 5005-10-01**

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REPORT





Table of Contents

PART A – FOUNDATION INVESTIGATION REPORT

1.0 INTRODUCTION.....	1
2.0 SITE DESCRIPTION.....	2
3.0 INVESTIGATION PROCEDURES	2
3.1 Foundation Investigation.....	2
4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS	4
4.1 Regional Geology	4
4.2 General Overview of Local Subsurface Conditions	5
4.3 Highway 69 NBL – STA 20+665 to STA 20+705 (High Fill 501)	5
4.4 Highway 69 SBL – STA 20+980 to STA 21+180 (High Fill 502)	6
4.5 Highway 69 NBL – STA 20+990 to STA 21+075 (High Fill 502)	12
4.6 Highway 69 SBL – STA 10+350 to STA 10+470 (Swamp 503)	17
4.7 Highway 69 NBL – STA 10+230 to STA 10+445 (Swamp 503)	20
4.8 Highway 69 NBL – STA 21+300 (Henvey) to STA 10+140 (Mowat) (Deep Cut 504)	24
5.0 CLOSURE	27

PART B – FOUNDATION DESIGN REPORT

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS.....	28
6.1 General.....	28
6.2 High Fill Embankments/Embankments Over Swamp and Deep Cut	28
6.2.1 Embankment Fill Types and Berm Requirements.....	29
6.2.2 Stability	30
6.2.2.1 Methodology	30
6.2.2.2 Parameter Selection	31
6.2.3 Settlement.....	33
6.2.3.1 Methodology	33
6.2.3.2 Parameter Selection	34
6.2.3.3 Settlement of Embankment Fill.....	35
6.3 Settlement Performance Requirements.....	36
6.4 Stability and Settlement Mitigation Options for Embankments	37



FOUNDATION REPORT – SWAMP CROSSING, HIGH FILL AREAS AND DEEP CUT - HIGHWAY 69 GWP 5347-08-00; WP 5005-10-01

6.4.1	Full Sub-Excavation	38
6.4.2	Preloading (and Partial Sub-Excavation, Stability Berms and/or Staged Construction)	39
6.4.3	Surcharging (and Partial Sub-Excavation, Stability Berms and/or Staged Construction)	40
6.4.4	Wick Drains	42
6.4.5	Lightweight Fill	42
6.4.6	Aggregate Piers	43
6.4.7	Deep Soil Mixing	44
6.4.8	Instrumentation and Monitoring	45
6.5	Stability Mitigation Options for Deep Cuts	45
6.6	Results of Analysis	46
6.6.1	Highway 69 NBL – STA 20+665 to STA 20+705 (High Fill 501)	46
6.6.2	Highway 69 SBL – STA 20+980 to STA 21+180 (High Fill 502)	47
6.6.3	Highway 69 NBL – STA 20+990 to STA 21+075 (High Fill 502)	49
6.6.4	Highway 69 SBL – STA 10+350 to STA 10+470 (Swamp 503)	50
6.6.4.1	Stability	51
6.6.4.2	Settlement	51
6.6.4.3	Mitigation of Stability Issues and/or Time Dependent Settlements	52
6.6.5	Highway 69 NBL – STA 10+230 to STA 10+445 (Swamp 503)	54
6.6.5.1	Stability	55
6.6.5.2	Settlement	55
6.6.5.3	Mitigation of Stability Issues and/or Time Dependent Settlements	56
6.6.6	Highway 69 NBL – STA 21+300 (Henvey) to STA 10+140 (Mowat) (Deep Cut 504)	60
6.6.6.1	Stability	61
6.7	Subgrade Preparation and Embankment Construction	61
6.7.1	Removal of Organic Materials	62
6.7.2	Excavation of Soft Soils	62
6.7.3	Groundwater and Surface Water Control	62
6.7.4	Backfilling	63
6.7.5	Embankment Fill Placement	63
6.8	Embankment Platform Widening	63
6.9	Cut Slope Construction	64
6.9.1	Excavation	64



FOUNDATION REPORT – SWAMP CROSSING, HIGH FILL AREAS AND DEEP CUT - HIGHWAY 69 GWP 5347-08-00; WP 5005-10-01

6.9.2	Surficial Instability and Erosion Protection	64
6.9.3	Groundwater and Surface Water Control	65

7.0 CLOSURE	65
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REFERENCES

Lists of Symbols and Abbreviations
Lithological and Geotechnical Rock Description Terminology

TABLES

Table 1	Summary of Swamp Crossings, High Fill Areas and Deep Cut
Table 2	Summary of Consolidation and Consolidated Undrained Triaxial (CIU) Test Results
Table 3	Summary of Foundation Engineering Parameters
Table 4	Summary of Settlement Analyses
Table 5	Summary of Preferred Foundation Mitigation Options
Table 6	Summary of Embankment Platform Widening Requirements
Table 7	Summary of Deep Cut Foundation Recommendations

DRAWINGS

Drawing 1	Site Location Plan
Drawing 2	Swamp Crossings, High Fill Areas and Deep Cut – Index Plan

LIST OF APPENDICES

Appendix A Highway 69 NBL – STA 20+665 to STA 20+705 (High Fill 501)

Drawing A1	Borehole Locations and Soil Strata
Record of Boreholes	S501-01 to S501-03
Record of DCPT	S501-DC01

Appendix B Highway 69 SBL – STA 20+980 to STA 21+180 (High Fill 502) Highway 69 NBL – STA 20+990 to STA 21+075 (High Fill 502)

Drawing B1	Borehole Locations
Drawings B2 to B6	Soil Strata
Record of Boreholes	S502-01 to S502-24, B501-02, B501-12 to B501-14, B502-02, B502-12 to B501-14
Record of Drillholes	B501-02, B501-12, B501-13, B502-02, B502-12 and B502-13
Record of DCPTs	S502-DC01 to S502-DC09
Table B.1	Point Load Test Results
Table B.2	Unconfined Compression Test – Borehole B501-12 Run 2
Table B.3	Unconfined Compression Test – Borehole B502-13 Run 2
Figure B.S502-01	Plasticity Chart – Organic Silt
Figure B.S502-02	Plasticity Chart – Clayey Silt to Silty Clay (Near Surface)
Figure B.S502-03A	Grain Size Distribution – Silt (Upper Deposit)
Figure B.S502-03B	Grain Size Distribution – Sandy Silt (upper Deposit)
Figure B.S502-03C	Grain Size Distribution – Silt and Sand (Upper Deposit)
Figure B.S502-03D	Grain Size Distribution – Silt and Sand to Silty Sand (Upper Deposit)
Figure B.S502-03E	Grain Size Distribution – Silt and Sand (Upper Deposit)
Figure B.S502-03F	Grain Size Distribution – Silt and Sand to Sand (Upper Deposit)
Figure B.S502-03G	Grain Size Distribution – Silt and Sand (Upper Deposit)
Figure B.S502-03H	Grain Size Distribution – Sand (Upper Deposit)
Figure B.S502-3I	Grain Size Distribution – Gravelly Silt and Sand (Upper Deposit)
Figure B.S502-04	Plasticity Chart – Silt
Figure B.S502-05	Plasticity Chart – Clayey Silt to Silty Clay (Pockets)
Figure B.S502-06	Grain Size Distribution – Clayey Silt to Silty Clay
Figure B.S502-07A	Plasticity Chart – Clayey Silt to Silty Clay
Figure B.S302-07B	Plasticity Chart – Silty Clay to Clay
Figure B.S502-08	Consolidation Test Summary – Borehole S502-01 SA 7
Figure B.S502-09	Consolidation Test Summary – Borehole S502-02 SA 12
Figure B.S502-10	Grain Size Distribution – Silt to Sandy Silt (Pockets)



FOUNDATION REPORT – SWAMP CROSSING, HIGH FILL AREAS AND DEEP CUT - HIGHWAY 69 GWP 5347-08-00; WP 5005-10-01

Figure B.S502-11	Plasticity Chart – Silt (Pockets)
Figure B.S502-12	Grain Size Distribution – Silt to Silt and Sand (Lower Deposit)
Figure B.S502-13	Grain Size Distribution – Sand and Gravel
Figure B.S502-14	Bedrock Core Photograph – Borehole B501-02
Figure B.S502-15	Bedrock Core Photograph – Borehole B501-12
Figure B.S502-16	Bedrock Core Photograph – Borehole B501-13
Figure B.S502-17	Grain Size Distribution – Clayey Silt (Pockets)
Figure B.S502-18	Plasticity Chart – Clayey Silt to Silty Clay (Pockets)
Figure B.S502-19A	Grain Size Distribution – Silt and Sand to Silty Sand (Upper Deposit)
Figure B.S502-19B	Grain Size Distribution – Silt and Sand to Silty Sand (Upper Deposit)
Figure B.S502-19C	Grain Size Distribution – Sand (Upper Deposit)
Figure B.S502-20	Plasticity Chart – Silt to Silt and Sand (Upper Deposit)
Figure B.S502-21	Grain Size Distribution – Clayey Silt
Figure B.S502-22A	Plasticity Chart – Clayey Silt
Figure B.S502-22B	Plasticity Chart – Silty Clay to Clay
Figure B.S502-23	Consolidation Test Summary – Borehole B502-13 SA 10
Figure B.S502-24	Consolidation Test Summary – Borehole S502-20 SA 10
Figure B.S502-25	Consolidation Test Summary – Borehole S502-20B SA 1
Figure B.S502-26	Grain Size Distribution – Silt and Sand (Pocket)
Figure B.S502-27	Plasticity Chart – Silt (Pockets)
Figure B.S502-28A	Grain Size Distribution - Silt (Lower Deposit)
Figure B.S502-28B	Grain Size Distribution – Silt to Silt and Sand (Lower Deposit)
Figure B.S502-29	Plasticity Chart – Silt (Lower Deposit)
Figure B.S502-30	Bedrock Core Photograph – Borehole B502-02
Figure B.S502-31	Bedrock Core Photograph – Borehole B502-12
Figure B.S502-32	Bedrock Core Photograph – Borehole B502-13
Figure B1	Summary Plot of Engineering Parameters for Cohesive Soils
Figure B2	Front Slope Stability – Base Case (SBL)
Figure B3	Side Slope Stability – Base Case (SBL)
Figure B4	Front Slope Stability – Base Case (NBL)
Figure B5	Side Slope Stability – Base Case (NBL)

Appendix C

Highway 69 SBL – STA 10+350 to STA 10+470 (Swamp 503) Highway 69 NBL – STA 10+230 to STA 10+445 (Swamp 503)

Drawings C1 to C4	Borehole Location and Soil Strata
Record of Boreholes	S503-01 to S503-30 and C501-01 to C501-06
Record of DCPTs	S503-DC01 to S503-DC14
Figure C.S503-01	Plasticity Chart – Clayey Silt to Silty Clay
Figure C.S503-02A	Grain Size Distribution – Silt and Sand to Silty Sand
Figure C.S503-02B	Grain Size Distribution – Sand
Figure C.S503-03	Grain Size Distribution – Sand and Gravel
Figure C.S503-04	Plasticity Chart – Organic Silt
Figure C.S503-05	Grain Size Distribution – Clayey Organic Silt
Figure C.S503-06	Plasticity Chart – Clayey Organic Silt
Figure C.S503-07	Plasticity Chart – Clayey Silt to Silty Clay
Figure C.S503-08A	Grain Size Distribution – Silt and Sand
Figure C.S503-08B	Grain Size Distribution – Sand
Figure C.S503-08C	Grain Size Distribution – Gravelly Silty Sand
Figure C.S503-09	Grain Size Distribution – Sand and Gravel
Figure C1	SBL and NBL Slope Stability (Median Infill / Outside Toe Berm on NBL)
Figure C2	SBL and NBL Slope Stability (Localized Sub-Excavation and Outside Toe Berm on NBL)
Figure C3	SBL and NBL Slope Stability (2 m Surcharge at NBL and Median Infill / Outside Toe Berm on NBL)
Figure C4	SBL and NBL Slope Stability (4.5 m EPS Fill at NBL)
Table C1	Evaluation of Stability/Settlement Mitigation Options: Highway 69 SBL – STA 10+350 to STA 10+470 (Swamp 503)
Table C2	Evaluation of Stability/Settlement Mitigation Options: Highway 69 NBL – STA 10+230 to STA 10+445 (Swamp 503)



Appendix D

Highway 69 NBL – STA 21+300 (Henvey) to STA 10+140 (Mowat) (Deep Cut 504)

Drawing D1	Borehole Locations and Soil Strata
Drawing D2	Soil Strata
Drawing D3	Cross-section
Record of Boreholes	D504-01 to D504-09
Figure D.D504-01	Grain Size Distribution – Sandy Silt to Silty Sand to Silt and Sand
Figure D.D504-02	Plasticity Chart – Silty Clay (Pockets)
Figure D.D504-03	Grain Size Distribution – Clayey Silt to Silty Clay
Figure D.D504-04	Plasticity Chart – Clayey Silt to Clay
Figure D.D504-05	Consolidation Undrained Triaxial Test Summary – Borehole D504-04 SA 8
Figure D.D504-06A	Grain Size Distribution – Silt to Sandy Silt
Figure D.D504-06B	Grain Size Distribution – Silt and Sand
Figure D.D504-07	Plasticity Chart – Sandy Silt
Figure D1	NBL Slope Stability (2H:1V Earth Cut Slope), Total Stress Analysis
Figure D2	NBL Slope Stability (2H:1V Earth Cut Slope), Effective Stress Analysis
Figure D3	NBL Slope Stability (2H:1V Earth Cut Slope) and 0.4 m Thick Granular Sheeting Covered by 0.5 m Thick Rip-Rap, Total Stress Analysis
Figure D4	NBL Slope Stability (2H:1V Earth Cut Slope) and 0.4 m Thick Granular Sheeting Covered by 0.5 m Thick Rip-Rap, Effective Stress Analysis

Appendix E

Non-Standard Special Provisions

Dewatering at Deep Cut Areas – Item No.



PART A

**FOUNDATION INVESTIGATION REPORT
SWAMP CROSSING, HIGH FILL AREAS AND DEEP CUT– CONTRACT 5
HIGHWAY 69 FOUR-LANING FROM 1.7 KM NORTH OF HIGHWAY 529
NORTHERLY TO 3.9 KM NORTH OF HIGHWAY 522
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5347-08-00; WP 5005-10-01**



1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by URS Canada Inc. (URS) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for three (3) swamp crossing/high fill embankment areas and a deep cut within the Contract 5 limits of the new Highway 69 alignment to the north of the junction with Highway 529. The proposed work in Contract 5 is part of the overall four-laning of Highway 69 from 1.7 km north of Highway 529 northerly to 3.9 km north of Highway 522, for a total project distance of 19.7 km. The foundation engineering components within the overall project limits include: high fill embankments and embankments over swamps; the Canadian National Railway (CNR) re-alignment; the Bevan Road and Highway 522 interchanges and structures; the Still River, Straight Lake and Key River structures; the Canadian Pacific Railway (CPR) and Canadian National Railway (CNR) structures; as well as a number of culvert crossings. The proposed embankments in Contract 5 extend from approximately 9 km north of the junction of the existing Highway 526 and Highway 69 northerly for a total distance of about 1.7 km. The general location and extent of the various contracts as part of the new Highway 69 four-laning alignment are shown on the Site Location Plan on Drawing 1.

The Terms of Reference and the Scope of Work for the foundation investigation are outlined in MTO's Request for Proposal, dated December 2008. Golder's proposal (Scope of Work) for foundation engineering services is contained in Section 6.8 of URS's Technical Proposal for this assignment. Golder's change request for additional foundation investigation and design for the deep cut area was submitted to URS on March 25, 2013 and approved on June 13, 2013. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundation engineering services for this project, dated April 19, 2010. The Base Plan showing the proposed horizontal alignment and the drawing showing the proposed vertical alignment for the swamp crossing/high fill areas and deep cut within the Contract 5 section of Highway 69 four-laning were provided to Golder by URS on April 23, 2012 and March 14, 2012, respectively. In addition, a drawing showing cross sections along the deep cut alignment and the General Agreement drawings for the section of roadway alignment between the Straight Lake and Key River were provided to Golder by URS on February 1, 2013 and October 9, 2013, respectively.

This report addresses the investigation carried out for the Contract 5 swamp crossing/high fill areas and deep cut only. A list and designation of the Contract 5 swamp crossing/high fill areas and deep cut is presented in Table 1. Separate reports address the foundation investigations for the related culvert crossing and the Straight Lake and Key River bridge structures within the Contract 5 section of the project.

The purpose of this investigation is to establish the subsurface conditions along the new highway alignment at the proposed Contract 5 swamp crossing/high fill areas and deep cut by methods of borehole drilling, rock coring, in situ testing and laboratory testing on selected samples. The centreline of the proposed swamp crossing/high fill areas and deep cut was staked in the field by Callon Dietz Inc., a professional surveying company retained by URS and the foundation investigation was carried out within the limits of the swamp crossing/high fill areas and deep cut as defined in the Terms of Reference. The investigation areas are shown on the Index Plan on Drawing 2.

Preliminary subsurface information for this project was available and was supplied by the MTO, in a report titled:

- Preliminary Foundation Investigation & Design Report, Swamp Crossings, Highway 69 Route Selection Study, 3.5 km N of Hwy 559 to 3.8 km N of Hwy 522, GWP 5377-02-00, Highway 69, GEOCRE No. 41H-51, dated September 12, 2005, by Trow Associates Inc.



2.0 SITE DESCRIPTION

The overall proposed Highway 69 alignment is oriented generally in a south-north direction extending within the Township of Wallbridge to the south and the Township of Henvey and Township of Mowat to the north. The Contract 5 section of the new four-lane Highway 69 alignment is also oriented generally in a south-north direction within the project limits, extending within the Township of Henvey and Township of Mowat for a total distance of about 1.3 km. The investigated areas are located between the south shore of Straight Lake at the northern limit of Contract 3, corresponding to approximately 7.8 km northwest of the present junction of Highway 69 and Highway 529, and the south bank of Key River.

In general, the topography of the Contract 5 section of the project consists of rolling terrain, including sparsely and densely populated treed areas and numerous bedrock outcrops separated by valleys. Swamps containing areas of standing water and various types of vegetation and organic soils are located within the valley areas of Straight Lake to the south and Key River to the north. A creek is also present traversing the Swamp 503 area. The ground surface within the limits of the Contract 5 swamp crossing/high fill areas and deep cut varies between about Elevations 196.7 m and 179.5 m, referenced to Geodetic datum. A detailed description of each investigated swamp crossing/high fill area and deep cut is presented in Section 4.0. The locations of these areas are shown in plan on Drawing 2.

3.0 INVESTIGATION PROCEDURES

3.1 Foundation Investigation

The investigation for the Contract 5 swamp crossing/high fill areas and deep cut was carried out between January 19 and 22, February 22 and March 20, July 14 and August 7, 2013 and March 4 and March 12, 2014 during which time a total of 83 boreholes and 24 Dynamic Cone Penetration Tests (DCPTs) were advanced at the locations of the swamp crossing/high fill areas and deep cut. The locations of the boreholes and DCPTs are summarized in Table 1 and are shown on Drawings A1 to D3 in Appendices A to D. In general, boreholes were advanced along the centreline and the toes of the proposed embankment or cut alignment. It should be noted that the number of boreholes and DCPTs summarized in Table 1 may be different from the actual total number of boreholes and DCPTs advanced as some boreholes/DCPTs are applicable to more than one roadway embankment alignment.

The field investigation was carried out using a variety of drilling equipment as a result of the varying nature of the terrain and accessibility within the Contract 5 project limits. The details of the drilling equipment and suppliers are listed below. Hand shovel excavation methods were used to expose bedrock, where appropriate depending on the terrain.

Drilling Equipment	Supplied and Operated By
Track Mounted CME 55	Landcore Drilling of Sudbury, Ontario
Portable Equipment	
Portable Equipment	OGS Inc. of Almonte, Ontario
Skid Mounted Diedrich D 25	Walker Drilling Ltd. of Utopia, Ontario

The boreholes were advanced through the overburden using 150 mm and 127 mm outer diameter (O.D.) solid-stem augers, 106 mm inner diameter (I.D.) hollow stem augers, and/or 'NW', 'BW', 'NQ' and 'HQ' casing with wash boring techniques. In general, soil samples were taken at intervals of depth of about 0.75 m and



1.5 m, using a 50 mm O.D. split-spoon sampler driven by an automatic hammer on the track-mounted drill rig and using manual hammers (rope and cat head) on the portable and skid-mounted equipment, and carried out in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586, Standard Test Method for Standard Penetration Test). One of the boreholes advanced by portable equipment employed a half-weight hammer lifted manually and dropped from the standard SPT height and the associated 'N'-value was corrected for the lower energy drive. Samples of cohesive soils were obtained at selected locations using 76 mm O.D. thin-walled 'Shelby' tubes (ASTM D1587, Standard Practice for Thin-Walled Tube Sampling) for relatively undisturbed samples. Field vane shear tests were carried out in cohesive soils for assessment of undrained shear strengths (ASTM D2573, Standard Test Method for Field Vane Strength Shear Test) using MTO Standard 'N' size vanes, and 'B' size vanes in the smaller diameter boreholes advanced by portable equipment.

The boreholes and DCPTs were advanced to depths up to 40.6 m below existing ground surface, generally penetrating 3 m into competent material, which is defined as material that will provide resistance to settlement or instability of the embankments, or to refusal. In general, boreholes and DCPTs were terminated on refusal to further auger, casing and/or split-spoon advancement, hand shovel penetration or dynamic cone penetration. These depths to refusal do not confirm bedrock surface elevations, but may be inferred to indicate potential proximity to the bedrock surface. At various borehole locations where refusal was encountered at shallow depth (less than about 0.2 m), the bedrock was exposed by hand shovel excavation to confirm the refusal condition. In six (6) boreholes (Boreholes B501-02, B501-12, B501-13, B502-02, B502-12 and B502-13), bedrock was cored for lengths of about 3.0 m to 3.4 m. Photographs of the recovered rock core samples are provided in the relevant appendices noted in Section 4.0.

The groundwater conditions and water levels in the open boreholes were observed during the drilling operations and are described on the Record of Borehole sheets provided in Appendices A to D. Groundwater elevations as encountered in the boreholes may not be representative of static groundwater levels since the groundwater levels in the boreholes may not have stabilized on completion of drilling, particularly when employing wash boring or coring techniques to advance the boreholes. Furthermore, groundwater elevations will vary depending on seasonal fluctuations, precipitation and local soil permeability. Standpipe piezometers were installed in Boreholes D504-04 and D504-07 to monitor the groundwater levels at these locations. The piezometers consisted of 38 mm diameter PVC pipe, with slotted screens sealed within the sandy silt strata. The borehole and annulus surrounding the piezometer pipe above the screen (and sand pack) were backfilled to the surface with bentonite pellets or soil cuttings with a bentonite seal at selected depths. Piezometer installation and water level readings are described on the Record of Borehole sheet presented in Appendix D. The water level in the piezometers was measured and the piezometers were decommissioned a few days after installation upon completion of the field work in the area. All open boreholes were backfilled with bentonite upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The fieldwork was observed by members of our engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the soil and rock samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Mississauga geotechnical laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content, organic content, grain size distribution and Atterberg limits) was carried out on selected soil samples. In addition, one-dimensional consolidation (Oedometer) tests and consolidated undrained triaxial (CIU) test with pore pressure measurements were carried out on selected samples of the cohesive deposits and the summary



of the tests results are presented in Tables 2 and 3, respectively. The results of the laboratory classification and strength testing are included in the associated appendices.

Classification of the rock mass quality of the bedrock cores with respect to the Rock Quality Designation (RQD) is described based on Table 3.10 of the Canadian Foundation Engineering Manual (CFEM, 2006)¹. The degree of weathering of the bedrock samples (i.e. fresh to slightly weathered – W1 to W2) and the strength classification of the intact rock mass based on field identification (i.e. strong to extremely strong – R4 to R6) are described in accordance with Table B.3 and Table B.6, respectively, of the International Society for Rock Mechanics (ISRM)² standard classification system. Classification of the bedrock cores related to the laboratory point load test results is described based on Table 3.5 in CFEM (2006).

The proposed centreline of the new highway alignment was staked in the field by Callon Dietz prior to drilling. The as-drilled borehole locations, in stations and offsets, were measured in reference to the centreline alignment and were subsequently converted into MTM NAD 83 coordinates in AutoCAD. Borehole elevations were surveyed by a member of our technical staff in reference to the ground surface elevations at the centreline median and to temporary benchmarks which were then surveyed by Callon Dietz upon completion of the fieldwork. The borehole locations shown on Drawings A1 to D3 in Appendices A to D are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

As delineated in *The Physiography of Southern Ontario*³, this section of the new Highway 69 lies within the physiographic region known as the Georgian Bay Fringe, which extends along the east side of Georgian Bay through the Parry Sound and Muskoka areas, then eastward from Muskoka in patches into the area north of the Kawartha Lakes.

This part of the Georgian Bay Fringe physiographic region was never submerged during periods of glacial recession. As a result, the surficial soils in this area consist of relatively shallow deposits of sand, silt and clay underlain by metamorphic bedrock and numerous bare knobs and ridges of bedrock are present throughout the area. Localized low-lying swampy areas, containing peat and/or organic soils overlying soft/loose native soils, sometimes to significant depth, are present in valleys between the bedrock knobs and ridges.

The bedrock in the area consists typically of crystalline gneisses of the Britt Domain of the Central Gneiss Belt, a subdivision of the Grenville Structural Province, as described in *Geology of Ontario*, OGS Special Volume 4⁴. Deposition of Paleozoic strata initially covered the bedrock and later erosion during glaciation exposed these Precambrian rocks.

¹Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, 4th Edition.

² International Society for Rock Mechanics Commission on Test Methods, 1985. Int. J. Rock Mech.Min. Sci. & Geomech. Abstr. Vol 22, No. 2, pp. 51-60.

³ Chapman, L.J. and Putnam, D.F., 1984. *The Physiography of Southern Ontario*, Ontario Geological Survey, Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000.

⁴ Ontario Geological Society, 1991. *Geology of Ontario*, Society Special Volume 4, Part 2. Ministry of Northern Development and Mines, Ontario.



4.2 General Overview of Local Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during this investigation (including excavations by hand shovel), together with the results of the laboratory tests carried out on selected soil samples, are presented on the Record of Borehole and Record of Drillhole sheets and the laboratory test sheets provided in Appendices A to D for the respective swamp crossing/high fill areas and deep cut. The results of the in situ field tests (i.e. SPT 'N'-values and the undrained shear strengths obtained from the field vanes) as presented on the Record of Borehole sheets and in Sections 4.3 to 4.8 are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling, observations of drilling progress and the results of SPTs and in situ testing. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations. The thickness of the overburden/depth to refusal in the investigated areas as inferred from the resistance to DCPT advancement are shown on the Record of DCPT sheets in Appendices A to D.

The inferred soil stratigraphy as encountered in the boreholes and DCPTs advanced for the Contract 5 swamp crossings/high fill areas and deep cut are shown in profile on Drawings A1 to D2 and in cross-section on Drawing D3, inclusive. The orientation (i.e. north, south, east, west) stated in the text of this report is typically referenced to project north and/or up-chainage (along the proposed Highway 69 alignment). For purposes of this report, Highway 69 is oriented in a north-south direction.

In general, the stratigraphy encountered at the various borehole locations typically consists of surficial, relatively thin layers of organic materials (peat, topsoil) underlain by alternating layers or deposits of cohesive and non-cohesive soils. In Swamp 503 however, thicker deposits of organic materials (clayey organic silt to organic silt) were encountered. The overburden (soil material) thickness is variable, ranging from relatively thin cover (i.e. less than about 0.2 m thick layer of cover on top of the bedrock or exposed bedrock at ground surface) up to about 40.6 m below ground surface upon borehole termination. The stratigraphy generally consists of:

- Surficial deposits of topsoil, fibrous and amorphous peat or organic silt to clayey organic silt;
- Non-cohesive deposits of silt to sand in places underlying the surficial deposits, interlayered with clayey silt to clay deposits and in some areas extending to the inferred bedrock; and,
- Cohesive deposits of clayey silt to clay generally interlayered with the non-cohesive deposits, in places, containing pockets of non-cohesive materials.

Detailed descriptions of the subsurface conditions at each investigated swamp crossing/high fill area and deep cut are provided in the following sections of this report. Where relatively significant thicknesses of overburden were encountered, the various soil types are described in detail for each main deposit.

4.3 Highway 69 NBL – STA 20+665 to STA 20+705 (High Fill 501)

The plan and profiles along the centreline and toes of the proposed embankment of the new Highway 69 NBL alignment showing the borehole locations and interpreted stratigraphy between about STA 20+665 and STA 20+705 in the Township of Henvey are presented on Drawing A1 in Appendix A. The proposed embankment within this section of the highway is up to about 10 m high relative to the existing ground surface.

A total of three (3) boreholes (Boreholes S501-01 to S501-03) and a Dynamic Cone Penetration Test (DCPT S501-DC01) were completed to investigate the subsurface conditions within this high fill area. This



section of the proposed highway embankment is located within a bedrock valley that extends to the south of Straight Lake. The bedrock outcrop is fully exposed within this area.

The subsurface soils along the NBL alignment in High Fill 501 generally consist of a relatively thin layer of peat or silty sand, trace organics underlain by bedrock.

Peat

An approximately 0.1 m to 0.2 m thick layer of fibrous peat was encountered at the ground surface in Boreholes S501-02 and S501-03. The surface of the peat layer is at Elevations 192.3 m and 196.7 m in the respective boreholes.

The natural water content measured on two (2) samples of the peat is about 112 per cent and 216 per cent.

Silty Sand

An approximately 0.2 m thick layer of silty sand, trace organics was encountered in Borehole S501-01 and a 0.2 m layer of organic silty sand was excavated through at DCPT S501-DC01. The top of the silty sand is at Elevation 189.9 m at Borehole B501-01 and at Elevation 194.2 m at DCPT S501-DC01.

An SPT 'N'-value of 4 blows per 0.1 m of penetration was measured in the silty sand layer, suggesting a loose consistency.

The natural water content measured on a sample of silty sand is about 10 per cent.

Refusal

The bedrock outcrops and is exposed in the vicinity of Boreholes S501-01 to S501-03 and DCPT S501-DC01.

Groundwater Conditions

In general, the soil samples taken in the boreholes were wet. The groundwater level in the hand shovel excavation of Borehole S501-02 was at Elevation 192.3 m, measured at the ground surface. Excavations of Boreholes S501-01 and S501-03 were dry upon completion of excavating.

4.4 Highway 69 SBL – STA 20+980 to STA 21+180 (High Fill 502)

The plan and profiles along the centerline and toes of the proposed embankment of the new Highway 69 SBL alignment showing the borehole locations and interpreted stratigraphy between about STA 20+980 and STA 21+180 in the Township of Henvey are presented on Drawings B1 to B4 in Appendix B. The proposed embankment within this section of the highway is up to about 7 m high relative to the existing ground surface.

A total of twenty-two (22) boreholes (Boreholes B501-02, B501-12 to B501-14, S502-01 to S502-17 and S502-21) and seven (7) Dynamic Cone Penetration Tests (DCPT S501-DC01 to S501-DC07) were completed to investigate the subsurface conditions within this high fill area. The topography along the proposed SBL



embankment is undulating, with the ground surface rising sharply to the north away from Straight Lake, then forming a plateau as the proposed embankment grade merges into the existing ground surface. In general, the ground cover consists of sparsely to densely treed areas and various types of low vegetation.

The subsurface soils along the SBL alignment in High Fill 502 generally consist of peat/organic silt or topsoil at ground surface, generally underlain by a thin near surface layer of cohesive soil which in turn is underlain by a deposit of silt to sand. The non-cohesive deposit of silt to sand is interlayered with a cohesive deposit comprised of clayey silt to silty clay to clay in the southern portion of the high fill area and contains occasional pockets of cohesive soils in the northern portion of the high fill area. The non-cohesive deposit is underlain by granitic gneiss bedrock at the south end of the area and by inferred bedrock along the alignment as delineated by refusal to further split-spoon sampler, auger and/or casing advancement or cone penetration.

Ice/Water

Ice and water were encountered at surface in Borehole B501-02 that was advanced near the shore of Straight Lake to a depth of 1.1 m.

Topsoil

An approximately 0.1 m to 0.3 m thick layer of topsoil was encountered in Boreholes S502-04, S502-06, S502-09 to S502-17 and S502-21. The surface of topsoil ranges from Elevations 192.1 m to 185.6 m.

The natural water content measured on a sample on the topsoil is about 71 per cent.

Peat/Organic Silt

An approximately 0.2 m to 2.4 m thick layer of fibrous peat and/or organic silt was encountered at the ground surface in Boreholes B501-02, S502-01, S502-02, S502-03, S502-05, S502-07 and S502-08 and below a clayey silt deposit in Borehole S502-14. The surface of the layer across the boreholes ranges from Elevations 190.6 m to 177.5 m.

SPT 'N'-values ranging between 0 blows (weight of rods) and 4 blows per 0.3 m of penetration were measured within the fibrous peat and organic silt deposits. The SPT 'N'-values suggest a very soft consistency for the peat deposit and a very soft to soft consistency for the organic silt deposit.

The natural water content measured on three (3) samples of the organic silt deposit ranges from about 48 per cent to 126 per cent.

The organic content measured on two (2) samples of the organic silt is about 6 per cent and 9 per cent.

An Atterberg limits test was carried out on a sample of organic silt and measured a liquid limit of about 43 per cent, a plastic limit of about 36 per cent and a corresponding plasticity index of about 7 per cent. The result of the Atterberg limits test is shown on the plasticity chart on Figure B.S502-01 and indicates that the material is classified as organic silt of intermediate plasticity.



Clayey Silt to Silty Clay (Near Surface Deposit)

A near surface deposit of cohesive soils comprised of brown to grey clayey silt to silty clay was encountered below the organic silt/peat or topsoil in Boreholes S502-02, S502-04, S502-06 to S502-09, S502-11 to S502-17. The deposit generally contains trace to some sand and trace organics at some locations. The top of the deposit ranges from Elevations 191.9 m to 181.9 m and the thickness of the deposit varies between 0.5 m and 1.3 m.

The SPT 'N'-values recorded within this near surface cohesive deposit range from 2 blows to 12 blows per 0.3 m of penetration, suggesting a very soft to stiff consistency.

The natural water content measured on eight (8) selected samples of this deposit ranges from about 18 per cent to 34 per cent.

Atterberg limits tests were carried out on eight (8) samples of the near surface cohesive deposit and measured liquid limits ranging from about 23 per cent to 43 per cent, plastic limits ranging from about 15 per cent to 18 per cent and plasticity indices ranging from about 8 per cent to 26 per cent. The results of Atterberg limits tests are shown on the plasticity chart on Figure B.S502-02 in Appendix B, and indicate that the material is classified as clayey silt of low plasticity to silty clay of intermediate plasticity.

Silt to Sand (Upper Deposit)

A deposit of non-cohesive soils comprised of brown to grey silt to sandy silt to silt and sand to silty sand to sand was encountered underlying the peat/organic silt or topsoil or surficial cohesive deposit in all boreholes except Boreholes B501-02 and S502-14. The upper portion of the deposit up to a depth of about 3.0 m generally contains trace organics. The non-cohesive deposit is interlayered with a cohesive stratum in the southern portion of the high fill area and in places contains pockets of cohesive soils. The top of this deposit ranges from Elevations 191.0 m to 179.9 m, and the overall thickness of the deposit (including a portion of the cohesive stratum and pockets up to about 3.5 m thick), ranges from 0.9 m to 15.8 m. Boreholes S502-05, S502-06, S502-09, S502-11 to S502-13, S502-15, S502-17 and B501-14 terminated within this deposit on split-spoon sampler and/or casing refusal at depths ranging from 4.1 m to 15.0 m below the existing ground surface.

The SPT 'N'-values recorded within this overall deposit of non-cohesive materials range from 0 blows (weight of rod) to 37 blows per 0.3 m of penetration, indicating a very loose to dense relative density.

The natural water content measured on eighty-one (81) samples of the non-cohesive deposit ranges from about 6 per cent to 37 per cent.

The results of grain size distribution tests completed on fifty-three (53) samples from the various portions of the non-cohesive deposit are shown on Figure B.S502-03A to B.S502-03I in Appendix B.

Atterberg limits tests were carried out on thirteen (13) samples of the fine portions of this deposit. Eleven of the Atterberg limits tests indicate that the fine materials are non-plastic and the other two (2) Atterberg limits tests measured liquid limits of about 15 per cent and 18 per cent, plastic limits of about 13 per cent and 16 per cent and plasticity indices of about 2 per cent. The result of the Atterberg limits tests are shown on the plasticity chart on Figure B.S502-04 in Appendix B, and indicate that the fine portion of the material is classified as a silt of slight plasticity.



Clayey Silt to Silty Clay (Pockets)

Boreholes S502-06 to S502-09, S502-11, S502-12 and S502-21 penetrated through approximately 0.1 m to 2.9 m thick pockets of cohesive soils comprised of clayey silt to silty clay within the non-cohesive silt to sand deposit. The top of the cohesive pockets ranges from Elevations 187.8 m to 181.7 m.

SPT 'N'-values of 0 blows (weight of hammer) and 2 blows per 0.3 m of penetration were measured within the cohesive soil pockets. In situ field vane tests carried out within the pockets measured undrained shear strengths ranging from 29 kPa to 48 kPa and the sensitivity values of 5 and 10. The SPT 'N'-values and field vane tests results suggest that the cohesive soil pockets have a very soft to firm consistency.

The natural water content measured on seven (7) samples of the cohesive soil pockets ranges from about 29 per cent to 43 per cent.

Atterberg limits tests were carried out on seven (7) samples of the cohesive soil pockets and measured liquid limits ranging from about 21 per cent to 48 per cent, plastic limits ranging from about 12 per cent to 18 per cent and plasticity indices ranging from about 6 per cent to 30 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B.S502-05 in Appendix B and indicate that the material is classified as a clayey silt of low plasticity to silty clay of intermediate plasticity.

Clayey Silt to Clay

A deposit of cohesive soil comprised of clayey silt to silty clay to clay was encountered underlying the organic silt layer in Borehole B501-02 and below the silt to sand deposit in Boreholes S502-01 to S502-05, S502-07, S502-08 and S502-21. The deposit contains trace sand and silt seams and contains pockets of non-cohesive soils comprised of silt to silty sand at some locations. The top of the deposit ranges from Elevations 179.7 m to 175.1 m and the overall thickness of the deposit varies between 1.2 m to 19.4 m. The thickness of the deposit decreases moving northerly away from Straight Lake.

The SPT 'N'-values measured within the deposit range from 0 blows (weight of rod) to 7 blows per 0.3 m of penetration. In situ field vane tests carried out within this deposit measured undrained shear strengths ranging from about 29 kPa to greater than 96 kPa, and the sensitivity ranges from about 2 to 9. The field vane tests results indicate that the clayey silt to clay deposit has a firm to stiff consistency.

The natural water content measured on forty-three (43) samples of the cohesive deposit ranges from about 30 per cent to 74 per cent.

The grain size distribution test results for three (3) samples of the cohesive deposit are shown on Figure B.S502-06 in Appendix B.

Atterberg limits tests were carried out on twenty-five (25) samples of the cohesive deposit and measured liquid limits ranging from about 20 per cent to 79 per cent, plastic limits ranging from about 14 per cent to 23 per cent, and plasticity indices ranging from about 5 per cent to 56 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B.S502-07A and B.S502-07B in Appendix B and indicate that the material is classified as clayey silt of low plasticity to clay of high plasticity. An Atterberg limits test was carried out on silt seams portion of a sample obtained within this deposit and indicates that the silt seams are non-plastic.



Laboratory consolidation tests were carried out on two (2) specimens of the silty clay to clay portion of the cohesive deposit obtained from Shelby tube samples in Boreholes S502-01 and S502-02. Preconsolidation stresses of about 130 kPa and 230 kPa were estimated from the void ratio versus logarithmic pressure plot and from the total work versus pressure plots. Bulk unit weights of about 15.5 kN/m³ and 16.7 kN/m³ and specific gravities of about 2.78 and 2.79 were measured on the consolidation test specimens. Details of the test results are shown on Figures B.S502-08 and B.S502-09 in Appendix B, and the test results are summarized below.

Borehole Sample No.	Sample Depth / Elevation	σ_{vo}' (kPa)	σ_p' (kPa)	$\sigma_p' - \sigma_{vo}'$ (kPa)	OCR	C_c	C_r	e_o	c_v^* (cm ² /s)
Borehole S502-01 Sample 7	5.8 m / 175.3 m	50	130	80	2.6	1.68	0.012	2.13	4.3×10^{-3}
Borehole S502-02 Sample 12	12.5 m / 170.0 m	115	230	115	2.0	0.97	0.023	1.53	4.9×10^{-3}

Note: * For stress range between in situ effective overburden stress and final stress due to a 7.0 m high embankment, that is $40 \text{ kPa} \leq \sigma_v' \leq 250 \text{ kPa}$.

where: σ_{vo}' is the in situ vertical effective overburden stress in kPa
 σ_p' is the preconsolidation stress in kPa
OCR is the overconsolidation ratio
 e_o is the initial void ratio
 C_c is the compression index
 C_r is the recompression index
 c_v is the coefficient of consolidation in cm²/s

Silt to Silty Sand (Pockets)

Boreholes B501-02, B501-12, S502-01 and S502-02 penetrated through approximately 0.6 m to 2.8 m thick pockets of non-cohesive soils comprised of silt, trace to some sand to sandy silt. The top of the non-cohesive pockets were encountered between Elevations 176.4 m and 165.7 m.

SPT 'N'-values measured within the non-cohesive pockets range from 0 blows (weight of hammer) to 18 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

The natural water content measured on four (4) samples of the non-cohesive pockets ranges between about 20 per cent and 25 per cent.

The results of grain size distribution tests completed on four (4) samples of the non-cohesive pockets are shown on Figure B.S502-10 in Appendix B.

An Atterberg Limits test completed on a sample from the non-cohesive pockets measured a liquid limit of about 17 per cent, a plastic limit of about 15 per cent and a corresponding plasticity index of about 2 per cent. The result of the Atterberg limits test is shown on the plasticity chart on Figure B.S502-11 in Appendix B and indicates that the fine portion is classified as a silt of slight plasticity.

Silt to Silt and Sand (Lower Deposit)

Below the clayey silt to clay stratum, Boreholes B501-02, B501-12, S502-01, S502-02 to S502-04, S502-08 and S502-21 penetrated into a lower non-cohesive deposit of silt to sandy silt to silt and sand. The top of the



deposit ranges from Elevations 175.8 m to 157.9 m and the thickness of the deposit ranges from 1.2 m to 16.7 m. Cobbles and/or boulder were encountered within this deposit in Boreholes B501-02 and S502-01.

SPT 'N'-values measured within this deposit range from 0 blows (weight of hammer) to 36 blows per 0.3 m of penetration, indicating a very loose to dense relative density.

The natural water content measured on nine (9) samples of this deposit ranges from about 19 per cent to 26 per cent.

The results of grain size distribution tests completed on seven (7) samples of this deposit are shown on Figure B.S502-12, in Appendix B.

An Atterberg limits test was carried out on one sample of this deposit and indicates that the fine material is non-plastic.

Sand and Gravel

An approximately 0.2 m to 0.3 m thick non-cohesive deposit of sand and gravel was encountered below the organic silt layer in Borehole S502-14 at Elevation 186.0 m and underlying the silt to sand deposit in Borehole S502-10 at Elevation 179.2 m. Both boreholes were terminated within this deposit upon refusal to further penetration of the split-spoon sampler or auger.

An SPT 'N'-value of 16 blows per 0.15 m of penetration was measured within this deposit in Borehole S502-14 (on refusal to further advancement of split-spoon sampler) and an SPT 'N'-value of 15 blows per 0.3 m of penetration was measured at the interface with the overlying silt and sand deposit in Borehole S502-10, suggesting a compact relative density.

The natural water content measured on a sample of this deposit is about 16 per cent.

The result of a grain size distribution test completed on one sample of this deposit is shown on Figure B.S502-13 in Appendix B.

Bedrock / Refusal

In Boreholes B501-14, S502-01 to S502-15, S502-17 and S502-21, DCPTs S502-DC01 to S502-DC07 and in the DCPT advanced from the bottom of Borehole S502-06 and in the DCPT advanced adjacent to Borehole S502-16, the bedrock surface has been inferred by refusal to further split-spoon and/or auger and/or casing advancement or dynamic cone penetration at depths between about 2.9 m and 27.5 m below the ground surface (between Elevations 186.3 m and 152.0 m). Refusal conditions were encountered at shallower depths near the north limit of the High Fill area and the greatest depths to refusal were encountered near the south limit of the high fill area adjacent to the north shore of Straight Lake.

Bedrock was encountered and core samples were recovered from Boreholes B501-02, B501-12 and B501-13 between depths of 13.6 m and 37.4 m below the existing ground surface, corresponding to between Elevations 171.5 m and 141.2 m as shown on the photographs presented on Figures B.S502-14 to B.S502-16 in Appendix B. The bedrock consists of granitic gneiss and the core samples are described as slightly weathered to fresh, thinly laminated to thinly bedded, medium to coarse crystalline, faintly porous, medium strong to very



strong, dark grey with light pink bands as described as presented on the Record of Drillhole sheets B501-02, B501-12 and B501-13 in Appendix B.

The Rock Quality Designation (RQD) measured on the core samples ranges from 53 per cent to 100 per cent, indicating a rock mass of fair to excellent quality. The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of the rock core samples are between 94 per cent and 100 per cent, and 58 per cent and 91 per cent, respectively.

Point load strength index tests (ASTM D5731) were carried out on selected samples of the bedrock core. The axial and diametral point load strength index values are shown on the relevant Record of Drillhole sheets and are presented in Table B.1 in Appendix B. The axial tests carried out on five (5) samples of the granitic gneiss bedrock core measured Is_{50} values between 1.0 MPa and 8.6 MPa and diametral tests carried out on eight (8) samples of the granitic gneiss bedrock core measured Is_{50} values ranging from about 4.8 MPa to 10.1 MPa.

An unconfined compression (UC) test (ASTM D7012) was carried out on a selected sample of the granitic gneiss bedrock obtained in Borehole B501-12 and measured a uniaxial compressive strength of about 51 MPa as detailed in Table B.2 in Appendix B. Based on the result of the UC test, the granitic gneiss bedrock is classified as strong (R_4 , $50 \text{ MPa} < UCS < 100 \text{ MPa}$) rock.

Groundwater Conditions

Borehole B501-02 was advanced from the ice surface at Straight Lake. In general, the soil samples taken in the boreholes were moist to wet. The depth to the groundwater measured in the open boreholes upon completion of drilling range from depths of about 0.8 m to 7.6 m below ground surface, between Elevations 189.6 m and 178.3 m, with the groundwater table generally located closer to the ground surface in the southern portion of the high fill area.

4.5 Highway 69 NBL – STA 20+990 to STA 21+075 (High Fill 502)

The plan and profiles along the centreline and toes of the proposed embankment of the new Highway 69 NBL alignment showing the borehole locations and interpreted stratigraphy between about STA 20+990 and STA 21+075 in the Township of Henvey are presented on Drawings B1, B5 and B6 in Appendix B. The proposed embankment within this section of the highway is up to about 4.4 m high relative to the existing ground surface.

A total of twelve (12) boreholes (Boreholes B502-02, B502-12 to B502-14, S502-18 to S502-24 and S502-20A) and five (5) DCPTs (DCPTs S502-DC01, S502-DC02, S502-DC04, S502-DC08 and S502-DC09) were completed to investigate the subsurface conditions within this high fill area. The topography of this section of the proposed highway rises progressively to the north away from the shore of Straight Lake and the area is covered with low brush and sparse trees.

The subsurface soils along the NBL alignment in High Fill 502 generally consist of peat/topsoil underlain in places by a deposit of silt and sand to silty sand; or a deposit of silt and sand to silty sand at ground surface, in turn underlain by a clayey silt to clay deposit. The cohesive deposit is underlain by a silt to silt and sand deposit which in turn is underlain by granitic gneiss bedrock at the south end of the area and by inferred bedrock along



the alignment as delineated by refusal to further split-spoon, auger and/or casing advancement and cone penetration.

Ice/Water

Borehole B502-02 was advanced from the Straight Lake frozen surface and encountered an approximately 0.4 m thick layer of ice, underlain by a 1.0 m depth of water.

Peat/Topsoil

An approximately 0.7 m thick layer of amorphous peat was encountered below the lake water in Borehole B502-02 and a 0.3 m and 0.4 m thick layer of fibrous peat was encountered at the ground surface in Boreholes S502-18 and S502-19. An approximately 0.1 m to 0.8 m thick layer of topsoil was encountered at the ground surface in Boreholes B502-12 to B502-14, S502-20 to S502-24 and S502-20A. The surface of the peat/topsoil layers ranges between Elevations 190.3 m and 177.2 m.

An SPT 'N'-value of 3 blows per 0.3 m of penetration was measured within the topsoil deposit in Borehole S502-24, suggesting a soft consistency and an SPT 'N'-value of 0 blows (weight of rod) per 0.3 m of penetration was measured within the amorphous peat deposit in Borehole B502-02, suggesting a very soft consistency.

The natural water content measured on a sample of the amorphous peat deposit from Borehole B502-02 is about 598 per cent and on two (2) samples of the topsoil is about 67 per cent and 68 per cent.

The organic content measured on a sample of the amorphous peat deposit from Borehole B502-02 is about 30 per cent and on two (2) samples of the topsoil is about 4 per cent and 6 per cent.

Organic Silt

An approximately 0.8 m and 2.3 m thick deposit of organic silt was encountered below the peat deposit in Boreholes S502-19 and B502-02, respectively. The top of the organic silt deposit is at Elevations 180.5 m and 176.5 m in the respective boreholes.

SPT 'N'-values of 0 blows (weight of hammer) per 0.3 m of penetration were measured within the organic silt deposit in Borehole B502-02 and 2 blows per 0.3 m of penetration were measured at the interface with the underlying deposit of the clayey silt layer in Borehole S502-19, suggesting that the organic silt has a very soft consistency.

The organic content measured on one sample of organic silt is about 13 per cent.

Clayey Silt to Silty Clay (Pockets)

Boreholes B502-14, S502-18, S502-20A, S502-21 to S502-23 penetrated approximately 0.5 m to 1.5 m thick pockets of cohesive soils comprised of clayey silt to silty clay below the peat/topsoil layers and/or within the non-cohesive silt and sand to sand deposit. The pockets encountered below the topsoil/peat generally contain trace organics. The top of the cohesive pockets ranges between Elevations 188.5 m and 179.8 m.



SPT 'N'-values ranging from 1 blow to 7 blows per 0.3 m of penetration were measured within the cohesive soil pockets. In situ field vane tests carried out within the cohesive pocket in Borehole B502-14 measured undrained shear strengths of about 49 kPa and 62 kPa and sensitivity values of 5. The SPT 'N'-values and field vane results suggest that the cohesive soil pockets have a very soft to stiff consistency.

The natural water content measured on five (5) samples of the cohesive soil pockets ranges from about 29 per cent to 38 per cent.

A grain size distribution test result for a sample from the cohesive soil pocket is shown on Figure B.S502-17 in Appendix B.

Atterberg limits tests were carried out on five (5) samples from the cohesive soil pockets and measured liquid limits ranging from about 24 per cent to 42 per cent, plastic limits ranging from about 15 per cent to 23 per cent and plasticity indices of about 8 per cent to 19 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B.S502-18 in Appendix B and indicate that the material is classified as clayey silt of low plasticity to silty clay of intermediate plasticity.

Silt to Sand (Upper Deposit)

An upper deposit of brown to grey silt to silt and sand to silty sand to sand, trace to some silt was encountered below the topsoil layer in Boreholes B502-12 to B502-14, S502-20, S502-20A, S502-21 and S502-24 and underlying the cohesive soil pockets in Boreholes S502-18, S502-22 and S502-23. The non-cohesive deposit generally contains trace to some clay and trace to some gravel and occasional pockets of clayey silt up to about 1.5 m thick. The top of this deposit is at Elevation 189.5 m at the north limit of the site decreasing to Elevation 178.9 m near the south limit of the site. The overall thickness of the deposit ranges from 0.8 m to 10.9 m at the south and north limits of the site, respectively.

The SPT 'N'-values measured within the non-cohesive deposit range from 0 blows (weight of hammer) to 19 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

The natural water content measured on twenty-three (23) samples of this deposit ranges from about 7 per cent to 31 per cent.

The results of grain size distribution tests completed on nineteen (19) samples from this deposit are shown on Figures B.S502-19A to B.S502-19C in Appendix B.

Atterberg limits tests were carried out on two (2) samples of the fines portion from the silt to silt and sand of this deposit and measured liquid limits of about 16 percent and 15 per cent, plastic limits of about 14 per cent and corresponding plasticity indices of about 2 per cent and 1 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B.S502-20 in Appendix B and indicate that the fines portion of the deposit is a silt of slight plasticity.

Clayey Silt to Clay

A deposit of brown to grey clayey silt to silty clay to clay was encountered below the organic silt or below the silt to sand deposit in Boreholes B502-02, B502-12 to B502-14, S202-20A and S502-18 to S502-24. The deposit contains silt to silty sand layers and pockets up to about 1.4 m thick in Boreholes B502-02, BS502-12, S502-19



and S502-22. The top of the cohesive deposit ranges between Elevations 179.0 m and 174.2 m and the overall thickness of the deposit varies between 1.1 m at the north limit and 16.4 m at the south limit of the site, including the thickness of the non-cohesive layers/pockets.

The SPT 'N'-values measured within this deposit range from 0 blows (weight of hammer) to 7 blows per 0.3 m of penetration. In situ field vane tests carried out within this deposit measured undrained shear strengths ranging from 11 kPa to greater than 96 kPa but generally greater than 25 kPa, indicating a soft to stiff consistency. The sensitivity of the cohesive deposit ranges from 2 to 10.

The natural water content measured on thirty-five (35) samples of this deposit ranges from about 27 per cent to 68 per cent.

The results of grain size distribution tests completed on of three (3) samples of the clayey silt portion of the deposit are shown on Figure B.S502-21 in Appendix B.

Atterberg limits tests carried out on twenty-seven (27) samples of the cohesive deposit measured liquid limits ranging from about 18 per cent to 55 per cent, plastic limits ranging from about 13 per cent to 22 per cent and plasticity indices ranging from about 4 per cent to 33 per cent. The results of the Atterberg limits tests are shown on the plasticity charts on Figures B.S502-22A and B.S502-22B in Appendix B and indicate that the material is classified as a clayey silt of low plasticity to a clay of high plasticity.

Laboratory consolidation tests were carried out on three (3) specimens of the silty clay portion of the cohesive deposit obtained from Shelby tube samples in Boreholes B502-13, S502-20 and S502-20B. A preconsolidation stresses ranging from about 150 kPa and 195 kPa were estimated from the void ratio versus logarithmic pressure plot and from the total work versus pressure plot. Bulk unit weights ranging from about 16.9 kN/m³ to 17.6 kN/m³ and specific gravities of about 2.75 and 2.76 were measured on the consolidation test specimens. Details of the test results are shown on Figures B.S502-23 to B.S502-25 in Appendix B, and the test results are summarized below.

Borehole Sample No.	Sample Depth / Elevation	σ_{vo}' (kPa)	σ_p' (kPa)	$\sigma_p' - \sigma_{vo}'$ (kPa)	OCR	C_c	C_r	e_o	c_v^* (cm ² /s)
Borehole B502-13 Sample 10	7.7 m / 175.8 m	75	160	85	2.1	0.62	0.06	1.23	4.6×10^{-4}
Borehole S502-20 Sample 10	9.4 m / 174.7 m	100	150	50	1.5	0.79	0.02	1.40	7.2×10^{-4}
Borehole S502-20B Sample 1	5.7 m / 178.5 m	55	195	140	3.5	0.80	0.06	1.43	1.0×10^{-3}

Note: * For stress range between effective overburden stress and final stress due to a 4.4 m high embankment, that is $40 \text{ kPa} \leq \sigma_v' \leq 185 \text{ kPa}$.

where: σ_{vo}' is the in situ vertical effective overburden stress in kPa
 σ_p' is the preconsolidation stress in kPa
OCR is the overconsolidation ratio
 e_o is the initial void ratio
 C_c is the compression index
 C_r is the recompression index
 c_v is the coefficient of consolidation in cm²/s



Silt to Silt and Sand (Pockets)

Boreholes B502-02, B502-12, S502-19 and S502-22 penetrated approximately 0.2 m to 1.4 m thick pockets of silt, some sand, trace to some clay to silt and sand, trace clay within the clayey silt to clay deposit. The top of the silty pockets ranges between Elevations 178.9 m and 168.7 m.

The SPT 'N'-values measured within the pockets of non-cohesive soil are between 1 blow and 2 blows per 0.3 m of penetration, indicating a very loose relative density.

The natural water content measured on two samples from the non-cohesive soil pockets is about 22 per cent.

The result of a grain size distribution test completed on one (1) sample of the silt and sand pocket is shown on Figure B.S502-26 in Appendix B.

An Atterberg limits test completed on the fines portion from a sample of this deposit, measured a liquid limit of about 19 per cent, a plastic limit of about 15 per cent and a corresponding plasticity index of about 4 per cent. The result of the Atterberg limits test is shown on the plasticity chart in Figure B.S502-27 in Appendix B and indicates that the material is classified as a silt of slight plasticity.

Silt to Silt and Sand (Lower Deposit)

A lower deposit of grey silt, trace to some sand to silt and sand was encountered underlying the cohesive deposit in Boreholes B502-02, B502-12 to B502-14, S502-18 to S502-24 and S502-20A. The deposit generally contains trace to some clay and trace gravel to gravelly. A 0.5 m thick layer of cobbles, boulders and rock fragments was encountered at the bottom of the deposit in Boreholes B502-02 and B502-13 at Elevations 150.6 m and 169.0 m, respectively. The top of this deposit ranges from about Elevation 176.8 m at the north limit to about Elevation 157.8 m at the south limit of the site and the thickness of the deposit ranges from 0.9 m to 7.2 m. The bottom of this deposit is defined by refusal to further casing and/or split-spoon advancement in Boreholes B502-14, S502-18 to S502-24 and S502-20A.

The SPT 'N'-values measured within this deposit range from 0 blows (weight of rod) per 0.3 m of penetration to 50 blows per 0.15 m of penetration, indicating a very loose to very dense relative density.

The natural water content measured on twenty-three (23) samples of this deposit ranges from about 19 per cent to 31 per cent.

The results of grain size distribution tests completed on twelve (12) samples of the deposit are shown on Figure B.S502-28A and B.S502-28B in Appendix B.

Atterberg limits tests were carried out on seven (7) samples of the silt to silt and sand deposit. The results of six (6) of the Atterberg limits tests indicate that the fines portions of the silt to silt and sand are non-plastic and the other Atterberg limits test measured a liquid limit of about 17 per cent, a plastic limit of about 16 per cent and a plasticity index of about 1 per cent. The result of the Atterberg limits test is shown on the plasticity chart on Figure B.S502-29 in Appendix B indicating the fine material is silt of slight plasticity.



Bedrock / Refusal

In Boreholes B502-14, S502-18 to S502-24 and in DCPTs S502-DC01, S502-DC02, S502-DC04, S502-DC08 and S502-DC09 the bedrock surface is inferred by refusal to further split-spoon and/or auger advancement or dynamic cone penetration at depths between about 9.8 m and 20.7 m below the ground surface, between Elevations 174.6 m and 160.8 m. Refusal was encountered at shallower depths near the north limit of the high fill area and the greatest depths to refusal were encountered near the south limit of the high fill area adjacent to the north shore of Straight Lake.

Bedrock was encountered and cored in Boreholes B502-02, B502-12 and B502-13 and between about 3.0 m and 3.3 m of core samples were recovered as shown on the photographs presented on Figures B.S502-30 to B.S502-32 in Appendix B. The bedrock consists of granitic gneiss and the core samples are described as slightly weathered to fresh, thinly laminated to thinly bedded, medium to coarse crystalline, faintly porous, medium strong to very strong, dark grey with light pink bands as described as presented on the Record of Drillhole sheets B502-02, B502-12 and B502-13 in Appendix B.

The Rock Quality Designation (RQD) measured on the three core runs ranges from 71 per cent and 100 per cent, indicating a rock mass of fair to excellent quality. The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of the rock core samples are between 97 per cent and 100 per cent, and between 50 per cent and 99 per cent, respectively.

Point load strength index tests (ASTM D5731) were carried out on selected samples of the bedrock core and the axial and diametral point load strength index values are shown on the relevant Record of Drillhole sheets and are presented in Table B.1 in Appendix B. The axial tests carried out on five (5) samples of the granitic gneiss bedrock core measured Is_{50} values of 2.5 MPa to 10.8 MPa and diametral tests carried out on seven (7) samples of the granitic gneiss bedrock core measured Is_{50} values ranging from about 4.8 MPa to 8.9 MPa.

An unconfined compression (UC) test (ASTM D7012) was carried out on a selected sample of the granitic gneiss bedrock obtained in Borehole B502-13 and measured a uniaxial compressive strength of about 111 MPa as detailed in Table B.3 in Appendix B. Based on the result of the UC test, the granitic gneiss bedrock is classified as very strong (R_5 , $100 \text{ MPa} < \text{UCS} < 250 \text{ MPa}$) rock.

Groundwater Conditions

Borehole B502-02 was advanced from the ice surface at Straight Lake. In general, the soil samples taken in the boreholes were moist to wet. The depth to groundwater levels measured in the open boreholes, upon completion of drilling range from 0.3 m to 6.0 m below ground surface or between Elevations 184.3 m and 178.9 m, with the groundwater table generally located closer to the ground surface in the southern portion of the high fill area.

4.6 Highway 69 SBL – STA 10+350 to STA 10+470 (Swamp 503)

The plan and profiles along the centreline and toes of the proposed embankment of the new Highway 69 SBL alignment showing the borehole and dynamic cone penetration test locations and interpreted stratigraphy between about STA 10+350 and STA 10+470 in the Township of Mowat are presented on Drawings C1 and C2 in Appendix C. The proposed embankment within this section of the highway is up to about 9 m high relative to the existing ground surface.



A total of fourteen (14) boreholes (Boreholes S503-01 to S503-11 and C501-01 to C501-03) and five (5) DCPTs (DCPTs S503-DC01 to S503-DC05) were completed to investigate the subsurface conditions within this swamp area. The topography of this section of the proposed highway is undulating, sloping down to the north and contains a low-lying area with brush, sparse trees and bedrock outcrops.

The subsurface soils along the SBL alignment in Swamp 503 generally consist of topsoil or organic silt/peat at the ground surface underlain in places by deposits of clayey silt to silty clay, underlain by deposits of silt and sand to sand. These deposits are underlain by a deposit of sandy gravel to sand and gravel and by inferred bedrock. Resistance to borehole advancement and dynamic cone penetration was encountered at depths of up to about 10.0 m below ground surface. The depths to refusal are generally greater in the southern portion of the swamp and shallower at the north limit of the swamp.

Water

Ponded water was encountered in Borehole C501-03 to a depth of about 1.1 m.

Topsoil

An approximately 0.1 m to 0.3 m thick layer of topsoil was encountered from the ground surface in Boreholes S503-01 to S503-04, S503-08 to S503-11, C501-01 and C501-02. The top of the topsoil layer ranges from Elevations 191.4 m to 183.1 m and the bottom of topsoil is defined by refusal to further hand shovel advancement at Boreholes S503-09 and S503-11.

The natural water content measured on a sample of the topsoil layer is about 41 per cent.

Organic Silt/Peat

An approximately 0.2 m to 0.7 m thick layer fibrous peat was encountered at the ground surface in Boreholes S503-06 and S503-07 and below the ponded water in Borehole C501-03. The surface of the peat layer ranges from Elevations 187.3 m to 184.1 m and the bottom of the peat layer is defined by refusal to further hand shovel advancement in Borehole S503-07.

A layer of organic silt was encountered below the topsoil in Borehole C501-01 and below the peat layer in Borehole S503-06. The top of the organic layer was encountered at Elevations 182.9 m and 185.0 m and the thickness of the layer is about 0.7 m and 0.4 m in the respective boreholes.

The natural water content measured on two (2) samples of the organic silt is about 35 per cent and 73 per cent and on two (2) samples of the peat is about 61 per cent and 132 per cent.

The organic content measured on a sample of the organic silt is about 6 per cent and on a sample of the peat is about 48 per cent.

Clayey Silt to Silty Clay

A deposit of cohesive soil comprised of sandy clayey silt to clayey silt to silty clay was encountered at the ground surface in Borehole S503-05 and below the topsoil in Boreholes S503-02 to S503-04 and S503-10 and also as



an interlayer within the upper portion of the silt and sand deposit in Borehole S503-03. The top of the deposit ranges from Elevations 191.2 to 186.2 m and the thickness of the deposit varies between 0.2 m to 0.9 m.

SPT 'N'-values ranging from 3 blows to 5 blows per 0.3 m of penetration were measured at the interface of this deposit and the overlying topsoil or the underlying silt and sand deposit, suggesting a soft to firm consistency.

The natural water content measured on six (6) samples of the cohesive deposit ranges from about 23 per cent to 34 per cent.

Atterberg limits tests were carried out on five (5) samples of the cohesive deposit and measured liquid limits ranging from about 19 per cent to 40 per cent, plastic limits ranging from about 13 per cent to 21 per cent and plasticity indices ranging from about 6 per cent to 19 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure C.S503-01 in Appendix C and indicate that the material is classified as clayey silt of low plasticity to silty clay of intermediate plasticity.

Silt and Sand to Sand

A non-cohesive deposit of brown to grey silt and sand to silty sand to sand trace to some silt was encountered below the topsoil in Boreholes S503-01, S503-08 and C501-02, below the organic silt in Boreholes S503-06 and C501-01, below the peat in Borehole C501-03 and underlying the cohesive deposit in Boreholes S503-02 to S503-05 and S503-10. The deposit generally contains trace to some gravel, trace clay and occasional clayey silt to silty clay seams and contains trace organics in Boreholes S503-01, S503-06 and S503-08 up to a depth of 1.8 m below ground surface. A boulder was encountered within this deposit in Borehole S503-02 at a depth of 1.1 m below ground surface corresponding to about Elevation 187.0 m. The top of the non-cohesive deposit ranges from Elevations 190.3 m to 182.2 m and the thickness of the deposit varies between 0.6 m and 5.5 m. The bottom of the non-cohesive deposit is defined by refusal to further split-spoon and/or casing advancement in Boreholes S503-02, S503-04, S503-05, S503-08, S503-10, C501-01 and C501-03.

The SPT 'N'-values measured within the deposit range from 4 blows to 44 blows per 0.3 m of penetration, indicating a loose to dense relative density. An SPT 'N'-value of 76 blows per 0.3 m of penetration was measured immediately above the interface of this deposit with the underlying sandy gravel deposit indicating a very dense relative density.

The natural water content measured on fourteen (14) samples of the deposit range from about 12 per cent and 48 per cent.

The organic content measured on two (2) samples of the non-cohesive deposit is about 1 per cent and 3 per cent.

The results of grain size distribution tests completed on ten (10) samples of this deposit are shown on Figures C.S503-02A and C.S503-02B in Appendix C.

Sand and Gravel to Sandy Gravel

A deposit of grey sand and gravel to sandy gravel was encountered below the silt and sand to sand deposit in Boreholes S503-01, S503-03, S503-06 and C501-02. The top of this deposit ranges between Elevations 185.5 m and 182.6 m and the thickness of the deposit ranges from 0.2 m to 0.9 m and may be up to



about 1.3 m as inferred from the DCPT advanced 1.2 m east of Borehole S503-06. The bottom of the deposit is defined by refusal to further split-spoon and casing advancement in Borehole S503-01, S503-03 and C501-02 and by refusal to further DCPT penetration in Borehole S503-06.

SPT 'N'-values of 11 blows and 12 blows per 0.3 m of penetration were measured within this deposit and SPT 'N'-values of 3 blows and 17 blows per 0.3 m of penetration were measured at the interface with the overlying silt and sand to sand deposit, indicating a very loose to compact relative density.

The natural water content measured on two (2) samples of this deposit is about 10 per cent and 23 per cent.

The result of a grain size distribution test completed on one sample of this deposit is shown on Figure C.S503-03 in Appendix C.

Refusal

The bedrock surface at the boreholes and DCPTs is inferred by refusal to further split-spoon sampler and/or casing advancement, hand shovel excavations and dynamic cone penetration at depths ranging from 0.1 m to 10.0 m below ground surface, between Elevations 191.4 m and 180.6 m. Refusal was encountered at shallower depths below ground surface near the north limit of the swamp.

Groundwater Conditions

The samples taken in the boreholes were moist to wet. Boreholes S503-02, S503-07, S503-09 and S503-11 were dry upon completion of drilling/excavation. Borehole C501-03 was advanced from the surface of ponded water 1.1 m deep. In the open boreholes, the water level was measured between Elevations 189.5 m and 182.6 m ranging from the ground surface to a depth of about 1.9 m below ground surface.

4.7 Highway 69 NBL – STA 10+230 to STA 10+445 (Swamp 503)

The plan and profiles along the centreline and toes of the proposed embankment of the new Highway 69 NBL alignment showing the borehole and dynamic cone penetration test (DCPT) locations and interpreted stratigraphy between about STA 10+230 and STA 10+445 in the Township of Mowat are presented on Drawings C1, C3 and C4 in Appendix C. The proposed embankment within this section of the highway is up to about 8 m high relative to the existing ground surface.

A total of twenty-two (22) boreholes (Boreholes S503-12 to S503-30 and C501-04 to C501-06) and nine (9) DCPTs (DCPTs S503-DC06 to S503-DC14) were completed to investigate the subsurface conditions within this swamp area. The topography of this section of the proposed highway is relatively flat to slightly low-lying and bounded by bedrock outcrops. The central portion of the swamp is occupied by shallow open water and the south perimeter is brush and tree covered.

The subsurface soils along the NBL alignment in Swamp 503 generally consist of a layer of peat and/or a deposit of organic silt to clayey organic silt immediately below the ground surface or ponded water. Two boreholes penetrated through a cohesive deposit immediately below ground surface or ponded water and one borehole penetrated through a non-cohesive silt and sand deposit. The organic deposits and surficial soil deposits are underlain by a non-cohesive deposit of silt and sand to sand and/or sand and gravel, or inferred



bedrock. Resistance to dynamic cone penetration and borehole advancement was encountered at depths of up to about 12.5 m below ground surface. The depths to refusal are greater in the middle of Swamp 503 and shallower at the south and north limits of the swamp.

Water

Ponded water (ranging in depth from about 0.5 m to 0.9 m) was encountered in Boreholes S503-15, S503-16, S503-18 to S503-20, S503-22 to S503-26, C501-04 to C501-06.

Peat

An approximately 0.1 m to 2.2 m thick deposit of peat was encountered at the ground surface and below the ponded water in Boreholes S503-15, S503-16, S503-18 to S503-22, S503-24 to S503-26, S503-28, S503-30 and C501-04 and C501-06. The top of the peat deposit is encountered between Elevations 192.6 m and 184.9 m.

The SPT 'N'-values measured within the peat range from 0 blows (weight of hammer) to 1 blow per 0.3 m of penetration, suggesting a very soft consistency.

The natural water content measured on six (6) samples of the peat deposit ranges from about 137 per cent to 874 per cent.

The organic content measured on two (2) samples of the peat is about 42 per cent and 48 per cent.

Organic Silt to Clayey Organic Silt

A deposit of dark brown to dark grey organic silt to clayey organic silt was encountered at the ground surface in Boreholes S503-12 to S503-14 and S503-17, underlying the peat deposit in Boreholes S503-15, S503-16, S503-18 to S503-20, S503-24, S503-25, C501-05 and C501-06, underlying a non-cohesive deposit in Boreholes S503-21 and S503-22 and below the cohesive deposit in Boreholes S503-26 and C501-04. The top of the organic deposit ranges from Elevations 188.9 m to 182.8 m and the thickness of the deposit varies between 0.2 m and 5.1 m. The bottom of this deposit is inferred from refusal to split-spoon sampler or casing advancement in Boreholes S503-14 and S503-21 and a DCPT advanced 1 m north of Borehole S503-15 at depths between 2.1 m and 4.3 m below ground surface, corresponding to between Elevations 183.5 m and 181.5 m.

The SPT 'N'-values measured within the organic silt deposit range from 0 blows (weight of hammer) to 5 blows per 0.3 m of penetration, suggesting a very soft to soft consistency. The SPT 'N'-values measured within the clayey organic silt deposit range from 0 blows (weight of hammer) to 3 blows per 0.3 m of penetration. In situ field vane tests were carried out within the clayey organic silt deposit and measured undrained shear strengths ranging from about 13 kPa to 57 kPa and the sensitivity ranges between 2 and 9. The SPT 'N'-values and in situ field vane tests results suggest that the clayey organic silt deposit has a very soft to stiff consistency.

The natural water content measured on seven (7) samples of the organic silt deposit ranges from about 30 per cent to 109 per cent, and on twenty-eight (28) samples of the clayey organic silt deposit ranges from about 14 per cent to 280 per cent.



The organic content measured on five (5) samples of the organic silt deposit ranges from about 5 per cent to 12 per cent and on eleven (11) samples of the organic clayey silt deposit ranges from about 5 per cent to 25 per cent.

Atterberg limits tests were carried out on four (4) samples of the organic silt deposit, three (3) of which indicated that the material is non-plastic while one test measured a liquid limit of about 36 per cent, a plastic limit of about 29 per cent and a plasticity index of about 7 per cent and as shown on the plasticity chart C.S503-04 in Appendix C, confirming that the material is classified as organic silt of intermediate plasticity.

The result of a grain size distribution test completed on a sample of clayey organic silt is shown on Figure C.S503-05 in Appendix C.

Atterberg limits tests were also carried out on eight (8) samples of the clayey organic silt deposit and measured liquid limits ranging from about 74 per cent to 91 per cent, plastic limits ranging from about 53 per cent to 71 per cent and plasticity indices ranging from about 19 per cent to 37 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure C.S503-06 in Appendix C and indicate that the material in this portion of the organic deposit is classified as clayey organic silt of high plasticity.

Clayey Silt to Silty Clay

A deposit of cohesive soil comprised of clayey silt to silty clay was encountered at ground surface in Borehole S503-27, below the ponded water layer in Borehole S503-23 and below the organic or peat deposits in Boreholes S503-12, S503-13, S503-16, S502-26, S503-28, S503-30 and C501-04. The deposit contains trace organics in places and generally contains trace to some sand and trace to some gravel. The top of the cohesive deposit ranges from Elevations 192.0 m to 181.4 m and the thickness of the deposit varies between 0.1 m and 1.6 m. The bottom of the cohesive deposit was inferred from refusal to split-spoon sampler and/or casing advancement in Boreholes S503-12, S503-13, S503-27 and S503-28 and refusal to further advancement of the DCPT adjacent Borehole S503-16.

The SPT 'N'-values measured within the cohesive deposit range from 0 blows (weight of hammer) to 10 blows per 0.3 m of penetration. Two in situ field vane tests were carried out within this deposit and measured undrained shear strengths of about 21 kPa and 38 kPa and sensitivity values of 2 and 3. The SPT 'N'-values and in situ field vane tests results suggest a very soft to stiff consistency.

The natural water content measured on twelve (12) samples of the cohesive deposit ranges from about 11 per cent to 111 per cent.

The organic content measured on three (3) samples of the cohesive deposit is between about 3 per cent and 5 per cent.

Atterberg limits tests completed on six (6) samples of this deposit measured liquid limits between about 31 per cent and 45 per cent, plastic limits between about 17 per cent and 19 per cent and plasticity indices between 13 per cent and 26 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure C.S503-07 in Appendix C and indicate that the material is classified as a clayey silt of low plasticity or silty clay of intermediate plasticity.



Silt and Sand to Sand

A deposit of non-cohesive soil comprised of silt and sand to silty sand to sand, trace to some silt, some gravel to gravelly silty sand in places was encountered in Boreholes S503-17 to S503-20, S503-22, S503-24 to S503-26, S503-29, S503-30 and C501-06. A pocket of silty sand was also encountered in Borehole S503-22 between the peat and clayey organic silt deposits. Cobbles were encountered at the bottom of this deposit in Borehole S503-19. The top of this deposit ranges from Elevations 191.2 m to 178.2 m and the thickness of the deposit varies from 0.1 m to 5.2 m. The bottom of this deposit was inferred from refusal of split-spoon sampler and/or casing advancement in Boreholes S503-17, S503-19, S503-22, S503-24, S503-25, S503-26, S503-29, S503-30 and C501-06.

The SPT 'N'-values measured within the non-cohesive deposit range from 0 blows (weight of hammer) to 27 blows per 0.3 m of penetration. The SPT 'N'-values indicate a very loose to compact relative density.

The natural water content measured on twelve (12) samples of the non-cohesive deposit ranges from 16 per cent to 77 per cent.

The organic content measured on a sample of this deposit is about 4 per cent.

The results of grain size distribution tests completed on ten (10) samples of the non-cohesive deposit are shown on Figures C.S503-08A to C.S503-08C in Appendix C.

Sand and Gravel

A deposit of sand and gravel was encountered underlying the clayey organic silt deposit in Boreholes C501-04 and C501-05, below the non-cohesive deposit in Boreholes S503-18 and S503-20 and below the cohesive deposit in Boreholes S503-23. The top of this deposit ranges from Elevations 183.6 m to 176.0 m and the thickness of the deposit ranges from 0.3 m to 2.5 m.

The SPT 'N'-values measured within this deposit range from 10 blows to 62 blows per 0.3 m of penetration, indicating a compact to very dense relative density.

The natural water content measured on two (2) samples of this deposit is about 16 per cent and 18 per cent.

A result of a grain size distribution test completed on a sample of this deposit is shown on Figure C.S503-09 in Appendix C.

Refusal

The bedrock surface at the boreholes and DCPTs is inferred by refusal to further split-spoon sampler and/or casing advancement and dynamic cone penetration at depths between 0.3 m to 12.5 m below ground surface, between Elevations 190.3 m and 173.3 m. Refusal was encountered at shallower depths below ground surface near the south and north limits of the swamp.

Groundwater Conditions

The samples taken in the boreholes were moist to wet. Ponded water was present at the surface in the central portion of the swamp, with the water surface at Elevation 185.8 m. While two (2) boreholes were dry, in general, the water level in the open boreholes was noted at between Elevations 190.9 m and 185.5 m, at depths between 0.1 m and 1.1 m below ground surface.



4.8 Highway 69 NBL – STA 21+300 (Henvey) to STA 10+140 (Mowat) (Deep Cut 504)

The plan and profiles along the centreline and toes of the proposed cut of the new Highway 69 NBL alignment showing the borehole locations and interpreted stratigraphy between about STA 21+300 in the Township of Henvey to STA 10+140 in the Township of Mowat are presented on Drawings D1 to D3 in Appendix D. The proposed cut within this section of the highway is up to about 4 m deep relative to the existing ground surface.

A total of nine (9) boreholes (Boreholes D504-01 to D504-09) were completed to investigate the subsurface conditions within this cut area. This section of the proposed highway extends through a knoll across the confines of valley slopes to the south and north. In general, the ground cover consists of shrubs and treed areas, and bedrock outcrops along the west side of the cut.

The subsurface soils along the NBL alignment in Deep Cut 504 generally consist of a layer of topsoil at the ground surface underlain in places by a sandy clayey silt deposit. Topsoil and/or surficial cohesive deposits are underlain by deposits of silt to sand which in turn is underlain by a relatively thick deposit of clayey silt to clay. The cohesive deposit is underlain by a deposit of silt to silt and sand.

Topsoil

An approximately 0.1 m to 0.3 m of topsoil was encountered immediately at the ground surface in all boreholes. The surface of the topsoil ranges from about Elevations 195.8 m to 194.0 m.

Sandy Clayey Silt

A surficial deposit of mottled brown and grey sandy clayey silt was encountered underlying the topsoil layer in Boreholes D504-05 and D504-08. The deposit contains trace organics in Borehole D504-08. The top of the deposit was encountered at Elevations 193.9 m and 193.8 m in the respective boreholes and the thickness of the deposit is about 0.5 m.

SPT 'N'- values of 3 blows and 4 blows per 0.3 m of penetration were measured at the top of the deposit at the interface with the overlying layer of topsoil, suggesting a soft consistency.

Silt to Sand

A deposit of non-cohesive soil comprised of silt to sandy silt to silt and sand to silty sand to sand was encountered immediately below the topsoil and/or surficial sandy silty clay deposit in all boreholes. The deposit contains trace organics in Boreholes D504-02, D504-06 and D504-09 and contains rootlets and wood fragments within its upper portion at some locations. An approximately 0.3 m thick pocket of silty clay was encountered within the non-cohesive deposit at Elevations 193.6 m and 194.7 m in Boreholes D504-01 and D504-03. The top of the silt to sand deposit ranges from Elevations 195.6 m to 193.3 m and the overall thickness of the deposit including the thickness of silty clay pockets varies between 1.8 m and 4.8 m.

The SPT 'N'-values measured within this non-cohesive deposit range from 5 blows to 25 blows per 0.3 m of penetration, indicating a loose to compact relative density. An SPT 'N'-value of 2 blows per 0.30 m of penetration was measured at the interface with the overlying topsoil deposit in Borehole D504-09, and SPT



'N'-values between 4 blows and 10 blows per 0.3 m of penetration were measured at the interface with the underlying silty clay to clay deposit.

The natural water content measured on twenty (20) samples of the silt to sand deposit range from about 17 per cent to 43 per cent and on two (2) samples of the silty clay pockets is 32 per cent and 29 per cent.

The organic content measured on two (2) samples of the non-cohesive deposit is about 1 per cent and 5 per cent.

The results of grain size distribution tests completed on five (5) samples of the non-cohesive deposit are shown on Figure D.D504-01 in Appendix D.

Atterberg limits tests were carried out on two (2) samples from the cohesive soil pockets and measured liquid limits of about 41 per cent and 43 per cent, plastic limits of about 17 per cent and plasticity indices of about 25 per cent and 27 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure D.D504-02 in Appendix D and indicate that the cohesive soil pockets consist of silty clay of intermediate plasticity.

Clayey Silt to Clay

A cohesive deposit of grey clayey silt to silty clay to clay was encountered below the silt and sand deposit in all boreholes. The cohesive deposit occasionally contains trace to some sand. An approximately 1.0 m thick sandy silt pocket was encountered in Borehole D504-06 at Elevation 189.7 m and 0.1 m thick sandy silt seams were encountered in Borehole D504-07 between Elevations 188.3 m and 187.7 m. The top of the cohesive deposit ranges from Elevations 192.1 m to 190.2 m and the overall thickness of the deposit, including the sandy silt pockets varies between 2.3 m and 5.3 m.

The SPT 'N'-values measured within the cohesive deposit range from 0 blows (weight of hammer) to 7 blows per 0.3 m of penetration. In situ field vane tests were carried out within this cohesive deposit and measured undrained shear strengths ranging from 14 kPa to greater than 96 kPa but generally less than 50 kPa, and the sensitivity values range from 3 to 13. The field vane tests results indicate that the clayey silt to clay deposit has a soft to stiff consistency.

The natural water content measured on twenty-three (23) samples of this deposit ranges from about 31 per cent to 86 per cent and on two (2) samples of the sandy silt seams and pockets are from 20 per cent and 21 per cent.

The results of grain size distribution tests completed on two (2) samples of the cohesive deposit are shown on Figure D.D504-03 in Appendix D.

Atterberg limits tests were carried out on eleven (11) samples of this cohesive deposit and measured liquid limits ranging from about 26 per cent to 55 per cent, plastic limits ranging from about 14 per cent to 20 per cent and plasticity indices ranging from about 7 per cent and 37 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure D.D504-04 in Appendix D, and indicate that the material is classified as clayey silt of low plasticity to clay of high plasticity.

Laboratory consolidated isotropic undrained triaxial compression tests (CIU) with pore pressure measurement were carried out on a Shelby tube sample of the cohesive deposit obtained in Borehole D504-04. In total, three specimens were tested under consolidation pressures ranging from 25 kPa to 150 kPa. The details of the test results are shown on Figure D.D504-05 in Appendix D and the results are summarized below.



Borehole Sample No.	Sample Depth / Elevation	Effective Cohesion, c' (kPa)	Effective Angle of Internal Friction, ϕ' (degrees)
Borehole D504-04 Sample 8	6.4 m / 188.4 m	5	27

The triaxial test samples were consolidated to pressures representative of the estimated in situ effective stress and effective stresses under the proposed deep cut conditions, at the sample depth. The effective strength parameters provided above are applicable only to design situations for the stress conditions used in the laboratory test. Reference should be made to individual test results given on Figure D.D504-05 for details of the testing conditions.

Silt to Silt and Sand

A deposit of non-cohesive soils comprised of silt to sandy silt to silt and sand was encountered underlying the clayey silt to clay deposit in all boreholes. The top of the non-cohesive deposit ranges from Elevations 189.7 m and 185.7 m and the thickness of the deposit ranges between 3.7 m and 8.2 m and may be up to 13.1 m as inferred from the DCPT extended from the bottom of Borehole D504-05.

The SPT 'N'-values measured within this non-cohesive deposit ranges from 0 blows (weight of hammer) to 25 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

The natural water content measured on fifteen (15) samples of this deposit ranges from about 21 per cent to 30 cent.

The results of grain size distribution tests completed on eight (8) samples of this deposit are shown on Figures D.D504-06A and D.D504-06B in Appendix D.

An Atterberg limits test carried out on one (1) sample of the silt portion of the non-cohesive deposit indicates that the material is non-plastic. One Atterberg limits test was carried out on the fines portion of sandy silt from the non-cohesive deposit and measured a liquid limit of about 22 per cent, a plastic limit of about 19 per cent and a corresponding plasticity index of about 3 per cent. The result of the Atterberg limits test is shown on the plasticity chart on Figure D.D504-07 in Appendix D and indicates that the material is classified as sandy silt of slight plasticity.

Refusal

The bedrock surface is inferred by refusal to further split-spoon sampler and auger advancement in Boreholes D504-03, D504-04 and D504-07 and refusal to dynamic cone penetration tests carried out from the bottom of Boreholes D504-01, D504-02 and D504-05 at depths between about 10.7 m and 20.7 m below ground surface, corresponding to between Elevations 185.1 m and 173.4 m.

Groundwater Conditions

The samples taken in the boreholes were moist to wet. The depth to the water was measured in selected open boreholes at depths between 1.5 m and 8.2 m below ground surface, corresponding to between about



Elevations 194.3 m and 185.8 m. Standpipe piezometers were installed in Boreholes D504-04 and D504-07 to allow monitoring of the groundwater level in the lower and upper sandy silt deposits at the site. Details of the piezometer installation and the groundwater level measurements are shown on the relevant Record of Borehole sheets in Appendix D, and the groundwater level measurements are summarized below.

Borehole	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date of Measurement
D504-04	194.8	4.1	190.7	July 25, 2013
D504-07	194.4	0.5	193.9	July 25, 2013

5.0 CLOSURE

The drilling program was directed by Mr. Indulis Dumpis, a senior field technician and assisted by several field personnel from Golder's Sudbury and London offices. This report was prepared by Mr. Al Varshoi, M.E.Sc., and was reviewed by Mr. J. Paul Dittrich, P.Eng., a senior geotechnical engineer and Principal with Golder. Mr. Jorge M. A. Costa, P.Eng., Golder's Designated MTO Foundations Contact for this project and Senior Consultant with Golder, conducted an independent quality control review of the report.



Report Signature Page

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[https://capws.golder.com/sites/0911116014highway69FourLaning/Contract 5/Reporting/Swamp and High Fills/Final/09-1111-6014 RPT 16Jul20 Contract 5 Highway 69 Swamp Crossing, High Fill Areas and Deep Cut.docx](https://capws.golder.com/sites/0911116014highway69FourLaning/Contract%205/Reporting/Swamp%20and%20High%20Fills/Final/09-1111-6014%20RPT%2016Jul20%20Contract%205%20Highway%2069%20Swamp%20Crossing,%20High%20Fill%20Areas%20and%20Deep%20Cut.docx)



PART B

FOUNDATION DESIGN REPORT

SWAMP CROSSING, HIGH FILL AREAS AND DEEP CUT– CONTRACT 5

HIGHWAY 69 FOUR-LANING FROM 1.7 KM NORTH OF HIGHWAY 529

NORTHERLY TO 3.9 KM NORTH OF HIGHWAY 522

MINISTRY OF TRANSPORTATION, ONTARIO

GWP 5347-08-00; WP 5005-10-01



6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides an interpretation of the geotechnical data obtained during the investigation and recommendations on the foundation aspects of design of the proposed works. The recommendations provided herein are intended for the guidance of the design engineer. Where comments are made on construction, they are provided to highlight aspects of construction that could affect the design of the project. Those requiring information on aspects of construction must make their own interpretation of the subsurface information provided as it affects their proposed construction methods, costs, equipment selection, scheduling and the like.

6.1 General

Golder Associates Ltd. (Golder) has been retained by URS Canada Inc. (URS) on behalf of the Ministry of Transportation, Ontario (MTO) to provide recommendations on foundation aspects for the detail design of a swamp crossing, high fill embankments and a deep cut at four locations within the Contract 5 section of the proposed Highway 69 alignment, associated with the four-laning of Highway 69 in the Townships of Wallbridge, Henvey and Mowat. The proposed Contract 5 swamp crossing, high fill areas and deep cut are located within the proposed alignment extending approximately 9 km north of the junction of the existing Highway 526 and Highway 69 northerly for a total distance of about 1.7 km. Table 1 summarizes the locations and extent of the areas investigated within the Contract 5 project limits (a total length of about 1 km) that require foundation design for the new Highway 69 alignment.

This report presents the results of stability and settlement analyses of the proposed roadway embankments and stability of the proposed deep cut slopes, and provides recommendations for stable embankment and cut slope geometry, use of alternative fill materials for embankment construction, and implementation of foundation mitigation alternatives that may be required as a means to improve stability and reduce post-construction settlements (where necessary) of both the subgrade soil deposits and embankment fill materials. The report also addresses potential construction concerns and geotechnical problems associated with embankment and cut slope construction, sub-excavation of soft/organic materials and placement of new fill materials.

6.2 High Fill Embankments/Embankments Over Swamp and Deep Cut

Based on the vertical profiles and cross-sections of the proposed Highway 69 alignment provided to Golder by URS on March 14, 2012 and February 1, 2013, respectively, as well as the General Arrangement drawings of the Straight Lake SBL and NBL bridge structures provided on February 24, 2016, the new highway crossings over swamp/high fill sections within the Contract 5 limits will require fill embankments ranging in height from about 4 m to 10 m, while the one cut section within the Contract 5 limits will be up to about 4 m deep.

A comparison of alternative fill materials for embankment construction is presented in Section 6.2.1. Sections 6.2.2 and 6.2.3 summarize the methods used to analyze the stability and settlement for critical sections of swamp crossing/high fill embankments and cut slope geometry/construction, where applicable. Section 6.3 outlines the settlement performance requirements for each foundation investigation area requiring high fill and/or embankment over swamp construction based on MTO's embankment settlement criteria. Section 6.4 provides a discussion related to recommendations for potential alternatives for mitigating embankment stability and settlement related design and construction issues; while Section 6.5 provides an overview of potential stability



mitigation options associated with the deep cut. The foundation engineering parameters and input values for the stability and settlement analyses are described in Section 6.2 and summarized in Tables 2 and 3. The results of the analyses and recommendations for mitigating instability and time-dependent settlements for each individual swamp crossing/high fill area and deep cut section, where applicable, are presented in Section 6.6 and summarized in Tables 4 to 7. General aspects of subgrade preparation and embankment construction are discussed in Section 6.7.

At all areas involving embankment construction, the analyses assume that the peat and near surface organic soils (encountered at and below the ground surface during drilling operations) will be removed from below the embankment footprint prior to construction of the new embankments (as discussed in Section 6.7.1). In some areas (i.e. Swamp 503) a greater depth of organic soil removal will be required as discussed in Section 6.6. For details on the thickness of organic deposits at each swamp crossing/high fill area, refer to Section 4.0 and the summary of maximum thickness of organic materials provided in Table 5. The piezometric conditions required in the analyses are typically based on the groundwater levels noted during and upon completion of drilling. However, where standpipe piezometers were installed in boreholes, the groundwater levels are based on measured water levels.

General aspects pertaining to surficial instability and erosion protection for the deep cut earth slope are addressed in Section 6.9.

6.2.1 Embankment Fill Types and Berm Requirements

Different embankment fill alternatives (i.e. rock fill and granular fill) provide relative advantages and disadvantages in terms of availability, weight (i.e. driving force and applied load to the founding deposit), construction cost and time, ease of construction and post-construction performance.

It is understood that rock fill is the preferred embankment fill material for this project due to its availability from rock blasting for road cuts required elsewhere on the alignment. In this regard, the majority of the stability and settlement analyses discussed in Section 6.6 have been carried out on the basis that the highway embankments will be constructed of rock fill.

Rock Fill

The main advantage of constructing embankments using rock fill is the ability to achieve steeper side slopes (1.25 horizontal to 1 vertical (1.25H:1V)), which is required in areas with limited right-of-way, thus reducing the overall quantity of fill material required for the project. In addition, use of rock fill is typically preferred for placement in sub-excavated areas under water. Rock fill will also be available locally, either from excavations in deep cuts through bedrock outcrops within this and other phases of the project alignment or from rock borrow areas close to the project limits. The disadvantage of using rock fill for the construction of embankments is that some post-construction settlement of the embankment fill itself will occur. Settlement of the rock fill is discussed further in Section 6.2.3.3.

In accordance with MTO Northern Region Pavement Practices and Guidelines (1997) as amended by MTO Memorandum “Use of Mid-Slope Berms for Rockfill Embankments” dated February 8, 2005, 2 m wide benches should be incorporated into the rock fill embankment side slope profile for uninterrupted slopes greater than 10 m high, as shown schematically on Ontario Provincial Standard Drawing (OPSD) 202.010 (Slope Flattening).



It should be noted that the height of several sections of the embankment within the limits of High Fill 502 are expected to exceed 10 m, as such, 2 m wide mid-slope benches will be required in this area, where applicable.

Granular Fill

The main advantage of using granular fill for embankment construction is the ease of construction and negligible post-construction settlement of the embankment fill itself. In addition, the use of granular material as backfill in sub-excavated areas is necessary at locations where driven pile installation will subsequently be required. However, this option will require a larger volume of fill and potentially a wider right-of-way because the side slopes of granular fill embankments (2H:1V) are flatter than those of rock fill. For this project, acceptable granular fill is considered to consist of well graded, locally available and/or imported granular material.

For granular fill embankments, 2 m wide benches should be incorporated into the side slope profiles for uninterrupted slopes greater than 8 m high, as shown schematically on OPSD 201.010 (Slope Flattening).

6.2.2 Stability

The following sections outline the methodology used to evaluate embankment stability along the various swamp crossing/high fill areas and slope stability for the cut section. Parameters used in the analyses for each of the critical section(s) are also presented. The results of the stability analyses are presented in Section 6.6 for each swamp crossing/high fill area and cut section where they are discussed together with the results of the settlement analyses (where applicable) and recommendations regarding possible design and construction alternatives to mitigate stability issues and/or post-construction settlement.

6.2.2.1 Methodology

Embankments

Stability analyses were carried out for the critical sections of the proposed fill embankments in each swamp crossing/high fill area. Critical sections correspond to the greatest new embankment height and/or the maximum thickness of soft, compressible cohesive soils. In all areas where cohesive deposits were encountered, the stability of the proposed new embankment section(s) was analyzed using limit equilibrium methods. In areas where cohesive deposits were not encountered (for example, High Fill 501), the stability of the proposed embankment section is considered adequate based on engineering judgement and precedent experience in similar soil conditions. The stability analyses assume that the organic soils encountered at/below ground surface have been removed and replaced in accordance OPSD 203.010 (Embankments Over Swamp – New Construction) prior to construction of the new embankments.

All limit equilibrium slope stability analyses were carried out using the commercially available program Slide (Version 6.0), developed by Rocscience Inc., employing the Morgenstern-Price method of analysis. For all analyses, the Factor of Safety (FoS) of numerous potential failure surfaces was computed in order to establish the minimum FoS. The FoS is defined as the ratio of the forces tending to resist failure to the driving forces tending to cause failure. A target minimum FoS of 1.3 is normally adopted for the design of embankment slopes under static conditions for MTO embankments. This FoS is considered adequate for the embankments at these sites considering the design requirements and the field data available and is based on deep-seated, global



failure surfaces that would affect the operation of the highway. The stability analyses were carried out to check that the target minimum FoS was achieved for the various embankment heights and geometries.

Cut Slopes

Stability analyses were also carried out for the critical sections of the proposed earth cut slopes in the Deep Cut 504 area. Critical sections correspond to the greatest depth of cut and/or highest groundwater level and/or the maximum thickness of soft/weak soils along the cut slopes and below the base of the excavation.

Limit equilibrium slope stability analyses were carried out to assess the stability of the permanent cut slopes during the short-term (i.e. immediately after excavation of the slope and assuming undrained conditions) and during the long-term (i.e. after a period of time when drained conditions have been reached). All analyses were carried out using the commercially available program Slide (Version 6.0), developed by Rocscience Inc., employing the Morgenstern-Price method of analysis. In addition, since the drained conditions represent a steady state where drainage equilibrium has been reached and there are no excess pore pressures, the slope stability analyses were supplemented with finite element steady state groundwater seepage analyses, using the same software, to establish the position of the new phreatic surface relative to the new cut geometry. The steady state groundwater analyses involve discretization of the boundaries and generation of a finite element mesh; assignment of steady state groundwater boundary conditions (generally based on total pressure head obtained from water level readings taken from the standpipe piezometers screened in various deposits); and definition of material permeability properties.

For both undrained and drained conditions, the Factor of Safety (FoS) of numerous potential failure surfaces was computed in order to establish the minimum FoS. A target minimum FoS of 1.3 is normally adopted for the design of earth cut slopes under static conditions for MTO's deep cut areas. Similarly to the minimum FoS for MTO embankments, this FoS is also considered adequate for earth cut slopes at these sites considering the design requirements and the field data available and is based on both deep-seated and shallow failure surfaces that would affect the operation of the highway or the long-term performance of the cut slope face. The stability analyses were carried out to check that the target minimum FoS was achieved at the critical sections.

6.2.2.2 Parameter Selection

The simplified stratigraphy together with the associated unit weight(s) and foundation engineering parameters employed for the different native soil types at the critical sections in each swamp crossing/high fill area and in the deep cut area are summarized in Table 3. Additional details of foundation engineering parameters employed for the thicker cohesive deposits (i.e. clayey silt/silty clay/clay) encountered in High Fill 502 are provided on Figure B1 in Appendix B. The following is a summary of embankment slope geometries, unit weights and effective friction angles/cohesion for the various fill types, where applicable, modelled in the analyses.

Fill Type	Recommended Slope Inclination	Unit Weight, γ (kN/m³)	Effective Friction Angle, ϕ' (°)	Cohesion, c' (kPa)
Rock Fill	1.25H:1V	19	40	0
Granular Fill	2H:1V	21	34	0
Lightweight Fill	2H:1V	0.5	0	15



The overburden encountered at the various swamp crossing/high fill areas and at the deep cut area is generally composed of a combination of cohesive deposits (clayey silt, silty clay and/or clay) and granular soils, except at High Fill 501 where the overburden is comprised of very thin layers of granular or organic soils. For granular soils, effective stress parameters were employed in the analyses assuming drained conditions. The effective stress parameters (effective friction angle and effective cohesion) for the organic soils (peat/topsoil/root mat) and granular soils were estimated from empirical correlations proposed by US Navy (1986) using the results of in situ SPTs, in conjunction with engineering judgement based on experience in similar soil conditions.

For cohesive deposits, total stress parameters were employed in the embankment and deep cut analyses assuming short-term, undrained conditions. The total stress parameters (i.e. average mobilized undrained shear strength – s_u) for the cohesive soils were assessed based on the results of in situ field vane shear tests, inferred from the laboratory consolidation tests results, and estimated from correlations with the SPT results and other laboratory test data (i.e. natural water content), where appropriate. For the consolidation tests, the following correlation proposed by Mesri (1975) was employed to estimate the undrained shear strength:

$$s_u = 0.22 \sigma'_p$$

where:

s_u	=	average mobilized undrained shear strength (kPa)
σ'_p	=	preconsolidation stress (kPa)

Where appropriate, Bjerrum's correction factor was employed to estimate the average mobilized undrained shear strength from the results of the in situ field vane tests as follows:

$$S_{u(mob)} = \mu S_{u(FV)} \quad (\text{after Bjerrum, 1973})$$

where:

$S_{u(mob)}$	=	average mobilized undrained shear strength (kPa)
$S_{u(FV)}$	=	undrained shear strength from field vane test (kPa)
μ	=	Bjerrum's correction factor based on Plasticity Index

Effective stress parameters were also employed to evaluate the stability of the cut slopes based on long-term, drained conditions. The effective stress parameters (effective friction angle (ϕ') and effective cohesion (c')) for the cohesive deposits were assessed based on the results of consolidated isotropic undrained (CIU) triaxial tests with pore pressure measurements carried out on three specimens of the silty clay to clay. The approximate, equivalent effective friction angle and effective cohesion estimated directly from the results of the triaxial tests are presented below.

Soil Unit	Borehole / Sample Number	Laboratory Test Type	Effective Cohesion, c' (kPa)	Effective Friction Angle, ϕ' (degrees)
Silty Clay to Clay	Borehole D504-04 Sample 8	CIU Triaxial	5 ¹	27 ¹

Note:

1. c' and ϕ' values represent approximate, equivalent shear strength parameters derived from the laboratory CIU triaxial test.

It should be noted that that the estimate of the effective cohesion and effective friction angle (presented above) represents an approximate linear equivalent of the shear-normal strength envelope. In the actual slope stability analysis representing the long-term, drained conditions, the effective strength parameters for the cohesive soils



were defined using a shear-normal strength envelope based on the results of the CIU triaxial test data. The inset plot in Table 2 shows Mohr's circles based on the triaxial test results with the fully defined Mohr-Coulomb failure envelope employed in the stability analysis.

Hydraulic properties (i.e. coefficient of permeability) were also assigned to the soils in the cut area in order to assess steady state conditions for use in the evaluation of slope stability under long-term, drained conditions. For the granular soils, the following correlation proposed by Hazen (1911) was employed to estimate the coefficient of permeability:

$$k = C (D_{10})^2$$

where:

k	=	coefficient of permeability (cm/sec)
C	=	Hazen's empirical coefficient (1 for D_{10} in mm; 100 for D_{10} in cm)
D_{10}	=	particle size for which 10 percent of soil is finer than (mm or cm)

For the cohesive soils, the coefficient of permeability for each stratum was estimated from typical values presented in literature, in conjunction with engineering judgement based on experience in similar soil conditions.

6.2.3 Settlement

The following sections outline the methods used to carry out the settlement analyses at the various swamp crossing/high fill areas and also present the parameters used in the analyses for each of the embankment critical section(s). The results of the analyses are presented in Section 6.6 for each swamp crossing/high fill area where they are discussed together with the results of the stability analyses and recommendations regarding potential design and construction alternatives to mitigate stability issues and/or post-construction settlement.

It should be noted that along the section where the deep cut excavation is required, some rebounding/swelling of the native soils, particularly the cohesive deposits, may occur as a result of unloading; however, the magnitude of the rebound is expected to be small (i.e. less than 25 mm) and not discussed further herein.

6.2.3.1 Methodology

To estimate the magnitude of the expected settlements, analyses were carried out at the critical sections of the proposed fill embankments using the commercially available program Settle3D (Version 2.0), developed by Rocscience Inc., and/or hand/spreadsheet calculations. Critical sections correspond to the greatest new embankment height and/or the maximum thickness of soft, compressible cohesive soils. The settlement analyses assume that the organic soils encountered at/below ground surface have been removed and replaced in accordance with OPSD 203.010 (Embankments Over Swamp – New Construction) prior to construction of the new embankment.

The sources of settlement are considered to include:

- Immediate settlement of the native granular soils;
- Primary time-dependent consolidation of the cohesive deposits (using Terzaghi's one-dimensional consolidation theory – long-term);



- Secondary time-dependent (creep) consolidation of the cohesive deposits (long-term); and,
- Self-weight compression of the embankment fill materials (short-term and long-term).

The thickness of the compressible foundation soils and the height of the embankments vary along the proposed highway alignment within each swamp crossing/high fill area, and as such the settlements along the length of a given alignment will similarly vary. Given that the analyses were carried out at the critical section(s) of each swamp crossing/high fill area, the settlements estimated generally represent the maximum anticipated value along a given section of the alignment.

6.2.3.2 Parameter Selection

The simplified stratigraphy together with the associated deformation and time-rate consolidation parameters employed for the different native soil types for the critical sections in each swamp crossing/high fill area are given in Table 3. Additional details of foundation engineering parameters employed for the thicker cohesive deposits (i.e. clayey silt/silty clay/clay) encountered in High Fill 502 are provided on Figure B1 in Appendix B.

The immediate compression of the non-cohesive deposits (i.e. silt, silt and sand, sandy silt to silty sand, sand, sand and gravel and sandy gravel) were modelled by estimating an elastic modulus of deformation based on the SPT 'N'-values and using correlations proposed by Bowles (1984) and Kulhawy and Mayne (1990). These estimated values were compared with the typical range of expected values for similar soil types, as outlined in the *Canadian Highway Bridge Design Code* (CHBDC, 2006) and adjusted, if necessary.

The consolidation settlement of the cohesive deposits was assessed using the results of the laboratory consolidation tests, where appropriate, and in situ field vane tests to estimate the stress history and deformation parameters for the cohesive deposits. In addition, the results of the laboratory index tests were employed to further assess deformation parameters (i.e. compression and recompression indices) using empirical correlations proposed in literature by Azzouz et al. (1976), Koppula (1986), Kulhawy and Mayne (1990), Nishida (1956) and Terzaghi and Peck (1967). The correlation by Nishida (1956) relating the void ratio to the compression index was found to be the most consistent with the results of laboratory consolidation tests for the clayey soils in High Fill 502.

The following correlation relating in situ undrained shear strength to preconsolidation stress (Mesri, 1975) was employed:

$$\sigma'_p = \frac{s_{u(mob)}}{0.22}$$

where:

$$\begin{aligned} \sigma'_p &= \text{preconsolidation stress (kPa); and,} \\ s_{u(mob)} &= \mu s_{u(FV)} \text{ (after Bjerrum, 1973), where } s_{u(mob)} = \text{average mobilized undrained shear strength (kPa)} \\ s_{u(FV)} &= \text{undrained shear strength from field vane test (kPa)} \\ \mu &= \text{Bjerrum's correction factor based on Plasticity Index} \end{aligned}$$

The coefficient of consolidation, c_v (cm²/s), required in the time-rate settlement analysis was established using the results of the laboratory consolidation tests and/or estimated from the U.S. Navy (1986) correlation with liquid limit assuming normally consolidated or over consolidated soils, as applicable.



In addition to primary consolidation within the cohesive deposits (i.e. clayey silt to clay), secondary compression may also occur. Secondary compression is referred to as creep settlement and occurs over a long period of time, after full dissipation of excess pore pressure under a constant stress. The following relationship has been employed for estimating the magnitude of creep settlement over the life of the embankment following the substantial completion of primary settlement at each location:

$$S_c = HC_{\alpha\epsilon} \log\left(\frac{t}{t_{EoP}}\right)$$

where :

S_c	=	secondary consolidation (creep) settlement (mm)
$C_{\alpha\epsilon}$	=	modified secondary compression index as estimated from laboratory consolidation tests and correlation by Mesri (1973)
H	=	initial thickness of compressible clay deposit (mm)
t	=	post-construction period of interest (20 years)
t_{EoP}	=	time to reach end of primary consolidation (years)

6.2.3.3 Settlement of Embankment Fill

Where rock fill is used for the construction of the proposed embankments, there will be settlement due to compression of the rock fill itself under self weight, in addition to the settlement of the underlying foundation soils as described above. The magnitude of settlement of the rock fill depends on the following factors:

- Type of rock/strength of particles;
- Size and shape of rock particles;
- Gradation of rock fill;
- Total height/thickness of rock fill (stress level); and
- Method of construction and sequence of placement (including lift thickness, compactive effort and state of packing).

The settlement of rock fill occurs as a result of re-arrangement of rock particles under load and wetting and as a result of localized crushing of rock particles at point contacts. The magnitude of both the short-term and long-term post-construction settlement of the rock fill is a function of the height of fill as well as the method of fill placement (i.e. compacted versus dumped rock fill) as outlined in “MTO Guideline for Rock Fill Settlement and Rock Fill Quantity Estimates”, dated September 2010.

Rock fill should be placed, whenever possible, in a controlled manner (i.e. not end-dumped) in accordance with OPSS.PROV 206 (Grading). Blading, dozing and ‘chinking’ the rock fill to form a dense, compact mass is required to minimize voids and bridging and reduce settlements, and should be used to construct rock fill embankments above the existing groundwater table. Where rock fill cannot be placed in a controlled manner (i.e. below the groundwater table), the post-construction settlement of the rock fill is expected to be greater.

Short-Term Rock Fill Settlement

The magnitude of short-term post-construction settlement associated with compacted and end-dumped rock fill may be estimated in accordance with the MTO Guideline (September 2010), as follows:



Height of Rock Fill, H	Short-Term Rock Fill Settlement	
	Compacted Rock Fill	Dumped Rock Fill
Up to 5 m	0.5% H	1.0% H
>5 m to 10 m	0.75% H	1.5% H
>10 m to 15 m	1.0% H	2.0% H

Approximately 90 per cent of the short-term settlement may be expected to occur within the first six (6) months following construction of the embankment to full height. The short-term settlement is expected to be fully completed within one (1) year following the completion of embankment construction to full height.

Long-Term Rock Fill Settlement

The magnitude of long-term post-construction settlement for compacted and end-dumped rock fill may be estimated in accordance with the MTO Guideline (September 2010), as follows:

Total Height of Rock Fill, H	Long-Term Rock Fill Settlement	
	Compacted Rock Fill	Dumped Rock Fill
Up to 15 m	0.1% H	0.2% H

The long-term rock fill settlement is expected to occur from one (1) year following the completion of construction over the life of the embankment.

6.3 Settlement Performance Requirements

The settlement performance criterion for design of high fill embankments and embankments over swamp crossings is in accordance with Section 1.1 of MTO's "Embankment Settlement Criteria for Design", dated July, 2010. In general, new embankments not approaching a structural element are to be designed as follows:

- Total settlements and differential settlement rates are to be less than 100 mm and 200:1, respectively, over a 20-year period following completion of construction for a Freeway.

However, where new embankments approach structural elements (such as culverts or bridge abutments) or where areas of compressible soils are located adjacent to areas of non-compressible soils or exposed bedrock, more stringent settlement criterion associated with these transition points apply to the overall design performance of each swamp crossing/high fill area in accordance with Section 1.2 of the MTO Guideline. The summary of post-construction settlement criterion at each swamp crossing/high fill area based on the guidelines summarized above is as follows:



Foundation Investigation Area	Site Area	Post-Construction Settlement Criterion over 20-year period following completion of construction
Highway 69 NBL – STA 20+665 to STA 20+705	High Fill 501	25 mm
Highway 69 SBL – STA 20+980 to STA 21+180	High Fill 502	N/A (south of STA 21+055) 25 mm (STA 21+055 to STA 21+075) ¹ 50 mm (north of STA 21+075)
Highway 69 NBL – STA 20+990 to STA 21+075	High Fill 502	N/A (south of STA 21+080) 25 mm (STA 21+080 to STA 21+100) ² 50 mm (north of STA 21+100)
Highway 69 SBL – STA 10+350 to STA 10+470	Swamp 503	75 mm
Highway 69 NBL – STA 10+230 to STA 10+445	Swamp 503	75 mm
Highway 69 NBL – STA 21+300 (Henvey) to STA 10+140 (Mowat)	Deep Cut 504	Not applicable

Notes:

1. North approach embankment associated with the proposed Straight Lake SBL bridge structure.
2. North approach embankment associated with the proposed Straight Lake NBL bridge structure.

6.4 Stability and Settlement Mitigation Options for Embankments

At each area of high fill embankment and embankment crossing a swamp, stability and settlement of the embankments have been assessed based on existing subsurface conditions and proposed embankment fill heights as the presence of weak/soft, compressible soils underlying a proposed embankment can lead to the potential for instability or unacceptably large settlements with the placement of fills. There are a number of options for mitigating the potential for settlements and/or instability, as presented below.

Details of the mitigation options for all swamp crossing/high fill areas requiring measures to enhance stability and minimize settlement issues of the foundation soils are provided in Section 6.6. These include: full and partial sub-excavation of unsuitable soils; preloading with or without surcharging; installation of wick drains with or without staged construction; incorporating lightweight fill (EPS) into the embankment mass; and combinations of these measures. Other ground improvement measures such as aggregate piers and deep soil mixing have been considered for some of these sites, but ultimately not deemed feasible or practical either due to high costs or because of the complexity of the composition of the deposit (i.e. cohesive soils), thickness of the deposit and/or high groundwater conditions, and are only discussed briefly herein. The advantages, disadvantages, relative costs and risks/consequences for each swamp/high fill area, where appropriate, are summarized in the Evaluation of Stability/Settlement Mitigation Options tables provided in the respective appendices. In addition, a comparison of the estimated post-construction settlement over a 20-year period between the base case (i.e. no foundation mitigation carried out) and the various mitigation alternatives considered has been carried out for each of the swamp crossing/high fill areas. The results of the settlement analyses for each area are summarized in Table 4.

A summary of the proposed works, recommended embankment fill type and side slope profile, maximum depth of organics encountered, preferred stability/settlement mitigation option, estimated settlement (during construction and post-construction), recommended width of platform widening and recommended excavation guideline for each swamp crossing/high fill area, where appropriate, is provided in Table 5. Depending on the area, one alternative or a combination of alternatives may be more advantageous than the others. Embankment platform widening requirements along pertinent sections of the embankments are provided in Table 6.



In areas where the foundation soils consist of granular soils only, it is anticipated that there will not be embankment stability issues or significant settlement problems, provided all organic layers (i.e. peat/topsoil/root mat) and existing fill materials are removed from below the embankment footprint prior to construction and mid-height berms are incorporated into the embankment cross-section, where necessary. As such, in these areas, generally there is no need to implement any special construction procedures to maintain stability or to minimize long-term foundation settlements, or to adjust the construction schedule. However, in areas where the height of the rock fill embankment is large, preloading of the rock fill will be required to satisfy the post-construction settlement criterion.

Recommendations (i.e. geometry of cut slopes and surface treatment for enhanced surficial stability) associated with the deep cut section of the highway alignment are provided in Table 8.

6.4.1 Full Sub-Excavation

Sub-excavation of the weak/soft and compressible (i.e. clayey and organic) deposits underlying the footprint of a proposed embankment in advance of the placement of rock fill is a viable option for improving the stability and controlling long-term settlement of the proposed embankment in some areas of this site. The removal of the soft, compressible cohesive soils would result in improved stability and reduced settlements within the areas underlain by cohesive and organic deposits and/or where high embankment fills are proposed. It should be noted that despite the reduction in foundation soil settlements, the post-construction settlement of rock fill may still exceed the settlement performance criterion. As such, the embankments may need to be preloaded to obtain acceptable post-construction settlements associated with long-term performance of the roadway. The portion of rock fill embankment below grade should be constructed with the same side slope profile as that of the above grade embankment (i.e. 1.25H:1V for rock fill). This option has the advantage that construction of the above grade embankment could proceed upon completion of sub-excavation and replacement without concerns of embankment instability. However, full sub-excavation of unsuitable materials may produce a large volume of spoil for disposal/management and may require a large volume of replacement with rock fill. The necessity to develop stable side slopes or back slopes within the excavation may result in cut slope geometries ranging from 1H:1V to as flat as 3H:1V. Flatter slopes would increase the lateral extent of the excavation, require more fill and may require additional land acquisitions to provide a wider right-of-way.

Based on the results of the subsurface investigation, the depth to the bottom of the weak/soft, compressible soils within the proposed embankment footprint in the swamp crossing/high fill areas varies across the project sites, up to a maximum of about 6.5 m below existing ground surface. In general, groundwater was encountered at or near ground surface at the swamp location and near the ground surface in the low-lying sections of the high fill areas. We understand that based on MTO field experience on similar embankment construction projects, the practical maximum depths that can be reached with conventional and long stick excavator equipment is about 6 m and 12 m, respectively. Below a depth of 12 m, either specialized drag-line equipment or a combination of dewatering and stepped excavation would be required. As such, in the absence of unforeseen conditions which would prohibit its application, sub-excavation of organic and soft compressible soils up to a practical depth of about 12 m and replacement with rock fill is considered a generally feasible option for construction of the highway embankments and would result in enhanced stability and reduced settlement of the embankments.

This option is however most suited for areas where there is a limited thickness of organics (i.e. peat/topsoil/root mat) and weak/soft compressible soils underlying the proposed embankment (i.e. less than 12 m), making their removal practical where there are no requirements for setbacks, where adequate right-of-way is available, and where there are no conflicts with encroachment on existing adjacent features.



The advantages of this option are:

- Improved stability;
- Typically reduced post-construction settlements of the foundation;
- May reduce delay in construction; and,
- No requirement for stabilizing toe berms.

The disadvantages of this option are:

- Generation of large volume of excavation spoil requiring disposal/management;
- Increased post-construction settlement of rock fill, typically requiring a preload period to satisfy the settlement performance criterion;
- May require a larger right-of-way corridor; and,
- Requires greater quantities of rock fill.
- Specialized equipment and/or procedures would be required for excavations deeper than 12 m.

6.4.2 Preloading (and Partial Sub-Excavation, Stability Berms and/or Staged Construction)

As an alternative to full sub-excavation and replacement of the weak/soft, compressible foundation soils, preloading may be considered for improving the stability and reducing post-construction settlements of the proposed embankments. Preloading refers to the placement of fill either up to the proposed profile grade of the highway or a portion thereof (i.e. partial preload), in one or more stages, in advance of embankment completion and final pavement construction, in order to preconsolidate the underlying compressible soils. Preloading reduces the magnitude of long-term, post-construction settlements by promoting such settlements to occur under fill loads in advance of final grading of the embankment. It also may increase the strength of cohesive soils underlying the embankment footprint, thereby improving stability.

In general, preloading requires placement of embankment fill (either in whole or part), and in some cases, monitoring of settlements, and possibly pore pressures, for a period of time corresponding to approximately the 'End of Primary' (EoP) consolidation of cohesive soils. EoP consolidation times will vary depending on the properties and thicknesses of the cohesive deposits, and the height of the fill. Where secondary consolidation (creep) settlements are expected to be small over the design life of the embankment, final grading for construction can proceed once the estimated EoP consolidation has occurred. Where creep settlements are considered to be large enough to affect the long-term performance of the highway, these settlements can be reduced by constructing a portion of the final embankment with lightweight fill (i.e. expanded polystyrene (EPS)) upon the completion of the design preload period or by surcharging.

In areas where cohesive deposits are thick and/or weak/soft, and where such conditions coincide with proposed high embankment fills, it may be necessary to carry out a partial sub-excavation of the weak/soft cohesive deposits, construct stability berms along the embankment toes and/or place the embankment fill in stages in layers of limited thickness to ensure that the stability of the embankment is maintained. For partial sub-excavation, either the upper portions of the weak/soft cohesive deposit could be removed or full



sub-excavation over a critical area below part of the embankment footprint could be carried out to improve the stability and partially reduce settlements of the embankment. In addition, stability (toe) berms consisting of rock fill buttresses placed against the toe of the proposed embankment fill, producing a stepped embankment cross-section geometry, may be required. This stepped configuration produces a similar effect (i.e. increased stability) as using flatter embankment slopes, but often requires less fill material. Depending on the subsurface conditions and the proposed embankment height, toe berms will typically be on the order of about one third to one half of the height of the final embankment. The lateral extent (width) of toe berms will vary depending on the results of the stability analyses, but could range from half to one times the embankment height, or greater. Where staged construction is required, the individual layers of fill would have limited thickness and each construction stage would be separated by a suitable time interval to allow pore pressures to dissipate and strength gain to occur in the underlying cohesive soils to limit the potential for instability of the embankment.

It should also be noted that with preloading, it is still required that all organic material be sub-excavated prior to placement of any fill, because organic soils are highly compressible and experience significant secondary consolidation (creep) settlements.

This option is most suited for areas where full depth removal of cohesive soils and their replacement with rock fill is not considered practical (i.e. depth of cohesive deposits is much greater than 12 m) and where a delay in the construction schedule is acceptable or can be accommodated.

The advantages of this option are:

- Reduced generation of excess excavation spoil compared with full sub-excavation;
- May not require a larger right-of-way corridor, unless large toe berms are required; and,
- The quantity of rock fill is limited to that required for sub-excavation and replacement of the near surface organics (if partial sub-excavation or toe berms are not required), and to compensate for consolidation and foundation soil settlements.

The disadvantages of this option are:

- Construction is delayed to allow for all or a portion of primary consolidation to be completed, and possibly for staged construction (if required);
- Increased quantity of rock fill if partial sub-excavation or toe berms are required for stability;
- May require lightweight fill for a portion of the construction of the final embankment to reduce long-term post-construction settlements if creep settlements are expected to be large;
- May require an instrumentation and monitoring program to assess when the settlement performance criterion has been achieved; and,
- Requires re-grading to account for settlement prior to construction of the final pavement structure.

6.4.3 Surcharging (and Partial Sub-Excavation, Stability Berms and/or Staged Construction)

Similar to preloading, surcharging refers to the placement of embankment fill in advance of final pavement construction to reduce long-term, post-construction settlements (including creep settlement). The difference



between preloading and surcharging is the amount of fill placed and the time required for consolidation to be completed. With surcharging, the fill is placed to the full embankment height, followed by an additional lift of fill (the surcharge) above that required to construct the final embankment geometry. This additional lift of fill applies greater stress to the underlying cohesive deposits and results in larger settlements and therefore reduces the time for primary consolidation of the final embankment geometry over that achieved by preloading only. At the EoP consolidation, the portion of the surcharge fill remaining above the required embankment height (sub-base level) is removed. The surcharge fill can also be left in place for a longer duration to reduce the long-term, creep settlements.

As with preloading, it may be necessary to carry out partial sub-excavation of the weak/soft cohesive deposits, construct toe berms or stage the placement of embankment fill and surcharge to limit the potential for instability. Upon the completion of the design surcharge period, the removed surcharge fill may be re-used on other parts of the site.

Surcharging is most suited to those areas considered appropriate for preloading, where the stability of the higher surcharged embankment can be practically maintained by reasonably sized partial sub-excavations, toe berms or staged construction, but where sufficient time for primary consolidation settlements to occur under preload fill loads alone is not available. Surcharging can also be considered for areas where large creep settlements are expected.

The advantages of this option are:

- Reduced generation of excess excavation spoil compared to full sub-excavation;
- Reduced secondary consolidation (creep) settlement;
- Will not require a larger right-of-way corridor, unless large toe berms are required;
- The quantity of rock fill is limited to that required for sub-excavation and replacement of organics, and to compensate for consolidation and foundation soil settlement (if partial sub-excavation or toe berms are not required); and,
- Decreased delay time for construction as compared preloading alone.

The disadvantages of this option are:

- Construction is delayed, albeit less than for preloading, to allow for primary consolidation to occur;
- Longer construction time if staged construction is required;
- Larger quantity of rock fill if toe berms or partial sub-excavation and replacement are required for stability as compared to preloading alone;
- May require an instrumentation and monitoring program to assess when EoP consolidation is reached; and,
- Increased handling of the surcharge fill.



6.4.4 Wick Drains

Where sub-excavation is not practical (i.e. due to the thickness of, or depth to the compressible soil deposits), and where the time required for preloading or surcharging (to reach the settlement performance criterion) is considered too long, consideration may be given to installing wick drains in conjunction with surcharging to accelerate the rate of primary consolidation. Wick drains are prefabricated geotextile drains installed vertically from ground surface into or through the soft, compressible foundation soils in order to shorten drainage paths and thereby increase the rate of excess pore pressure dissipation. Typically, wick drains are installed on a 1 m to 3 m triangular grid spacing over the embankment footprint. In some cases stability berms and/or staged construction may be required in conjunction with wick drain installation to maintain embankment stability during construction.

The use of wick drains is most suited to areas with thick (i.e. greater than about 5 m) deposits of soft, compressible foundation soils and high proposed embankment fills where primary consolidation times are large even under surcharge conditions.

It would still be necessary to sub-excavate and remove surficial organics and place a granular drainage blanket at ground surface prior to the installation of the wick drains.

The advantages of this option are:

- Decreased consolidation time under preloading/surcharging; and
- Increased rate of staged construction, if required to maintain stability during construction.

The disadvantages of this option are:

- Additional time and expense to install wick drains prior to embankment construction;
- May require pre-drilling at wick drain locations if a compact/very stiff near surface layer is present, incurring additional time and expense;
- Additional long-term settlements due to faster onset of creep settlement of the cohesive deposit (if not compensated for by surcharging or lightweight fill);
- Requires a detailed wick drain investigation and design
- Requires an instrumentation and monitoring program to assess when the settlement performance criterion has been achieved; and,
- Requires re-grading to account for settlement prior to construction of the final pavement structure.

6.4.5 Lightweight Fill

Another alternative for reducing the magnitude of long-term settlement and improving stability in areas of weak/soft, compressible foundation soils is to use lightweight fill, such as expanded polystyrene (EPS), for embankment construction. The use of lightweight fill reduces the load applied to the foundation soils due to the low density of the fill materials. This in turn reduces the magnitude of post-construction settlement and reduces the potential for instability.



Lightweight fill is not considered a practical option for general use due to the expense and/or shipping costs for the supply of these types of fills. Rather, lightweight fill is most suited for areas underlain by deep compressible cohesive deposits, where sub-excavation is not practical or feasible, where long-term post-construction creep settlements affect the performance of the highway and where there is limited or no available time in the construction schedule to allow for a sufficient preload or surcharge period. In addition, lightweight fill can be used in conjunction with preloading, surcharging and wick drain designs to further enhance stability and reduces post-construction settlement.

The advantages of this option are:

- Improved stability;
- Reduced long-term post-construction settlements; and,
- Shortened construction schedule.

The disadvantages of this option are:

- Requires embankments to be constructed with 2H:1V side slopes given the need for granular fill for levelling pad and conventional soil cover on the side slopes (i.e. cannot use rock fill);
- Significant additional expense of lightweight fill (depending on the volume required); and,
- Not feasible to install below the groundwater table (due to buoyancy forces) and in low height embankments (due to minimum conventional soil cover requirement on top of the EPS).

6.4.6 Aggregate Piers

Aggregate piers can also be considered to improve stability and reduce the long-term settlement of weak/soft, compressible foundation soils. The general installation process of aggregate piers involves placing successive lifts of stone/aggregate either within a pre-drilled hole or by direct displacement using a specialized hollow mandrel driven into the ground followed by ramming/compacting each lift to create a vertical column of stone/aggregate that typically penetrates the entire weak/soft soil deposit. The aggregate piers are installed in a triangular grid pattern at spacings typically ranging from about 2 m to 5 m (depending on site-specific foundation conditions and embankment height) such that the piers form a very dense reinforced soil mass.

The advantages of this option are:

- Improved stability of the soft/weak strata;
- Improved long-term settlement performance (reduced settlement); and,
- Generally shortened construction schedule.

The disadvantages of this option are:

- Significant additional expense to install the aggregate piers (depending on the length and spacing of the aggregate piers as well as the plan area to be treated);



- Potential need for use of a temporary casing to keep the hole open in caving soils adding construction time and expense where the use of the alternative displacement-type construction is not recommended or applicable; and,
- Addition of cement grout to the aggregate piers may be required in soft/sensitive or organic soils to stiffen the pier and bond the aggregate and provide additional strength against long-term squeeze by the surrounding soil.

6.4.7 Deep Soil Mixing

In areas where more conventional construction mitigation methods are not deemed feasible, consideration could be given to a method of ground improvement that would directly stabilize the existing soil mass in-situ thereby improving stability and reducing settlement of the proposed embankment. Deep soil mixing could be considered as a means of improving both the strength and stiffness of the weak and compressible foundation soils.

Deep soil mixing can include construction of a 'grillage' of cemented soil panels across the area requiring improvement in order to provide either a strengthened 'key' to cut-off potential slip surfaces through soft foundation soils and/or a stiffened foundation zone to reduce settlements caused by fill loads. An added benefit of this form of ground improvement is that the soil mixed panels could be designed to support the fill pads and/or foundation elements of adjacent bridge structures if the ground improvement is carried out within the approach embankment area.

The deep soil mixing technology involves the use of specialized cutter soil mixer (CSM) equipment consisting of a cutter head mounted on a base carrier that mixes cement (either in dry or wet form) directly into the foundation soils. The CSM installs vertical overlapping cemented soil columns measuring 2.8 m by 1.0 m in plan. The columns are typically assembled into panels, staged in a primary/secondary arrangement and spacings typically ranging from 3 m to 6 m depending on the application.

The advantages of this option are:

- Improved stability of the soft/weak strata and long-term stability of the new embankment;
- Improved long-term settlement performance (reduced settlement);
- Shortened construction schedule following completion of the deep soil mixing panel installation; and,
- Potential to support adjacent structure foundations directly on the soil mixed zone thereby avoiding the need for pile foundations (where applicable).

The disadvantages of this option are:

- Costs may be higher than conventional construction mitigation options (depending on volume of ground improvement required as compared with volume of materials required for alternative options);
- Additional investigation, testing (bench scale mix trials) and design would be required to develop the most cost-effective design (i.e. to optimize the amount of cement required in the mixed panels);
- Specialty contractor would need to be retained to carry-out the ground improvement works;



6.4.8 Instrumentation and Monitoring

For areas where certain foundation mitigation options are adopted such as preloading, surcharging, wick drains and/or staged construction, the magnitude and time-rate of settlement, as well as the development and dissipation of pore pressures during and after construction of embankments, should be assessed with monitoring instrumentation to verify design assumptions and confirm minimum delay periods. Such monitoring could consist of installing settlement pins/stakes (SPs), settlement rods (SRs) and vibrating wire piezometers (VWPs) below the embankment and taking regular measurements/readings at given intervals of time during and after construction of the embankment for the duration of the construction as well as the preloading/surcharging period. In addition, standpipe piezometers (SPPs) are usually installed to provide background groundwater levels / pore pressure readings for the vibrating wire piezometers. This monitoring instrumentation is particularly important where it is considered necessary to carefully monitor the stability of the foundation soils during staged placement of embankment fill.

The extent of instrumentation and the frequency of monitoring required will depend on the foundation treatment alternative chosen for a given site and the height of the proposed embankment fill. Where the specific types of foundation mitigation options indicated above are adopted, specifications for the type, number and layout of the instrumentation, together with the supply, installation, protection and monitoring frequency would need to be included as Non-Standard Special Provisions in the Contract Documents. For this particular Contract/site, instrumentation and monitoring is not anticipated to be required so long as the recommended preferred foundation mitigation options are adopted in the design and construction as described in Section 6.6.

6.5 Stability Mitigation Options for Deep Cuts

At the deep cut area section of the highway, stability has been assessed based on existing subsurface conditions and proposed cut slope geometry. The presence of a high groundwater table and associated seepage flow as well as weak/soft soils along the cut slopes or below the base of the excavation can lead to slope instability. Details of the mitigation options for the deep cut area to mitigate stability issues of the cut slopes are provided in Section 6.6. There are several options for mitigating the potential for instability and these measures commonly include slope flattening or installation of a granular/rock blanket along the face of the slope. In this case, slope flattening involves a reduction in the overall slope angle, thus unloading the upper portion of the slope, which in turn enhances slope stability. Installation of a drainage blanket by replacing the near surface portion/face of the slope with a material which has a greater friction angle also enhances surficial stability. In addition, the granular/rock blanket is free-draining and results in a reduction of pore pressures near the slope face which in turn increases the resisting forces and enhances slope stability.

Other more extensive slope stabilization measures such as soil nailing, slope strengthening, reinforced earth slopes and lowering of the groundwater table are not considered economical due to the relatively low complexity of the proposed slope cuts, and are not further discussed herein.

It should be noted that in areas where special stabilization techniques are not required, surficial slope instability and erosion protection measures will still need to be implemented.



6.6 Results of Analysis

The results of the stability and settlement analyses for the three swamp crossing/high fill areas and one deep cut section are provided in the following sections. In addition, the options and recommendations for achieving the target FoS for the required embankment or cut slope geometry and for reducing the time-dependent, post-construction settlements of embankments to achieve the settlement performance requirements as outlined in Section 6.3 are also discussed. For swamp crossing/high fill areas that require stability and/or settlement mitigation, the advantages, disadvantages, relative costs, and risks/consequences of various alternatives for these areas are summarized and ranked in the Evaluation of Stability/Settlement Mitigation Options tables in the corresponding appendices for each area.

In areas where the foundation soils consist of non-cohesive deposits only, it is anticipated that there will not be any significant risk of instability of the embankments, and the settlement of the foundation soils in these areas is expected to occur during or shortly after construction, as a result of the estimated relatively high permeability of these soils. As such, in these areas there is typically no need to implement any special construction procedures, or modify the schedule, to maintain stability or to mitigate settlement of the foundation soils. However, where the post-construction settlement of the rock fill itself in these areas is unacceptable, preload periods are specified to ensure adequate long-term performance of the embankment.

In areas where the foundation soils are comprised of cohesive deposits, time-dependent settlements of the new embankments are expected. In addition, in some of these areas, the presence of weak/soft cohesive deposits constitutes zones of potential instability for the proposed embankments. In these areas, consideration must be given to an enhanced design and/or to follow a construction sequence that will achieve the minimum target FoS of 1.3 for the proposed new embankment height and geometry and limit the post-construction settlements and subsequent maintenance of the new highway pavement structure.

For new embankments constructed with rock fill, or where sub-excavation and backfilling with rock fill is carried out, settlement of the embankment rock fill is also expected due to compression of the rock fill itself (see Section 6.2.3.3). Depending on the thickness of the rock fill embankment, the post-construction settlement of rock fill may exceed the settlement performance criterion. In these areas, the embankment will need to be preloaded to obtain acceptable post-construction settlements associated with long-term performance of the embankment.

6.6.1 Highway 69 NBL – STA 20+665 to STA 20+705 (High Fill 501)

The area extending from about STA 20+665 to STA 20+705 (40 m section) along the proposed Highway 69 NBL alignment requires a new embankment up to about 10 m high at the centreline to achieve the proposed vertical highway profile. This section of the proposed highway embankment is located within a bedrock valley, immediately south of Straight Lake.

The subsoils in this area are very thin and generally consisting of an up to about 0.2 m thick layer of peat or 0.2 m thick layer of silty sand, underlain by bedrock.

Bedrock outcrops are present in and around the area of the proposed alignment, and refusal to shovel excavation at shallow depth is indicative of the shallow bedrock surface. In general, refusal was encountered at depths up to about 0.2 m below existing ground surface.



Details of the subsurface conditions for this high fill area are presented in Section 4.3 and shown on Drawing A1 in Appendix A.

The simplified stratigraphy and the associated unit weight, strength and deformation parameters employed for the different soil types encountered in this area are summarized in Table 3. The piezometric condition used in the analyses is the water table at about or near the ground surface, based on the groundwater levels noted during and upon completion of the investigation.

Due to the presence of thin non-cohesive deposits underlain by bedrock or bedrock outcrops encountered at the existing ground surface, no stability issues are anticipated for the proposed up to about 10 m high embankment..

The total settlement of the rock fill embankment itself (based on a 10 m high embankment plus about 0.2 m of additional rock fill required after removal of the organic deposit) is estimated to be about 85 mm, with about 70 mm expected to occur within six (6) months of construction of the embankment, 5 mm occurring during the next six (6) months and about 10 mm expected to occur over the remaining design life of the embankment.

In order to satisfy the post-construction settlement criterion of 25 mm over a 20-year period following completion of construction, preloading of the rock fill for a duration of 130 days will be required. The estimated total post-construction settlement of the rock fill is 25 mm.

6.6.2 Highway 69 SBL – STA 20+980 to STA 21+180 (High Fill 502)

The foundation investigation area extends from about STA 20+980 to STA 21+180 (200 m section) along the proposed Highway 69 SBL alignment. A new highway embankment up to about 7 m high at the centreline is required north of STA 21+055 (i.e. the proposed location of the north abutment of the Straight Lake SBL Bridge structure which will extend across Straight Lake and over a portion of the High Fill 502 area) to achieve the highway profile.

It is noted that the north abutment of the Straight Lake SBL structure was originally located at STA 20+989 (i.e. closer to the north shoreline of Straight Lake) and had a very high approach embankment associated with the original abutment location (i.e. up to about 15 m high). However, given the presence of very soft peat/organic silt underlain by a thick deposit of soft to firm clayey silt to clay (undrained shear strengths ranging between about 20 kPa and 45 kPa), stability and settlement analyses indicated that significant foundation mitigation measures would be required to address embankment stability issues and excessive settlements, including post-construction settlements. Furthermore, the costs associated with the technically feasible foundation mitigation alternatives were very high, and more importantly, the risk level in terms of potential instability, poor long-term performance of the roadway and encountering problems during construction was considered high as well. Ultimately, following discussions with URS and MTO, it was agreed to shift the north abutment of the Straight Lake SBL Bridge to the currently proposed location (i.e. STA 21+055) in order that the embankment would be founded on predominantly non-cohesive deposits and would not require the implementation of extensive stability and settlement mitigation measures. Details pertaining to the Straight Lake SBL Bridge, including a more comprehensive summary of the factors leading to the decision to shift the north abutment further north to its current location, is provided in Golder's pre-draft Foundation Investigation and Design Report titled, "Straight Lake SBL Bridge Structure, Site No. 44-461/2; Highway 69 Four-Laning from 1.7 km North of Highway 529; Northerly to 3.9 km North of Highway 522; Ministry of Transportation, Ontario; GWP 5005-10-00; WP 5146-08-01."



The subsoils below the footprint of the proposed embankment (north of STA 21+055) generally consist of an up to about 0.3 m thick layer of peat or topsoil underlain by an up to about 1.3 m thick near surface deposit of clayey silt to silty which in turn is underlain by an up to about 14.2 m thick, non-cohesive deposit of silt to sandy silt to silt and sand to silty sand to sand. The non-cohesive deposit is underlain by inferred bedrock.

Based on the results of the subsurface investigation and review of the highway profile drawings, the critical section for stability (i.e. the greatest embankment height and/or maximum thickness of soft, compressible foundation soils, where present) is located at approximately STA 21+060 (i.e. immediately north of the Straight Lake SBL north abutment) where the proposed embankment is up to about 5.5 m. Other than some thin pockets of clayey silt to silty clay and a near surface deposit of clayey silt to silty clay (which is recommended to be sub-excavated and replaced with rock fill prior to construction of the embankment), thick cohesive deposits were not encountered immediately below the footprint of the proposed embankment. However, a cohesive deposit was encountered south of the embankment. The cohesive deposit is relatively thin (i.e. about 1.2 m thick) at the toe of the proposed front slope of the embankment, but significantly increases in thickness to the south towards Straight Lake. The stability analyses performed on the front and side slopes of the embankment at the critical section indicate that after completion of construction, the embankment will have a FoS of 1.3 or greater for a deep-seated, global failure surfaces that would impact the operation of the highway, as shown on Figures B2 and B3.

To estimate the magnitude of the expected settlements due to new construction, analyses were carried out at two critical sections representative of the subsurface conditions within the high fill area, located at approximately STA 21+085 and STA 21+125. At STA 21+085 the proposed embankment height is up to about 5.5 m and the settlement criterion is 25 mm over a 20-year period following completion of construction. At STA 21+125 the proposed embankment height is up to about 7 m and the settlement criterion is 50 mm over a 20-year period following completion of construction.

The results of the settlement analyses indicate that with the organic material and the near surface cohesive deposit sub-excavated and replaced with rock fill, the settlement of the foundation soils at the critical sections is estimated to range from about 85 mm (at STA 21+125) to 320 mm (at STA 21+085), predominantly comprised of immediate settlement due to compression of the non-cohesive deposits.

In addition, the total settlement of the rock fill embankment itself at STA 21+085 (based on a 5.5 m high embankment plus about 0.7 m of additional rock fill required after removal of the organic deposit and the near surface cohesive deposit) is estimated to be about 50 mm, with about 40 mm expected to occur within six (6) months of construction of the embankment, 5 mm occurring during the next six (6) months and about 5 mm expected to occur over the remaining design life of the embankment. At STA 21+125, the total settlement of the rock fill embankment itself (based on a 7 m high embankment plus about 1.2 m of additional rock fill required after removal of the organic deposit and the near surface cohesive deposit) is estimated to be about 70 mm, with about 55 mm expected to occur within six (6) months of construction of the embankment, 5 mm occurring during the next six (6) months and about 10 mm expected to occur over the remaining design life of the embankment.

In order to satisfy the long-term settlement performance criterion of the embankment, it is recommended that the rock fill embankment be preloaded for a minimum period of 90 days. The magnitude of the remaining total post-construction settlement of the rock fill after the recommended preload period is estimated to be about 25 mm at STA 21+085, and about 35 mm at STA 21+125, within the settlement tolerances outlined in Section 6.3.



6.6.3 Highway 69 NBL – STA 20+990 to STA 21+075 (High Fill 502)

The foundation investigation area extends from about STA 20+990 to STA 21+075 (85 m section) along the proposed Highway 69 NBL alignment. A new highway embankment up to about 4.4 m high at the centreline is required north of STA 21+080 (i.e. the proposed location of the north abutment of the Straight Lake NBL Bridge structure which will extend across Straight Lake and over a portion of the High Fill 502 area) to achieve the highway profile.

It is noted that the north abutment of the Straight Lake NBL structure was originally located at STA 20+989 (i.e. closer to the north shoreline of Straight Lake) and had a very high approach embankment associated with the original abutment location (i.e. about 16.5 m high). However, given the presence of very soft peat/organic silt underlain by a thick deposit of soft to firm clayey silt to clay (undrained shear strength ranging between about 20 kPa and 45 kPa), stability and settlement analyses indicated that significant foundation mitigation measures would be required to address stability issues and excessive settlements, including post-construction settlements. Furthermore, the costs associated with the technically feasible alternatives were very high, and more importantly, the risk level in terms of potential instability, poor long-term performance of the roadway and encountering problems during construction was considered high as well. Ultimately, following discussions with URS and MTO, it was agreed to shift the north abutment of the Straight Lake NBL Bridge to the currently proposed location (i.e. STA 21+080) in order that the embankment would be founded on predominantly non-cohesive deposits and would not require the implementation of extensive stability and settlement mitigation measures. Details pertaining to the Straight Lake NBL Bridge, including a more comprehensive summary of the factors leading to the decision to shift the north abutment further north to its current location, is provided in Golder's pre-draft Foundation Investigation and Design Report titled, "Straight Lake NBL Bridge Structure, Site No. 44-461/1; Highway 69 Four-Laning from 1.7 km North of Highway 529; Northerly to 3.9 km North of Highway 522; Ministry of Transportation, Ontario; GWP 5005-10-00; WP 5145-08-01."

The subsoils immediately south of STA 21+075 consist of a 0.8 m thick layer of topsoil underlain by a 16.9 m thick layer of silt to silt and sand to sand containing a 1.8 m thick interlayer of clay at a depth of about 11.7 m below existing ground surface. The relatively thin clay interlayer encountered near STA 21+075 significantly increases in thicknesses to the south towards Straight Lake. It is noted that foundation investigation boreholes were not advanced along the NBL alignment north of STA 21+075 (i.e. the defined north limit of the foundation investigation area in accordance with the original RFP). However, based on the boreholes and DCPTs advanced near the centreline median of the embankments north of STA 21+075, the subsoils below the footprint of the proposed NBL embankment (north of STA 21+075) are interpreted to consist of an up to about 0.2 m thick layer of topsoil underlain by an up to about 1.1 m thick near surface deposit of clayey silt to silty which in turn is underlain by an up to about 11.4 m thick, non-cohesive deposit of silt to silt and sand to sand. The non-cohesive deposit is underlain by inferred bedrock.

Based on the results of the subsurface investigation and review of the highway profile drawings, the critical section for stability (i.e. the greatest embankment height and/or maximum thickness of soft, compressible foundation soils) is located at approximately STA 21+085 where the proposed embankment is up to about 4.4 m high and the cohesive deposit is estimated to be about 1 m thick. The stability analyses performed on the front and side slopes of the embankment at the critical section indicate that after completion of construction, the embankment will have a FoS of 1.3 or greater for a deep-seated, global failure surfaced that would impact the operation of the highway, as shown on Figures B4 and B5.

To estimate the magnitude of the expected settlements due to new construction, an analysis was carried out at the critical section representative of the subsurface conditions within the high fill area, located at approximately



STA 21+085 where the proposed embankment height is up to about 4.4 m and the cohesive deposit is estimated to be about 1 m thick.

The results of the settlement analysis indicate that with the surficial organic material and any near surface clayey silt to silty clay sub-excavated and replaced with rock fill, the settlement of the foundation soils at the critical section is estimated to be about 305 mm. The settlement is estimated to be comprised of about 235 mm of immediate settlement due to compression of the non-cohesive deposits and about 70 mm of primary consolidation within the cohesive deposit.

Based on an average coefficient of consolidation (c_v) of about $1.4 \times 10^{-3} \text{ cm}^2/\text{s}$ estimated for the cohesive deposit, the imposed loading conditions for the approximately 4.4 m high embankment plus about 0.6 m backfill for replacement of the surficial organics and/or surficial clayey silt/silty clay layer, and assuming two-way drainage of the 1 m thick cohesive deposit, it is estimated that about 90 per cent of the primary consolidation settlement will be completed in about 20 days.

The magnitude of total secondary consolidation (creep) settlement for the cohesive deposit is estimated to be about 5 mm per log-cycle of time for this area corresponding to about 15 mm over a 20-year period following completion of construction.

In addition, the total settlement of the rock fill embankment itself (based on a 4.4 m high embankment plus about 0.6 m of additional rock fill required after removal of the surficial organic/silty clay deposits) is estimated to be about 30 mm, with about 20 mm expected to occur within six (6) months of construction of the embankment, 5 mm occurring during the next six (6) months and about 5 mm expected to occur over the remaining design life of the embankment.

In order to satisfy the long-term settlement performance criterion of the embankment, the rock fill embankment should be preloaded for a minimum period of 90 days. The magnitude of the remaining primary and secondary consolidation settlement of the clay interlay and the post-construction settlement due to compression of the rock fill embankment is estimated to be about 25 mm within the first 20 years following completion of construction, within the settlement tolerances outlined in Section 6.3.

6.6.4 Highway 69 SBL – STA 10+350 to STA 10+470 (Swamp 503)

The area extending from about STA 10+350 to STA 10+470 along the proposed Highway 69 SBL alignment requires a new embankment up to about 9 m high at the centerline to achieve the proposed vertical highway profile. The natural topography of this section of the proposed highway is undulating, sloping down to the north and contains a low-lying area with standing water brush, sparse trees and bedrock outcrops.

The subsoils in this area generally consist of a 0.4 m thick layer of topsoil or organic silt/peat at the ground surface, underlain in places by deposits of clayey silt between about 0.2 m to 1.3 m thick, extending to depths of up to about 1.5 m below existing ground surface. The cohesive deposit is underlain by up to about 5.5 m thick deposits of silt and sand to sand. These deposits are in turn underlain in places by deposits of sandy gravel to sand and gravel and by inferred bedrock.

Bedrock outcrops were observed along the northern limit of the investigated area. Refusal to split-spoon and/or casing advancement, dynamic cone penetration and shovel excavation was encountered between depths of about 0.1 m and 10 m below ground surface. The depths to refusal were relatively greater in the southern portion of the swamp and shallower at the northern limit of the swamp.



Details of the subsurface conditions for this section of the swamp crossing are presented in Section 4.6 and shown on Drawing C2 in Appendix C.

The simplified stratigraphy and the associated unit weight and the strength, deformation and time-rate consolidation parameters employed for the different soil types encountered in this area are summarized in Table 3. The piezometric condition used in the analyses is the water table at about or near the ground surface, based on the groundwater levels noted during and upon completion of drilling.

6.6.4.1 Stability

Based on the results of the subsurface investigation and review of the highway profile drawings, the critical section for stability (i.e. the greatest embankment height and/or maximum thickness of soft, compressible foundation soils) for this area is located at approximately STA 10+375 where the proposed embankment height is about 3.5 m and the cohesive deposit is about 1.3 m thick. Although the embankment fill is higher near STA 10+460, the foundation soils in this area are very thin and mainly cohesionless. The stability analyses performed on the critical section indicate that after completion of construction, the embankment will have a FoS of about 1.0 on the east side of the SBL embankment for a deep-seated, global failure surface that would impact operation of the roadway.

To achieve a FoS equal to or greater than 1.3 for the east side of the SBL rock fill embankment, it would be necessary to infill the centreline median. Stability analyses indicate that a 1.5 m thick infill would be required between the SBL and NBL embankment for the full length of the swamp crossing as shown on Figure C1.

6.6.4.2 Settlement

To estimate the magnitude of the expected settlements due to new construction, analyses were carried out at two critical sections representative of the subsurface conditions within the swamp crossing area. One section was analyzed at approximately STA 10+375 where the proposed embankment height is about 3.5 m and the cohesive deposit is about 1.3 m thick. The other section was analyzed at approximately STA 10+460 where the proposed embankment height is about 9 m, but no cohesive deposits were encountered in this area.

Based on the results of the settlement analysis with the surficial organic material sub-excavated and replaced with rock fill at STA 10+375, the settlement of the foundation soils in the critical section is estimated to be about 65 mm. This settlement is estimated to be comprised of about 20 mm of immediate settlement due to compression of the non-cohesive deposits and about 45 mm of primary consolidation within the cohesive deposit.

Based on an average coefficient of consolidation (c_v) of about $5.7 \times 10^{-3} \text{ cm}^2/\text{s}$ estimated for the cohesive deposit and the imposed loading conditions for the approximately 3.5 m high embankment plus about a 0.2 m thick layer backfill for replacement of the surficial organic deposit, and assuming two-way drainage of the approximately 1.3 m thick cohesive deposit, it is estimated that about 90 percent of the primary consolidation settlement will be completed in about 7 days.

The magnitude of secondary consolidation (creep) settlement for the cohesive deposit is estimated to be less than 5 mm per log-cycle of time for this area corresponding to about 5 mm over a 20-year period following completion of construction.



In addition, the total settlement of the rock fill embankment itself at STA 10+375 (based on a 3.7 m total thickness) is estimated to be about 25 mm, with about 15 mm expected to occur within six (6) months of construction of the embankment, 5 mm occurring during the next six (6) months and about 5 mm expected to occur over the remaining design life of the embankment.

At STA 10+460, the proposed rock fill embankment is founded directly on bedrock. As such, the total settlement is only comprised of the rock fill embankment component. Based on a 9 m high embankment, the total rock fill settlement is estimated to be about 80 mm, with about 60 mm expected to occur within six (6) months of construction of the embankment, 10 mm occurring during the next six (6) months and about 10 mm expected to occur over the remaining design life of the embankment.

6.6.4.3 Mitigation of Stability Issues and/or Time Dependent Settlements

The stability and the settlement of the proposed up to about 9 m high SBL embankment is influenced by the up to about 1.3 m thick clayey silt deposit below the centerline as well as the up to about 5.1 m thick clayey organic silt/organic silt deposit encountered beneath the immediately adjacent NBL embankment. In order to construct the SBL embankment to achieve a FoS equal to or greater than 1.3, and to minimize post-construction settlements, the alternative remedial measures presented below can be considered. The alternatives described have been evaluated and ranked on the basis of the advantages, disadvantages, relative costs and risk/consequences and are summarized in Table C1 in Appendix C. Given the relative thinness of the weak/soft cohesive deposit, the presence of the highly organic deposit encountered below the east side slope of the SBL embankment, and considering that full sub-excavation is the preferred mitigation option along the NBL embankment within Swamp 503 (see Section 6.6.5), the full sub-excavation option is ranked as the preferred alternative for this area.

Full Sub-Excavation

The bottom of the cohesive deposit at approximately STA 10+375 is up to about 1.5 m below existing ground surface within the proposed SBL embankment footprint. However, the clayey organic silt/organic silt deposit, encountered predominantly below the footprint of the immediately adjacent NBL embankment, also extends below the east side slope of the SBL embankment to a depth of about 3.5 m below existing ground surface. Due to the compressibility and high organic content of the clayey organic silt/organic silt deposit, this deposit will have to be sub-excavated. Full sub-excavation of the cohesive and organic deposits in this area below both the SBL and NBL embankment footprints is feasible and would be the best technical solution.

Since the groundwater table is located at or near the ground surface, the majority of the sub-excavation would have to be carried out 'in-the-wet' (i.e. below the water level). Excavation 'in-the-wet' results in less risk of instability and base heave than under dry conditions but will create more uncertainty regarding full removal of the cohesive/organic deposits. Excavation 'in-the-wet' to remove the cohesive/organic deposits in this area should be carried out with side slopes no steeper than 1H:1V to limit the risk of instability. Complete removal of the cohesive/organic deposits should extend to a horizontal distance beyond the toe of the proposed embankment equal to the horizontal component of the side slope profile (i.e. 1.25H:1V for rock fill) multiplied by the depth to the bottom of the cohesive/organic deposits below the ground surface (in accordance to OPSPD 203.010 (Embankments Over Swamp)).



Full sub-excavation of the cohesive/organic deposits will increase the effective thickness of the new embankment fill by up to about an additional 1.5 m along the centreline of the embankment. The additional below grade fill would need to be constructed with the same slope profile as that used for the above-grade embankment. Based on a 3.5 m high embankment plus about 1.5 m of rock fill required after full sub-excavation along the centreline of the embankment, the post-construction short-term and long-term settlement of the rock fill is estimated to be about 35 mm and 5 mm, respectively, at the critical section. It should be noted that at approximately STA 10+460, the rock fill embankment is founded on bedrock and sub-excavation is not required (other than removal of any surficial organic material); however, at this particular location the embankment is up to about 9 m high and the post-construction short-term and long-term settlement of the rock fill is estimated to be about 70 mm and 10 mm, respectively.

In order to satisfy long-term settlement performance criterion of the embankment (i.e. 75 mm) in the area of STA 10+460, after full sub-excavation of the clayey and organic deposits and replacement with rock fill, the rock fill embankment should be preloaded for a minimum period of 15 days. The magnitude of the remaining short-term and long-term post-construction settlement of the rock fill after the preload period is estimated to be about 65 mm and 10 mm, respectively.

Preloading

For this stability mitigation alternative, to achieve a FoS equal to or greater than 1.3 for the up to about 9 m high rock fill embankment, it would be necessary to infill the centreline median (i.e. between the SBL and NBL embankment). Stability analyses indicate that a 1.5 m thick infill would be required between the SBL and NBL embankment for the full length of the swamp crossing as shown on Figure C1. However, the clayey organic silt/organic silt deposit encountered below the east side slope of the SBL embankment would be partially sub-excavated and replaced with rock fill to avoid differential settlement between the centreline and the east crest of the SBL embankment. To ensure long-term performance of the roadway, the stability analyses indicate that the 1.5 m high median infill is not required, as shown on Figure C2.

Based on the estimated coefficient of consolidation (c_v) of about $5.7 \times 10^{-3} \text{ cm}^2/\text{s}$ for the cohesive deposit at approximately STA 10+375, it is estimated that 90 percent of primary consolidation settlement will be completed in about 7 days. To eliminate the need for instrumentation and settlement monitoring during and after the construction of the embankment, a minimum preload period of 15 days is recommended. If the construction schedule can accommodate this preload period and if the clayey organic silt/organic silt deposit encountered below the east side slope of the SBL embankment is sub-excavated and replaced with rock fill, preloading the foundation soils could be considered at this location.

The magnitude of the remaining primary consolidation settlement, secondary consolidation settlement and the post-construction settlement due to compression of the rock fill embankment at approximately STA 10+375 is estimated to be about 20 mm along the centreline of the embankment within the first 20 years following completion of construction. Along the east side slope, where sub-excavation of the clayey organic silt/organic silt deposit and replacement with rock fill is recommended, the magnitude of the post-construction settlement is estimated to be about 55 mm, which is comprised of only short-term and long-term settlement of the rock fill. At approximately STA 10+460, the short-term and long-term settlement of the rock fill is estimated to be about 70 mm.



Surcharging

Given the short duration required for the preloading mitigation option and given that sub-excavation of the clayey organic silt / organic silt encountered below the east side slope is still required, surcharging is not expected to offer any significant advantages and is not recommended for this area.

Wick Drains

Due to localized and limited thickness of the cohesive deposit (varying between about 0.2 m and 1.3 m) and relatively small foundation mitigation area, the use of wick drains to reduce the time period required for primary consolidation settlement is not considered to be practical in this area.

Lightweight Fill

Given the short duration recommended for the preloading mitigation option, the limited amount of excavation required for the full sub-excavation option, the absence of stability issues along the west side of the SBL embankment, and the relatively short length of the swamp crossing which consists of bedrock outcrops and shallow deposits overlying bedrock near the northern limit of the swamp crossing, the use of expensive lightweight fill (i.e. EPS) is not considered practical for this area.

Aggregate Piers

Due to localized extent and limited thickness of the cohesive deposit (varying between about 0.2 m and 1.3 m) and the high cost associated with the construction of aggregate piers, the use of aggregate piers to further reduce the very short preload period, is not considered to be practical for this area.

Deep Soil Mixing

Due to the localized extent and limited thickness of the cohesive deposit (varying between about 0.2 m and 1.3 m) and the high cost associated with deep soil mixing construction, the use of deep soil mixing panels to further reduce the very short preload period, is not considered to be practical for this area.

6.6.5 Highway 69 NBL – STA 10+230 to STA 10+445 (Swamp 503)

The area extending from about STA 10+230 to STA 10+445 along the proposed Highway 69 NBL alignment requires a new embankment up to about 8 m high at the centerline to achieve the proposed vertical highway profile. The topography of this section of the proposed highway is relatively flat to low-lying and bounded by bedrock outcrops. The central portion of the swamp is occupied by shallow open water and the south perimeter is brush and tree covered.

The subsoils in this area generally consist of an about 2.2 m thick layer of peat and/or an up to about 5.1 m thick deposit of organic silt to clayey organic silt below the ground surface, or ponded water. The organic deposits are underlain by an up to about 5.2 m thick, non-cohesive deposit of silt and sand to sand and/or sand and gravel, or inferred bedrock.



Bedrock outcrops were observed along the northern limit of the investigated area. Refusal to split-spoon and/or casing advancement and dynamic cone penetration was encountered at depths of up to about 12.5 m below ground surface. The depths to refusal are greater in the middle of Swamp 503 than at the south and north limits of the swamp.

Details of the subsurface conditions for this section are presented in Section 4.6 and shown on Drawings C3 and C4 in Appendix C.

The simplified stratigraphy and the associated unit weight, and the strength, deformation and time-rate consolidation parameters employed for the different soil types encountered in this area are summarized in Table 3. The piezometric condition used in the analyses is the water table at about or above the ground surface (i.e. standing water), based on the groundwater levels noted during and upon completion of drilling.

6.6.5.1 Stability

Based on the results of the subsurface investigation and review of the highway profile drawings, the critical section for stability (i.e. the greatest embankment height and/or maximum thickness of soft, compressible foundation soils) for this area is located at approximately STA 10+360 where the proposed embankment height is about 7.5 m and the clayey organic silt/organic silt deposit is about 5.1 m thick. The stability analyses performed on the critical section indicate that after the completion of construction, the embankment will have a FoS of less than 1.0 on the east side of the NBL embankment for a deep-seated, global failure surface that would impact operation of the roadway.

To achieve a FoS equal to or greater than 1.3 for the east side of the NBL rock fill embankment, it would be necessary to construct a stability toe berm along the outside toe of the embankment (i.e. along the east side of the NBL alignment). Stability analysis indicates that a 3 m high by 16 m wide toe berm (including excavation and replacement of the surficial peat deposit) would be required along the outside toe of the embankment for the full length of the swamp crossing, as shown on Figure C1. Furthermore, as indicated in Section 6.6.4.1 and as shown on Figure C1, given that a 1.5 m high median infill would be required between the SBL and NBL embankment to achieve a FoS equal to or greater than 1.3 for the inner toe of the SBL embankment (i.e. east side of the SBL alignment), the median infill further increases the FoS of the NBL west slope to a value much greater than 1.3.

6.6.5.2 Settlement

To estimate the magnitude of the expected settlements due to new construction, an analysis was carried out on the critical section representative of the subsurface conditions within the swamp crossing area, at approximately STA 10+360 where the proposed embankment height is about 7.5 m and the clayey organic silt/organic silt deposit is about 5.1 m thick.

Based on the results of the settlement analysis with the surficial peat deposit sub-excavated and replaced with rock fill, the settlement of the foundation soils in the critical section is estimated to be about 700 mm. This settlement is estimated to be comprised of about 100 mm of immediate settlement due to compression of the non-cohesive deposits and about 600 mm of primary consolidation within the clayey organic silt/organic silt deposit.



Based on an average coefficient of consolidation (c_v) of about $3.14 \times 10^{-3} \text{ cm}^2/\text{s}$ estimated for the 5.1 m thick organic silt deposit and the imposed loading conditions for the approximately 7.5 m high embankment plus about 0.3 m thick backfill for replacement of the surficial peat deposit, and assuming two-way drainage of the approximately organic deposit, it is estimated that about 90 percent of the primary consolidation settlement will be completed in about 205 days.

The magnitude of secondary consolidation (creep) settlement for the cohesive deposit is estimated to be less than 65 mm per log-cycle of time for this area corresponding to about 105 mm over a 20-year period following completion of construction.

In addition, the total settlement of the rock fill embankment itself (based on a 7.8 m total thickness) is estimated to be about 70 mm, with about 55 mm expected to occur within six (6) months of construction of the embankment, 5 mm occurring during the next six (6) months and about 10 mm expected to occur over the remaining design life of the embankment.

6.6.5.3 Mitigation of Stability Issues and/or Time Dependent Settlements

The presence of the up to about 5.1 m thick clayey organic silt/organic silt deposit influences both the stability and the settlement of the proposed up to about 7.5 m high NBL embankment. In order to construct the embankment to achieve a FoS equal to or greater than 1.3, and to minimize post-construction settlements, the alternatives presented below can be considered. The alternatives described have been evaluated and ranked on the basis of the advantages, disadvantages, relative costs and risk/consequences and are summarized in Table C2 in Appendix C. Considering the stability issues along the entire length of the swamp crossing, given the uncertainty associated with the magnitude of long-term settlement of the highly organic silt deposit and taking into account the relative thickness of this deposit, the full sub-excavation option is ranked as the preferred alternative for this area.

Full Sub-Excavation

The bottom of the organic silt/clayey organic silt deposit is up to about 6.5 m below existing ground surface within the proposed embankment footprint at this location. Full sub-excavation of the organic deposit to this depth in this area is feasible and is the preferred alternative foundation remedial alternative.

Since the groundwater table is located at or above the ground surface, the majority of the sub-excavation would have to be carried out 'in-the-wet' (i.e. below the water level). Excavation 'in-the-wet' results in less risk of instability and base heave than under dry conditions but will create more uncertainty regarding full removal of the cohesive/organic deposits. Excavation 'in-the-wet' to remove the organic deposits in this area should be carried out with side slopes no steeper than 1H:1V to limit the risk of instability. Complete removal of the organic deposits should extend to a horizontal distance beyond the toe of the proposed embankment equal to the horizontal component of the side slope profile (i.e. 1.25H:1V for rock fill) multiplied by the depth to the bottom of the organic deposits below the ground surface (in accordance to OPSD 203.010 (Embankments Over Swamp)).

It should be noted that full sub-excavation of the organic deposits will increase the effective thickness of the new embankment fill by up to about an additional 6.5 m along the centreline of the embankment. The additional below grade fill would need to be constructed with the same slope profile as that used for the above-grade embankment. Based on a 7.5 m high embankment plus about 6.5 m of rock fill required after full sub-excavation



along the centreline of the embankment, the post-construction short-term and long-term settlement of the rock fill is estimated to be about 155 mm and 20 mm, respectively, at the critical section.

In order to satisfy long-term settlement performance criterion of the embankment (i.e. 75 mm), the rock fill embankment should be preloaded for a minimum period of 95 days. The magnitude of the remaining short-term and long-term post-construction settlement of the rock fill after the preload period is estimated to be about 55 mm and 20 mm, respectively.

Preloading and Toe Berms

To achieve a FoS equal to or greater than 1.3 for the up to about 7.5 m high rock fill embankment, it would be necessary to construct a stability berm along the outside toe of the embankment (i.e. east side of the NBL alignment). Stability analyses indicate that a 3 m high by 16 m wide toe berm (including excavation and replacement of the surficial peat deposit) would be required along the outside toe of the embankment for the full length of the swamp crossing, as shown of Figure C1. Furthermore, as indicated in Section 6.6.4.1 and as shown on Figure C1, given that a 1.5 m high median infill would also be required between the SBL and NBL embankment to achieve a FoS equal to or greater than 1.3 for the inner toe of the SBL embankment (i.e. east side of the SBL alignment), the median infill further enhances the stability of the NBL west slope to a FoS much greater than 1.3.

Based on the estimated coefficient of consolidation (c_v) of about $3.14 \times 10^{-3} \text{ cm}^2/\text{s}$ for the organic silt deposits, it is estimated that 90 percent of primary consolidation settlement will be completed in about 205 days. However, in order to meet the settlement performance criterion and considering the magnitude of creep settlement at this location, a minimum preload period of 800 days (i.e. about 2.2 years) would be required.

The magnitude of the remaining primary consolidation settlement, secondary consolidation settlement and the post-construction settlement due to compression of the rock fill embankment after the 200 day preload period is estimated to be about 65 mm and 10 mm, respectively, (75 mm total) within the first 20 years following completion of construction.

Considering the duration associated with the preload period at this location, it is recommended that the magnitude and time-rate of settlement, as well as the dissipation of excess pore pressures during and after construction of the surcharge embankment, be assessed by monitoring this area to confirm the end of the preload period if this alternative is adopted. Monitoring instrumentation would consist of settlement rods (SRs), vibrating wire piezometers (VWPs) and standpipe piezometers (SPPs).

Given the very long duration of the preload period, requirements for a relatively large toe berm to maintain embankment stability and the need for instrumentation and monitoring, preloading is not considered to be the preferred mitigation option.

Surcharging (2 m high) and Toe Berms

To achieve a FoS equal to or greater than 1.3 for the up to about 9.5 m surcharge embankment (consisting of 7.5 m of rock fill and 2 m of granular surcharge), it would be necessary to construct a stability berm along the outside toe of the embankment (i.e. east side of the NBL alignment) and a median infill. Stability analyses indicate that a 3 m high by 21 m wide toe berm (including excavation and replacement of surficial peat deposit) would be required along the outside toe of the embankment, as well as a 1.5 m infill high along the median



between the SBL and NBL embankment (associated with stability enhancement of the SBL) for the full length of the swamp crossing, as shown of Figure C3.

Based on the estimated coefficient of consolidation (c_v) about $3.14 \times 10^{-3} \text{ cm}^2/\text{s}$ for the cohesive deposit with a granular surcharge fill 2 m thick, it is estimated that 90 percent of primary consolidation settlement of the foundation soils under the final embankment height will be completed in about 115 days. However, in order to meet the settlement performance criterion (75 mm or less), a minimum surcharge period of 200 days would be required.

Considering the duration associated with the surcharge period at this location, it is recommended that the magnitude and time-rate of settlement, as well as the dissipation of excess pore pressures during and after construction of the surcharge embankment, be assessed by monitoring this area to confirm the end of the preload period if this alternative is to be adopted. Monitoring instrumentation would consist of settlement rods (SRs), vibrating wire piezometers (VWPs) and standpipe piezometers (SPPs).

The magnitude of the remaining primary consolidation settlement, secondary consolidation settlement and the post-construction settlement due to compression of the rock fill embankment is estimated to be about 55 mm and 15 mm, respectively (70 mm total) within the first 20 years following completion of construction.

Given the relatively long duration of the surcharge period, requirements for a long toe berm to maintain embankment stability and the need for instrumentation and monitoring, surcharging is not considered to be the preferred mitigation option.

Wick Drains

Taking into account the thickness of the compressible deposit, the low coefficient of horizontal consolidation (estimated based on empirical correlations and engineering experience with similar soils), and given the relatively high creep rate of the organic soils (i.e. about 65 mm per log-cycle of time), and considering the effects of smearing during wick drain installation (i.e. reduced horizontal permeability of the organic silt deposit immediately adjacent to the wick drains), preliminary analyses indicate that wick drains are not expected to offer any significant advantages in terms of the preload/surcharge times to satisfy the settlement performance criterion of 75 mm of settlement over a 20-year period following completion of construction.

Furthermore, taking into consideration the need for a detailed wick drain investigation and design (including instrumentation and monitoring plan), as well as the additional stability analyses to confirm/assess whether staged construction and/or smaller toe berms could be utilized to maintain a FoS greater than or equal to 1.3, this alternative is not considered practical at this location.

Lightweight Fill

Consideration could be given to constructing the NBL embankment with lightweight (i.e. EPS) fill to mitigate stability and settlement issues. For the up to about 7.5 m high embankment with 2H:1V side slopes (consisting of a 2 m thick granular base, including a 300 mm thick levelling pad, a 4.5 m thick EPS core and 1 m of granular protective cover/pavement structure), stability analysis indicates that the embankment will have a FoS of greater than 1.3 for deep-seated, global failure surfaces, as shown on Figure C4.



Based on the results of the settlement analysis, the total settlement of the foundation soils under the loading imposed by the combined EPS and granular fill is estimated to be about 230 mm. The estimated total settlement is comprised of about 45 mm of immediate settlement due to compression of the non-cohesive deposits and about 185 mm of primary and secondary consolidation settlement of the organic deposits.

In order to meet the settlement performance criterion of 75 mm of settlement over a 20-year period following completion of construction, it is estimated that the embankment with the 4.5 m thick EPS core would require preloading for a minimum preload period of 175 days. However, considering the duration associated with the preload period at this location, it is recommended that the magnitude and time-rate of settlement, as well as the dissipation of excess pore pressures during and after construction of the preload embankment, be assessed by monitoring this area to confirm the end of the preload period if this alternative is to be adopted. Monitoring instrumentation would consist of settlement rods (SRs), vibrating wire piezometers (VWPs) and standpipe piezometers (SPPs).

The magnitude of the remaining primary consolidation settlement and the secondary consolidation settlement is estimated to be about 55 mm and 15 mm, respectively (total of 70 mm) within the first 20 years following completion of construction.

Considering the very high cost associated with EPS installation, the length of the required preload period and the need for instrumentation and monitoring, this option is not the preferred mitigation measure for this area. However, if it is necessary to minimize the disposal of sub-excavation materials and/or reduce the volume of embankment fill associated with toe berms, this option could be considered.

Aggregate Piers

Given the long preload/surcharge periods required to complete primary consolidation of the organic silt deposit under the loading of the up to about 7.5 m high rock fill embankment, consideration could be given to the installation of aggregate piers through the foundation soils below the footprint of the embankment. It should be noted that a temporary casing will most likely be required for aggregate pier construction due to the soft nature of the deposit and high water table. Alternatively, the use of displacement-type aggregate piers may be possible.

Preliminary analyses using an aggregate pier spacing of 1.5 m in a triangular pattern for the full depth through the bottom of the organic silt deposit (i.e. up to about 9.6 m below existing ground surface) indicates that a preload period of about 15 days would be required to meet the settlement performance criterion of 75 mm of settlement over a 20-year period following completion of construction. The magnitude of the remaining time-dependent settlement of the organic silt deposit within the aggregate pier-reinforced zone is estimated to be negligible and the post-construction settlement due to compression of the rock fill embankment is estimated to be about 60 mm within the first 20 years following completion of construction.

Alternatively, in order to reduce the cost and still maintain a reasonable preload period, an aggregate pier spacing of 2.5 m in a triangular pattern for the full depth through the bottom of the organic deposit could be considered. Preliminary analyses indicate that a preload period of about 65 days would be required to meet the settlement performance criterion. The magnitude of the remaining time-dependent settlement of the organic deposit within the aggregate pier-reinforced zone is estimated to be negligible and the post-construction settlement due to compression of the rock fill embankment itself is estimated to be about 40 mm within the first 20 years following completion of construction.



Given the need for a detailed aggregate pier design and the cost associated with construction of aggregate piers, the aggregate pier option is not ranked as the preferred stability and settlement mitigation alternative at this location. However, if the time period required for surcharging alone must be reduced to accommodate construction schedule constraints and the amount of excavated spoil must be minimized, consideration could be given to the use of aggregate piers in combination with preloading the embankment to reduce the time period for the time-dependent settlement of the aggregate pier-reinforced soil and post-construction settlement of the rock fill itself, as noted above.

Deep Soil Mixing

Deep soil mixing may be a technically feasible solution for ground improvement at this location to satisfy the stability and post-construction settlement performance of the embankment. However, given the highly organic nature of the soils requiring improvement, the need for detail design (including bench scale laboratory tests to design a suitable soil/cement mix) and the high costs associated with deep soil mixing construction, the use of deep soil mixing panels to avoid the need for sub-excavation and replacement is not considered to be practical for this area.

6.6.6 Highway 69 NBL – STA 21+300 (Henvey) to STA 10+140 (Mowat) (Deep Cut 504)

The area extending from about STA 21+300 in the Township of Henvey to STA 10+140 in the Township of Mowat along the proposed Highway 69 NBL requires an earth cut up to about 4 m deep to achieve the proposed vertical highway profile. This section of the proposed highway profile is located within a relatively flat to slightly undulating topography, sloping down to the north, with ground cover consisting of shrubs and treed areas, and bedrock outcrops to the east.

The subsoils in this area generally consist of a layer of topsoil at the ground surface underlain in places by a thin deposit of sandy clayey silt. The topsoil and/or surficial cohesive deposit are underlain by deposits of silt to sand which in turn are underlain by a relatively thick deposit of clayey silt to clay. The overall thickness of the cohesive deposit (including occasional sandy silt to silty sand seams / pockets) varies from about 2.3 m to 5.3 m, extending to depths of up to about 9.4 m below existing ground surface. The cohesive deposit is underlain by a thick deposit of silt to silt and sand.

Details of the subsurface conditions for this section are presented in Section 4.8 and shown on Drawings D1 to D3 in Appendix D.

The simplified stratigraphy and the associated unit weight, and strength parameters employed for the different soil types encountered in this area are summarized in Table 3. The piezometric conditions used in the analyses are based on groundwater level measurements obtained from two standpipe piezometers installed in the lower and upper sandy silt deposits encountered at this site.



6.6.6.1 Stability

Based on the results of the subsurface investigation and review of highway profile drawings, the critical section for stability (i.e. the deepest cut) for this area is located at approximately STA 10+060 where the proposed cut through the overburden soils is about 4 m deep.

Stability analyses were carried out at the critical section to assess the stability of the permanent cut slopes during the short-term (i.e. immediately after excavation and assuming undrained conditions) and during the long-term (i.e. after a period of time when drained conditions have been reached and the phreatic surface has reached a new equilibrium). The analyses assume permanent side slopes of 2H:1V and that the groundwater level has stabilized after installation of ditches and pavement subdrains. The results of the analyses indicate that during the short-term, the cut slopes will have a FoS equal to or greater than 1.3 for deep-seated, global failure surfaces that would impact the operation of the roadway/ditch line, as shown on Figure D1 in Appendix D. During the long term, the results of the analyses also indicate that a FoS equal to or greater than 1.3 is achieved for deep-seated, global failure surfaces, however, the FoS is less than unity (1) for shallow failure surfaces, as shown on Figure D2 in Appendix D.

To achieve a FoS equal to or greater than 1.3 against shallow/surficial instability during the long-term (which can eventually result in progressive failure of the overall cut slope), it is recommended that the surface of the slopes be protected/covered with granular sheeting. Given the fine-grained nature of the native sandy silt to silt and sand soils along the upper portion of the proposed cut slope and the presence of silty seams / pockets encountered within the cohesive deposit along the bottom portion of the proposed cut slope, the granular sheeting should be constructed to a minimum thickness of 400 mm and comprised of OPSS.PROV 1004 (Aggregates – Miscellaneous) granular sheeting material placed directly on the native soils along the entire slope face. Moreover, considering the likely ongoing nature of the groundwater seepage from the slope face, and in order to minimize surface water erosion, it is recommended that the granular sheeting be covered with an approximately 500 mm thick layer of OPSS.PROV 1004 rip-rap. Additional details pertaining to the construction of the granular sheeting and rip-rap layer are provided in Section 6.9.2. With the granular sheeting and rip-rap placed over the entire face of the slope, the results of stability analyses indicate that the FoS is equal to or greater than 1.3 for both shallow and deep-seated, global failure surfaces during the short-term and long-term, as shown on Figures D3 and D4, respectively, in Appendix D.

Given that the proposed design of the cut at this location will require excavation into a silty clay stratum underlain by a silt and sand aquifer under artesian conditions, a stability check has also been carried out on the resistance of the excavation geometry to base heave. For the proposed base of excavation at or above Elevation 190.5 m, the Factor of Safety against base heave is estimated to be greater than 1.4 for the conditions at the site at the time of investigation.

6.7 Subgrade Preparation and Embankment Construction

The following sections discuss general aspects of subgrade preparation and embankment construction for the swamp crossing/high fill areas in the Contract 5 project limits, including: removal of surficial and near surface organic materials; excavation and replacement of deeper/thicker organic silt/clayey organic silt deposits and soft, cohesive deposits, where required; groundwater control; and placement of embankment fills.

A summary of the recommended/preferred foundation mitigation option for each swamp crossing/high fill area is presented in Table 5. The summary contains: recommendations on embankment fill types and side slope



profiles; estimated maximum depth of organic deposits encountered; the estimated settlement (during and post-construction) for the embankment materials and the foundation soils; recommended width of platform widening as may be required to accommodate future raising of the embankment; and the recommended OPSD excavation guideline.

6.7.1 Removal of Organic Materials

Based on the information from the boreholes advanced during the field investigation, the thickness of the surficial organic deposits (i.e. topsoil/peat/organic silt/clayey organic silt) and near surface cohesive deposits (i.e. clayey silt to silty clay) requiring removal in the Contract 5 section of the proposed Highway 69 alignment generally ranges from about 0.1 m to up to 6.5 m. After clearing and grubbing of the swamp crossing/high fill areas and prior to the placement of any fill for the new construction, all surficial and near surface layers of organic and cohesive deposits within the swamp crossing/high fill areas shall be stripped from the plan limits of the proposed works, including toe berms, if applicable. The organic materials should be removed using construction procedures in accordance with OPSS 209 (Embankments over Swamps and Compressible Soils).

In areas where the new embankments are being constructed away from existing embankments, the excavation limits should be consistent with OPSD 203.010 (Embankments over Swamp for New Construction), modified to remove the restrictions on the height of the embankment and the depth of excavation (i.e. Note A).

All excavations must be carried out in accordance with Ontario Regulation 213 Ontario Occupational Health and Safety Act for Construction Projects (as amended).

6.7.2 Excavation of Soft Soils

In areas where stability and/or post-construction settlement issues require mitigation measures to enhance the performance of the highway embankment, full sub-excavation and replacement of soft deposits is recommended. Excavation up to about 2.7 m below existing ground surface is anticipated in some areas of the Contract 5 section of the project where sub-excavation and replacement of soft/weak materials is recommended as the preferred mitigation option. Conventional equipment is considered suitable for the excavation of soft/weak deposits up to depths of about 2.7 m. The soft deposits should be removed using construction procedures in accordance with OPSS 209 (Embankments over Swamps and Compressible Soils).

Where excavation is required through bedrock outcrops, rock excavation and blasting will be required to accommodate the new alignment. All rock excavation and grading should be carried out in accordance with the requirements as outlined in OPSS.PROV 206 (Grading).

All excavations must be carried out in accordance with Ontario Regulation 213 Ontario Occupational Health and Safety Act for Construction Projects (as amended by Ontario Regulation 443). In addition, provisions for traffic control measures should be included in the Contract Documents to maintain the safe operation of Highway 69 and any associated side roads or detours that are in close proximity to the excavation operations, if applicable.

6.7.3 Groundwater and Surface Water Control

Excavation within the plan limits of the proposed works for the removal of organic and/or soft deposits prior to embankment fill placement, will extend below the water table. Groundwater flow into the excavations will occur



due to the presence of relatively permeable deposits and relatively high groundwater levels observed in the low-lying swamp crossing/high fill areas. Unwatering is not required for the excavation and backfilling operations in the swamp crossing/high fill areas, however, surface water should be directed away from the excavations at all times.

6.7.4 Backfilling

In general, it is recommended that rock fill be used for replacement of the sub-excavated material. However, in areas where driven piles are to be installed for support of adjacent bridge structure foundations, it is recommended that granular fill (i.e. OPSS.PROV 1010 Granular 'B' Type II) be used for the replacement of the sub-excavated material. Where sub-excavation of organic materials and soft deposits is carried out as a foundation mitigation option, rock fill or granular fill will be most likely placed below the water table by end dumped as the excavation advances and should be carried out consistent with the requirements in OPSS.PROV 206 (Grading).

6.7.5 Embankment Fill Placement

Placement of rock fill and granular/earth fill above the water table for construction of new embankments should be carried out in accordance with the requirements as outlined in OPSS.PROV 206 (Grading) and granular/earth fill should be compacted in accordance with OPSS 501 (Compacting). The rock fill should not be dumped in final position, but should be deposited on and pushed forward over the end of the layer being constructed. Voids and bridging should be minimized by blading, dozing and 'chinking' the rock to form a dense, compacted mass. Side slopes for rock fill embankments should be no steeper than 1.25H:1V. Side slopes for granular fill should be no steeper than 2H:1V.

6.8 Embankment Platform Widening

In accordance with the requirements of MTO Northern Region Engineering Directive NRE 98-200, Northern Region Embankment Design Guidelines, the construction of the embankments should include an allowance for platform widening (in 0.5 m increments) to accommodate settlements during construction as well as post-construction settlements so that the minimum standard shoulder widths are maintained if future grade raises on the embankments are required. According to NRE 98-200, the need for future raises in road grade could occur due to settlement/compression of the embankment fill, settlement of the foundation soils and to accommodate future pavement overlays up to 200 mm thick. It is understood that this directive applies to all rock fill embankments as well as for granular fill embankments where widening restrictions are present (such as the presence of a sensitive body of water or space/property issues). It is further understood that the minimum required platform widening on major highways (i.e. including Highway 69) over swamp crossings (and for high fill embankments) is 2 m per side, unless the preferred mitigation option eliminates uncertainty regarding embankment settlement/performance (i.e. full sub-excavation to bedrock and backfilling with granular material).

The minimum required embankment platform widening (per embankment side) is calculated based on the estimated consolidation settlement of the foundation soils (including creep) and the settlement/compression of the embankment fill, plus an additional 200 mm for the future pavement overlay, multiplied by the horizontal



component of the side slope of the pavement structure (4H:1V), but cannot be less than the minimum platform widening requirements as described above.

For the proposed embankments in these swamp crossing/high fill areas, the minimum platform widening for the preferred option to mitigate stability and settlement is summarized in Table 6.

6.9 Cut Slope Construction

The following sections discuss general aspects of excavation, mitigation of surficial instability and erosion protection, as well as groundwater and surface water control measures for the Deep Cut 504 area.

A summary of the side slope profiles and recommended measures is presented in Table 7.

6.9.1 Excavation

The proposed Highway 69 NBL within Deep Cut 504 area will require lowering the existing ground surface by a depth of up to about 4 m. Temporary and permanent excavations will be made through very loose to compact silt to sand and soft to stiff clayey silt to clay deposits. The water levels measured in piezometers screened in the upper silt to sand deposit overlying the cohesive deposit and in the lower silt to silt and sand deposit underlying the cohesive deposit were at 0.5 m and 4.1 m below existing ground surface, respectively.

As a result of the existing high perched water table, it is recommended that the proposed Highway 69 profile within Deep Cut 504 area be excavated with ditches and sub-drains installed progressively as the subgrade is lowered and in advance of the final side slopes being excavated to the design grade, to allow the groundwater to drain progressively so as to reduce the risk of surficial instability during the short-term and to minimize softening of the subgrade soils.

If granular sheeting and a layer of rip-rap/rock fill are placed immediately after the excavation to the final slope inclination, permanent side slopes no steeper than 2H:1V are considered adequate. Details pertaining to the construction of the granular sheeting and a layer of rip-rap/rock fill are provided in Section 6.9.2.

For temporary excavations, the very loose to compact silt to sand and the soft to stiff clayey silt to clay deposits are considered Type 3 soils according to Ontario Regulation 213 Ontario Occupational Health and Safety Act for Construction Projects (as amended by Ontario Regulation 443). Temporary excavations within Type 3 soils would typically be sloped no steeper than 1H:1V from the existing ground surface down to the base of the excavation; however, given the likely ongoing nature of groundwater seepage along the excavated slope face, which can lead to shallow/surficial instability (which in turn can result in progressive failure of the overall slope), it is recommended that temporary excavations be sloped no steeper than 2H:1V.

6.9.2 Surficial Instability and Erosion Protection

The granular sheeting, which is intended to function as a filter layer, should consist of a minimum thickness of 400 mm of OPSS.PROV 1004 (Aggregates – Miscellaneous) granular sheeting material, distributed evenly over the slope face. The filter layer should be covered with a minimum thickness of 500 mm of rip-rap meeting the requirements of OPSS.PROV 1004 (Aggregates – Miscellaneous). The granular sheeting and the rip-rap layers



should be placed from the toe of the slope and progress upwards to the crest of the slope in accordance with OPSS 511 (Rip-Rap, Rock Protection and Granular Sheeting).

6.9.3 Groundwater and Surface Water Control

Given the high level of perched water table and the cohesionless nature of the upper silt to sand deposit, as well as the presence of water bearing silty / sandy seams and pockets within the cohesive deposit, it is expected that water will drain freely from the cut slopes during construction. Highway ditches and longitudinal sub-drains should be installed to adequately draw down the water level, to avoid disturbance to the proposed highway subgrade and to prevent surficial sloughing of the deep cut slopes during the short-term. A NSSP for dewatering during the deep cut excavation operations is included in Appendix E.

It is recommended that a drainage ditch be constructed at the top of the deep cut slopes immediately beyond the crest of the slopes to divert surface water run-off away from the slopes.

7.0 CLOSURE

This report was prepared by Mr. Tomasz Zalucki, P.Eng. The technical aspects were reviewed by Mr. J. Paul Dittrich, Ph.D., P.Eng., a senior geotechnical engineer and Principal with Golder. Mr. Jorge M. A. Costa, P.Eng., Golder's Designated MTO Foundations Contact for this project and a Senior Consultant with Golder, conducted an independent quality control review of the report.



Report Signature Page

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[https://capws.golder.com/sites/0911116014highway69FourLaning/Contract 5/Reporting/Swamp and High Fills/Final/09-1111-6014 RPT 16Jul20 Contract 5 Highway 69 Swamp Crossing, High Fill Areas and Deep Cut.docx](https://capws.golder.com/sites/0911116014highway69FourLaning/Contract%205/Reporting/Swamp%20and%20High%20Fills/Final/09-1111-6014%20RPT%2016Jul20%20Contract%205%20Highway%2069%20Swamp%20Crossing,%20High%20Fill%20Areas%20and%20Deep%20Cut.docx)



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ASTM D1587	Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
ASTM D2573	Standard Test Method for Field Vane Shear Test in Cohesive Soil
ASTM D5731	Standard Test Method for Determination of the Point Load Strength Index of Rock and Application of Rock Strength Classification

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OPSD 202.010 Slope Flattening Using Surplus Excavated Material on Earth or Rock Embankment

OPSD 203.010 Embankments Over Swamp – New Construction

Ontario Provincial Standard Specifications:

OPSS. PROV 206 Construction Specification for Grading

OPSS.PROV 1004 Material Specification for Aggregates - Miscellaneous



**FOUNDATION REPORT – SWAMP CROSSING, HIGH FILL
AREAS AND DEEP CUT - HIGHWAY 69 GWP 5347-08-00; WP 5005-10-01**

OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material
OPSS 209	Construction Specification for Embankments over Swamps and Compressible Soils
OPSS 501	Construction Specification for Compacting
OPSS 511	Construction Specification for Rip-Rap, Rock Protection, and Granular Sheeting

Ontario Water Resources Act:

Ontario Regulation 903/90 Wells



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
FoS	factor of safety

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

* Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	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_{α}	secondary compression index
m_v	coefficient of volume change
C_v	coefficient of consolidation (vertical direction)
C_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{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
2

$\tau = c' + \sigma' \tan \phi'$
shear strength = (compressive strength)/2



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

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.) drive open sampler for a distance of 300 mm (12 in.)

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.

III. SOIL DESCRIPTION

(a) Non-cohesive (Cohesionless) Soils

Density Index	N
Relative Density	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

(b) Cohesive Soils Consistency

	kPa	Cu, Su	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

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.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand



LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	Less than 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

JN Joint	PL Planar
FLT Fault	CU Curved
SH Shear	UN Undulating
VN Vein	IR Irregular
FR Fracture	K Slickensided
SY Stylolite	PO Polished
BD Bedding	SM Smooth
FO Foliation	SR Slightly Rough
CO Contact	RO Rough
AXJ Axial Joint	VR Very Rough
KV Karstic Void	
MB Mechanical Break	



TABLES



**FOUNDATION REPORT – SWAMP CROSSING, HIGH FILL
AREAS AND DEEP CUT - HIGHWAY 69 GWP 5347-08-00; WP 5005-10-01**

**Table 1: Summary of Swamp Crossing, High Fill Areas and Deep Cut
Highway 69 Four-Laning**

Foundation Investigation Area	Foundation Investigation Area Designation	Proposed Maximum Embankment / Cut Slope Height ¹	Boreholes/DCPTs	Reference Appendix
Highway 69 NBL STA 20+665 to STA 20+705	High Fill 501	10.0	3 Boreholes (S501-01 to S501-03) 1 DCPT (S501-DC01)	A
Highway 69 SBL STA 20+980 to STA 21+180	High Fill 502	7.0 ²	22 Boreholes (S502-01 to S502-17, S502-21, B501-02 and B501-12 to B501-14) 7 DCPTs (S502-DC01 to S502-DC07)	B
Highway 69 NBL STA 20+990 to STA 21+075	High Fill 502	4.4 ³	12 Boreholes (S502-18 to S502-24, S502-20A, B502-02 and B502-12 to B502-14) 5 DCPTs (S502-DC01, S502-DC02, S502-DC04, S502-DC08 and S502-DC09)	
Highway 69 SBL STA 10+350 to STA 10+470	Swamp 503	9.0	14 Boreholes (S503-01 to S503-11 and C501-01 to C501-03) 5 DCPTs (S503-DC01 to S503-DC05)	C
Highway 69 NBL STA 10+230 to STA 10+445	Swamp 503	8.0	22 Boreholes (S503-12 to S503-30 and C501-04 to C501-06) 9 DCPTs (S503-DC06 to S303-DC14)	
Highway 69 NBL ⁴ STA 21+300 (Henvey) to STA 10+140 (Mowat)	Deep Cut 504	4.0	9 Boreholes (D504-01 to D504-09)	D

Note:

1. Based on centreline profile of highway alignment and existing ground surface profiles provided by URS on March 14, 2012, February 1, 2013 and February 24, 2016. Embankment / cut slope heights are approximate and relative to original ground surface.
2. The southern limit of the Highway 69 SBL embankment is at STA 21+055 (i.e. the Straight Lake SBL north abutment).
3. The southern limit of the Highway 69 NBL embankment is at STA 21+080 (i.e. the Straight Lake NBL north abutment).
4. Cross-over chainages at about STA 21+470 (Henvey) \equiv STA 10+000 (Mowat).

Prepared By: ARV/TZ

Reviewed By: JPD/JMAC



FOUNDATION REPORT – SWAMP CROSSING, HIGH FILL AREAS AND DEEP CUT - HIGHWAY 69 GWP 5347-08-00; WP 5005-10-01

**Table 2: Summary of Consolidation and Consolidated Undrained Triaxial (CIU) Test Results
Highway 69 Four-Laning**

Foundation Investigation Area	Borehole and Sample No.	Sample Elevation (m)	σ_{vo}' (kPa)	σ_p' (kPa)	$\sigma_p' - \sigma_{vo}'$ (kPa)	OCR	C_c	C_r	e_o	c_v^1 (cm ² /s)	Reference Appendix
Highway 69 SBL High Fill 502	Borehole S502-01 Sample 7	175.3	50	130	80	2.6	1.68	0.012	2.13	4.3×10^{-3}	B
	Borehole S502-02 Sample 12	170.0	115	230	115	2.0	0.97	0.023	1.53	4.9×10^{-3}	
Highway 69 NBL High Fill 502	Borehole B502-13 Sample 10	175.8	75	160	85	2.1	0.62	0.060	1.23	4.6×10^{-4}	
	Borehole S502-20 Sample 10	174.7	100	150	50	1.5	0.79	0.020	1.40	7.2×10^{-4}	
	Borehole S502-20B Sample 1	178.5	55	195	140	3.5	0.80	0.060	1.43	1.0×10^{-3}	

Note:

- For stress range between sample in situ effective overburden stress and final stress due to embankment construction for all embankments (4.4 m to 8.0 m high).

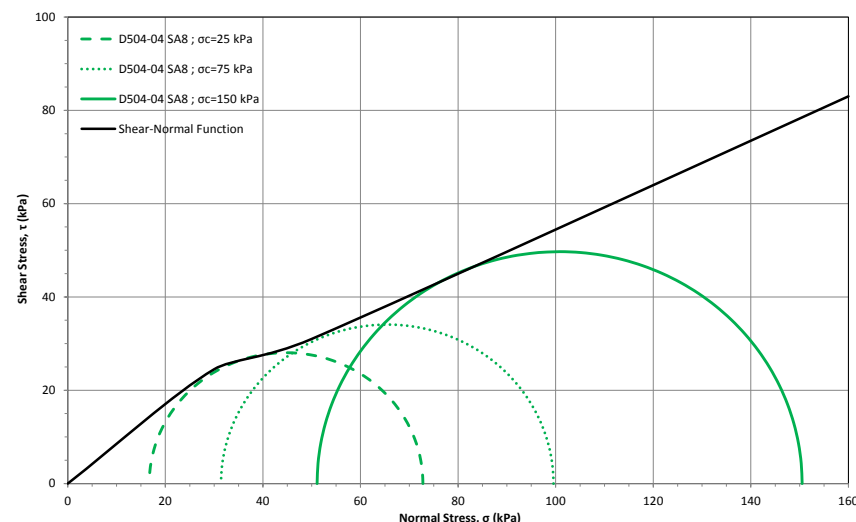
where: σ_{vo}' is the effective overburden stress in kPa
 σ_p' is the preconsolidation stress in kPa
OCR is the overconsolidation ratio
 C_c is the compression index
 C_r is the recompression index
 e_o is the initial void ratio
 c_v is the coefficient of consolidation in cm²/s

Foundation Investigation Area	Borehole and Sample No.	Sample Elevation (m)	γ' (kN/m ³)	ϕ' (°)	c' (kPa)
Highway 69 NBL Deep Cut 504	Borehole D504-04 Sample 8	188.4	16.5	27 ¹	5 ¹

Note:

- ϕ' and c' values represent approximate, equivalent shear strength parameters derived from the laboratory CIU triaxial test. The shear strength used in the stability analyses were derived at various shear stress (τ)/normal stress (σ) points from the shear-normal function line (as shown on the inset plot).

Shear-Normal Function for Cohesive Deposits in Deep Cut 504



Prepared By: TZ

Reviewed By: JPD/JMAC



Table 3: Summary of Foundation Engineering Parameters
Highway 69 Four-Laning

Foundation Investigation Area	Stratigraphic Unit	Top Elevation (m)	Thickness (m)	γ' (kN/m ³)	ϕ' (°)	c' (kPa)	S_u (kPa)	σ_p' (kPa)	e_o	C_c	C_r	m_v (kPa ⁻¹)	E' (MPa)	c_v (cm ² /s)	k (m/s)
Highway 69 NBL STA 20+665 to STA 20+705 (High Fill 501)	Peat	196.7 to 192.3	0.1 to 0.2	12	28	1	-	-	-	-	-	-	-	-	-
	Silty Sand	~189.9	~0.2	19	28	0	-	-	-	-	-	-	5	-	-
Highway 69 SBL STA 20+980 to STA 21+180 and Highway 69 NBL STA 20+990 to STA 21+075 (High Fill 502)	Peat / Topsoil	192.1 to 177.2	0.1 to 0.8	12 to 15	28	1	-	-	-	-	-	-	-	-	-
	Organic Silt	180.5 to 176.5	0.8 to 2.3	15	-	-	10	-	-	-	-	-	-	-	-
	Clayey Silt to Silty Clay (Surficial)	191.9 to 181.9	0.5 to 1.3	17	-	-	30	135	-	-	-	7.5×10^{-4}	-	-	-
	Silt to Sand	191.0 to 178.3	0.9 to 14.2	18.5 to 19	28 to 29	0	-	-	-	-	-	-	5 to 10	-	-
	Clayey Silt to Silty Clay (Pockets)	188.5 to 179.8	~0.1 to 2.9	17	-	-	30	135	-	-	-	2.0×10^{-4}	-	-	-
	Clayey Silt to Clay ¹ (south of STA 21+055 - SBL)	179.7 to 175.1	0.8 to 19.4	17	-	-	20 to 45	90 to 205	1.0 to 2.0	0.8 to 1.7	0.04 to 0.085	-	-	6.00×10^{-4}	-
	Clayey Silt to Silty Clay – Pockets Only (north of STA 21+055 - SBL)	187.5 to 179.8	0.1 to 1.0	17	-	-	30	135	-	-	-	2.0×10^{-4}	-	-	-
	Clayey Silt to Clay ¹ (south of STA 21+070 - NBL)	181.6 to 174.2	1.1 to 16.4	17	-	-	20 to 45	90 to 205	1.0 to 2.0	0.8 to 1.7	0.04 to 0.085	-	-	6.00×10^{-4}	-
	Clayey Silt to Clay ¹ (north of STA 21+070 - NBL)	179.3 to 178.6	~0.1 to 1.8	17	-	-	20 to 30	90 to 135	1.0 to 2.0	0.8 to 1.7	0.04 to 0.085	-	-	1.40×10^{-3}	-
	Silt to Silty Sand (Pockets)	180.9 to 163.7	0.2 to 2.8	19	28	0	-	-	-	-	-	-	5	-	-
	Silt to Silt and Sand	178.1 to 157.8	0.9 to 14.2	19	29	0	-	-	-	-	-	-	10	-	-
	Sand and Gravel	186.0 to 179.2	0.2 to 0.3	21	34	0	-	-	-	-	-	-	25	-	-
Highway 69 SBL STA 10+350 to STA 10+470 (Swamp 503)	Topsoil	191.4 to 183.1	0.1 to 0.3	15	28	1	-	-	-	-	-	-	-	-	-
	Peat / Organic Silt	187.3 to 184.1	0.3 to 0.7	12 to 16	28	1	-	-	-	-	-	-	-	-	-
	Clayey Silt to Silty Clay	191.1 to 186.2	0.2 to 0.9	17	-	-	25	115	-	-	-	5.0×10^{-4}	-	5.70×10^{-3}	-
	Silt and Sand to Sand	190.3 to 182.2	0.6 to 5.5	19	31	0	-	-	-	-	-	-	5 to 10	-	-
	Sand and Gravel to Sandy Gravel	185.5 to 182.6	0.2 to 0.9	21	34	0	-	-	-	-	-	-	20	-	-
Highway 69 NBL STA 10+230 to STA 10+445 (Swamp 503)	Peat	192.6 to 184.9	0.1 to 2.2	12	28	1	-	-	-	-	-	-	-	-	-
	Organic Silt to Clayey Organic Silt	188.9 to 182.8	0.6 to 5.6	16	-	-	20	90	3.5	1.60	0.16	-	-	3.14×10^{-3}	-
	Clayey Silt to Silty Clay	192.0 to 181.4	0.1 to 1.6	17	-	-	20	90	-	-	-	1.0×10^{-3}	-	3.00×10^{-3}	-
	Silt and Sand to Sand	191.2 to 178.2	0.1 to 5.2	19	31	0	-	-	-	-	-	-	3 to 5	-	-
	Sand and Gravel	183.6 to 176.0	0.3 to 2.5	21	34	0	-	-	-	-	-	-	20	-	-
Highway 69 NBL STA 21+300 (Henvey) to STA 10+140 (Mowat) (Deep Cut 504)	Topsoil	195.8 to 194.0	0.1 to 0.3	15	28	1	-	-	-	-	-	-	-	-	-
	Sandy Clayey Silt	193.9 to 193.8	~0.5	19	30	0	20	90	-	-	-	-	-	-	-
	Silt to Sand	195.6 to 194.1	1.8 to 4.8	19	33	0	-	-	-	-	-	-	-	-	1.6×10^{-5}
	Clayey Silt to Clay	192.1 to 190.2	2.3 to 5.3	17	27 ²	5 ²	20	90	-	-	-	-	-	-	1.0×10^{-9}
	Silt to Silt and Sand	189.7 to 186.5	3.7 to 8.2	19	33	0	-	-	-	-	-	-	-	-	9.0×10^{-6}

Notes:
1. Additional details of foundation engineering parameters for the cohesive deposits encountered in High Fill 502 are provided on Figure B1 in Appendix B.
2. The strength values of the cohesive deposit encountered in Deep Cut 504 are derived from a fully defined shear-normal function based on the results of triaxial testing (approximately equivalent to $c' = 5$ kPa and $\phi' = 27^\circ$ over the stress range of $0 \text{ kPa} \leq \sigma'_n \leq 160 \text{ kPa}$). See inset in Table 2.

Table 4: Summary of Settlement Analyses
Highway 69 Four-Laning

Foundation Investigation Area	Settlement (mm) / Delay Time ¹ (days)	Estimated Post-Construction Settlement Over 20-Year Period at the Critical Section (mm)										Preferred Foundation Mitigation Option				
		No Foundation Mitigation ²		Preloading ³		Surcharging ³		Full Sub-Excavation		Full Sub-Excavation and Preloading of Rock Fill ³			Lightweight Fill ³	Lightweight Fill and Preloading ³	Aggregate Piers ³	
Highway 69 NBL STA 20+665 to STA 20+705 (High Fill 501)	δ _{primary}	0		0		-		-		-		-	-	-	-	Preloading of rock fill (130 days)
	δ _{secondary}	0		0		-		-		-		-	-	-	-	
	δ _{rock fill}	85		25		-		-		-		-	-	-	-	
	δ _{total}	85		25		-		-		-		-	-	-	-	
	t _{delay}	0 days		130 days		-		-		-		-	-	-	-	
Highway 69 SBL STA 20+980 to STA 21+180 (High Fill 502) ⁴	δ _{primary}	0	0	0	0	-		-		-		-	-	-	-	Preloading of rock fill (90 days)0
	δ _{secondary}	0	0	0	10	-		-		-		-	-	-	-	
	δ _{rock fill}	50	70	25	35	-		-		-		-	-	-	-	
	δ _{total}	50	70	25	35	-		-		-		-	-	-	-	
	t _{delay}	0 days	0 days	90 days	90 days	-		-		-		-	-	-	-	
Highway 69 NBL STA 20+990 to STA 21+075 (High Fill 502)	δ _{primary}	70		0		-		-		-		-	-	-	-	Preloading (90 days)
	δ _{secondary}	15		10		-		-		-		-	-	-	-	
	δ _{rock fill}	30		15		-		-		-		-	-	-	-	
	δ _{total}	115		25		-		-		-		-	-	-	-	
	t _{delay}	0 days		90 days		-		-		-		-	-	-	-	
Highway 69 SBL STA 10+350 to STA 10+470 (Swamp 503) ⁵	δ _{primary}	45	0	~0	0	-	-	0	0	0	0	-	-	-	-	Full sub-excavation (up to about 3.5 m deep) and preloading of rock fill (15 days)
	δ _{secondary}	5	0	~0	0	-	-	0	0	0	0	-	-	-	-	
	δ _{rock fill}	25	80	20	70	-	-	40	80	35	75	-	-	-	-	
	δ _{total}	75	80	20	70	-	-	40	80	35	75	-	-	-	-	
	t _{delay}	0 days	0 days	15 days	15 days	-	-	0 days	0 days	15 days	15 days	-	-	-	-	
Highway 69 NBL STA 10+230 to STA 10+445 (Swamp 503)	δ _{primary}	600		~0		~0		0		0		130	55	~ 0	~ 0	Full sub-excavation (up to about 6.5 m deep) and preloading of rock fill (95 days)
	δ _{secondary}	105		65		55		0		0		55	15	~ 0	~ 0	
	δ _{rock fill}	70		10		15		175		75		0	0	60	40	
	δ _{total}	775		75		70		175		75		185	70	60 ⁶	40 ⁷	
	t _{delay}	0 days		800 days		200 days		0 days		95 days		0 days	175 days	15 days	65 days	
Highway 69 NBL STA 21+300 (Henvey) to STA 10+140 (Mowat) (Deep Cut 504)	Earth cuts up to about 4 m deep are anticipated along this section of the alignment. These cuts represent a net unloading above the proposed Highway 69 NBL grade. Consequently, no settlements are anticipated and settlement mitigation options are not required.															

- Notes:
1. Delay time refers to the preload or surcharge duration.
 2. Refer to Section 6.6 for requirements for stability berms, where applicable.
 3. Refer to Section 6.6 and the respective "Evaluation of Stability / Settlement Mitigation Options" tables in the Appendices for the recommended preload and surcharge durations and requirements for stability berms, where applicable.
 4. Two critical sections (i.e. at approximately STA 20+085 and STA 21+125) were analyzed.
 5. Two critical sections (i.e. at approximately STA 10+375 and STA 10+460) were analyzed.
 6. Assuming an aggregate pier spacing of 1.5 m in a triangular pattern.
 7. Assuming an aggregate pier spacing of 2.5 m in a triangular pattern.

Prepared By: TZ

Reviewed By: JPD/JMAC



**FOUNDATION REPORT – SWAMP CROSSING, HIGH FILL
AREAS AND DEEP CUT - HIGHWAY 69 GWP 5347-08-00; WP 5005-10-01**

**Table 5: Summary of Preferred Foundation Mitigation Options
Highway 69 Four-Laning**

Foundation Investigation Area	Foundation Design Issue (Maximum Height of Fill)	Topography and Surface Conditions	Recommended Embankment Side Slope and Platform Widening Width	Maximum Thickness of Organics Encountered Along Alignment ¹	Preferred Stability / Settlement Mitigation Option ^{2,3}	Estimated Settlement (δ) During Construction ⁴ at the Critical Section	Estimated Post-Construction Settlement (δ) Over 20-Year Period at the Critical Section	Swamp Excavation / Organic Removal Specification
Highway 69 NBL STA 20+665 to STA 20+705 (High Fill 501)	High Fill Area (up to about 10 m)	The topography consists of a bedrock valley with Straight Lake located immediately to the north of the high fill area. Bedrock outcrops are present in and around the area of the proposed alignment.	1.25H:1V (Rock Fill) 2 m per side	Peat up to about 0.2 m below ground surface.	Sub-excavation of peat (up to about 0.2 m deep) Preloading of rock fill (130 days)	$\delta_{\text{Immediate}} = 0 \text{ mm}$ $\delta_{\text{Primary}} = 0 \text{ mm}$ $\delta_{\text{Rock Fill}} = 60 \text{ mm}$	$\delta_{\text{Primary}} = 0 \text{ mm}$ $\delta_{\text{Secondary}} = 0 \text{ mm}$ $\delta_{\text{Rock Fill}} = 25 \text{ mm}$	OPSD 203.010
Highway 69 SBL STA 20+980 to STA 21+180 (High Fill 502)	High Fill Area (up to about 7 m – the highway embankment extends north of STA 21+055))	The topography is undulating, with the ground surface rising sharply to the north away from the Straight Lake shore, then forms a plateau. In general, the ground cover consists of sparsely to densely treed areas and various types of low vegetation.	1.25H:1V (Rock Fill) 2 m per side	Topsoil, peat, organic silt and near surface clayey silt to silty clay up to about 2.7 m below ground surface.	Sub-excavation of topsoil, peat, organic silt and near surface clayey silt to silty clay (up to about 2.7 m deep) Preloading of rock fill (90 days)	$\delta_{\text{Immediate}} = 85 \text{ mm to } 320 \text{ mm}$ $\delta_{\text{Primary}} \approx 0 \text{ mm}$ $\delta_{\text{Rock Fill}} = 25 \text{ mm to } 35 \text{ mm}$	$\delta_{\text{Primary}} \approx 0 \text{ mm}$ $\delta_{\text{Secondary}} \approx 0 \text{ mm}$ $\delta_{\text{Rock Fill}} = 25 \text{ mm to } 35 \text{ mm}$	OPSD 203.010
Highway 69 NBL STA 20+990 to STA 21+075 (High Fill 502)	High Fill Area (up to about 4.4 m – the highway embankment extends north of STA 21+080)	The topography rises progressively to the north away from the shore of Straight Lake and the area is covered with brush and sparse trees.	1.25H:1V (Rock Fill) 2 m per side	Topsoil and near surface clayey silt or silty clay up to about 1.3 m below ground surface.	Sub-excavation of topsoil and near surface clayey silt to silty clay (up to about 1.3 m deep) Preloading (90 days)	$\delta_{\text{Immediate}} = 235 \text{ mm}$ $\delta_{\text{Primary}} = 70 \text{ mm}$ $\delta_{\text{Rock Fill}} = 15 \text{ mm}$	$\delta_{\text{Primary}} \approx 0 \text{ mm}$ $\delta_{\text{Secondary}} = 10 \text{ mm}$ $\delta_{\text{Rock Fill}} = 15 \text{ mm}$	OPSD 203.010



**FOUNDATION REPORT – SWAMP CROSSING, HIGH FILL
AREAS AND DEEP CUT - HIGHWAY 69 GWP 5347-08-00; WP 5005-10-01**

**Table 5: Summary of Preferred Foundation Mitigation Options
Highway 69 Four-Laning**

Foundation Investigation Area	Foundation Design Issue (Maximum Height of Fill)	Topography and Surface Conditions	Recommended Embankment Side Slope and Platform Widening Width	Maximum Thickness of Organics Encountered Along Alignment ¹	Preferred Stability / Settlement Mitigation Option ^{2,3}	Estimated Settlement (δ) During Construction ⁴ at the Critical Section	Estimated Post-Construction Settlement (δ) Over 20-Year Period at the Critical Section	Swamp Excavation / Organic Removal Specification
Highway 69 SBL STA 10+350 to STA 10+470 (Swamp 503)	Swamp Crossing (up to about 9 m)	Undulating topography sloping down to the north and containing a low-lying swampy area with brush and sparse trees. Bedrock outcrops were observed along the northern limit of the investigated area.	1.25H:1V (Rock Fill) 2 m per side	Topsoil/peat to a depth of about 0.4 m underlain by clayey silt up to about up to about 1.5 m below ground surface; clayey organic silt to a depth of about 3.5 m below the east toe of the embankment	Sub-excavation of topsoil/ peat Full sub-excavation of clayey silt and clayey organic silt / organic silt (up to about 4.5 m deep under the east toe of the embankment) and preloading of rock fill (15 days)	$\delta_{\text{Immediate}} = 0 \text{ mm to } 105 \text{ mm}$ $\delta_{\text{Primary}} = 0 \text{ mm}$ $\delta_{\text{Rock Fill}} = 5 \text{ mm to } 10 \text{ mm}$	$\delta_{\text{Primary}} = 0 \text{ mm}$ $\delta_{\text{Secondary}} = 0 \text{ mm}$ $\delta_{\text{Rock Fill}} = 35 \text{ mm to } 75 \text{ mm}$	OPSD 203.010
Highway 69 NBL STA 10+230 to STA 10+445 (Swamp 503)	Swamp Crossing (up to about 8 m)	The topography is relatively flat low-lying and is bounded by bedrock outcrops. The central portion of the swamp is occupied by shallow open water and the south perimeter is brush and tree covered.	1.25H:1V (Rock Fill) 2 m per side	Peat and/or clayey organic silt/organic silt up to about 6.5 m below ground surface.	Sub-excavation of peat (up to about 2.2 m deep) Full sub-excavation of clayey silt to silty clay and/or clayey organic silt / organic silt (up to about 6.5 m deep) and preloading of rock fill (95 days)	$\delta_{\text{Immediate}} = 100 \text{ mm}$ $\delta_{\text{Primary}} = 0 \text{ mm}$ $\delta_{\text{Rock F-ill}} = 100 \text{ mm}$	$\delta_{\text{Primary}} = 0 \text{ mm}$ $\delta_{\text{Secondary}} = 0 \text{ mm}$ $\delta_{\text{Rock Fill}} = 75 \text{ mm}$	OPSD 203.010

- Notes:
1. Depths do not include any ponded water that may be present over the peat.
 2. In all swamp crossing/high fill areas, removal of organic deposits (i.e. topsoil, peat and/or organic silt/sand) is required prior to embankment construction.
 3. Full sub-excavation implies complete removal of soft, compressible cohesive deposits.
 4. "During Construction" period includes the preload / surcharge period.

Prepared By: TZ

Reviewed By: JPD/JMAC



**FOUNDATION REPORT – SWAMP CROSSING, HIGH FILL
AREAS AND DEEP CUT - HIGHWAY 69 GWP 5347-08-00; WP 5005-10-01**

**Table 6: Summary of Embankment Platform Widening Requirements
Highway 69 Four-Laning**

Foundation Investigation Area	Preferred Mitigation Option	Time from Start of Construction to End of Preload / Surcharge Period (days)	Estimated Settlement From Start of Construction to 20-Years Following Preload/Surcharge Period¹ (mm)	Assumed Side Slope of Pavement Structure	Minimum Embankment Platform Widening Per Side (m)
Highway 69 NBL STA 20+665 to STA 20+705 (High Fill 501)	Preloading of rock fill	130	60 + 25	4H:1V	2.0
Highway 69 SBL STA 20+980 to STA 21+180 (High Fill 502)	Preloading of rock fill	90	25 + 25 35 + 35 ²	4H:1V	2.0
Highway 69 NBL STA 20+990 to STA 21+075 (High Fill 502)	Preloading	90	85 + 25	4H:1V	2.0
Highway 69 SBL STA 10+350 to STA 10+470 (Swamp 503)	Full sub-excavation and preloading of rock fill	15	5 + 35 5+ 75 ³	4H:1V	2.0
Highway 69 NBL STA 10+230 to STA 10+445 (Swamp 503)	Full sub-excavation and preloading of rock fill	95	100 + 75	4H:1V	2.0
Highway 69 NBL STA 21+300 (Henvey) to STA 10+140 (Mowat) (Deep Cut 504)	Placement of a granular blanket and rip-rap / rock fill along the 2H:1V cut slopes	Not applicable	Not applicable	4H:1V	Not applicable

- Notes:
1. Estimated settlement is comprised of settlement during construction plus (+) post-construction settlement and includes primary and secondary (creep) consolidation of the cohesive deposits as well as rock fill settlement. The settlements do not include the immediate settlement of the granular fills and foundation soils, where applicable.
 2. Two critical sections (i.e. at approximately STA 20+085 and STA 21+125) were analyzed.
 3. Two critical sections (i.e. at approximately STA 10+375 and STA 10+460) were analyzed.

Prepared By: TZ

Reviewed By: JPD/JMAC



**FOUNDATION REPORT – SWAMP CROSSING, HIGH FILL
AREAS AND DEEP CUT - HIGHWAY 69 GWP 5347-08-00; WP 5005-10-01**

**Table 7: Summary of Deep Cut Foundation Recommendations
Highway 69 Four-Laning**

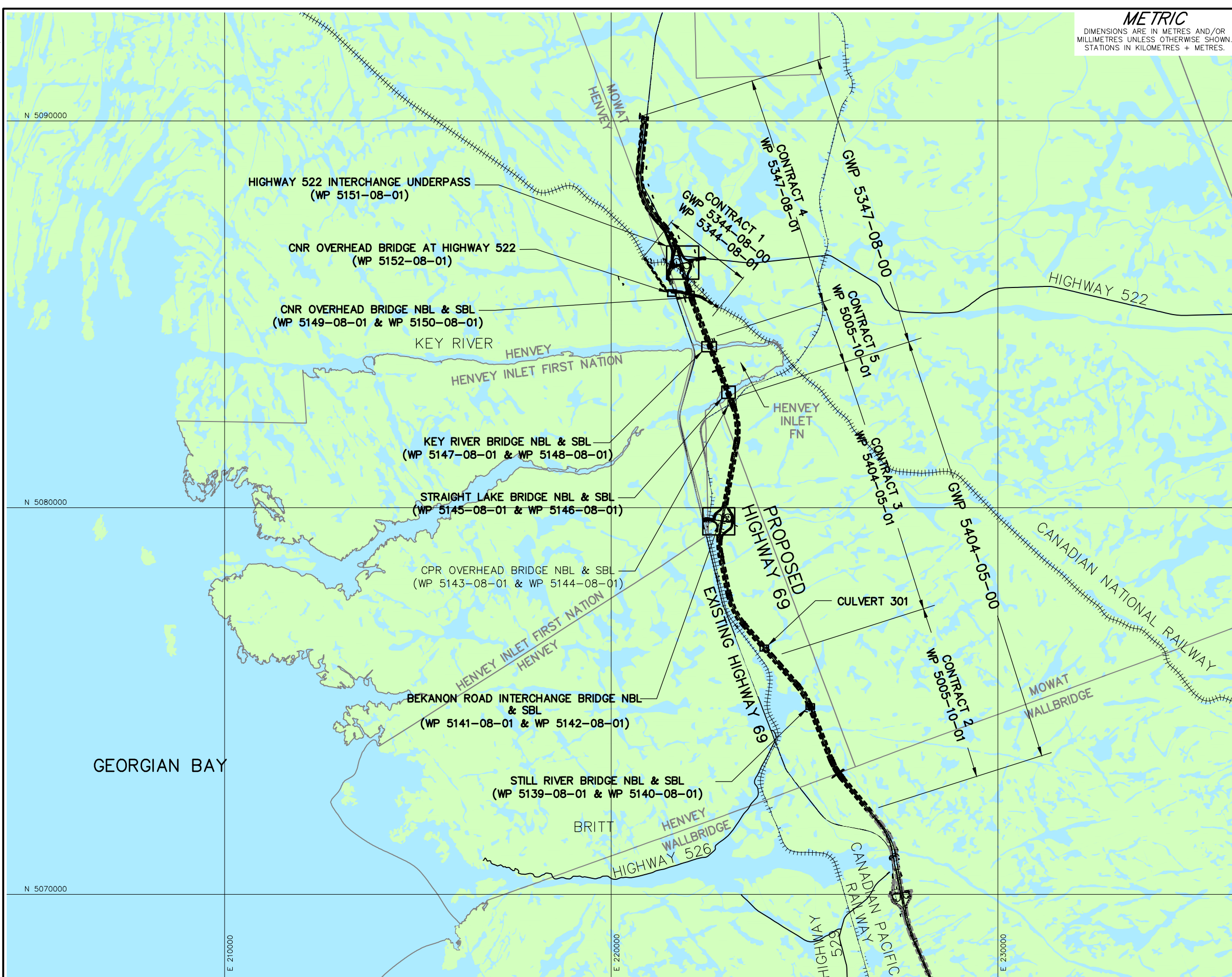
Foundation Investigation Area	Foundation Design Issue (Maximum Depth of Cut)	Topography and Surface Conditions	Recommended Cut Side Slope	Recommended Measures
Highway 69 NBL STA 21+300 (Henvey) to STA 10+140 (Mowat) (Deep Cut 504)	Deep Cut Area (up to about 4 m deep excavation)	The topography consists of a low-lying area with ground cover consisting of shrubs and treed areas. Bedrock outcrops are present to the west.	2H:1V (in native soils)	<ul style="list-style-type: none">■ Construct a minimum 400 mm thick granular sheeting consisting of OPSS.PROV 1004 (Aggregates Miscellaneous). Granular sheeting material to be overlain by a minimum 500 mm thick layer of R10 rip-rap along the entire face of the proposed cut slope immediately after excavation.■ The granular sheeting and rip-rap should be placed in accordance with OPSS 511.

Prepared By: TZ

Reviewed By: JPD/JMAC



DRAWINGS



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

CONT No.
GWP No. 5404-05-00

HIGHWAY 69
SITE LOCATION PLAN

SHEET

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

KEY PLAN
NOT TO SCALE

PLAN



REFERENCE
Base Data – MNR NRVIS, obtained 2004, CANMAP v2008
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, ©Queens Printer 2008
Datum : NAD 83 Projection : MTM Zone 10

NO.	DATE	BY	REVISION
Geocres No. 41H-164			
HWY. 69	PROJECT NO. 09-1111-6014		DIST.
SUBM'D. TVA	CHKD. TVA	DATE: Oct. 2013	SITE:
DRAWN: JFC	CHKD. CN	APPD. JPD/JMAC	DWG. 1

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

CONT No.
WP No. 5005-10-01

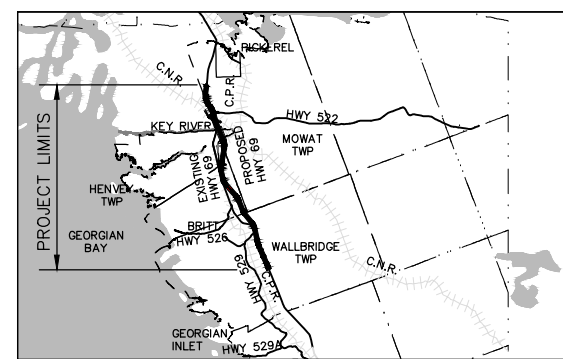


HIGHWAY 69
SWAMP CROSSING, HIGH FILL AREAS
AND DEEP CUT
INDEX PLAN

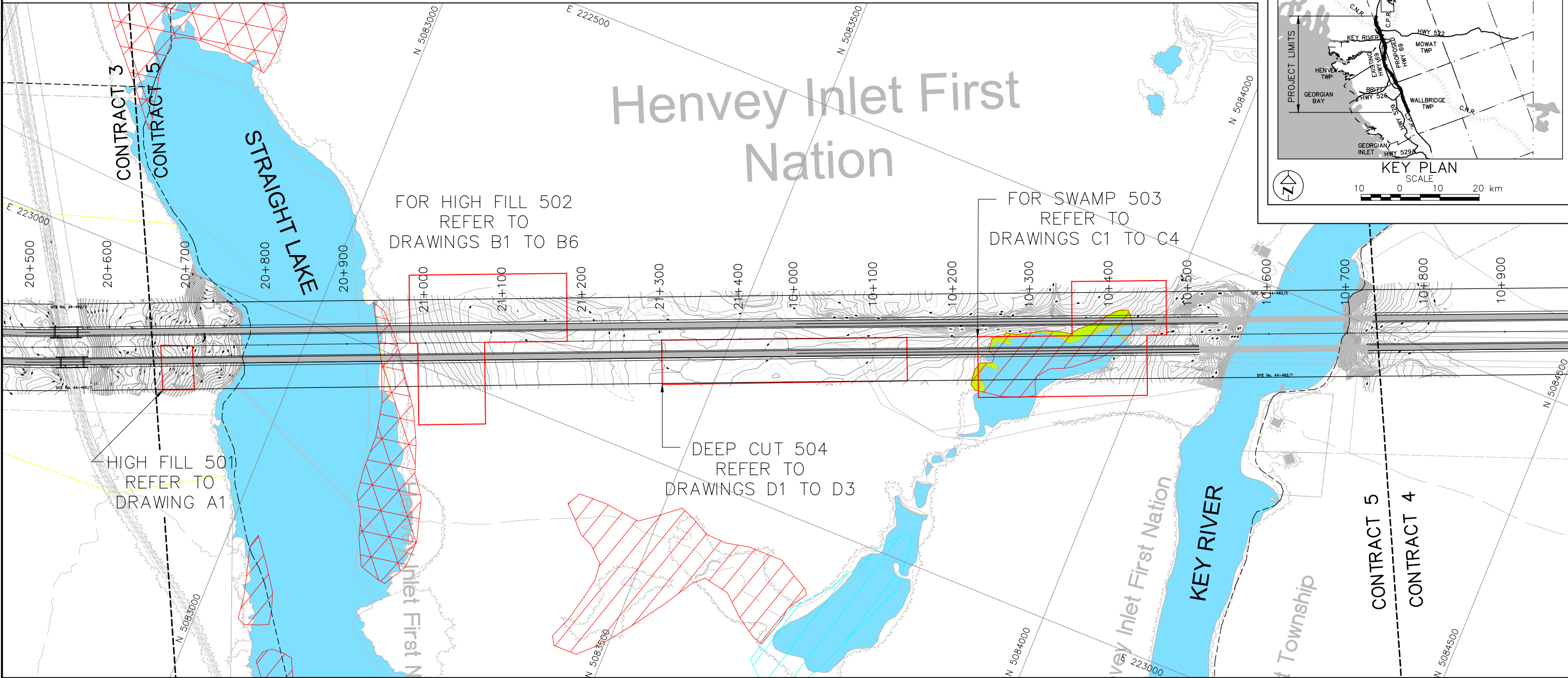
SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN
SCALE
10 0 10 20 km



PLAN

SCALE
50 0 50 100 m

REFERENCE

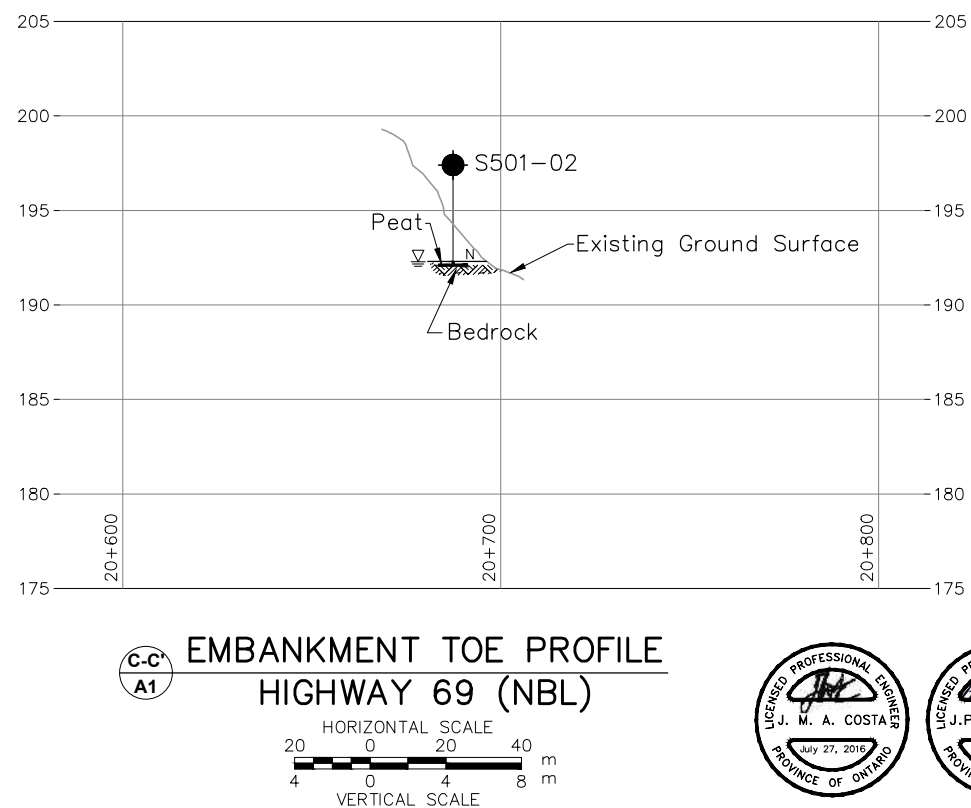
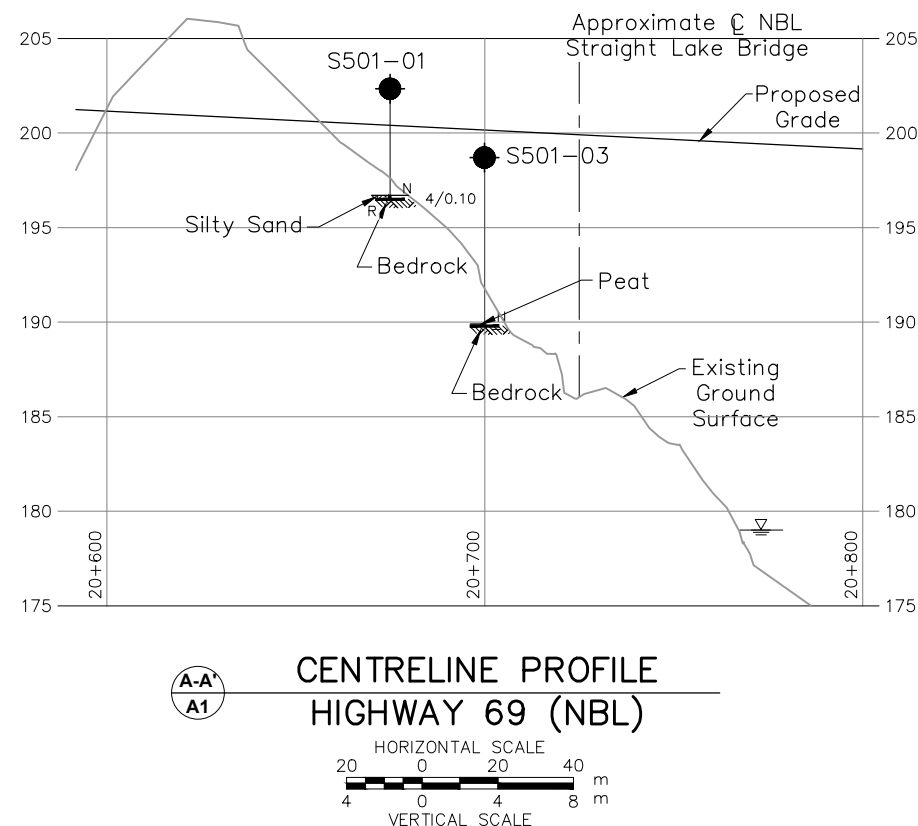
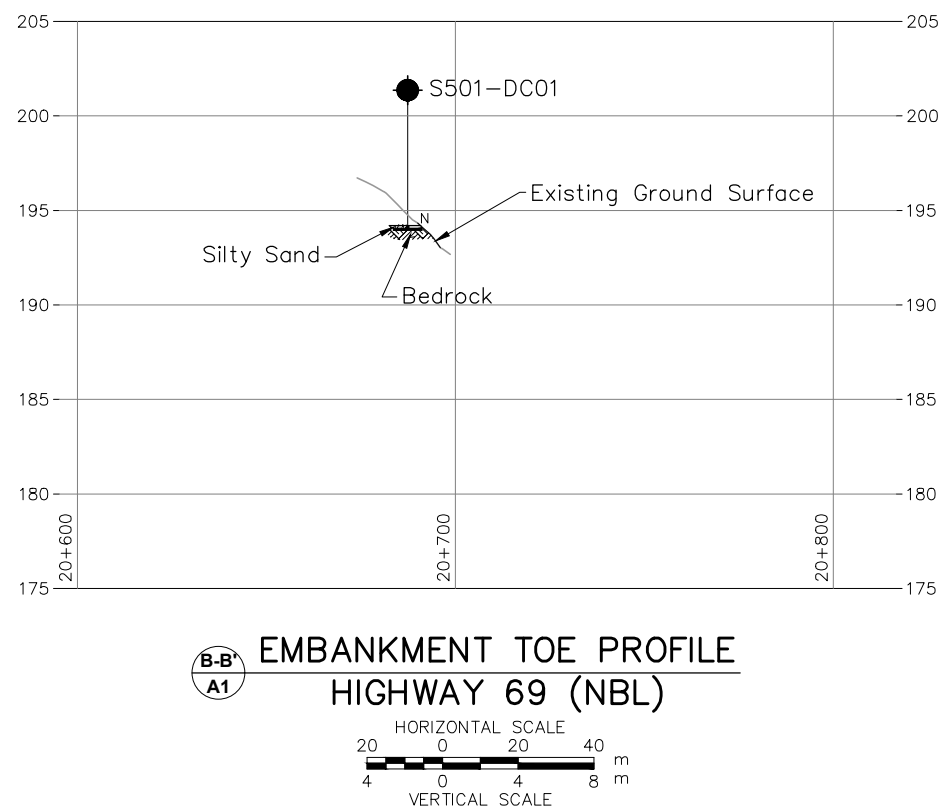
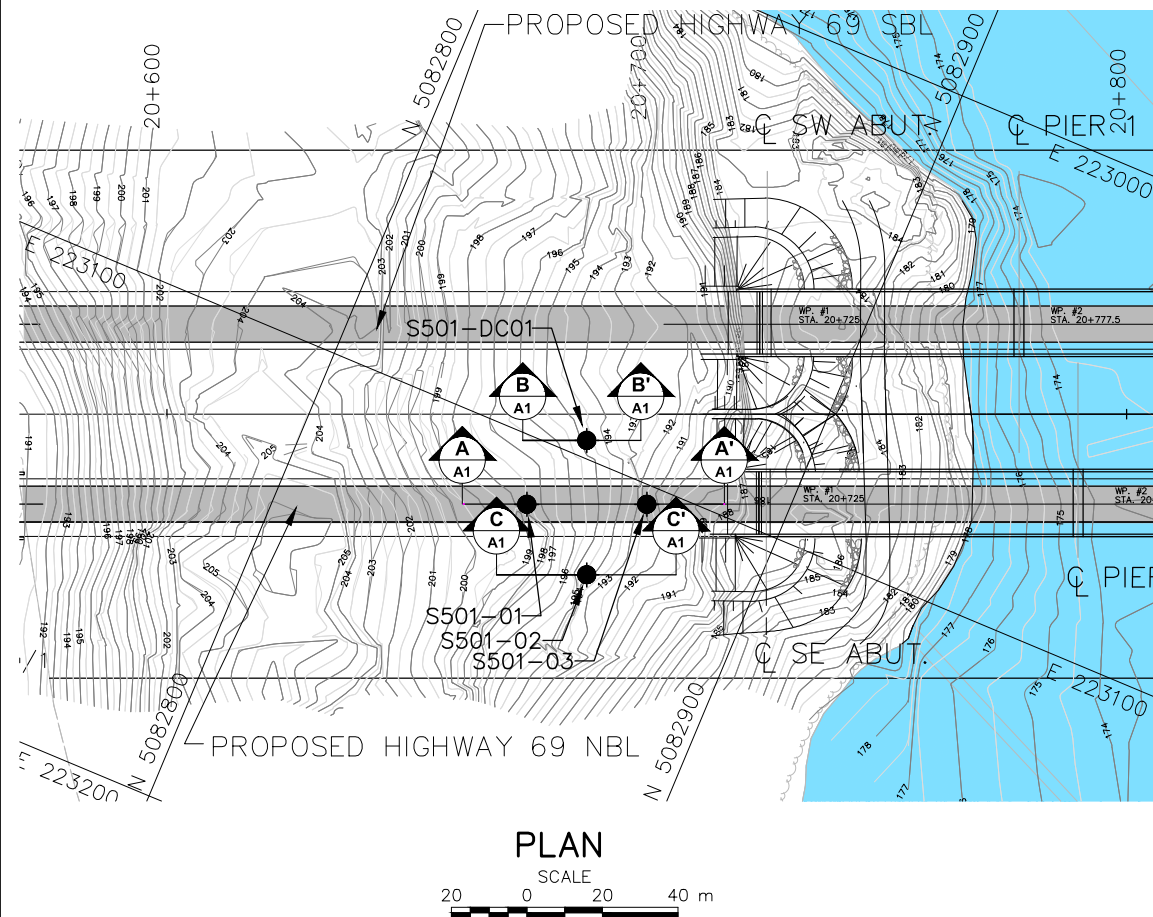
Base plans provided in digital format by URS, drawing files
Hwy69_base.dwg received December 16, 2009, Alignment drawing file
Hwy69_plan.dwg, received February 02, 2012, Contour drawing file
HWY69_Contour-Plan_C3.dwg, received April 23, 2012 and Contour
drawing HWY69_Contour-Plan_C5.dwg, received August 31, 2013.

NO.	DATE	BY	REVISION	
Geocres No. 41H-164				
HWY. 69		PROJECT NO. 09-1111-6014		DIST.
SUBM'D. AV		CHKD. AV	DATE: Oct. 2014	SITE:
DRAWN: JFC		CHKD. AV	APPD. JPD/JMAC	DWG. 2



APPENDIX A

Highway 69 NBL – STA 20+665 to STA 20+705 (High Fill 501)



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

CONT No.
WP No. 5005-10-01

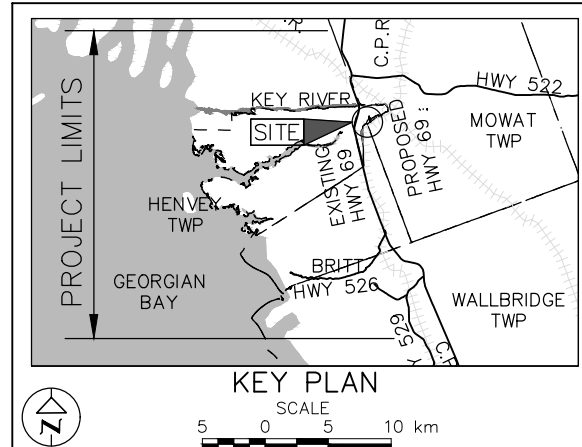


HIGHWAY 69
STA 20+665 TO 20+705 (NBL)
BOREHOLE LOCATIONS AND SOIL
STRATA



SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



LEGEND

- | | |
|---|--|
|  | Borehole – Current Investigation |
| N | Standard Penetration Test Value |
| 16 | Blows/0.3m unless otherwise stated
(Std. Pen. Test, 475 j/blow) |
|  | WL upon completion of drilling |
| R | Refusal |

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
S501-01	196.7	5082849.2	223113.5
S501-02	192.3	5082866.4	223122.3
S501-03	189.9	5082872.3	223103.9
S501-DC01	194.2	5082855.6	223096.4

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by URS, drawing file nos. Alignment and Contours from Hwy69_Contour-Plan_C3.dwg, received April 23, 2012 and Existing Ground Surface cut from contour drawing file Hwy69_Contour-Plan_C5.dwg, received August 31, 2012, the Existing, Proposed Grade obtained from drawing file Hwy69_profile March 2012.dwg, received March 14, 2012 and Straight Lake Bridge GA's provided in digital format by AECOM, drawing file no's GA_NBL_StraightLakeCrossing.dwg and GA_SBL_StraightLakeCrossing.dwg, received February 24, 2016.

NO.	DATE	BY	REVISION		
Geocres No. 41H-164					
HWY. 69		PROJECT NO. 09-1111-6014			DIST.
SUBM'D. ARV	CHKD. ARV	DATE: Oct. 2014		SITE:	
DRAWN: JFC/MR	CHKD. ARV	APPD. JPD/JMAC		DWG. A1	



PROJECT		5005-10-01		LOCATION		N 5082849.2 ; E 223113.5		ORIGINATED BY		MJR									
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, Hand Shovel Excavation		COMPILED BY		GRL									
DATUM		Geodetic		DATE		March 12, 2013		CHECKED BY		CN									
SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa													
196.7	GROUND SURFACE																		
0.0	Silty SAND, some gravel, trace organics, cobbles		1	SS	4/0.10														
0.2	Loose Brown Wet END OF BOREHOLE/EXCAVATION BEDROCK																		
NOTES: 1. Bedrock surface was exposed by hand excavation upon split-spoon sampler refusal. 2. Excavation dry upon completion. 3. Borehole advanced using portable drilling equipment with a half-weight hammer. The SPT "N" value shown has been adjusted to reflect value that would be obtained with a standard weight hammer.																			

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		RECORD OF BOREHOLE		No S501-02		SHEET 1 OF 1		METRIC								
W.P. 09-1111-6014		LOCATION		N 5082866.4 ; E 223122.3		ORIGINATED BY		MJR								
DIST		HWY 69		BOREHOLE TYPE		Hand Shovel Excavation		COMPILED BY								
GRL		DATE		March 12, 2013		CHECKED BY		CN								
DATUM		Geodetic														
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
192.3	GROUND SURFACE															
0.0	PEAT (Fibrous)		1	CS	-											
0.2	Dark brown Wet															
	END OF EXCAVATION BEDROCK															
	NOTE: 1. Water level at ground surface (Elev. 192.3 m) in open excavation.															

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S501-03		SHEET 1 OF 1		METRIC										
W.P. 5005-10-01		LOCATION N 5082872.3 ; E 223103.9		ORIGINATED BY MJR												
DIST _____ HWY 69		BOREHOLE TYPE Hand Shovel Excavation		COMPILED BY GRL												
DATUM Geodetic		DATE March 12, 2013		CHECKED BY CN												
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
189.9	GROUND SURFACE															
0.0	PEAT (Fibrous)		1	CS												
0.1	Dark brown Wet															
	END OF EXCAVATION BEDROCK															
	NOTE: 1. Excavation dry upon completion.															

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT 09-1111-6014				RECORD OF DCPT No S501-DC01				SHEET 1 OF 1				METRIC					
W.P. 5005-10-01				LOCATION N 5082855.6 ; E 223096.4				ORIGINATED BY MJR									
DIST _____ HWY 69				BOREHOLE TYPE Hand Shovel Excavation				COMPILED BY GRL									
DATUM Geodetic				DATE March 12, 2013				CHECKED BY CN									
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W _p W W _L				
194.2	GROUND SURFACE						20	40	60	80	100	WATER CONTENT (%)					
0.0	Organic silty SAND, trace to some gravel					194											
0.2	Dark brown Wet																
	END OF EXCAVATION BEDROCK																
	NOTES:																
	1. Bedrock exposed by hand shovel excavation at a depth of 0.2 m below ground surface (Elev. 194.0 m) at location of DCPT.																
	2. Excavation dry upon completion.																

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16



APPENDIX B

Highway 69 SBL – STA 20+980 to STA 21+180 (High Fill 502)

Highway 69 NBL – STA 20+990 to STA 21+075 (High Fill 502)



NOTES

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The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by URS, drawing file no's. Alignment and Contours from Hwy69_Contour-Plan_C3.dwg, received April 23, 2012, Straight Lake Bridge GA's provided in digital format by AECOM, drawing file no's GA_NBL_StraightLakeCrossing.dwg and GA_SBL_StraightLakeCrossing.dwg, received February 24, 2016.

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

CONT No.
WP No. 5005-10-01



HIGHWAY 69

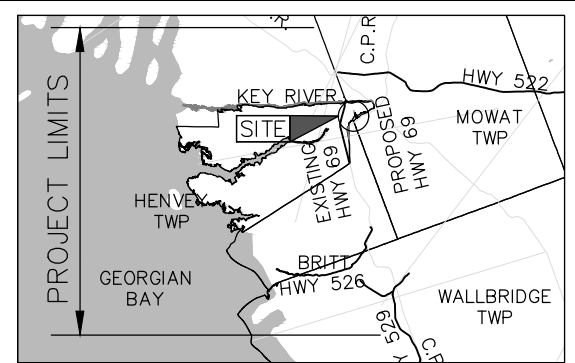
STA 20+980 TO 21+180 (SBL)
STA 20+990 TO 21+075 (NBL)

BOREHOLE LOCATIONS

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN

SCALE
5 0 5 10 km

BOREHOLE CO-ORDINATES

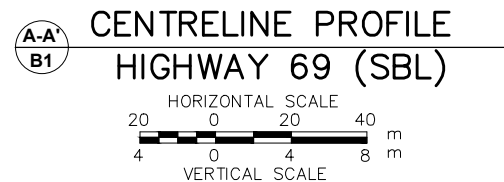
No.	ELEVATION	NORTHING	EASTING
B501-02	178.6	5083071.8	222979.6
B501-12	181.0	5083106.9	222964.9
B501-13	185.1	5083153.0	222945.6
B501-14	188.3	5083171.5	222937.8
B502-02	178.6	5083086.2	223014.2
B502-12	179.3	5083121.2	222999.6
B502-13	183.5	5083167.3	222980.3
B502-14	186.2	5083185.8	222972.5
S502-01	181.1	5083111.4	222963.0
S502-02	182.5	5083111.7	222931.2
S502-03	183.0	5083134.5	222953.3
S502-04	185.6	5083135.7	222923.9
S502-05	186.1	5083157.5	222943.7
S502-06	188.4	5083161.2	222920.1
S502-07	190.3	5083180.6	222934.0
S502-08	190.6	5083197.7	222942.6
S502-09	191.0	5083203.6	222924.4
S502-10	190.3	5083209.0	222904.8
S502-11	191.5	5083226.7	222914.7
S502-12	192.1	5083243.4	222922.1
S502-13	188.3	5083249.8	222905.1
S502-14	188.7	5083253.9	222882.6
S502-15	189.1	5083272.8	222895.4
S502-16	191.4	5083291.2	222906.9
S502-17	189.8	5083295.9	222885.7
S502-18	181.3	5083149.0	222988.0
S502-19	180.9	5083170.6	223007.3
S502-20	184.1	5083172.0	222978.4
S502-20A	184.2	5083189.5	222993.4
S502-20B	184.2	5083189.5	222993.9
S502-21	187.3	5083176.3	222956.2
S502-22	188.0	5083195.1	222968.7
S502-23	188.7	5083212.8	222978.6
S502-24	190.3	5083218.2	222959.0



Geocres No. 41H-164

HWY. 69	PROJECT NO. 09-1111-6014	DIST.
SUBM'D. AV	CHKD. AV	DATE: Oct. 2014
DRAWN: JFC	CHKD. AV	APPD. JPD/JMAC
		DWG. B1

NO.	DATE	BY	REVISION		
Geocres No. 41H-164					
HWY. 69			PROJECT NO. 09-1111-6014		DIST.
SUBM'D. ARV	CHKD. ARV	DATE: Oct. 2014		SITE:	
DRAWN: JFC	CHKD. ARV	APPD. JPD/JMAC		BEG. B2	



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

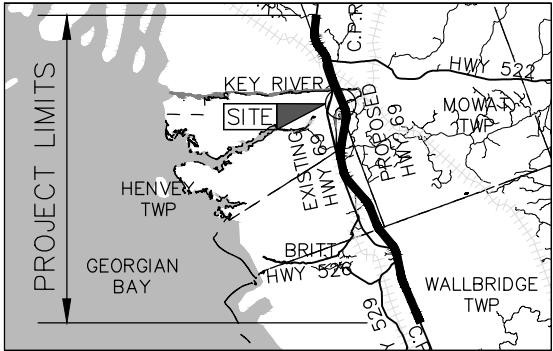
CONT No.
WP No. 5005-10-01

HIGHWAY 69
STA 20+980 to 21+180 (SBL)
SOIL STRATA

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN

SCALE
5 0 5 10 km

LEGEND

- Borehole - Current Investigation
- ⊕ Dynamic Cone Penetration Test
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ≡ WL upon completion of drilling
- R Refusal

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
S502-02	182.5	5083111.7	222931.2
S502-04	185.6	5083135.7	222923.9
S502-06	188.4	5083161.2	222920.1
S502-10	190.3	5083209.0	222904.8
S502-14	188.7	5083253.9	222882.6

DCPT CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
S502-DC03	190.4	5083183.9	222915.3
S502-DC05	186.3	5083232.6	222896.3
S502-DC07	188.6	5083277.0	222873.0

NOTES

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The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Existing Ground Surface cut from contours provided in digital format by URS, drawing file no. Hwy69_Contour-Plan_C5.dwg, received August 31, 2012.



NO.	DATE	BY	REVISION
Geocres No. 41H-164			
HWY. 69			PROJECT NO. 09-1111-6014
SUBM'D. ARV	CHKD. ARV	DATE: Oct. 2014	SITE:
DRAWN: JFC	CHKD. ARV	APPD. JPD/JMAC	DWG. B3

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

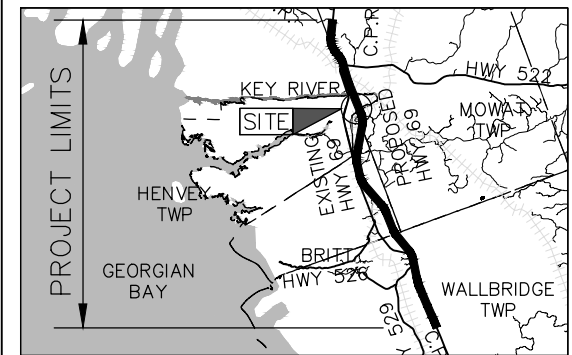
CONT No.
WP No. 5005-10-01

HIGHWAY 69
STA 20+980 to 21+180 (SBL)
SOIL STRATA

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN
SCALE
5 0 5 10 km

LEGEND

- Borehole - Current Investigation
- ⊕ Dynamic Cone Penetration Test
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL upon completion of drilling
- R Refusal

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
S502-08	190.6	5083197.7	222942.6
S502-12	192.1	5083243.4	222922.1
S502-16	191.4	5083291.2	222906.9
S502-21	187.3	5083176.3	222956.2

DCPT CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
S502-DC01	181.1	5083130.2	222975.5
S502-DC02	183.4	5083151.2	222966.7
S502-DC04	191.5	5083218.6	222933.6
S502-DC06	192.5	5083268.1	222916.6

NOTES

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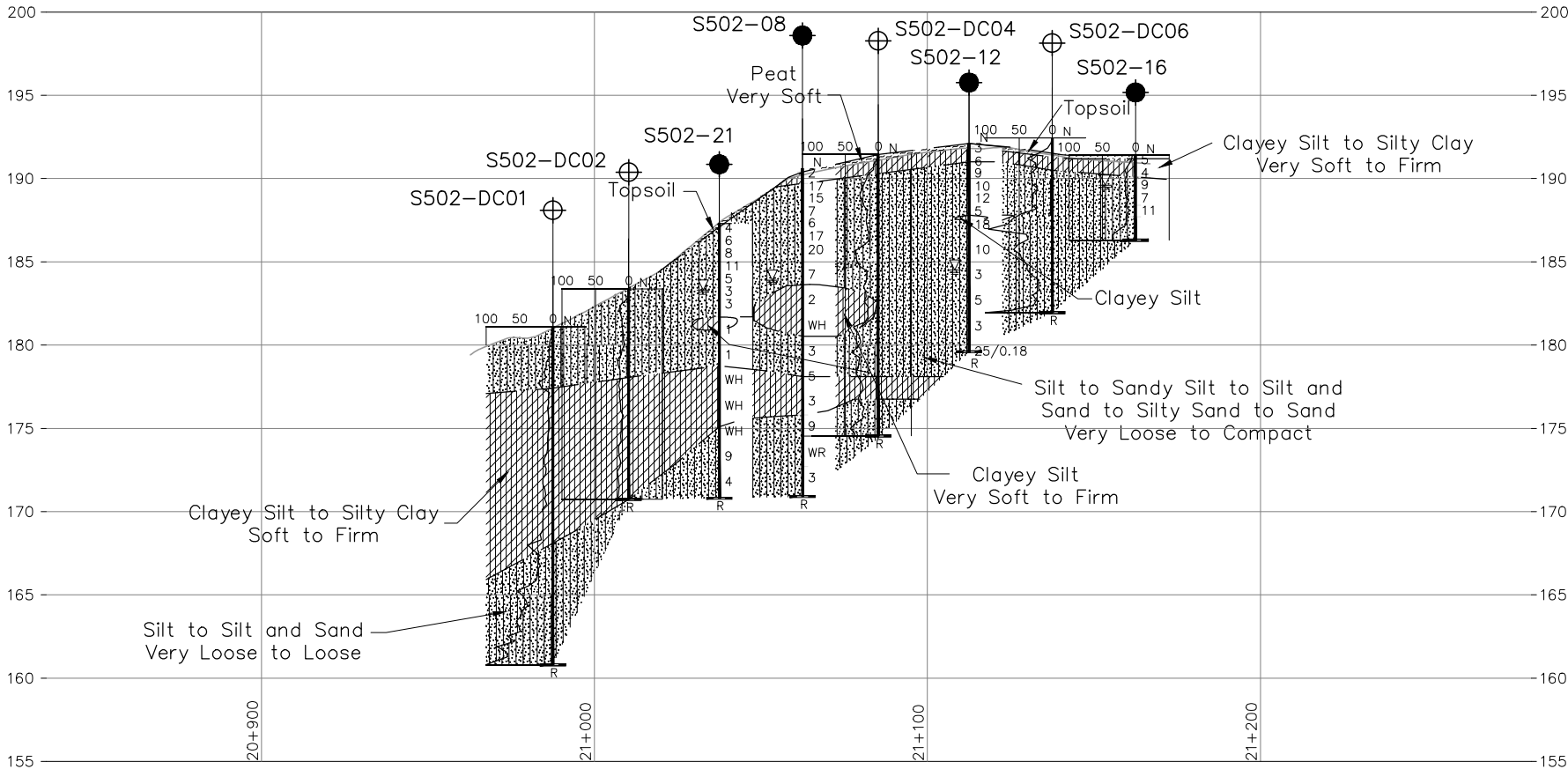
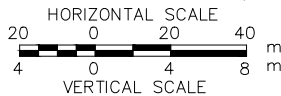
The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

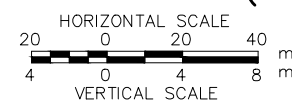
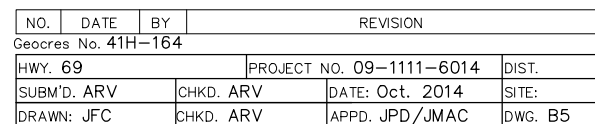
Existing Ground Surface cut from contours provided in digital format by URS, drawing file no. drawing file Hwy69_Contour-Plan_C5.dwg, received August 31, 2012.

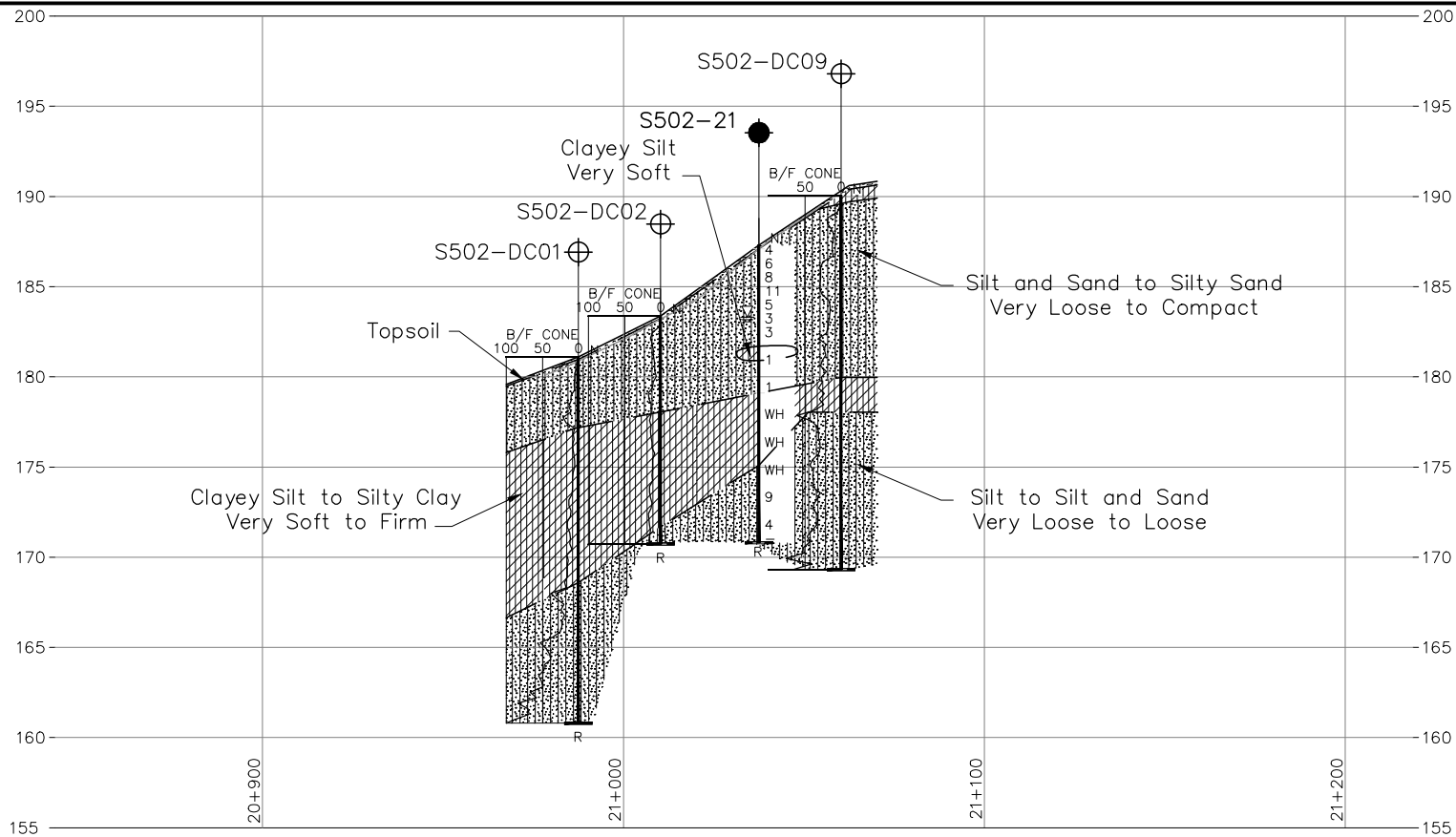


**EMBANKMENT TOE PROFILE
HIGHWAY 69 (SBL)**

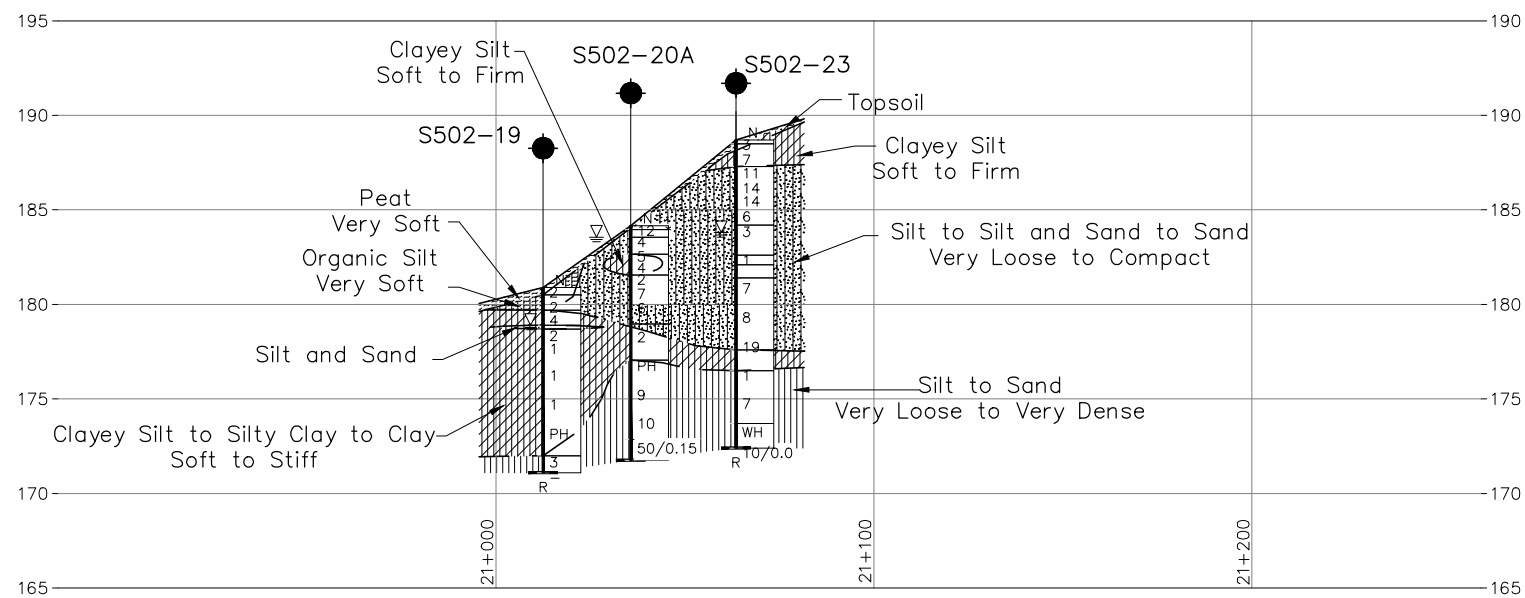
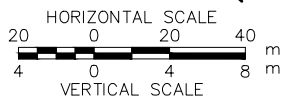


SHEET

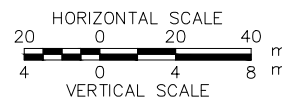




E-E'
B1
EMBANKMENT TOE PROFILE
HIGHWAY 69 (NBL)



F-F'
B1
EMBANKMENT TOE PROFILE
HIGHWAY 69 (NBL)



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

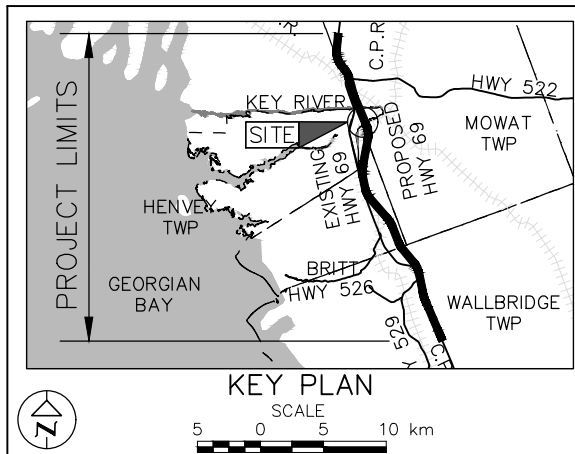
CONT No.
WP No. 5005-10-01

HIGHWAY 69
STA 20+990 TO 21+075 (NBL)
SOIL STRATA

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



LEGEND

- Borehole - Current Investigation
- ⊕ Dynamic Cone Penetration Test
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ≡ WL upon completion of drilling
- R Refusal

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
S502-19	180.9	5083170.6	223007.3
S502-21	187.3	5085035.0	222948.9
S502-23	188.7	5083212.8	222978.6

DCPT CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
S502-DC01	181.1	5084988.8	222968.3
S502-DC02	183.4	5083151.2	222966.7
S502-DC08	184.2	5083189.8	222994.3
S502-DC09	190.0	5083199.0	222951.4

NOTES

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REFERENCE

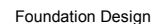
Existing Ground Surface cut from contours provided in digital format by URS, drawing file no. drawing file Hwy69_Contour-Plan_C5.dwg, received August 31, 2012.



NO.	DATE	BY	REVISION
Geocres No. 41H-164			
HWY. 69		PROJECT NO. 09-1111-6014	DIST.
SUBM'D. ARV	CHKD. ARV	DATE: Oct. 2014	SITE:
DRAWN: JFC	CHKD. ARV	APPD. JPD/JMAC	DWG. B6

PROJECT 09-1111-6014			RECORD OF BOREHOLE No S502-01			SHEET 2 OF 2			METRIC								
W.P. 5005-10-01			LOCATION N 5083111.4 ; E 222963.0			ORIGINATED BY MA											
DIST HWY 69			BOREHOLE TYPE 150 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring			COMPILED BY AV											
DATUM Geodetic			DATE March 9 and 10, 2013			CHECKED BY CN											
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									
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100					
	CLAYEY SILT, silt seams Firm to very stiff Grey Wet		13	SS	WH		166										
			14	SS	WH		165										
			15	SS	1		164										
			16	SS	4		163										
							162										
							161										
							160										
159.6 21.5	SILT, trace clay, trace sand Compact Grey Wet		17	SS	17		159										
							158										
							157										
156.4 24.7	SILT and SAND Dense Grey Wet		18	SS	33		156										
							155										
							154										
153.6 27.5	END OF BOREHOLE CASING REFUSAL																
	NOTES: 1. Water level in open borehole at a depth of 1.2 m below ground surface (Elev. 178.3 m) upon completion of drilling. * NR: Not Recorded																

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16



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

PROJECT		RECORD OF BOREHOLE		No S502-02		SHEET 2 OF 2		METRIC					
W.P. 09-1111-6014		LOCATION		N 5083111.7 ; E 222931.2		ORIGINATED BY		ID					
DIST		HWY 69		BOREHOLE TYPE		106 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring		COMPILED BY					
GRL/AV		DATE		February 22 to 26, 2013		CHECKED BY		CN					
DATUM Geodetic													
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
167.3							20	40	60	80	100		
15.2	SILTY CLAY Stiff Grey Wet		14	SS	4								
165.7													
16.8	SILT, trace sand, trace clay Very loose Grey Wet		15	SS	3								
			16	SS	WH								
163.1													
19.4	SILTY CLAY, containing silt seams Stiff Grey Wet		17	SS	2								
			18	SS	3								
160.3													
22.2	SILT, trace to some clay, trace sand Compact to dense Grey Wet		19	SS	32								
			20	SS	30								
157.0			21	SS	35/0.0								
25.5	END OF BOREHOLE SPLIT-SPOON AND CASING REFUSAL NOTE: 1. Water level in open borehole at a depth of 2.7 m below ground surface (Elev. 179.8 m) upon completion of drilling.												

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		09-1111-6014		RECORD OF BOREHOLE No S502-03		SHEET 1 OF 2		METRIC							
W.P.		5005-10-01		LOCATION		N 5083134.5 ; E 222953.3		ORIGINATED BY ID							
DIST		HWY 69		BOREHOLE TYPE		106 mm I.D. Continuous Flight Hollow Stem Augers		COMPILED BY GRL/AV							
DATUM		Geodetic		DATE		March 15, 2013		CHECKED BY CN							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
183.0	GROUND SURFACE														
0.0	ORGANIC SILT Dark brown		1A	SS	10										
0.2	SAND, trace gravel, trace organics		1B	SS											
182.2	Loose Brown Moist		2	SS	9										
0.8	SILT, trace clay														
181.5	Loose Brown Wet		3	SS	3										
1.5	SILT and SAND, trace clay Very loose to loose Grey Wet		4	SS	2										
			5	SS	2										
			6	SS	3										
			7	SS	6										
177.4	SILT, trace clay Very loose Grey Wet		8	SS	3										
5.6															
176.3	SILTY CLAY to CLAY Firm Grey Wet		9	SS	4										
6.7			10	SS	3										
172.6	CLAYEY SILT, trace sand, silt seams Firm Grey Wet		11	TO	PH										
10.4			12	SS	2										
169.7	SILTY CLAY Firm Grey Wet		13	SS	1										
13.3															
168.0															

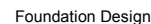
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+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		RECORD OF BOREHOLE		No S502-03		SHEET 2 OF 2		METRIC								
W.P. 5005-10-01		LOCATION		N 5083134.5; E 222953.3		ORIGINATED BY		ID								
DIST		HWY 69		BOREHOLE TYPE		106 mm I.D. Continuous Flight Hollow Stem Augers		COMPILED BY								
GRL/AV		DATE		March 15, 2013		CHECKED BY		CN								
DATUM		Geodetic														
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
	--- CONTINUED FROM PREVIOUS PAGE ---															
15.0	SILT, trace clay Loose Grey Wet		14	SS	7											
166.7						167										
16.3	END OF BOREHOLE SPLIT-SPOON AND AUGER REFUSAL NOTE: 1. Water level in open borehole at a depth of 0.8 m below ground surface (Elev. 182.2 m) upon completion of drilling.		15	SS												

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16





PROJECT 09-1111-6014		RECORD OF BOREHOLE No S502-04		SHEET 1 OF 2		METRIC	
W.P. 5005-10-01		LOCATION N 5083135.7 ;E 222923.9		ORIGINATED BY		ID	
DIST HWY 69		BOREHOLE TYPE 106 mm I.D. Continuous Flight Hollow Stem Augers		COMPILED BY		AV	
DATUM Geodetic		DATE March 11 and 12, 2013		CHECKED BY		CN	

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S502-04				SHEET 2 OF 2		METRIC										
W.P. 5005-10-01		LOCATION N 5083135.7 ;E 222923.9				ORIGINATED BY ID												
DIST HWY 69		BOREHOLE TYPE 106 mm I.D. Continuous Flight Hollow Stem Augers				COMPILED BY AV												
DATUM Geodetic		DATE March 11 and 12, 2013				CHECKED BY CN												
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										
	--- CONTINUED FROM PREVIOUS PAGE ---						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100					WATER CONTENT (%) 20 40 60						
169.1	CLAYEY SILT to SILTY CLAY, containing sandy silt seams Soft to firm Grey Wet		14	SS	WH		170											
16.5	SILT and SAND, some gravel Loose Grey Wet		15	SS	4		169											
167.9	END OF BOREHOLE SPLIT-SPOON AND AUGER REFUSAL		16	SS			168											
17.7	NOTE: 1. Water level in open borehole at a depth of 4.4 m below ground surface (Elev. 181.2 m) upon completion of drilling.																	

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S502-05		SHEET 1 OF 2		METRIC																					
W.P. 5005-10-01		LOCATION N 5083157.5 ; E 222943.7		ORIGINATED BY ID																							
DIST HWY 69		BOREHOLE TYPE 106 mm I.D. Continuous Flight Hollow Stem Augers		COMPILED BY GRL																							
DATUM Geodetic		DATE February 28, 2013		CHECKED BY CN																							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			SHEAR STRENGTH kPa			WATER CONTENT (%)			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		ELEVATION SCALE	20	40	60	80	100	W _p	W	W _L	UNCONFINED	FIELD VANE	QUICK TRIAXIAL	REMOULDED	20	40	60	γ	GR	SA	SI	CL
186.1	GROUND SURFACE		1A		7		186																				
0.0	PEAT (Fibrous)		1B	SS																							
0.2	Dark brown Wet																										
	SAND, trace silt Loose to compact Brown Wet		2	SS	12		185																				
			3	SS	11		184																				
			4	SS	8		183																				
183.1	Sandy SILT, trace clay Very loose to loose Brown Wet		5	SS	10		182																				
3.0			6	SS	4		181																				
			7	SS	3		180																				
			8	SS	4		179																				
178.5	CLAYEY SILT, trace to some sand, with silt lenses Very soft Grey Wet		9	SS	1		178																				
7.6							177																				
177.0	SILT, trace to some sand, trace to some clay Very loose Grey Wet		10	SS	2		176																				
9.1							175																				
175.8	SILT and SAND, trace clay Very loose to loose Grey Wet		11	SS	8		174																				
10.3							173																				
			12	SS	WH																						
172.5			13	SS	4/0.05																						
13.6																											

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No S502-05		SHEET 2 OF 2		METRIC										
W.P. <u>5005-10-01</u>		LOCATION <u>N 5083157.5 ; E 222943.7</u>		ORIGINATED BY <u>ID</u>												
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>106 mm I.D. Continuous Flight Hollow Stem Augers</u>		COMPILED BY <u>GRL</u>												
DATUM <u>Geodetic</u>		DATE <u>February 28, 2013</u>		CHECKED BY <u>CN</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	SHEAR STRENGTH kPa					W _p W W _L			
	--- CONTINUED FROM PREVIOUS PAGE ---						<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 </div>					<div style="display: flex; justify-content: space-between;"> 20 40 60 </div>				
	END OF BOREHOLE SPLIT-SPOON AND AUGER REFUSAL NOTE: 1. Water level in open borehole at a depth of 5.2 m below ground surface (Elev. 180.9 m) upon completion of drilling.															

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		RECORD OF BOREHOLE		No S502-06		SHEET 1 OF 1		METRIC								
W.P. 09-1111-6014		LOCATION		N 5083161.2 ; E 222920.1		ORIGINATED BY		ID								
DIST		HWY 69		BOREHOLE TYPE		106 mm I.D. Continuous Flight Hollow Stem Augers		COMPILED BY								
GRL		DATE		March 12, 2013		CHECKED BY		CN								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
188.4	GROUND SURFACE															
0.0	TOPSOIL		1A													
0.2	CLAYEY SILT, some sand, trace organics		1B	SS	3											
187.6	Soft Brown Moist															
0.8	SAND, trace silt		2	SS	12											
	Loose to compact															
	Brown Moist to wet		3	SS	8											
185.9	CLAYEY SILT		4A	SS	4											
2.5	Firm Grey Wet		4B													
185.4	Sandy SILT, trace clay		5	SS	12											
3.0	Compact Brown Moist to wet															
			6	SS	19											
			7	SS	19											
182.8	SAND, some silt, trace clay															
5.6	Compact Brown Wet		8	SS	12											
181.2	SILT, some sand, trace clay															
7.2	Very loose Grey Wet		9	SS	2											
179.7	CLAYEY SILT															
8.7	Firm Grey Wet		10	SS	WH											
178.0	SILT															
10.4	Very loose Grey Wet		11	SS	1											
176.8	END OF BOREHOLE		12	SS												
11.6	SPLIT-SPOON AND AUGER REFUSAL															
NOTE: 1. Water level in open borehole at a depth of 7.4 m below ground surface (Elev. 181.0 m) upon completion of drilling.																

PROJECT		09-1111-6014		RECORD OF BOREHOLE No S502-07		SHEET 1 OF 2		METRIC						
W.P.		5005-10-01		LOCATION		N 5083180.6 ; E 222934.0		ORIGINATED BY ID						
DIST		HWY 69		BOREHOLE TYPE		106 mm I.D. Continuous Flight Hollow Stem Augers		COMPILED BY BM						
DATUM		Geodetic		DATE		March 18, 2013		CHECKED BY CN						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
190.3	GROUND SURFACE													
0.0	PEAT (Fibrous) Dark brown Wet		1A	SS	5									
0.2			1B											
189.6	CLAYEY SILT, trace sand, trace organics Firm Brown Wet		2	SS	14									
0.7														
	Silty SAND Loose to compact Brown Wet		3	SS	7									
188.1														
2.2	SAND, trace silt Loose Brown Moist to wet		4	SS	5									
186.8			5A	SS	4									
			5B											
186.5	SILTY CLAY, trace sand Soft Brown Wet		6	SS	14									
3.8														
185.8	SILT and SAND, trace clay Compact Brown Wet		7	SS	15									
4.5														
	SAND, trace silt Loose to compact Brown to grey Wet													
			8	SS	6									
183.1														
7.2	SILT, some sand Very loose Grey Wet		9	SS	3									
181.6														
8.7	SAND, trace silt Compact Grey Wet		10	SS	11									
179.3			11A	SS	1									
11.0	CLAYEY SILT, silt seams Firm Grey Wet		11B											
178.1														
12.2	SILT, trace to some sand, trace clay Very loose to loose Grey Wet		12	SS	10									
			13	SS	3									

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S502-07				SHEET 2 OF 2		METRIC									
W.P. 5005-10-01		LOCATION N 5083180.6 ; E 222934.0				ORIGINATED BY ID											
DIST _____ HWY 69		BOREHOLE TYPE 106 mm I.D. Continuous Flight Hollow Stem Augers				COMPILED BY BM											
DATUM Geodetic		DATE March 18, 2013				CHECKED BY CN											
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									
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100					
174.2	SILT, trace to some sand, trace clay Very loose to loose Grey Wet		14	SS	4		175										
173.8	Gravelly SILT and SAND, trace clay Compact Grey Wet		15	SS	27/0.15		174										21 46 30 3
16.5	END OF BOREHOLE SPLIT-SPOON AND AUGER REFUSAL NOTE: 1. Water level in open borehole at a depth of 7.5 m below ground surface (Elev. 182.8 m) upon completion of drilling.																

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S502-08		SHEET 1 OF 2		METRIC	
W.P. 5005-10-01		LOCATION N 5083197.7 ; E 222942.6		ORIGINATED BY SA			
DIST _____ HWY 69		BOREHOLE TYPE 106 mm I.D. Continuous Flight Hollow Stem Augers		COMPILED BY GRL			
DATUM Geodetic		DATE March 6 and 7, 2013		CHECKED BY CN			

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 × REMOULDED	W _p	W	W _L						
190.6	GROUND SURFACE														GR	SA	SI	CL
0.0	PEAT (Fibrous)		1A															
0.2	Very soft Dark brown Wet		1B	SS	2													
189.7	CLAYEY SILT		2A															
0.9	Very soft Brown Wet		2B	SS	17													
	SAND, trace to some silt, trace clay Loose to compact Brown to becoming grey below a depth of 3.8 m Moist to Wet		3	SS	15													
			4	SS	7													
			5	SS	6													
			6	SS	17													
			7	SS	20													
185.0	Sandy SILT, trace clay Loose Grey Wet		8	SS	7													
183.4	CLAYEY SILT		9	SS	2													
7.2	Firm Grey Wet		10	SS	WH													
180.5	SILT, trace to some sand, trace clay Very loose to loose Grey Wet		11	SS	3													
10.1			12	SS	5													
177.3	CLAYEY SILT, containing silt seams Soft Grey Wet		13	SS	3													
13.3																		
175.8																		
14.8																		

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		RECORD OF BOREHOLE		No S502-08		SHEET 2 OF 2		METRIC							
W.P. 09-1111-6014		LOCATION		N 5083197.7 ; E 222942.6		ORIGINATED BY		SA							
DIST		HWY 69		BOREHOLE TYPE		106 mm I.D. Continuous Flight Hollow Stem Augers		COMPILED BY							
GRL		DATE		March 6 and 7, 2013		CHECKED BY		CN							
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							
	--- CONTINUED FROM PREVIOUS PAGE ---							20 40 60 80 100							
172.7	SILT, trace to some sand, trace clay Very loose to loose Grey Wet		14	SS	9		175								0 10 87 3
							174								
			15	SS	WR		173								
17.9	SILT and SAND, trace clay Very loose Grey Wet		16	SS	3		172								0 39 57 4
170.9	END OF BOREHOLE SPLIT-SPOON AND AUGER REFUSAL		17	SS			171								
19.7	NOTE: 1. Water level in open borehole at a depth of 6.7 m below ground surface (Elev. 183.9 m) upon completion of drilling.														

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No S502-09		SHEET 1 OF 2		METRIC	
W.P. <u>5005-10-01</u>		LOCATION <u>N 5083203.6 ; E 222924.4</u>		ORIGINATED BY <u>ID</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>106 mm I.D. Continuous Flight Hollow Stem Augers</u>		COMPILED BY <u>AV</u>			
DATUM <u>Geodetic</u>		DATE <u>March 12 and 13, 2013</u>		CHECKED BY <u>CN</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			SHEAR STRENGTH kPa		W _p	W	W _L		
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × REMOULDED					
191.0	GROUND SURFACE													
0.0	TOPSOIL		1A											
0.2	CLAYEY SILT, trace sand		1B	SS	2									
190.2	Soft Brown Wet													
0.8	SAND, trace silt, trace clay		2	SS	14									0 93 5 2
	Loose to compact Brown Wet													
			3	SS	8									
			4	SS	8									
			5	SS	6									
			6	SS	25									
			7	SS	28									
185.3	SILT and SAND, trace clay													
5.7	Loose Brown Wet		8	SS	8									0 64 35 1
			9A	SS	4									
182.9	CLAYEY SILT, trace to some sand		9B											
8.1	Firm Grey Wet													
181.9	SILT and SAND, trace clay		10	SS	5									0 37 59 4
	Loose Grey Wet													
180.8	SILT, trace to some sand, trace clay													
10.2	Very loose to loose Grey Wet		11	SS	WR									Non-Plastic
			12	SS	WR									Non-Plastic
			13	SS	5									0 9 87 4
176.0														

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S502-09				SHEET 2 OF 2		METRIC												
W.P. 5005-10-01		LOCATION N 5083203.6 ; E 222924.4				ORIGINATED BY ID														
DIST HWY 69		BOREHOLE TYPE 106 mm I.D. Continuous Flight Hollow Stem Augers				COMPILED BY AV														
DATUM Geodetic		DATE March 12 and 13, 2013				CHECKED BY CN														
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												
	--- CONTINUED FROM PREVIOUS PAGE ---						<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> ○ UNCONFINED + FIELD VANE </div> <div style="display: flex; justify-content: space-between;"> ● QUICK TRIAXIAL × REMOULDED </div>													
15.0	END OF BOREHOLE AUGER REFUSAL NOTE: 1. Water level in open borehole at a depth of 7.6 m below ground surface (Elev. 183.4 m) upon completion of drilling.																			

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		RECORD OF BOREHOLE		No S502-10		SHEET 1 OF 1		METRIC						
W.P. 09-1111-6014		LOCATION		N 5083209.0 ; E 222904.8		ORIGINATED BY		SA						
DIST. HWY 69		BOREHOLE TYPE		106 mm I.D. Continuous Flight Hollow Stem Augers		COMPILED BY		GRL						
DATUM Geodetic		DATE		March 8, 2013		CHECKED BY		CN						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
190.3	GROUND SURFACE							20 40 60 80 100	20 40 60					
0.0	TOPSOIL		1A	SS	4		190							
0.2	SAND, trace to some silt, trace clay, containing clayey silt seams, trace organics Loose to compact Brown Moist to wet		1B	SS	4									
			2	SS	10									
			3	SS	11		189							
			4	SS	8		188							0 89 8 3
187.3	SILT and SAND, some clay, containing silty clay seams Loose Brown and grey Wet		5	SS	5		187							0 39 41 20
186.6	SILT, trace sand Very loose to compact Grey Wet		6	SS	15		186							
3.7			7	SS	12		185							
			8	SS	2		184							
			9	SS	7		183							Non-Plastic
			10	SS	4		181							
180.1	SILT and SAND, trace clay Compact Grey Wet		11A	SS	15		180							0 51 47 2
179.2	SAND and GRAVEL Compact Grey Wet		11B				179							
178.9	END OF BOREHOLE AUGER REFUSAL													
11.4	NOTE: 1. Water level in open borehole at a depth of 7.2 m below ground surface (Elev. 183.1 m) upon completion of drilling.													

PROJECT		RECORD OF BOREHOLE		No S502-11		SHEET 1 OF 1		METRIC														
W.P.		LOCATION		ORIGINATED BY		DIST		BOREHOLE TYPE		COMPILED BY												
DATUM		DATE		CHECKED BY		GR		CN														
09-1111-6014		N 5083226.7 ; E 222914.7		SA		69		106 mm I.D. Continuous Flight Hollow Stem Augers		GRL												
Geodetic		March 7 and 8, 2013		CN																		
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV	DEPTH	DESCRIPTION	STRAT	NUMBER	TYPE	"N" VALUES		ELEVATION	SCALE	20	40	60	80	100	W _p	W	W _L	γ	GR	SA	SI	CL
191.5	0.0	GROUND SURFACE																				
0.0		TOPSOIL		1A	SS	5		191														
0.2		SILTY CLAY, trace organics Firm Grey Wet		1B	SS																	
190.6				2A	SS	9																
0.9		SAND, trace to some silt, trace clay Loose to compact Brown Moist to wet		2B	SS																	
				3	SS	11																
				4	SS	10																
				5	SS	9																
187.5				6A	SS	10																
4.1		CLAYEY SILT Brown Wet		6B	SS																	
		SILT and SAND, trace clay Loose to compact Grey Wet		6C	SS																	
				7	SS	20																
				8	SS	7																
184.3				9	SS	1																
7.2		SILT, trace to some sand, some clay Very loose Grey Wet																				
182.8				10	SS	9																
8.7		SILT and SAND, trace clay, containing clayey silt seams Loose Grey Wet																				
181.3				11	SS	7																
10.2		SILT, trace to some sand, trace clay Very loose to loose Grey Wet																				
				12	SS	WH																
178.4				13	SS	75/0.00																
13.1		END OF BOREHOLE SPLIT-SPOON REFUSAL																				
NOTE: 1. Water level in open borehole at a depth of 7.5 m below ground surface (Elev. 184.0 m) upon completion of drilling.																						

PROJECT 09-1111-6014			RECORD OF BOREHOLE No S502-12			SHEET 1 OF 1			METRIC																		
W.P. 5005-10-01			LOCATION N 5083243.4 ; E 222922.1			ORIGINATED BY SA																					
DIST _____ HWY 69			BOREHOLE TYPE 106 mm I.D. Continuous Flight Hollow Stem Augers			COMPILED BY GRL																					
DATUM Geodetic			DATE March 7, 2013			CHECKED BY CN																					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			SHEAR STRENGTH kPa			WATER CONTENT (%)			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		ELEVATION SCALE																				
192.1	GROUND SURFACE						192																				
0.0	TOPSOIL		1A	SS	3																						
0.2	CLAYEY SILT Soft to firm Grey Wet		1B	SS	3																						
191.0			2A	SS	6		191																				
1.1	SAND, trace to some silt, trace to some clay, trace gravel Loose to compact Brown and grey Wet		2B	SS	6																						
			3	SS	9																						
			4	SS	10		190																				
			5	SS	12		189																				
			6A	SS	5		188																				
187.8	CLAYEY SILT Brown Wet		6B	SS	5																						
187.5	SILT and SAND, trace clay Very loose to compact Grey Wet		7	SS	18		187																				
4.6			8	SS	10		186																				
			9	SS	3		185																				
			10	SS	5		184																				
			11	SS	3		183																				
			12	SS	25/0.18		182																				
179.6	END OF BOREHOLE SPLIT-SPOON AND AUGER REFUSAL						181																				
12.5	NOTE: 1. Water level in open borehole at a depth of 7.6 m below ground surface (Elev. 184.5 m) upon completion of drilling.						180																				

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		RECORD OF BOREHOLE		No S502-13		SHEET 1 OF 1		METRIC							
W.P. 09-1111-6014		LOCATION		N 5083249.8 ; E 222905.1		ORIGINATED BY		LK							
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment		COMPILED BY							
AV		DATE		January 19, 2013		CHECKED BY		CN							
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							
188.3	GROUND SURFACE														
0.0	TOPSOIL		1A	SS	6										
0.3	SILTY CLAY, trace sand Firm Grey Wet		1B	SS	7										
187.1			2	SS	7										
1.2	SAND, trace to some silt, trace clay Loose to compact Brown Wet		3	SS	7										
			4	SS	7										
			5	SS	13										
185.3			6	SS	11										
3.0	SILT and SAND, trace to some clay Compact Grey Wet		7	SS	18										
			8	SS	15										
183.4			9	SS	13										
4.9	SILT, trace sand, trace clay Loose to compact Grey Wet		10	SS	9										
			11	SS	14										
			12	SS	14										
181.0	END OF BOREHOLE SPLIT-SPOON REFUSAL														
7.3	NOTE: 1. Water level in open borehole at a depth of 1.9 m below ground surface (Elev. 186.4 m) upon completion of drilling.														

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		RECORD OF BOREHOLE		No S502-14		SHEET 1 OF 1		METRIC								
W.P.		LOCATION		ORIGINATED BY		COMPILED BY		CHECKED BY								
DIST		BOREHOLE TYPE		DATE		GRL/AV		CN								
Geodetic		March 3, 2013														
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
188.7	GROUND SURFACE							20	40	60	80	100				
0.0	TOPSOIL		1A													
0.2	Black CLAYEY SILT, trace to some sand Soft Brown Wet		1B	SS	4											
187.2			2	SS	4											
1.5	ORGANIC SILT, trace sand Soft Dark brown Wet		3	SS	4											
186.0			4	AS	-											
2.9	SAND and GRAVEL, some silt, trace clay Compact to dense Grey Wet END OF BOREHOLE SPLIT-SPOON REFUSAL END OF DCPT Refusal to Further Penetration NOTES: 1. Water level in open borehole at a depth of 1.1 m below ground surface (Elev. 187.6 m) upon completion of drilling. 2. A Dynamic Cone Penetration Test was advanced 1 m East of Borehole S502-14. 3. Refusal to further penetration reached at a depth of 2.9 m below ground surface (Elev. 185.8 m).		5	SS	16/0.15											51 35 13 1

PROJECT		RECORD OF BOREHOLE		No S502-15		SHEET 1 OF 1		METRIC												
W.P.		LOCATION		ORIGINATED BY		LK														
DIST		BOREHOLE TYPE		COMPILED BY		AV														
DATUM		DATE		CHECKED BY		CN														
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ kN/m ³	GR SA SI CL			
							20 40 60 80 100	20 40 60 80 100	20 40 60	20 40 60	20 40 60	20 40 60	20 40 60							
189.1	GROUND SURFACE		1A	SS	5		189													
0.0	TOPSOIL		1B	SS	12															
0.2	CLAYEY SILT, trace sand Firm to stiff Grey Wet		2	SS	12															
187.6	SAND, some silt, trace gravel, trace clay Very loose to compact Grey Wet		3A	SS	6		188													
1.5			3B	SS	2															
			4	SS	2		187													
			5	SS	16															
185.7	Sandy SILT, trace clay Loose to compact Grey Wet		6A	SS	13		186													
3.4			6B	SS	5															
			7	SS	5		185													
			8	SS	7															
			9	SS	12		184													
183.6	Gravelly SILT and SAND, trace clay Compact Grey Wet		10	SS	16															
5.5																				
183.1	END OF BOREHOLE SPLIT-SPOON REFUSAL																			
6.0																				
NOTE: 1. Water level in open borehole at a depth of 1.5 m below ground surface (Elev. 187.6 m) upon completion of drilling.																				

PROJECT		09-1111-6014		RECORD OF BOREHOLE No S502-16		SHEET 1 OF 1		METRIC							
W.P.		5005-10-01		LOCATION		N 5083291.2 ; E 222906.9		ORIGINATED BY EHS							
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment		COMPILED BY GRL							
DATUM		Geodetic		DATE		March 3, 2013		CHECKED BY CN							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
191.4	GROUND SURFACE														
0.0	TOPSOIL		1A												
0.2	Black		1B	SS	5										
	SILTY CLAY, trace sand, trace organics														
	Soft to firm														
	Brown														
	Wet														
190.1			2	SS	4										
1.3	SAND, trace to some silt, trace clay														
	Loose														
	Brown														
	Wet														
188.4			3	SS	9										
			4	SS	7										
187.7															
3.0	SILT and SAND, trace clay														
	Compact														
	Grey														
	Wet														
187.7	END OF BOREHOLE		5	SS	11										
	Dynamic Cone Penetration Test (DCPT)														
186.3	END OF DCPT														
5.1	Refusal to Further Penetration														
	NOTES:														
	1. Borehole caved in at a depth of 3.7m (Elev. 187.7 m) during drilling.														
	2. Water level in open borehole at a depth of 1.8 m (Elev. 189.6 m) upon completion of drilling.														

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		RECORD OF BOREHOLE				No S502-17		SHEET 1 OF 1		METRIC				
W.P. 09-1111-6014		LOCATION				N 5083295.9 ; E 222885.7		ORIGINATED BY		EHS				
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment		COMPILED BY		GRL				
DATUM		Geodetic		DATE		March 3, 2013		CHECKED BY		CN				
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			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 (%)				
189.8	GROUND SURFACE													
0.0	TOPSOIL		1A		7									
0.2	Black SILTY CLAY, trace to some sand Firm to stiff Brown Wet		1B	SS										
			2	SS	9									
188.3														
1.5	SAND, trace silt Compact Brown Moist		3	SS	10									
187.6														
2.2	Sandy SILT to SILT and SAND, trace clay Loose to compact Brown to grey Wet		4	SS	11									0 21 77 2
			5	SS	5									
186.0														
185.7	SILT and SAND, trace clay Loose Grey Wet		6	SS	6/0.20									0 33 64 3
4.1	END OF BOREHOLE SPLIT-SPOON REFUSAL NOTE: 1. Water level in open borehole at a depth of 2.7 m below ground surface (Elev. 187.1 m) upon completion of drilling.													

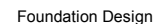
GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		09-1111-6014		RECORD OF BOREHOLE No S502-18		SHEET 1 OF 2		METRIC						
W.P.		5005-10-01		LOCATION		N 5083149.0 ; E 222988.0		ORIGINATED BY ID						
DIST		HWY 69		BOREHOLE TYPE		106 mm I.D. Continuous Flight Hollow Stem Augers		COMPILED BY AV						
DATUM		Geodetic		DATE		March 13 and 14, 2013		CHECKED BY CN						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
181.3	GROUND SURFACE													
0.0	PEAT (Fibrous)		1A	SS	1									
0.3	Very soft Black Wet		1B											
180.5	CLAYEY SILT, trace to some sand, trace gravel, trace organics		2	SS	7									
0.8	Very soft Dark grey Wet													
179.8	SAND, trace to some gravel		3	SS	1									
1.5	Loose Brown Wet													
179.1	CLAYEY SILT, with silt seams		4	SS	4									
2.2	Very soft Grey Wet													
	SILT and SAND, trace clay		5	SS	3									
	Very loose Grey Wet													
177.6	SILTY CLAY, with silt seams		6	SS	7									
3.7	Firm Grey Wet													
			7	SS	WH									
175.5	CLAYEY SILT		8	SS	1									
5.8	Firm to stiff Grey Wet													
			9	TO	PH									
			10	SS	3									
			11A	SS	1									
170.2	SILT, trace to some sand, trace to some clay		11B											
11.1	Very loose to compact Grey Wet													
			12	SS	8									
			13	SS	16									
166.6	END OF BOREHOLE													
14.7														

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16



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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		RECORD OF BOREHOLE		No S502-19		SHEET 1 OF 1		METRIC								
W.P. 09-1111-6014		LOCATION		N 5083170.6; E 223007.3		ORIGINATED BY		MA								
DIST. HWY 69		BOREHOLE TYPE		150 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY		AV								
DATUM Geodetic		DATE		March 11, 2013		CHECKED BY		CN								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
180.9	GROUND SURFACE															
0.0	PEAT (Fibrous)		1A	SS	2											
0.4	Very soft Dark brown Wet		1B	SS	2											
179.7	ORGANIC SILT, trace sand		2A	SS	2											
1.2	Very soft Grey Wet		2B	SS	2											
178.9	CLAYEY SILT, containing sand seams and silt lenses		3A	SS	4											
	Soft to firm Grey Wet		3B	SS	4											
2.2	SILT and SAND		4	SS	2											
	Grey Wet															
	CLAYEY SILT, containing silty sand seams		5	SS	1											
	Firm to stiff Grey Wet															
			6	SS	1											
			7	SS	1											
			8	TO	PH											
172.0	SILT		9	SS	3											
8.9	Very loose Grey Wet															
171.1	END OF BOREHOLE SPLIT-SPOON AND AUGER REFUSAL		10	SS	-											
9.8																
NOTE: 1. Water level in open borehole at a depth of 2.0 m below ground surface (Elev. 178.9 m) upon completion of drilling.																

PROJECT		RECORD OF BOREHOLE		No S502-20		SHEET 1 OF 2		METRIC							
W.P. 5005-10-01		LOCATION		N 5083172.0 ; E 222978.4		ORIGINATED BY		ID							
DIST		HWY 69		BOREHOLE TYPE		106 mm I.D. Continuous Flight Hollow Stem Augers		COMPILED BY							
GRL		DATE		March 1 and 4, 2013		CHECKED BY		CN							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
184.1	GROUND SURFACE														
0.0	TOPSOIL		1A	SS	6										
183.8	Black		1B	SS	7										
0.3	SAND, trace silt, trace organics Very loose to loose Brown becoming grey below a depth of 2.3 m Moist to wet		2	SS	6										
			3	SS	6										
			4	SS	WH										
			5	SS	WH										
180.4	SILT and SAND, trace clay Loose Grey Wet		6	SS	6										
3.7	Clayey silt seams below a depth of 4.6 m		7	SS	5										
178.0	CLAY Soft to stiff Grey Wet		8	SS	WH										
6.1			9	SS	1										
			10	TO	PH										
173.6	CLAYEY SILT Very soft Grey Wet		11A	SS	WH										
10.5			11B	SS	WH										
173.0	SILT, some sand, trace to some clay Very loose Grey Wet														
11.1															
172.4	SILT and SAND, trace clay Very loose Grey Wet		12	SS	3										
11.7															
170.6			13	SS	10/0.05										
13.5															

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No S502-20				SHEET 2 OF 2		METRIC								
W.P. <u>5005-10-01</u>		LOCATION <u>N 5083172.0 ; E 222978.4</u>				ORIGINATED BY <u>ID</u>										
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>106 mm I.D. Continuous Flight Hollow Stem Augers</u>				COMPILED BY <u>GRL</u>										
DATUM <u>Geodetic</u>		DATE <u>March 1 and 4, 2013</u>				CHECKED BY <u>CN</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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
	--- CONTINUED FROM PREVIOUS PAGE ---															
	END OF BOREHOLE SPLIT-SPOON AND AUGER REFUSAL NOTE: 1. Water level in open borehole at a depth of 2.1 m below ground surface (Elev. 182.0 m) upon completion of drilling.															

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PROJECT		09-1111-6014		RECORD OF BOREHOLE No S502-20A		SHEET 1 OF 2		METRIC						
W.P.		5005-10-01		LOCATION		N 5083189.5 ; E 222993.4		ORIGINATED BY						
DIST		HWY 69		BOREHOLE TYPE		150 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY						
DATUM		Geodetic		DATE		March 9, 2014		CHECKED BY						
								JPD						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
184.2	GROUND SURFACE													
0.0	TOPSOIL Dark brown Moist		1A	SS	12 *									
183.6	SAND, some gravel, trace silt Loose to compact Brown Moist		1B	SS	4									
0.6	SILT, trace sand, trace clay Loose Brown to grey Wet		2	SS	5									
182.7	CLAYEY SILT, trace sand Soft to firm Grey Wet		3A	SS	4									
1.5	SAND Very loose to loose Grey Wet		3B	SS	2									
181.6	SAND Very loose to loose Grey Wet		4	SS	7									
2.6	SAND Very loose to loose Grey Wet		5	SS	6									
			6	SS										
			7	SS										
179.0	SILT CLAY to CLAY, trace sand Soft to firm Grey Wet													
5.2	SILT CLAY to CLAY, trace sand Soft to firm Grey Wet		8	SS	2									
177.1	SILT, trace to some sand, trace clay Loose Grey Wet		9	TO	PH									
7.1	SILT, trace to some sand, trace clay Loose Grey Wet													
			10	SS	9									
172.9	SAND, some gravel Very dense Grey Wet		11	SS	10									
11.3	SAND, some gravel Very dense Grey Wet													
171.8			12	SS	50/0.15									
12.4														

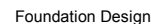
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+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG09-1111-6014.GPJ GAL-GTA-GDT 07/25/16

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No S502-20A				SHEET 2 OF 2		METRIC									
W.P. <u>5005-10-01</u>		LOCATION <u>N 5083189.5 ;E 222993.4</u>				ORIGINATED BY <u>MR</u>											
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>150 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring</u>				COMPILED BY <u>BM</u>											
DATUM <u>Geodetic</u>		DATE <u>March 9, 2014</u>				CHECKED BY <u>JPD</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	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)
	--- CONTINUED FROM PREVIOUS PAGE ---																
	END OF BOREHOLE NOTES: 1. Water level in open borehole at a depth of 0.6 m below ground surface (Elev. 183.6 m) upon completion of drilling. 2. An (S502-20B) additional borehole was advanced 0.5 m east of borehole S502-20A to obtain a Shelby Tube sample at a depth of 5.5 m (Elev. 178.7 m) and to carry out in situ field vanes at depths of 6.4 m (Elev. 177.8 m) and 6.7 m (Elev. 177.5 m). * "N" Value impacted by frozen ground.																

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16



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PROJECT 09-1111-6014		RECORD OF BOREHOLE No S502-21		SHEET 1 OF 2		METRIC														
W.P. 5005-10-01		LOCATION N 5083176.3 ; E 222956.2		ORIGINATED BY ID																
DIST HWY 69		BOREHOLE TYPE 106 mm I.D. Continuous Flight Hollow Stem Augers		COMPILED BY GRL																
DATUM Geodetic		DATE February 27, 2013		CHECKED BY CN																
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ kN/m ³	GR SA SI CL			
							20 40 60 80 100	20 40 60 80 100	20 40 60	20 40 60	20 40 60	20 40 60								
187.3	GROUND SURFACE		1A				187													
0.0	TOPSOIL		1B	SS	4															
0.2	Silty SAND, trace clay Loose Brown Moist		2	SS	6															
			3	SS	8															
185.1							186													
2.2	SILT and SAND, trace to some clay Very loose to compact Brown Moist to wet		4	SS	11															
			5	SS	5															
			6	SS	3															
	Containing clayey silt seams below a depth of 4.6 m.		7	SS	3															
181.7							185													
5.6	CLAYEY SILT, trace to some sand Very soft Grey Moist		8A																	
180.9			8B	SS	1															
6.4	SILT and SAND, trace clay Very loose Grey Wet						184													
			9	SS	1															
178.6							183													
8.7	SILTY CLAY Firm Grey Wet		10	SS	WH															
							182													
			11	SS	WH															
175.1							181													
12.2	SILT, some sand, trace clay Very loose to loose Grey Wet		12	SS	WH															
							180													
			13	SS	9															
							179													
							178													
							177													
							176													
							175													
							174													
							173													

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA-GDT 07/25/16

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S502-21				SHEET 2 OF 2		METRIC									
W.P. 5005-10-01		LOCATION N 5083176.3 ; E 222956.2				ORIGINATED BY ID											
DIST _____ HWY 69		BOREHOLE TYPE 106 mm I.D. Continuous Flight Hollow Stem Augers				COMPILED BY GRL											
DATUM Geodetic		DATE February 27, 2013				CHECKED BY CN											
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)
	--- CONTINUED FROM PREVIOUS PAGE ---						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					20 40 60				GR SA SI CL	
170.8	SILT, some sand, trace clay Very loose to loose Grey Wet		14	SS	4		172										
16.5	END OF BOREHOLE SPLIT-SPOON AND AUGER REFUSAL NOTE: 1. Water level in open borehole at a depth of 4.0 m below ground surface (Elev. 183.3 m) upon completion of drilling.		15	SS	-		171										

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No S502-22		SHEET 1 OF 2		METRIC	
W.P. <u>5005-10-01</u>		LOCATION <u>N 5083195.1 ; E 222968.7</u>		ORIGINATED BY <u>SA</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>106 mm I.D. Continuous Flight Hollow Stem Augers</u>		COMPILED BY <u>CC/AV</u>			
DATUM <u>Geodetic</u>		DATE <u>March 4 and 5, 2013</u>		CHECKED BY <u>CN</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		W _p	W	W _L		
							20 40 60 80 100							
188.0	GROUND SURFACE													
0.0	TOPSOIL		1A	SS	5									
0.1	SILTY CLAY, trace organics Firm Brown and grey Wet		1B	SS										
187.1			2A	SS	7									
0.9	Silty SAND, trace clay Very loose to compact Brown Moist		2B	SS										
			3	SS	9									
			4	SS	11									
185.0														
3.0	SILT and SAND, trace clay Very loose to compact Grey Moist to wet		5	SS	10									
			6	SS	2									
			7	SS	4									
			8	SS	2									
			9	SS	5									
178.6			10A	SS	4									
9.4	CLAYEY SILT, trace sand Firm Grey Wet		10B	SS										
177.5														
10.5	SILT, some sand Very loose Grey Wet		11A	SS	2									
177.0			11B	SS										
11.0	SILTY CLAY, trace sand Firm to stiff Grey Wet													
			12	TO	PH									
174.7														
13.3	SILT, trace to some sand, trace clay Loose Grey Wet		13	SS	7									
173.3														
14.7														

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT 09-1111-6014			RECORD OF BOREHOLE No S502-22			SHEET 2 OF 2			METRIC															
W.P. 5005-10-01			LOCATION N 5083195.1 ; E 222968.7			ORIGINATED BY SA																		
DIST _____ HWY 69			BOREHOLE TYPE 106 mm I.D. Continuous Flight Hollow Stem Augers			COMPILED BY CC/AV																		
DATUM Geodetic			DATE March 4 and 5, 2013			CHECKED BY CN																		
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			ELEVATION SCALE			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES																			
--- CONTINUED FROM PREVIOUS PAGE ---																								
	SILT and SAND, trace clay Very loose Grey Wet		14	SS	WR																			
			15	SS	WR																			
170.2																								
17.8	SILT, trace to some sand, trace clay Very loose to loose Grey Wet																							
169.3			16	SS	4																			
18.7	END OF BOREHOLE SPLIT-SPOON REFUSAL NOTE: 1. Water level in open borehole at a depth of 4.6 m below ground surface (Elev. 183.4 m) upon completion of drilling.																							

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No S502-23		SHEET 1 OF 2		METRIC	
W.P. <u>5005-10-01</u>		LOCATION <u>N 5083212.8 ; E 222978.6</u>		ORIGINATED BY <u>SA</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>106 mm I.D. Continuous Flight Hollow Stem Augers</u>		COMPILED BY <u>GRL</u>			
DATUM <u>Geodetic</u>		DATE <u>March 5 and 6, 2013</u>		CHECKED BY <u>CN</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			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								<div><div><div></div><div></div><div></div><div></div><div></div></div></div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × REMOULDED</div>							<div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div></div>
188.7	GROUND SURFACE						20	40	60	80	100	<div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div></div>			
0.0	TOPSOIL		1A														
0.2	CLAYEY SILT, trace sand, trace organics Soft to firm Brown Moist		1B	SS	3												
			2	SS	7												
187.3																	
1.4	SILT and SAND, trace to some clay Loose to compact Brown, becoming grey below a depth of 3.8m Wet		3	SS	11												
			4	SS	14												
			5	SS	14												
			6	SS	6												
184.2																	
4.5	SAND, some silt Very loose Grey Wet		7	SS	3												
182.6																	
6.1	SILT, trace to some clay, containing silty clay seams Very loose Grey Wet		8	SS	1												
181.4																	
7.3	SILT and SAND, trace clay Loose to compact Grey wet		9	SS	7												
			10	SS	8												
177.6			11A	SS	19												
11.1	SILTY CLAY Firm to stiff Grey Wet		11B														
176.5																	
12.2	SILT, trace to some sand, trace clay Very loose to loose Grey Wet		12	SS	1												
			13	SS	7												
173.7																	

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		RECORD OF BOREHOLE		No S502-23		SHEET 2 OF 2		METRIC								
W.P. 5005-10-01		LOCATION		N 5083212.8 ; E 222978.6		ORIGINATED BY		SA								
DIST		HWY 69		BOREHOLE TYPE		106 mm I.D. Continuous Flight Hollow Stem Augers		COMPILED BY								
GRL		DATE		March 5 and 6, 2013		CHECKED BY		CN								
DATUM		Geodetic														
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
	--- CONTINUED FROM PREVIOUS PAGE ---															
15.0	SILT Very loose to loose Grey wet		14	SS	WH		173									
172.4																
16.3	END OF BOREHOLE SPLIT-SPOON AND AUGER REFUSAL NOTE: 1. Water level in open borehole at a depth of 4.9 m below ground surface (Elev. 183.8 m) upon completion of drilling.		15	SS	10/0.0											

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No S502-24		SHEET 1 OF 2		METRIC	
W.P. <u>5005-10-01</u>		LOCATION <u>N 5083218.2 ; E 222959.0</u>		ORIGINATED BY <u>ID</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>106 mm I.D. Continuous Flight Hollow Stem Augers</u>		COMPILED BY <u>GRL</u>			
DATUM <u>Geodetic</u>		DATE <u>February 27 and 28, 2013</u>		CHECKED BY <u>CN</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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × REMOULDED					
190.3	GROUND SURFACE													
0.0	TOPSOIL Soft Dark brown to black Wet		1	SS	3		190						OC = 6.3%	
189.5							189							
0.8	SAND, trace to some silt, trace clay Loose to compact Brown Moist		2	SS	9									
			3	SS	13									
			4	SS	8									0 88 9 3
			5	SS	10									
			6	SS	15									
			7	SS	17									
184.7							185							
5.6	SILT and SAND, trace clay Very loose to loose Grey Wet Clayey silt seams below a depth of 7.6 m		8	SS	5		184							0 62 36 2
			9	SS	2									0 47 49 4
181.6							182							
8.7	SAND, some silt Very loose to loose Grey Wet		10	SS	5		181							
			11	SS	3									
178.6							179							
11.7	CLAY, with silt seams Firm Grey Wet		12	SS	1		178							
176.8							177	5						
13.5	SILT, trace clay Very loose Grey Wet		13	SS	1		176							Non-Plastic

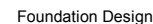
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+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		RECORD OF BOREHOLE		No S502-24		SHEET 2 OF 2		METRIC													
W.P. 5005-10-01		LOCATION		N 5083218.2; E 222959.0		ORIGINATED BY		ID													
DIST		HWY 69		BOREHOLE TYPE		106 mm I.D. Continuous Flight Hollow Stem Augers		COMPILED BY													
GRL		DATE		February 27 and 28, 2013		CHECKED BY		CN													
Geodetic		DATE		February 27 and 28, 2013		CHECKED BY		CN													
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100						20	40	60	20
174.0	SILT, trace clay Very loose Grey Wet		14	SS	WH																
16.3	SILT and SAND, trace gravel, trace clay Loose Grey Wet		15	SS	8																
172.6	END OF BOREHOLE SPLIT-SPOON AND AUGER REFUSAL		16	SS																	
17.7	NOTE: 1. Water level in open borehole at a depth of 6.0 m below ground surface (Elev. 184.3 m) upon completion of drilling.																				

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16



METRIC

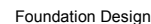
ORIGINATED BY MA/CS

COMPILED BY MCK

CHECKED BY AB

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

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



GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

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

PROJECT 09-1111-6014		RECORD OF BOREHOLE No B501-02		SHEET 3 OF 3		METRIC											
W.P. 5146-08-01		LOCATION N 5083071.8 ; E 222979.6		ORIGINATED BY MA/CS													
DIST _____ HWY 69		BOREHOLE TYPE NW Casing, Wash Boring, NQ Coring		COMPILED BY MCK													
DATUM Geodetic		DATE March 6 to 8, 2013		CHECKED BY AB													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ kN/m³	GR SA SI CL
							20 40 60 80 100	20 40 60 80 100	20 40 60	20 40 60	20 40 60	20 40 60	20 40 60				
	--- CONTINUED FROM PREVIOUS PAGE ---																
145.4	SILT, some SAND to SILT and SAND, trace clay Compact Grey Wet		18	SS	10		148										
33.2	BOULDER		19	SS	REC 100%		145										
144.9																	
33.7	SILT, some sand to SILT and SAND, some gravel, trace clay Very loose to compact Grey Wet		20	SS	3		144										
							143										
141.2			21	SS	15		142										13 15 70 2
37.4	Granitic Gneiss (BEDROCK) Bedrock cored from depths of 37.4 m to 40.6 m. For bedrock coring details refer to Record of Drillhole B501-02.		1	RC	REC 99%		141										RQD = 70%
							140										
			2	RC	REC 98%		139										RQD = 91%
138.0							138										
40.6	END OF BOREHOLE																

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: WALKER DRILLING

CHECKED: AB

PROJECT		RECORD OF BOREHOLE		No B501-12		SHEET 1 OF 3		METRIC					
W.P.		LOCATION		ORIGINATED BY									
DIST		BOREHOLE TYPE		COMPILED BY									
DATUM		DATE		CHECKED BY									
09-1111-6014		N 5083106.9 ; E 222964.9		MR									
5146-08-01		150 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		MCK									
Geodetic		March 6 and 7, 2014		AB									
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	GR SA SI CL
181.0	GROUND SURFACE												
0.0	PEAT (FIBROUS) Very soft Dark brown Wet		1	SS	1								
179.9			2A	SS	1		180						
1.1	Silty SAND, trace organics to a depth of 1.5 m Very loose to loose Grey Wet		2B										
			3	SS	8		179						
			4	SS	4								
178.3													
2.7	SILTY CLAY, trace sand Very soft Grey Wet		5	SS	1		178						0 2 55 43
			6	SS	1		177						
176.4			7A	SS	7								
4.6	Sandy SILT Loose Grey Wet		7B				176						
175.7													
5.3	CLAYEY SILT to SILTY CLAY, trace sand Firm to stiff Grey Wet		8	SS	1		175						0 2 60 38
							174						
			9	SS	2								
							173						
							172						
	Silt seams below a depth of 8.8 m		10	SS	1								
							171						
170.6			11	TO	PH		170						
10.4	Sandy SILT, trace clay Loose Grey Wet												
			12	SS	5		169						0 22 73 5
168.2							168						
12.8	SILTY CLAY, silt and sand seams throughout Firm to stiff Brown to grey Wet		13	SS	5		167						

Continued Next Page

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


GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No B501-12		SHEET 2 OF 3		METRIC																
W.P. <u>5146-08-01</u>		LOCATION <u>N 5083106.9 ; E 222964.9</u>		ORIGINATED BY <u>MR</u>																		
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>150 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring</u>		COMPILED BY <u>MCK</u>																		
DATUM <u>Geodetic</u>		DATE <u>March 6 and 7, 2014</u>		CHECKED BY <u>AB</u>																		
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ			GR SA SI CL			
	--- CONTINUED FROM PREVIOUS PAGE ---							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W _p ——— W ——— W _L 20 40 60			kN/m ³						
	SILTY CLAY, silt and sand seams throughout Firm to stiff Brown to grey Wet		14	TO	PH		165															
			15	SS	1		164															
			16	SS	3		163															
			17	TO	PH		162															
			18	SS	17		161															
			19	SS	36		160															
159.4	SILT, trace sand, trace clay, trace gravel Compact to dense Grey Wet		20				159															
21.6			21				158															
			22				157															
			23				156															
			24				155															
153.7	Cobbles		25				154															
27.4	Granitic Gneiss (BEDROCK)		26				153															
	Bedrock cored from depths of 27.4 m to 30.9 m.		27	RC	REC 94%		152															
	For bedrock coring details refer to Record of Drillhole B501-12.		28	RC	REC 100%																	
			29	RC	REC 97%																	

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT 09-1111-6014		RECORD OF BOREHOLE No B501-12				SHEET 3 OF 3		METRIC													
W.P. 5146-08-01		LOCATION N 5083106.9 ; E 222964.9				ORIGINATED BY MR															
DIST HWY 69		BOREHOLE TYPE 150 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring				COMPILED BY MCK															
DATUM Geodetic		DATE March 6 and 7, 2014				CHECKED BY AB															
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													
	--- CONTINUED FROM PREVIOUS PAGE ---						<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 </div>														
150.2 30.9	END OF BOREHOLE NOTE: 1. Between 26.8 m and 27.4 m depth, corresponding to Elev. 154.2 m to Elev. 153.6 m, artesian conditions encountered. After pulling core barrel and pulling casing tip to 26.2 m depth (Elev. 154.8 m), Artesian stabilized at 1.3 m above ground surface (Elev. 182.3 m) and dissipated after pulling casing tip to 23.2 m (Elev. 157.8 m).		3	RC	REC 97%																

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B501-12

SHEET 1 OF 1

LOCATION: N 5083106.9 ;E 222964.9


DRILLING DATE: March 7, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: Diedrich D25

DRILLING CONTRACTOR: WALKER DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX PER 0.25	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY			Diametral Point Load Index (MPa)	RMC -Q AVG	NOTES		
								TOTAL CORE %	SOLID CORE %			TYPE AND SURFACE DESCRIPTION		K, cm/sec									
								80 60 40 20	80 60 40 20			Jr	Ja	Jn	10 10 10 10								
								0 10 20 30 40 50 60 70 80 90 100	0 10 20 30 40 50 60 70 80 90 100			B Angle	DIP w.r.t. CORE AXIS	0 10 20 30 40 50 60 70 80 90 100									
		Continued from Record of Borehole B501-12		153.60																			
28	NW casing	Slightly weathered, dark grey, medium grained, non-porous, strong GRANITIC GNEISS		27.43	1																		
29	NQRC March 7, 2014			2																			
30				3																			
31		END OF DRILLHOLE		150.18 30.85																			
32																							
33																							
34																							
35																							
36																							
37																							

DEPTH SCALE

1 : 50




LOGGED: MR

CHECKED: AB

GTA-RCK 018 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-MISS.GDT 07/25/16

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

PROJECT 09-1111-6014		RECORD OF BOREHOLE No B501-13				SHEET 2 OF 2		METRIC									
W.P. 5146-08-01		LOCATION N 5083153.0 ; E 222945.6				ORIGINATED BY MAS											
DIST _____ HWY 69		BOREHOLE TYPE 150 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring				COMPILED BY MCK											
DATUM Geodetic		DATE March 11, 2014				CHECKED BY AB											
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)
	--- CONTINUED FROM PREVIOUS PAGE ---						20	40	60	80	100						
	Granitic Gneiss (BEDROCK)		2	RC	REC 100%												RQD = 89%
	Bedrock cored from depths of 13.6 m to 16.8 m. For bedrock coring details refer to Record of Drillhole B501-13.		3	RC	REC 100%												RQD = 94%
168.3	END OF BOREHOLE																
16.8	NOTE: 1. Water level in open borehole at a depth of 4.9 m below ground surface (Elev. 180.2 m) upon completion of drilling.																

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: WALKER DRILLING

CHECKED: AB

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No B501-14		SHEET 1 OF 2		METRIC	
W.P. <u>5146-08-01</u>		LOCATION <u>N 5083171.5; E 222937.8</u>		ORIGINATED BY <u>MAS</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>150 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring</u>		COMPILED BY <u>MCK</u>			
DATUM <u>Geodetic</u>		DATE <u>March 12, 2014</u>		CHECKED BY <u>AB</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			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × REMOULDED			W _p			W	W _L	
188.3	GROUND SURFACE							20	40	60	80	100	20	40	60		
0.0	TOPSOIL																
0.2	SILT and SAND, trace clay Loose to compact Brown becoming grey below a depth of 6.1 m Moist to wet		1	SS	11												
			2	SS	12												
			3	SS	10												
			4	SS	22												
			5	SS	29												
			6	SS	25												
			7	SS	19												
			8	SS	8												
			9	SS	9												
179.6	CLAY Firm Grey Wet		10	SS	2												
			11	SS	2												
176.1	SILT, trace to some clay, trace sand Loose to compact Grey Wet		12	SS	17												
			13	SS	7												
173.5																	
14.8																	

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		RECORD OF BOREHOLE				No B501-14		SHEET 2 OF 2		METRIC							
W.P. 09-1111-6014		LOCATION				N 5083171.5; E 222937.8		ORIGINATED BY MAS									
DIST		HWY 69		BOREHOLE TYPE				150 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring									
DATUM Geodetic		DATE		March 12, 2014				COMPILED BY MCK									
								CHECKED BY AB									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100					
172.6	SILT and SAND Dense Grey Wet		14	SS	37		173										
15.7	END OF BOREHOLE SPLIT-SPOON REFUSAL NOTE: 1. Water level in open borehole at a depth of 6.1 m below ground surface (Elev. 182.2 m) upon completion of drilling.																

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16



METRIC

ORIGINATED BY MA

COMPILED BY MCK

CHECKED BY AB

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT 09-1111-6014		RECORD OF BOREHOLE No B502-02		SHEET 2 OF 3		METRIC																
W.P. 5145-08-01		LOCATION N 5083086.2 ; E 223014.2		ORIGINATED BY MA																		
DIST _____ HWY 69		BOREHOLE TYPE NW Casing, Wash Boring, NQ Coring		COMPILED BY MCK																		
DATUM Geodetic		DATE February 26 to 28, 2013		CHECKED BY AB																		
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ			GR SA SI CL			
	--- CONTINUED FROM PREVIOUS PAGE ---							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100					W _p W W _L 20 40 60			kN/m ³						
157.8	CLAYEY SILT, trace to some sand, with silt seams Firm to stiff Grey Wet		11	SS	15		163															0 1 68 31
			12	SS	3		162															
			13	TO	PH		161															
			14	SS	3		160															
			15	SS	17		159															
20.8	SILT, trace to some sand, trace clay, with sand and clayey silt seams Compact Grey Wet		16	SS	10		158															
			17	SS	36		157															
			1	RC	REC		156															
152.2	Gravelly SILT and SAND, trace clay Dense Grey Wet		2	RC	REC 98%		155															
26.4	COBBLES AND BOULDERS		3	RC			154															
28.0	Granitic Gneiss (BEDROCK)						153															
28.5	Bedrock cored from depths of 28.5 m to 31.8 m. For bedrock coring details refer to Record of Drillhole B502-02.						152															
							151															
							150															
							149															

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT 09-1111-6014		RECORD OF BOREHOLE No B502-02				SHEET 3 OF 3		METRIC									
W.P. 5145-08-01		LOCATION N 5083086.2 ; E 223014.2				ORIGINATED BY MA											
DIST HWY 69		BOREHOLE TYPE NW Casing, Wash Boring, NQ Coring				COMPILED BY MCK											
DATUM Geodetic		DATE February 26 to 28, 2013				CHECKED BY AB											
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									
	--- CONTINUED FROM PREVIOUS PAGE ---						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%)					
	Granitic Gneiss (BEDROCK)		3	RC	REC 100%												RQD = 96%
146.8	Bedrock cored from depths of 28.5 m to 31.8 m. For bedrock coring details refer to Record of Drillhole B502-02.		4	RC	REC 97%												RQD = 73%
31.8	END OF BOREHOLE																

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: WALKER DRILLING

[illegible]

CHECKED: AB

GTARCK 018 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-MISS.GDT 07/25/16


PROJECT 09-1111-6014		RECORD OF BOREHOLE No B502-12		SHEET 1 OF 2		METRIC	
W.P. 5145-08-01		LOCATION N 5083121.2; E 222999.6		ORIGINATED BY MR			
DIST HWY 69		BOREHOLE TYPE 150 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY MCK			
DATUM Geodetic		DATE March 4 and 5, 2014		CHECKED BY AB			

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		W _p	W	W _L		
								○ UNCONFINED	+ FIELD VANE					
179.3	GROUND SURFACE													
0.0	PEAT		1A	SS	1									
178.9	Very loose Dark brown Moist		1B	SS										
0.4														
178.1	Silty SAND, trace organics Loose Grey Wet		2A	SS	9									
1.2			2B	SS										
	CLAYEY SILT to SILTY CLAY, trace to some sand Soft to firm Grey Wet		3	SS	2									
			4	SS	1									
			5	TO	PH									
			6	SS	2									
			7	SS	1									
			8	SS	1									
			9	SS	3									
			10	SS	1									
			11	SS	8									
			1	RC	REC 100%									

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009-1111-6014 (URS, HWY 69, HENVEY)\LOG09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No B502-12				SHEET 2 OF 2		METRIC									
W.P. <u>5145-08-01</u>		LOCATION <u>N 5083121.2; E 222999.6</u>				ORIGINATED BY <u>MR</u>											
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>150 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring</u>				COMPILED BY <u>MCK</u>											
DATUM <u>Geodetic</u>		DATE <u>March 4 and 5, 2014</u>				CHECKED BY <u>AB</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 (%)
	--- CONTINUED FROM PREVIOUS PAGE ---																
	Granitic Gneiss (BEDROCK)		1	RC	REC 100%		164										RQD = 100%
	Bedrock cored from depths of 14.7 m to 18.0 m.		2	RC	REC 100%		163										RQD = 100%
	For bedrock coring details refer to Record of Drillhole B502-12.		3	RC	REC 100%		162										RQD = 93%
161.3 18.0	END OF BOREHOLE																
	NOTE: 1. Water level in open borehole at a depth of 0.5 m below ground surface (Elev. 178.8 m) upon completion of drilling.																

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B502-12

SHEET 1 OF 1

LOCATION: N 5083121.2 ;E 222999.6

DRILLING DATE: March 5, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: Diedrich D25

DRILLING CONTRACTOR: WALKER DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	JN - Joint FLT - Fault SH - Shear VN - Vein CJ - Conjugate										BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage										PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular										PO - Polished K - Slickensided SM - Smooth RO - Rough VR - Very Rough										MB - Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.										NOTES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
							FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX PER 0.25	B Angle	DIP w.r.t. CORE AXIS	DISCONTINUITY DATA			HYDRAULIC CONDUCTIVITY K, cm ³ /sec			Diameter Point Load Index (MPa)	RMC -Q AVG																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
								TOTAL CORE %	SOLID CORE %					TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	10 ⁻⁶	10 ⁻⁵			10 ⁻⁴	10 ⁻³																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	

DEPTH SCALE

1 : 50



LOGGED: MR

CHECKED: AB


GTA-RCK 018 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-MISS.GDT 07/25/16

PROJECT		09-1111-6014		RECORD OF BOREHOLE No B502-13		SHEET 1 OF 2		METRIC														
W.P.		5145-08-01		LOCATION		N 5083167.3 ; E 222980.3		ORIGINATED BY														
DIST		HWY 69		BOREHOLE TYPE		150 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY														
DATUM		Geodetic		DATE		March 8, 2014		CHECKED BY														
								AB														
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV	DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ			GR SA SI CL		
183.5	0.0	GROUND SURFACE		1	AS	-			20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W _p — W — W _L 20 40 60			kN/m ³					
183.0	0.5	TOPSOIL		2A	SS	12		183														
		SILT, some clay, trace sand		2B	SS	12																
		Compact Brown Moist		3	SS	8		182														
		SAND, trace silt, trace organics to a depth of 1.0 m		4	SS	4																
		Very loose to compact		5	SS	2		181												0 96 4 0		
		Brown to grey Wet		6	SS	5		180														
				7	SS	6		179														
				8	SS	8		178														
178.0	5.5	CLAYEY SILT to SILTY CLAY, trace sand		9	SS	4		177														
		Firm Grey Wet		10	TO	PH		176									17.6					
				11	SS	1		175														
173.0	10.5	SILT, trace to some sand, trace to some clay, trace gravel		12	SS	4		174														
		Loose to compact Grey Wet		13	SS	10		173												4 8 81 7		
				14	SS	7		172														
169.0		BOULDER		15	RC REC	100%		169														
168.7																						

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No B502-13				SHEET 2 OF 2		METRIC									
W.P. <u>5145-08-01</u>		LOCATION <u>N 5083167.3 ; E 222980.3</u>				ORIGINATED BY <u>MR</u>											
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>150 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring</u>				COMPILED BY <u>MCK</u>											
DATUM <u>Geodetic</u>		DATE <u>March 8, 2014</u>				CHECKED BY <u>AB</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	SHEAR STRENGTH kPa					W _p W W _L				
--- CONTINUED FROM PREVIOUS PAGE ---																	
15.0	Granitic Gneiss (BEDROCK) Bedrock cored from depths of 15.0 m to 18.0 m. For bedrock coring details refer to Record of Drillhole B502-13.		1	RC	REC 100%	168											RQD = 100%
			2	RC	REC 100%	167											
165.5 18.0	END OF BOREHOLE NOTES: 1. Water level in piezometer at a depth of 1.4 m below ground surface (Elev. 182.1 m) on March 19, 2014. 2. Piezometer was installed 0.5 m West of Borehole B502-13.						166										

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B502-13

SHEET 1 OF 1

LOCATION: N 5083167.3 ;E 222980.3

DRILLING DATE: March 8, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: Diedrich D25

DRILLING CONTRACTOR: WALKER DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	FLUSH	JN - Joint FLT - Fault SH - Shear VN - Vein CJ - Conjugate	BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage	PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular	PO - Polished K - Slickensided SM - Smooth RO - Rough VR - Very Rough	MB - Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.	NOTES
15	NW (Casing)	Continued from Record of Borehole B502-13		168.50									
15		Slightly weathered, dark grey to pink bands, fine to medium grained, non-porous, very strong GRANITIC GNEISS		15.00	1								
16													
17	NQRC March 8, 2014	Bands of coarse grained feldspar											
18		Alteration halos around joints between depths of 17.6 m and 17.8 m			2								
18		END OF DRILLHOLE		165.46									
19				18.04									
20													
21													
22													
23													
24													
25													

DEPTH SCALE

1 : 50



LOGGED: MR

CHECKED: AB

GTA-RCK 018 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-MISS.GDT 07/25/16

PROJECT		RECORD OF BOREHOLE		No B502-14		SHEET 1 OF 2		METRIC							
W.P. 5145-08-01		LOCATION		N 5083185.8 ; E 222972.5		ORIGINATED BY		MAS							
DIST _____ HWY 69		BOREHOLE TYPE		150 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY		MCK							
DATUM Geodetic		DATE		March 10, 2014		CHECKED BY		AB							
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							
186.2	GROUND SURFACE														
0.0	TOPSOIL		1A		7										
0.2	SILT and SAND, trace clay Loose to compact Brown Moist		1B	SS											
			2	SS	14										
			3	SS	16										
			4	SS	13										
			5	SS	8										
181.6	CLAYEY SILT Stiff Grey Wet		6	SS	3										
180.1	SILT and SAND, trace clay Loose Grey Wet		7	SS	6										
178.0	CLAYEY SILT to SILTY CLAY Firm Grey Wet		8	SS	6										
			9	SS	4										
			10	TO	PH										
			11	SS	WH										
172.5	SILT, some sand Compact Grey Wet		12	SS	13										
171.4															
14.8															

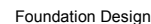
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+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No B502-14				SHEET 2 OF 2		METRIC															
W.P. <u>5145-08-01</u>		LOCATION <u>N 5083185.8 ;E 222972.5</u>				ORIGINATED BY <u>MAS</u>																	
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>150 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring</u>				COMPILED BY <u>MCK</u>																	
DATUM <u>Geodetic</u>		DATE <u>March 10, 2014</u>				CHECKED BY <u>AB</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															
	--- CONTINUED FROM PREVIOUS PAGE ---						<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> ○ UNCONFINED + FIELD VANE </div> <div style="display: flex; justify-content: space-between;"> ● QUICK TRIAXIAL × REMOULDED </div>																
	END OF BOREHOLE SPLIT-SPOON REFUSAL NOTE: 1. Water level in open borehole at a depth of 4.3 m below ground surface (Elev. 181.9 m) upon completion of drilling.																						

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

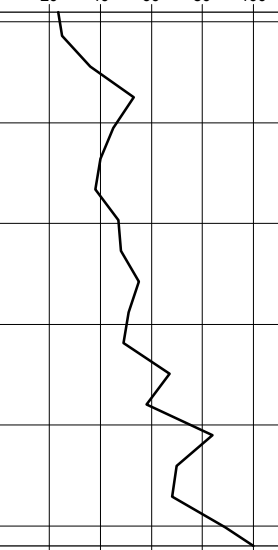
**METRIC**

CHECKED BY JPD

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT <u>09-1111-6014</u>						RECORD OF DCPT No S502-DC01				SHEET 2 OF 2		METRIC					
W.P. <u>5005-10-01</u>		LOCATION <u>N 5083130.2;E 222975.5</u>				ORIGINATED BY <u>MJR</u>											
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Dynamic Cone Penetration Test</u>				COMPILED BY <u>AV</u>											
DATUM <u>Geodetic</u>		DATE <u>March 12 and 13, 2013</u>				CHECKED BY <u>JPD</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									
	--- CONTINUED FROM PREVIOUS PAGE ---						<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> ○ UNCONFINED + FIELD VANE </div> <div style="display: flex; justify-content: space-between;"> ● QUICK TRIAXIAL × REMOULDED </div>										
160.8	20.3																
	END OF DCPT Refusal to Further Penetration (100 Blows/0.23 m)																

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT <u>09-1111-6014</u>		RECORD OF DCPT No S502-DC02		SHEET 1 OF 1		METRIC							
W.P. <u>5005-10-01</u>		LOCATION <u>N 5083151.2 ; E 222966.7</u>		ORIGINATED BY <u>ID</u>									
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Dynamic Cone Penetration Test</u>		COMPILED BY <u>AV</u>									
DATUM <u>Geodetic</u>		DATE <u>March 14, 2013</u>		CHECKED BY <u>JPD</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					
183.4 0.0	GROUND SURFACE Dynamic Cone Penetration Test (DCPT)						<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> ○ UNCONFINED + FIELD VANE </div> <div style="display: flex; justify-content: space-between;"> ● QUICK TRIAXIAL × REMOULDED </div>						
183													
182													
181													
180													
179													
178													
177													
176													
175													
174													
173													
172													
171													
170.8 12.7	END OF DCPT Refusal to Further Penetration												

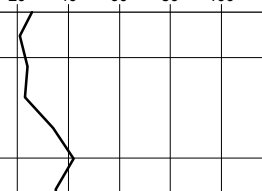
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PROJECT 09-1111-6014		RECORD OF DCPT No S502-DC03		SHEET 1 OF 1		METRIC							
W.P. 5005-10-01		LOCATION N 5083183.9;E 222915.3		ORIGINATED BY EHS									
DIST _____ HWY 69		BOREHOLE TYPE Dynamic Cone Penetration Test		COMPILED BY AV									
DATUM Geodetic		DATE March 4, 2013		CHECKED BY JPD									
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
190.4	GROUND SURFACE						20 40 60 80 100	20 40 60					
0.0	Dynamic Cone Penetration Test (DCPT)						20 40 60 80 100	20 40 60					
							190						
							189						
							188						
							187						
							186						
							185						
							184						
							183						
							182						
							181						
							180						
							179						
178.1	END OF DCPT												
12.3	Refusal to Further Penetration												

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16



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

PROJECT <u>09-1111-6014</u>				RECORD OF DCPT No S502-DC04				SHEET 2 OF 2				METRIC				
W.P. <u>5005-10-01</u>				LOCATION <u>N 5083218.6 ; E 222933.6</u>				ORIGINATED BY <u>ID</u>								
DIST <u> </u> HWY <u>69</u>				BOREHOLE TYPE <u>Dynamic Cone Penetration Test</u>				COMPILED BY <u>AV</u>								
DATUM <u>Geodetic</u>				DATE <u>March 13, 2013</u>				CHECKED BY <u>JPD</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	SHEAR STRENGTH kPa					W _p W W _L			
	--- CONTINUED FROM PREVIOUS PAGE ---						<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED </div>					WATER CONTENT (%) 20 40 60				
174.6	Dynamic Cone Penetration Test (DCPT)					176										
16.9	END OF DCPT Refusal to Further Penetration					175										


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PROJECT <u>09-1111-6014</u>				RECORD OF DCPT No S502-DC05				SHEET 1 OF 1				METRIC					
W.P. <u>5005-10-01</u>				LOCATION <u>N 5083232.6 ; E 222896.3</u>				ORIGINATED BY <u>LK</u>									
DIST <u> </u> HWY <u>69</u>				BOREHOLE TYPE <u>Dynamic Cone Penetration Test</u>				COMPILED BY <u>AV</u>									
DATUM <u>Geodetic</u>				DATE <u>January 22, 2013</u>				CHECKED BY <u>JPD</u>									
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W _p	W			
186.3	GROUND SURFACE						20	40	60	80	100	20	40	60			
0.0	Dynamic Cone Penetration Test (DCPT)						20	40	60	80	100	20	40	60			
184.1	END OF DCPT Refusal to Further Penetration (100 Blows / 0.08 m)						20	40	60	80	100	20	40	60			
2.2							20	40	60	80	100	20	40	60			

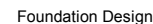
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PROJECT <u>09-1111-6014</u>		RECORD OF DCPT No S502-DC07		SHEET 1 OF 1		METRIC											
W.P. <u>5005-10-01</u>		LOCATION <u>N 5083277.0 ; E 222873.0</u>		ORIGINATED BY <u>LK</u>													
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Dynamic Cone Penetration Test</u>		COMPILED BY <u>AV</u>													
DATUM <u>Geodetic</u>		DATE <u>January 22, 2013</u>		CHECKED BY <u>JPD</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	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)
188.6 0.0	GROUND SURFACE Dynamic Cone Penetration Test (DCPT)						20	40	60	80	100						
							20	40	60	80	100						
186.0 2.6	END OF DCPT Refusal to Further Penetration (100 Blows / 0.15 m)																

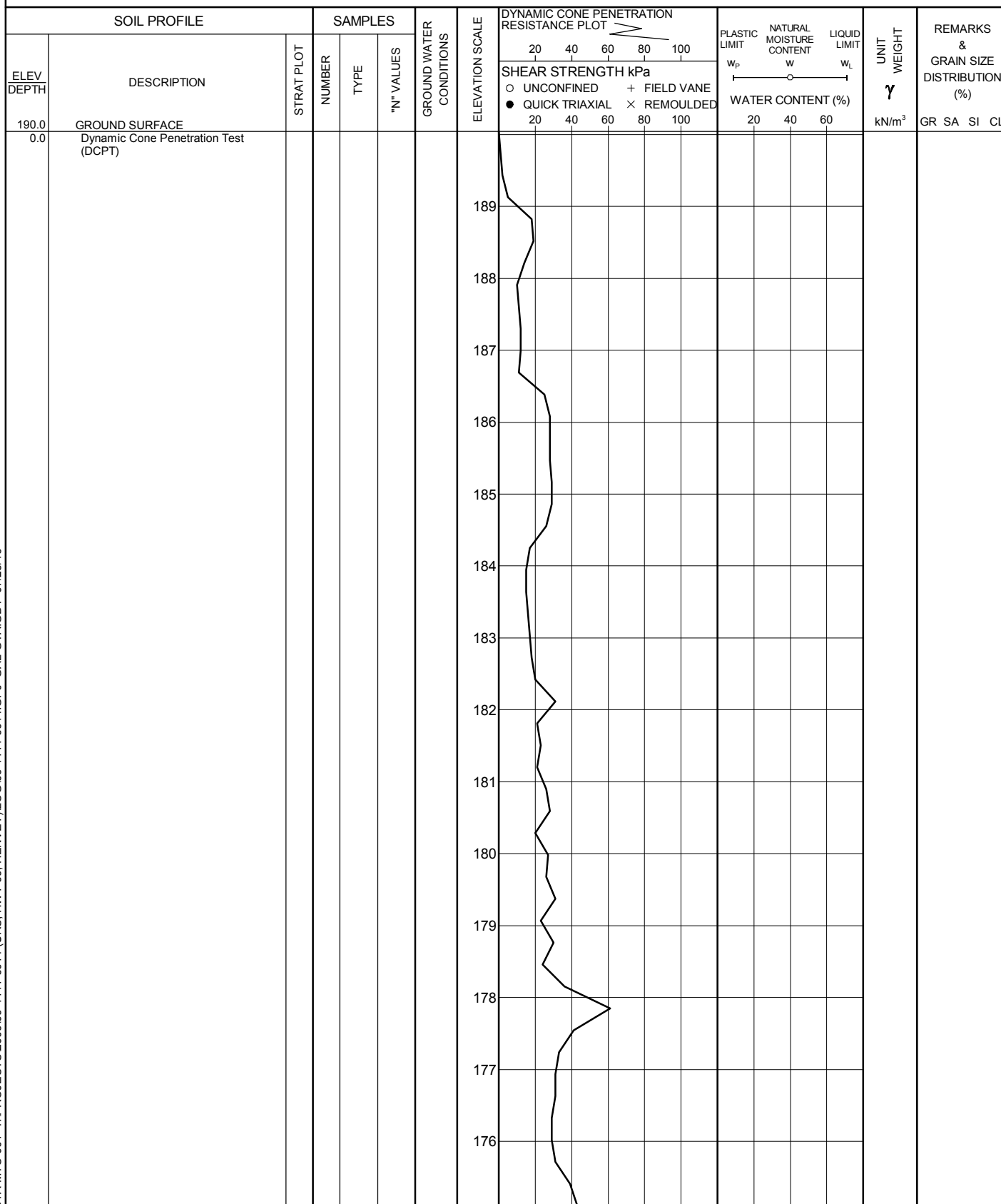
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PROJECT <u>09-1111-6014</u>		RECORD OF DCPT No S502-DC08		SHEET 1 OF 1		METRIC				
W.P. <u>5005-10-01</u>		LOCATION <u>N 5083189.8 ; E 222994.3</u>		ORIGINATED BY <u>ID</u>						
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Dynamic Cone Penetration Test</u>		COMPILED BY <u>AV</u>						
DATUM <u>Geodetic</u>		DATE <u>February 27, 2013</u>		CHECKED BY <u>JPD</u>						
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT  SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE						
184.2 0.0	GROUND SURFACE Dynamic Cone Penetration Test (DCPT)									
						184				
						183				
						182				
						181				
						180				
						179				
						178				
						177				
						176				
						175				
						174				
						173				
						172				
171.3 13.0	END OF DCPT Refusal to Further Penetration (30 Blows / 0.0 m)									

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16



PROJECT <u>09-1111-6014</u>		RECORD OF DCPT No S502-DC09		SHEET 1 OF 2		METRIC	
W.P. <u>5005-10-01</u>		LOCATION <u>N 5083199.0 ;E 222951.4</u>		ORIGINATED BY <u>EHS</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Dynamic Cone Penetration Test</u>		COMPILED BY <u>AV</u>			
DATUM <u>Geodetic</u>		DATE <u>March 4, 2013</u>		CHECKED BY <u>JPD</u>			



Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT 09-1111-6014										RECORD OF DCPT No S502-DC09										SHEET 2 OF 2										METRIC									
W.P. 5005-10-01										LOCATION N 5083199.0 ; E 222951.4										ORIGINATED BY EHS																			
DIST _____ HWY 69										BOREHOLE TYPE Dynamic Cone Penetration Test										COMPILED BY AV																			
DATUM Geodetic										DATE March 4, 2013										CHECKED BY JPD																			
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 (%)																												
	--- CONTINUED FROM PREVIOUS PAGE ---																																						
	Dynamic Cone Penetration Test (DCPT)																																						
169.7																																							
20.3	END OF DCPT Refusal to Further Penetration (41 Blows / 0.15m)																																						

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

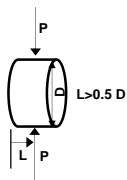
TABLE B.1
POINT LOAD TEST RESULTS ON ROCK SAMPLES

Borehole Number	Run Number	Sample Depth (m)	Sample Elevation (m)	Bedrock Description	Test Type	Core Length (mm)	Core Diameter (mm)	Is (50mm) (MPa)	Approx. UCS Value ⁽¹⁾ (MPa)
B501-02	1	37.4	141.2	Granitic Gneiss	Diametral	70.00	47.50	8.6	112
B501-02	1	37.5	141.1	Granitic Gneiss	Axial	34.70	47.50	8.5	111
B501-02	1	37.5	141.1	Granitic Gneiss	Diametral	78.00	47.50	7.3	94
B501-02	1	39.0	139.6	Granitic Gneiss	Axial	45.80	47.60	6.3	82
B501-02	1	39.0	139.6	Granitic Gneiss	Diametral	104.00	47.60	4.8	62
B501-02	2	40.6	138.1	Granitic Gneiss	Diametral	102.00	47.50	5.5	71
B501-12	1	28.3	152.8	Granitic Gneiss	Diametral	150.00	45.00	6.0	78
B501-12	2	29.1	151.9	Granitic Gneiss	Axial	60.00	45.00	4.4	58
B501-12	3	29.6	151.4	Granitic Gneiss	Diametral	120.00	45.00	8.6	112
B501-13	1	13.8	171.4	Granitic Gneiss	Diametral	165.00	45.00	10.1	131
B501-13	1	13.9	171.3	Granitic Gneiss	Axial	62.00	45.00	8.6	112
B501-13	2	15.7	169.4	Granitic Gneiss	Axial	42.00	45.00	1.0	14
B501-13	2	15.9	169.2	Granitic Gneiss	Diametral	120.00	45.00	10.1	132
B502-02	2	29.0	149.6	Granite Gneiss	Diametral	97.00	47.50	5.6	73
B502-02	2	29.0	149.6	Granite Gneiss	Axial	33.80	47.50	9.5	124
B502-02	3	30.2	148.4	Granitic Gneiss	Diametral	85.00	47.40	8.9	115
B502-02	3	30.2	148.4	Granitic Gneiss	Axial	39.60	47.50	10.8	140
B502-02	3	31.3	147.3	Granitic Gneiss	Diametral	90.00	47.40	7.9	103
B502-02	3	31.3	147.3	Granitic Gneiss	Axial	39.50	47.50	9.4	122
B502-12	1	15.5	163.8	Granitic Gneiss	Diametral	105.00	45.00	4.8	63
B502-12	1	15.6	163.7	Granitic Gneiss	Axial	55.00	45.00	9.8	128
B502-12	3	17.3	162.0	Granitic Gneiss	Diametral	115.00	45.00	4.8	63
B502-12	3	17.4	161.9	Granitic Gneiss	Axial	55.00	45.00	2.5	33
B502-13	1	15.3	168.2	Granitic Gneiss	Axial	55.00	45.00	3.7	48
B502-13	1	16.4	167.1	Granitic Gneiss	Diametral	160.00	45.00	7.5	97
B502-13	2	17.2	166.3	Granitic Gneiss	Diametral	115.00	45.00	7.8	101

⁽¹⁾ $I_{s50} \times K$, from ASTM Designation: D 5731 "Standard Test Method for Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classifications". A value of $K = 13$ has been used, based on three (3) UCS tests.

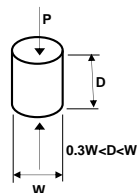
DIAMETRAL SPECIMEN SHAPE REQUIREMENTS

Note: Diametral tests are perpendicular to core axis (planes of weakness)



AXIAL SPECIMEN SHAPE REQUIREMENTS

Note: Axial tests are parallel to core axis (planes of weakness)



Compiled by: ARV

Reviewed by: JPD/JMAC

TABLE B.2
UNCONFINED COMPRESSION TEST (UC)
ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	09-1111-6014	RUN NUMBER	2
BOREHOLE NUMBER	B501-12	SAMPLE DEPTH, m	29.35-29.60

TEST CONDITIONS

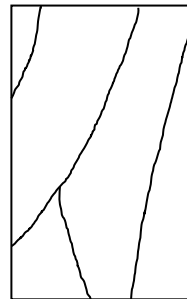
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.16

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	10.26	WATER CONTENT, (specimen) %	0.12
SAMPLE DIAMETER, cm	4.75	UNIT WEIGHT, kN/m ³	29.55
SAMPLE AREA, cm ²	17.70	DRY UNIT WT., kN/m ³	29.51
SAMPLE VOLUME, cm ³	181.65	SPECIFIC GRAVITY	-
WET WEIGHT, g	547.54	VOID RATIO	-
DRY WEIGHT, g	546.88		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	51.5
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REMARKS:	DATE: 4/17/2014
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TABLE B.3
UNCONFINED COMPRESSION TEST (UC)
ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	09-1111-6014	RUN NUMBER	2
BOREHOLE NUMBER	B502-13	SAMPLE DEPTH, m	16.52-16.74

TEST CONDITIONS

MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.20

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	10.47	WATER CONTENT, (specimen) %	0.08
SAMPLE DIAMETER, cm	4.75	UNIT WEIGHT, kN/m ³	26.15
SAMPLE AREA, cm ²	17.70	DRY UNIT WT., kN/m ³	26.13
SAMPLE VOLUME, cm ³	185.23	SPECIFIC GRAVITY	-
WET WEIGHT, g	494.15	VOID RATIO	-
DRY WEIGHT, g	493.75		

VISUAL INSPECTION

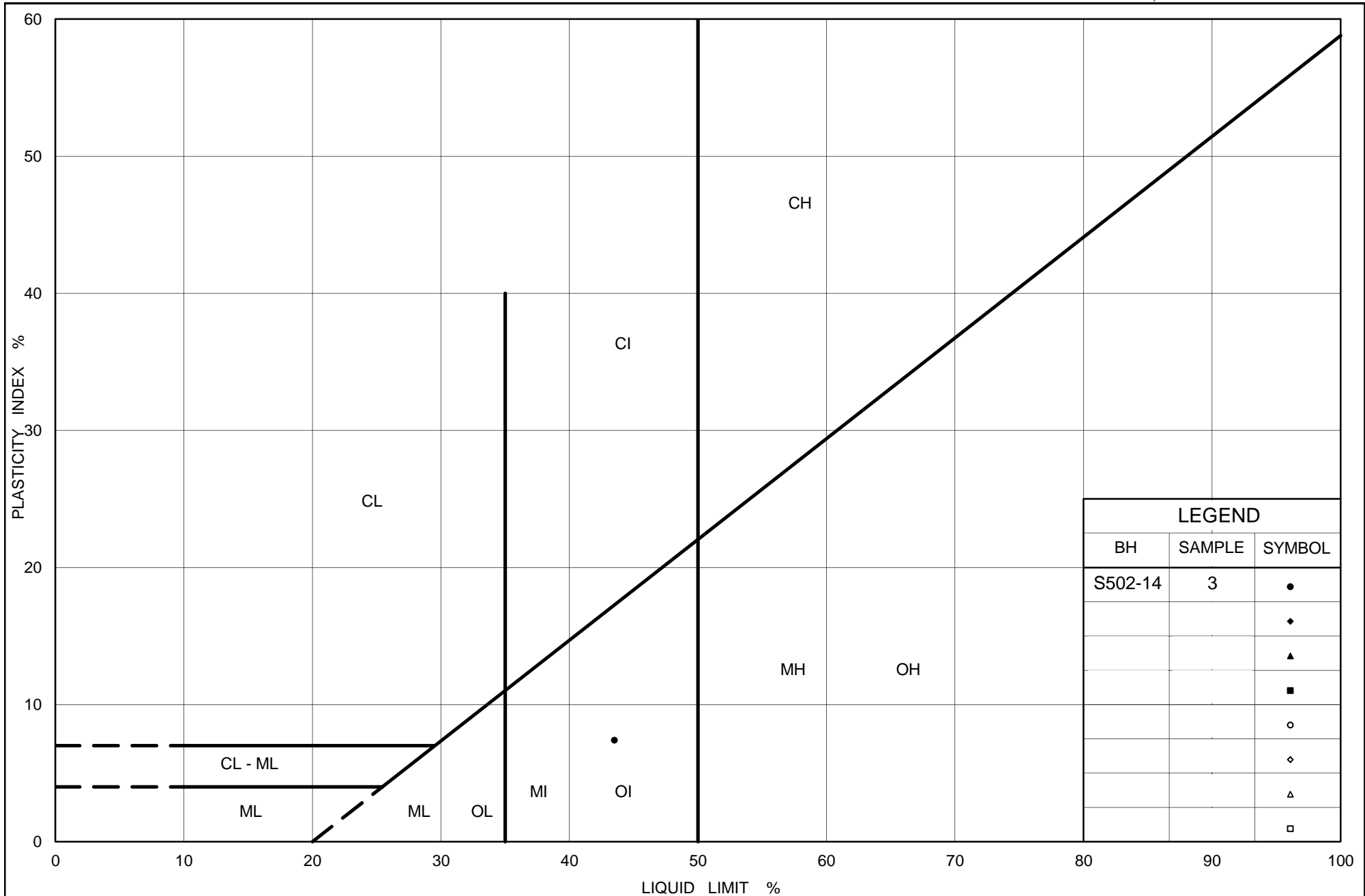
FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	110.6
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REMARKS:	DATE: 4/17/2014
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Ministry of Transportation

Ontario

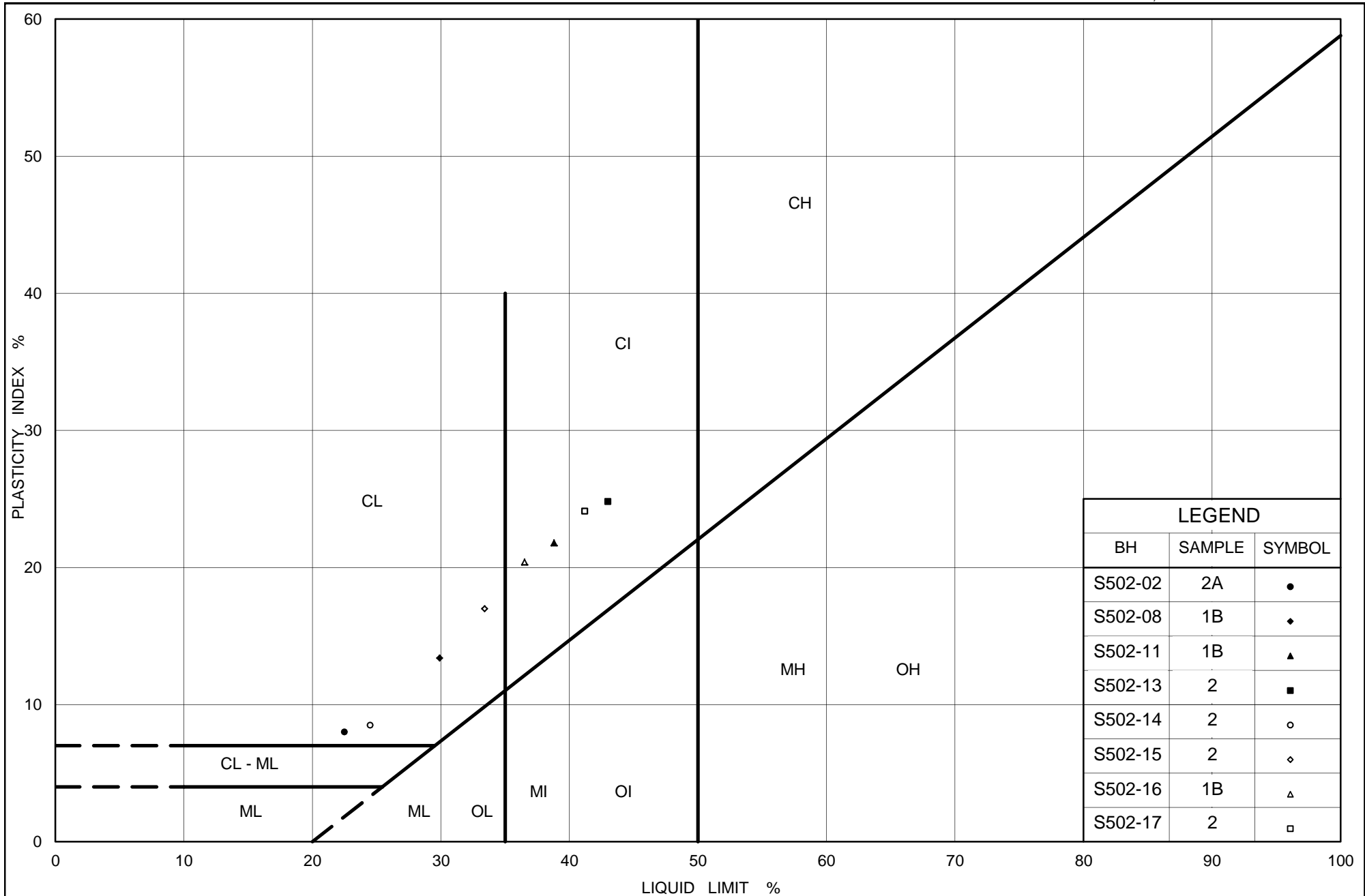
PLASTICITY CHART Organic Silt

Highway 69 (SBL) STA 20+980 to 21+180 (High Fill 502)

Figure No. B.S502-01

Project No. 09-1111-6014

Checked By: AV



Ministry of Transportation

Ontario

PLASTICITY CHART
 Clayey Silt to Silty Clay (Near Surface)
 Highway 69 (SBL) STA 20+980 to 21+180 (High Fill 502)

Figure No. B.S502-02

Project No. 09-1111-6014

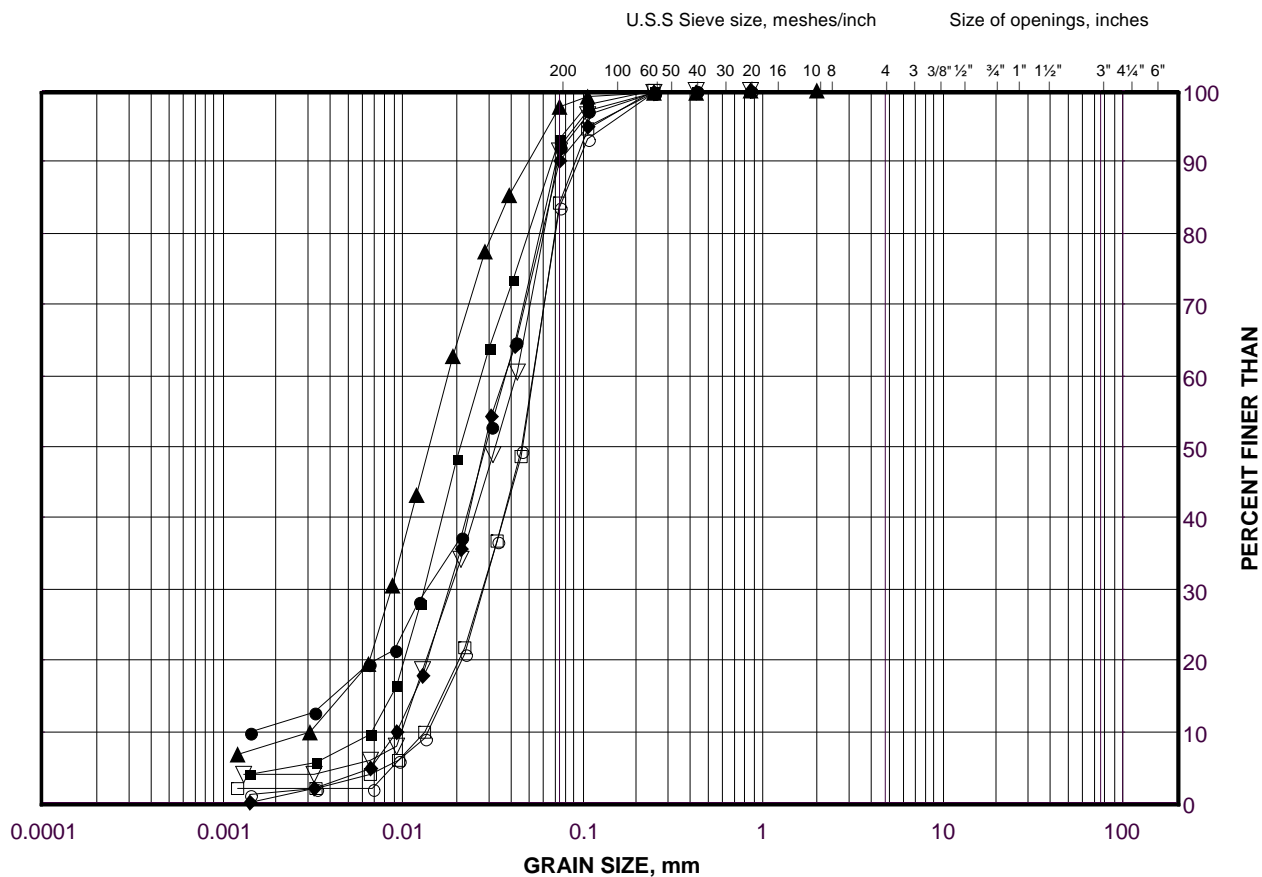
Checked By: AV

GRAIN SIZE DISTRIBUTION

Silt (Upper Deposit)

Highway 69 (SBL) STA 20+980 to 21+180 (High Fill 502)

FIGURE B.S502-03A



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S502-05	10	176.7
■	B501-13	11	174.1
◆	S502-11	11	180.5
▲	B501-14	12	175.8
▽	S502-09	13	177.0
○	S502-07	13	176.2
□	S502-06	9	180.5

Project Number: 09-1111-6014

Checked By: AV

Golder Associates

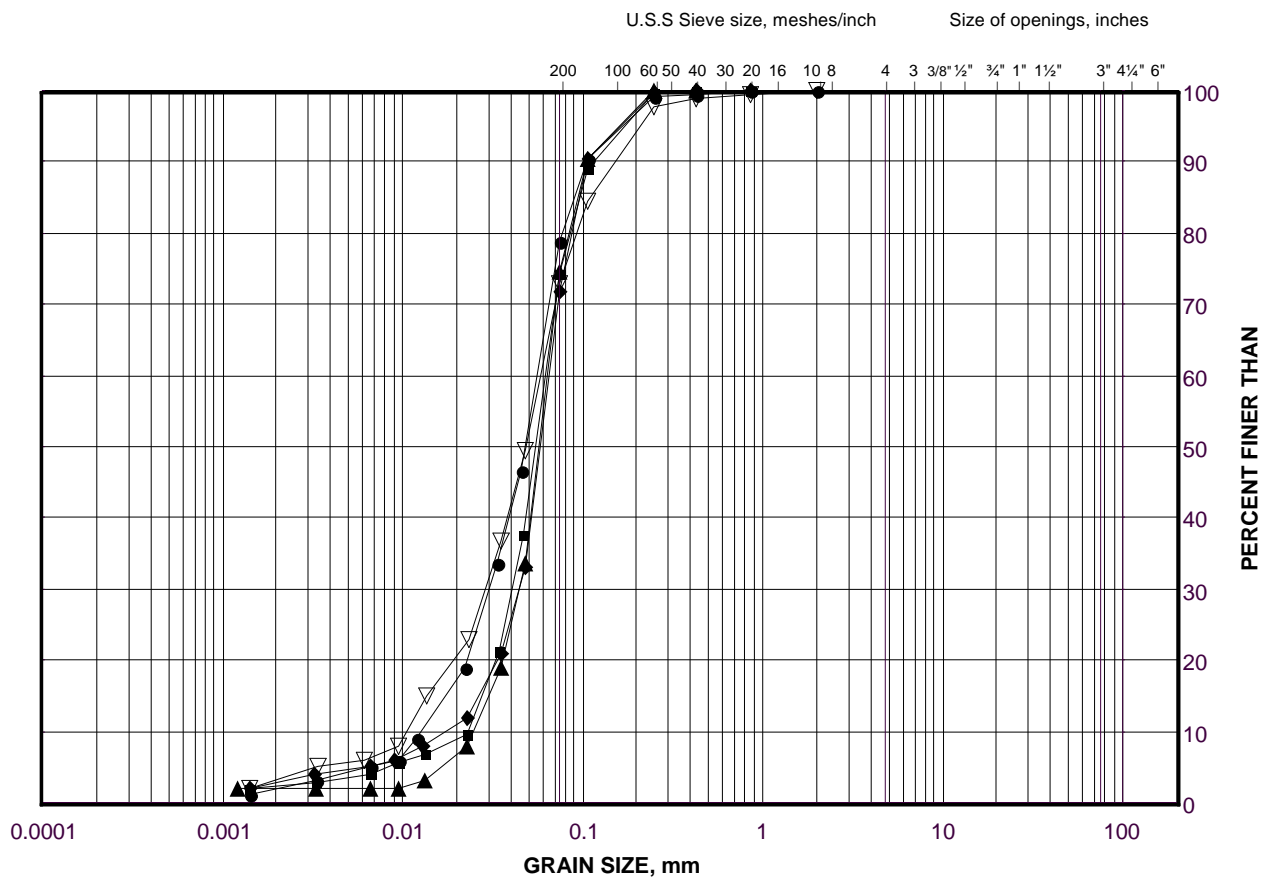
Date: 17-Oct-14

GRAIN SIZE DISTRIBUTION

Sandy Silt (Upper Deposit)

Highway 69 (SBL) STA 20+980 to 21+180 (High Fill 502)

FIGURE B.S502-03B



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S502-17	4	187.2
■	S502-05	5	182.7
◆	S502-05	6	182.0
▲	S502-06	7	183.5
▽	S502-15	8	184.5

Project Number: 09-1111-6014

Checked By: AV

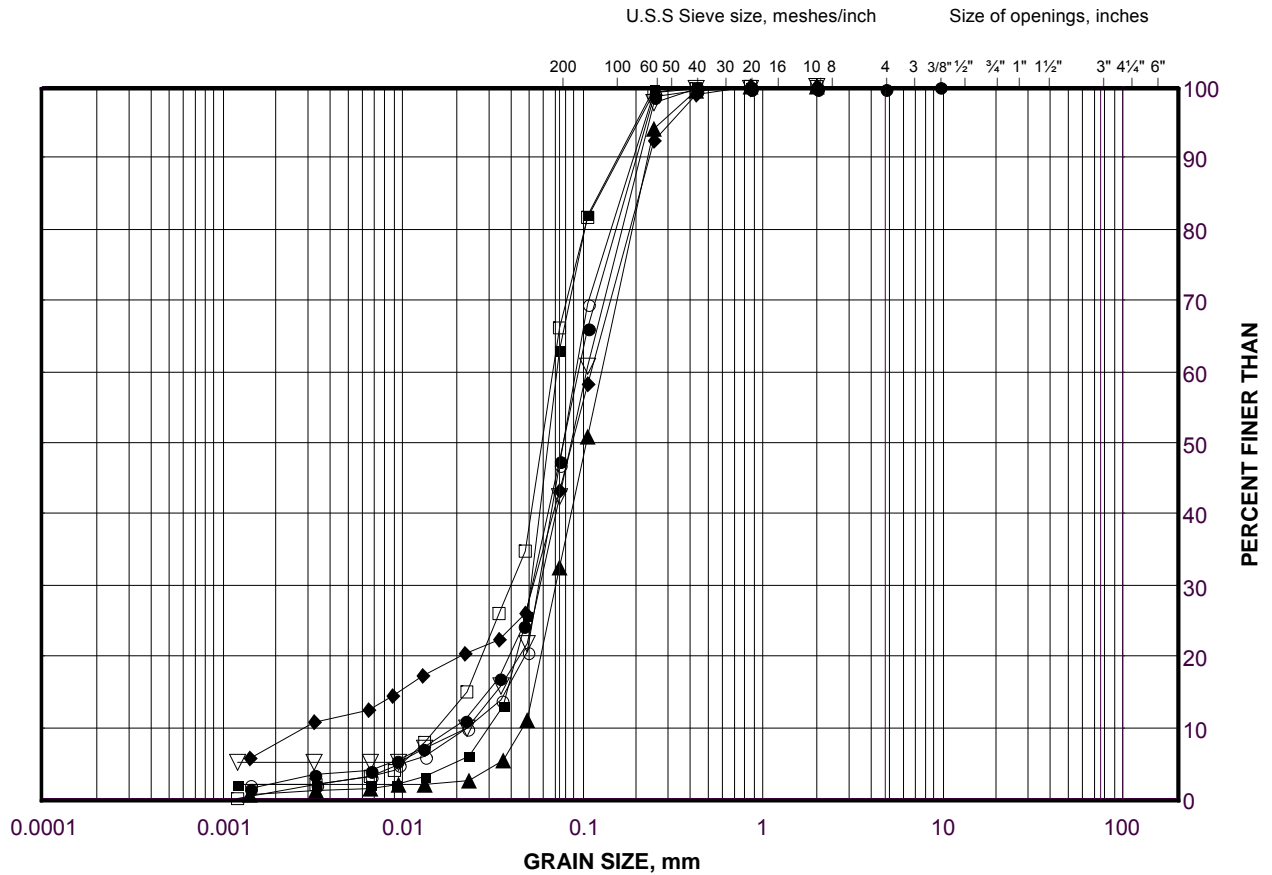
Golder Associates

Date: 17-Oct-14

GRAIN SIZE DISTRIBUTION

Silt and Sand (Upper Deposit)
Highway 69 (SBL) STA 20+980 to 21+180 (High Fill 502)

FIGURE B.S502-03C



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S502-01	3	179.3
■	S502-04	4	183.0
◆	S502-02	5	179.1
▲	S502-07	6	186.2
▽	S502-03	7	178.1
○	S502-04	8	179.2
□	S502-02	8	176.1

Project Number: 09-1111-6014

Checked By: AV

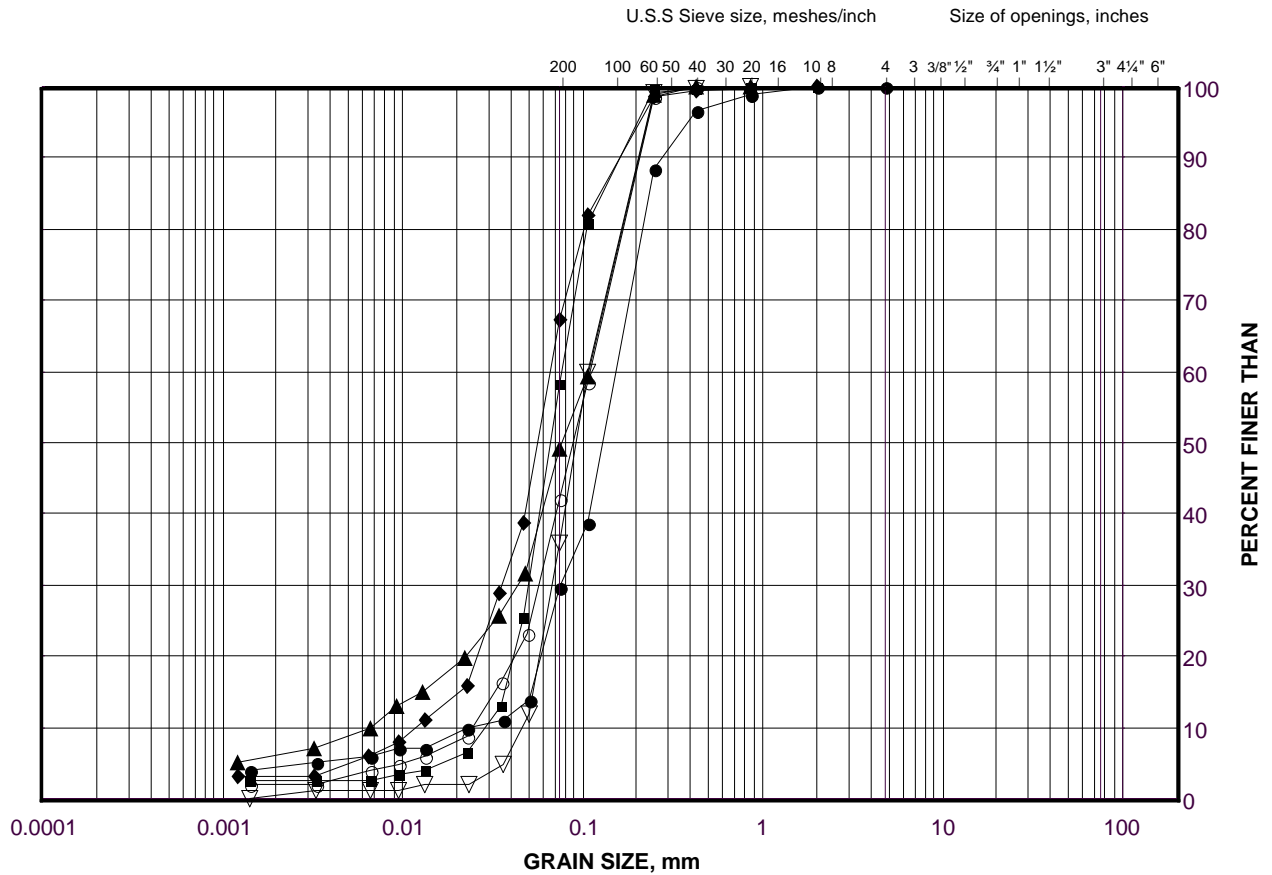
Golder Associates

Date: 20-Dec-13

GRAIN SIZE DISTRIBUTION

Silt and Sand to Silty Sand (Upper Deposit)
Highway 69 (SBL) STA 20+980 to 21+180 (High Fill 502)

FIGURE B.S502-03D



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	S502-21	3	185.5
■	B501-13	5	181.8
◆	S502-17	6	185.8
▲	S502-21	7	182.4
▽	S502-09	8	184.6
○	S502-21	8B	180.7

Project Number: 09-1111-6014

Checked By: AV

Golder Associates

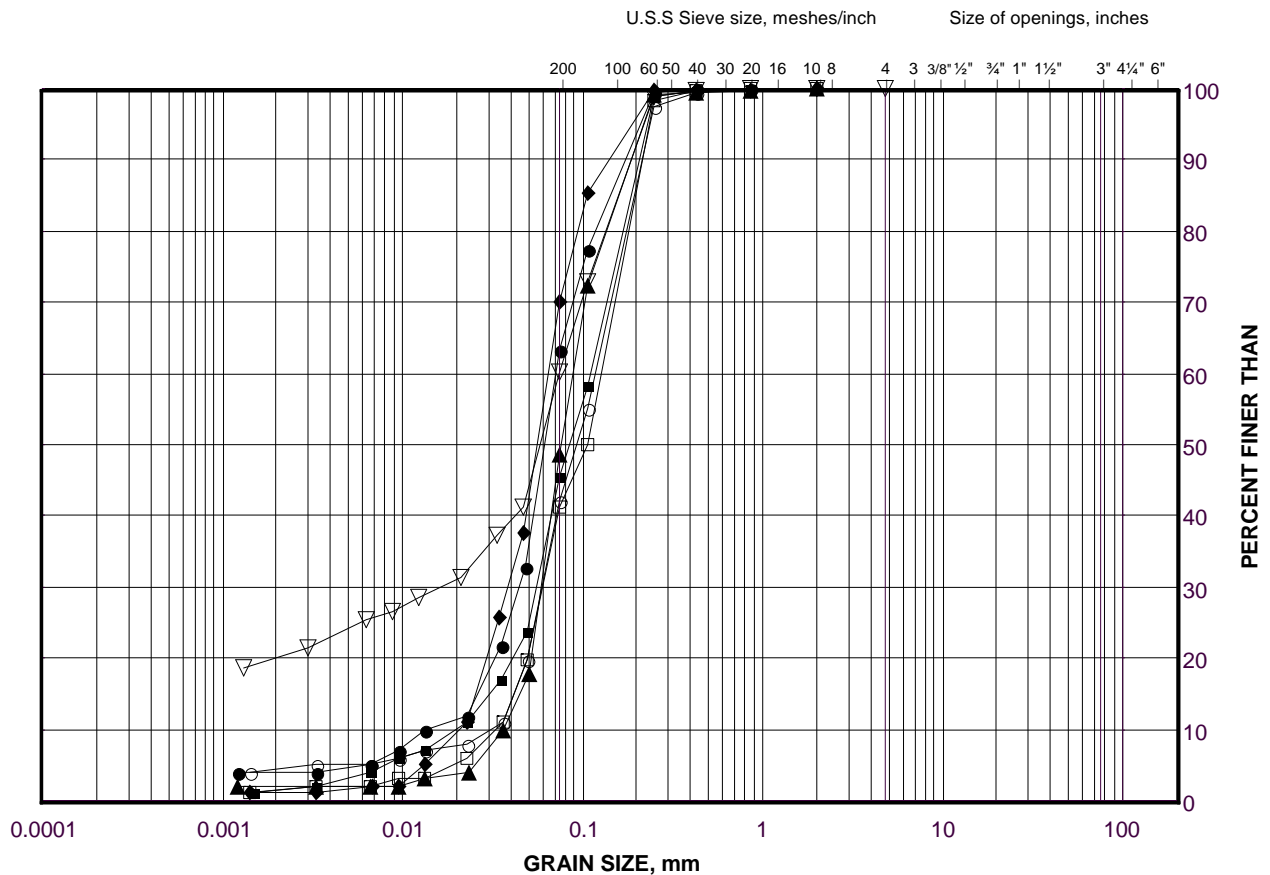
Date: 17-Oct-14

GRAIN SIZE DISTRIBUTION

Silt and Sand (Upper Deposit)

Highway 69 (SBL) STA 20+980 to 21+180 (High Fill 502)

FIGURE B.S502-03E



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S502-09	10	181.6
■	S502-11	10	182.1
◆	S502-12	11	181.2
▲	S502-10	11A	179.4
▽	S502-10	5	187.0
○	S502-12	7	187.2
□	S502-11	7	186.6

Project Number: 09-1111-6014

Checked By: AV

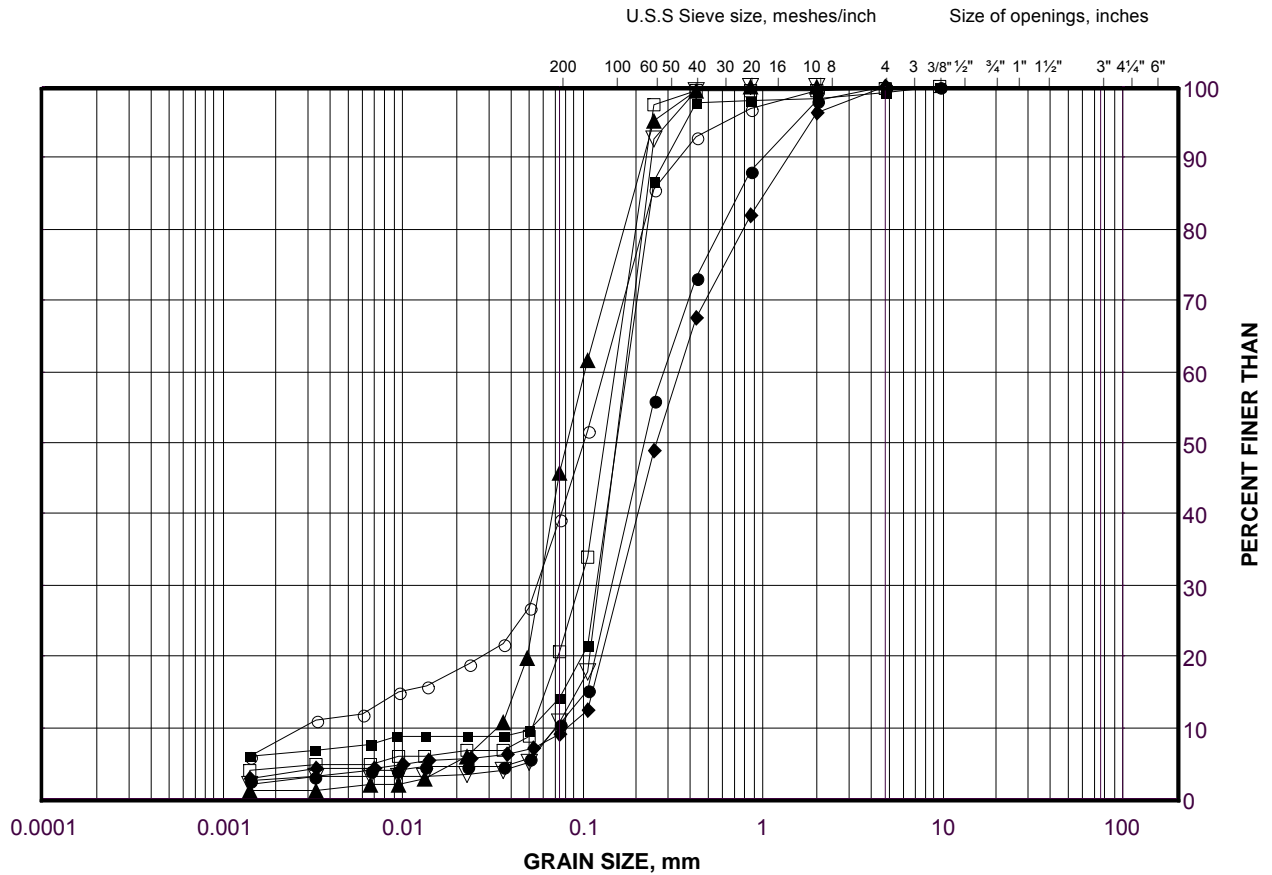
Golder Associates

Date: 17-Oct-14

GRAIN SIZE DISTRIBUTION

Silt and Sand to Sand (Upper Deposit)
Highway 69 (SBL) STA 20+980 to 21+180 (High Fill 502)

FIGURE B.S502-03F



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S502-16	3	189.6
■	S502-12	4	189.5
◆	S502-13	4	186.2
▲	S502-16	5	188.0
▽	S502-11	5	188.1
○	S502-13	6	185.0
□	S502-12	6A	188.1

Project Number: 09-1111-6014

Checked By: AV

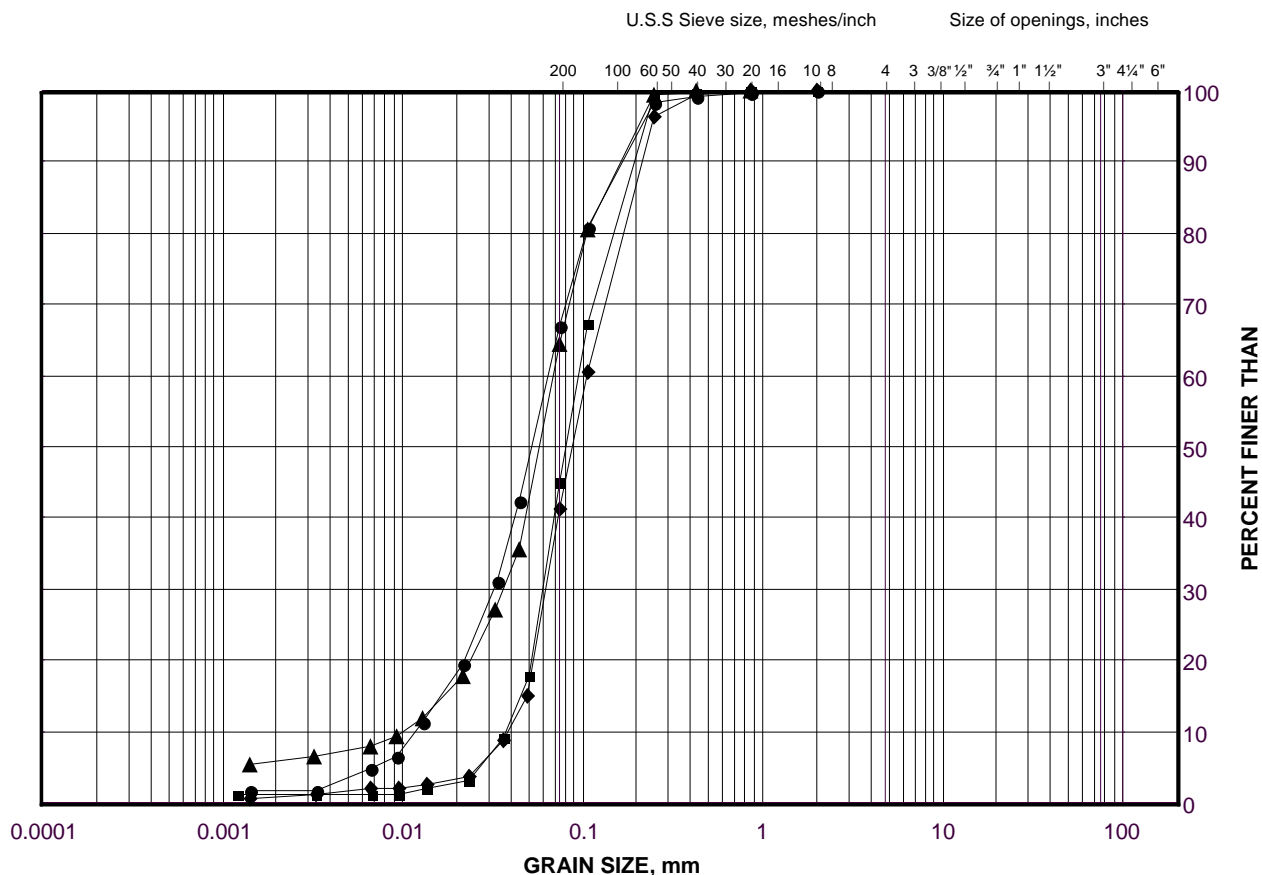
Golder Associates

Date: 07-Nov-13

GRAIN SIZE DISTRIBUTION

Silt and Sand (Upper Deposit)
Highway 69 (SBL) STA 20+980 to 21+180 (High Fill 502)

FIGURE B.S502-03G



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S502-05	12	173.6
■	S502-03	3	181.2
◆	B501-14	4	185.7
▲	B501-13	8	178.7

Project Number: 09-1111-6014

Checked By: AV

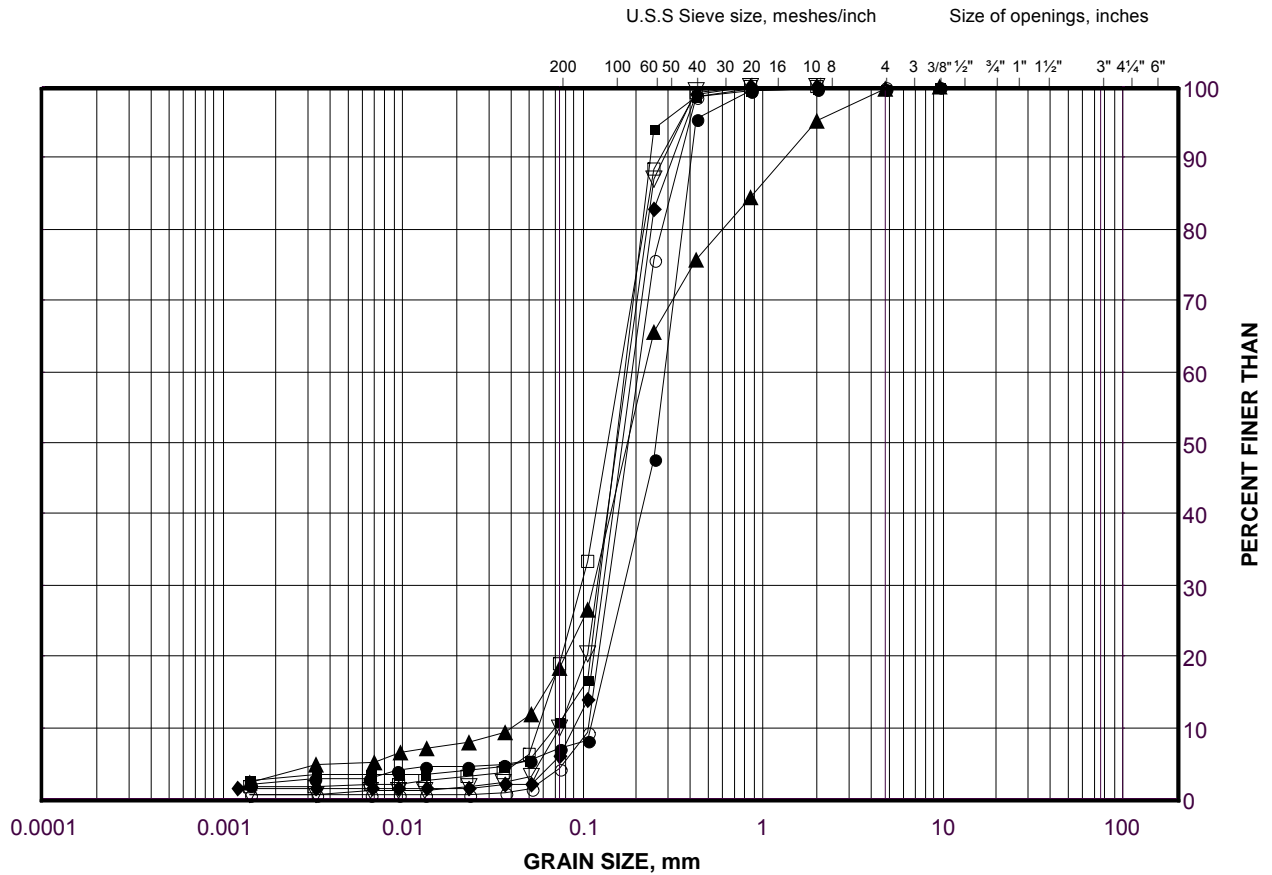
Golder Associates

Date: 17-Oct-14

GRAIN SIZE DISTRIBUTION

Sand (Upper Deposit)
Highway 69 (SBL) STA 20+980 to 21+180 (High Fill 502)

FIGURE B.S502-03H



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S502-09	2	189.9
■	S502-10	4	187.7
◆	S502-02	4	179.9
▲	S502-15	5	186.4
▽	S502-08	7	185.8
○	S502-04	7	180.7
□	S502-06	8	182.0

Project Number: 09-1111-6014

Checked By: AV

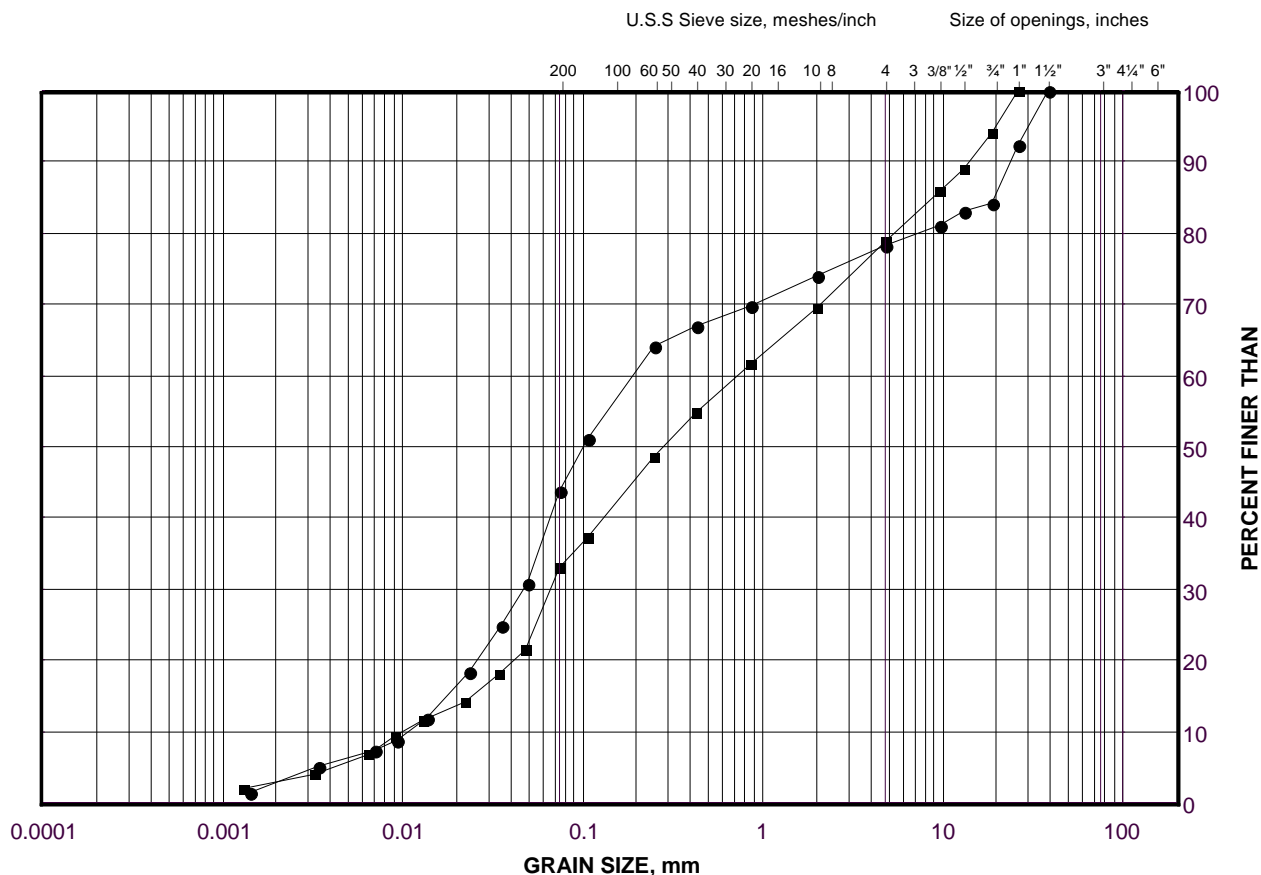
Golder Associates

Date: 07-Nov-13

GRAIN SIZE DISTRIBUTION

Gravelly Silt and Sand (Upper Deposit)
Highway 69 (SBL) STA 20+980 to 21+180 (High Fill 502)

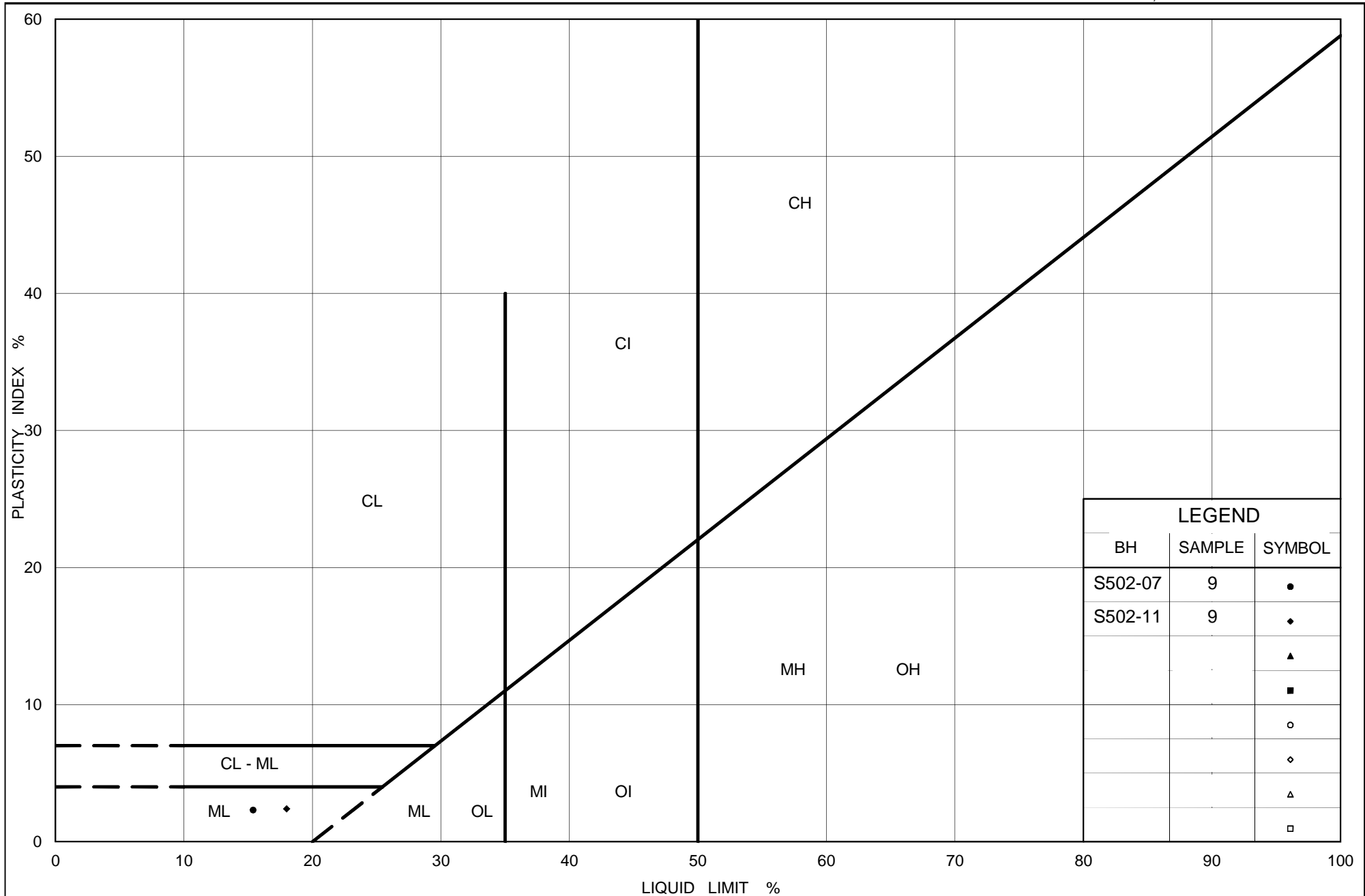
FIGURE B.S502-03I



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S502-15	10	183.3
■	S502-07	15	173.9



Ministry of Transportation

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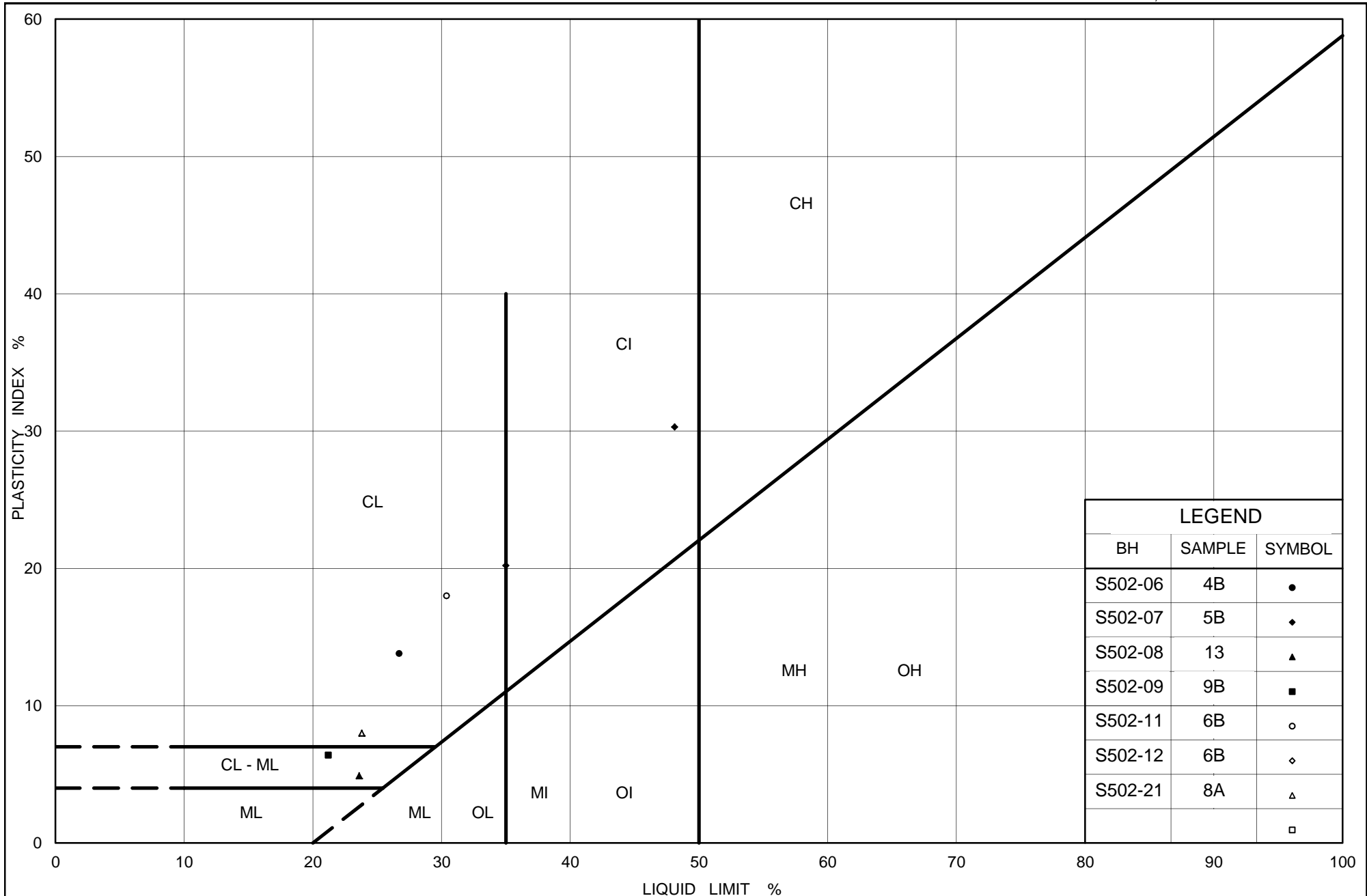
PLASTICITY CHART Silt

Highway 69 (SBL) STA 20+980 to 21+180 (High Fill 502)

Figure No. B.S502-04

Project No. 09-1111-6014

Checked By: AV



Ministry of Transportation

Ontario

PLASTICITY CHART
 Clayey Silt to Silty Clay (Pockets)
 Highway 69 (SBL) STA 20+980 to 21+180 (High Fill 502)

Figure No. B.S502-05

Project No. 09-1111-6014

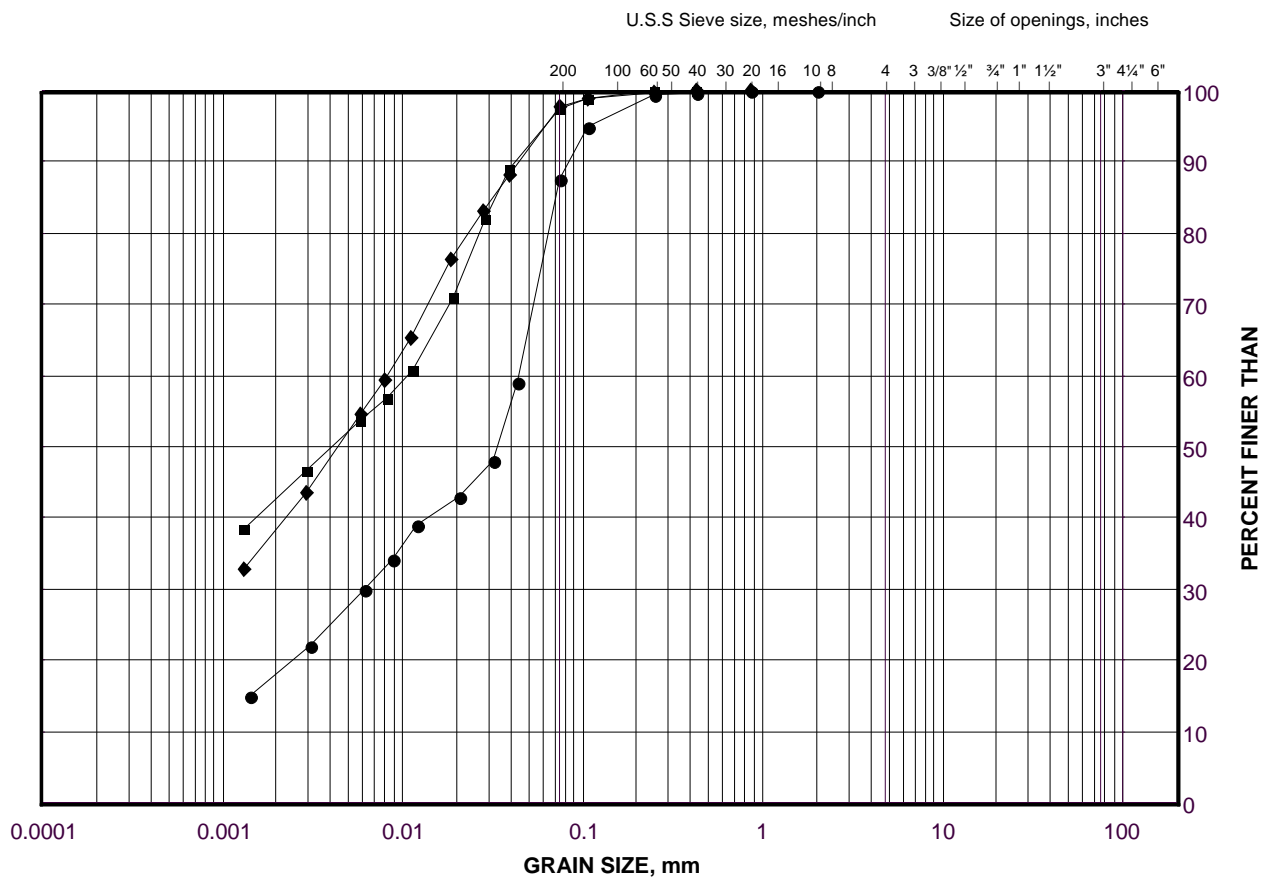
Checked By: AV

GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay

Highway 69 (SBL) STA 20+980 to 21+180 (High Fill 502)

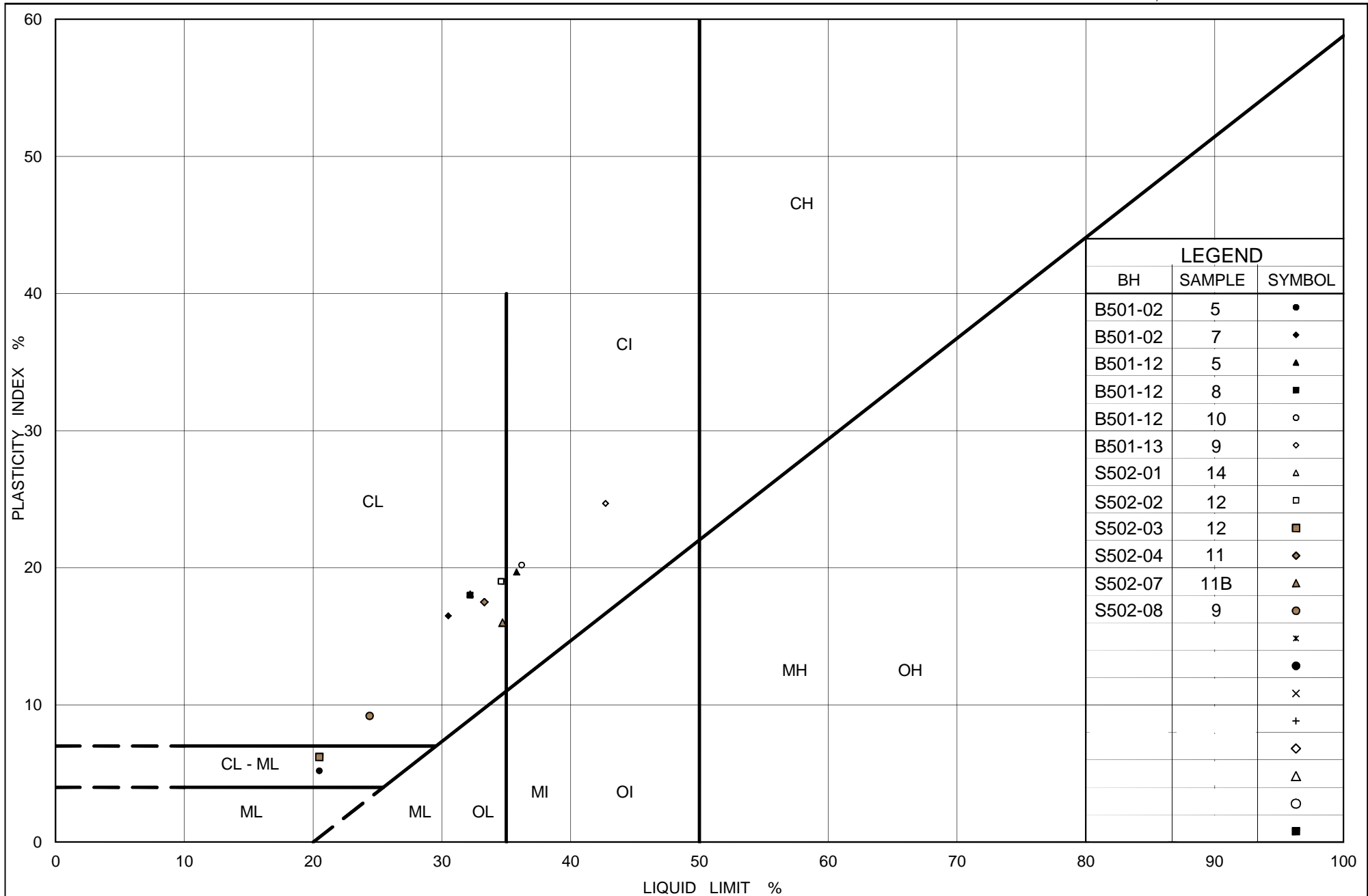
FIGURE B.S502-06



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S502-03	11	172.0
■	B501-12	5	178.0
◆	B501-12	8	174.9



Ministry of
Transportation

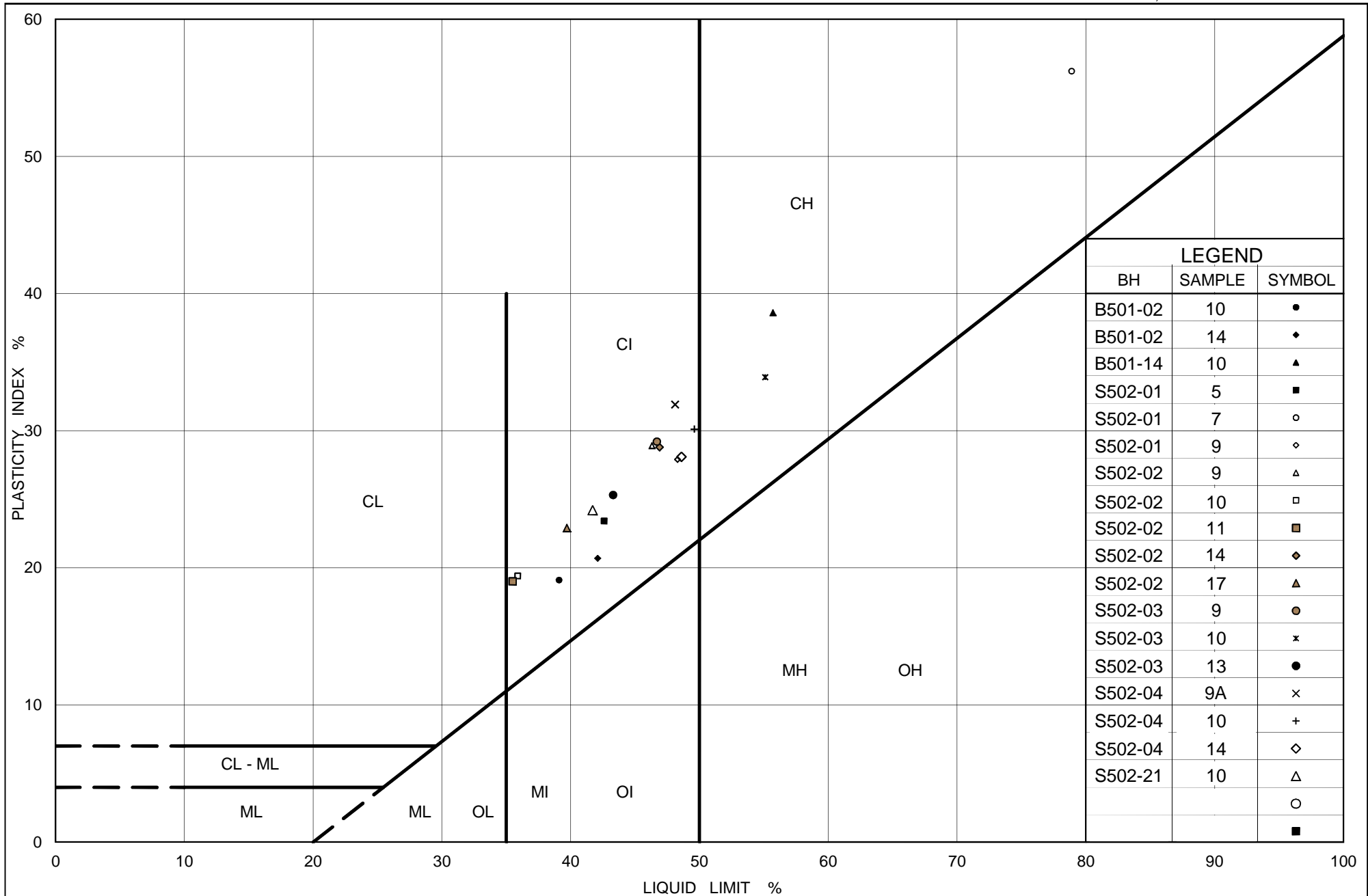
Ontario

PLASTICITY CHART
Clayey Silt to Silty Clay
Highway 69 (SBL) STA 20+980 to 21+180 (High Fill 502)

Figure No. B.S502-07A

Project No. 09-1111-6014

Checked By: AV



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Transportation

Ontario

PLASTICITY CHART

Silty Clay to Clay

Highway 69 (SBL) STA 20+980 to 21+180 (High Fill 502)

Figure No. B.S502-07B

Project No. 09-1111-6014

Checked By: AV

CONSOLIDATION TEST SUMMARY**Figure B.S502-08**
Sheet 1 of 4**SAMPLE IDENTIFICATION**

Project Number	09-1111-6014	Sample Number	7
Borehole Number	S502-01	Sample Depth, m	5.6-5.9

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	8		
Date Started	8/21/2013		
Date Completed	9/10/2013		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.90	Unit Weight, kN/m ³	15.52
Sample Diameter, cm	6.30	Dry Unit Weight, kN/m ³	8.71
Area, cm ²	31.19	Specific Gravity, measured	2.78
Volume, cm ³	59.27	Solids Height, cm	0.607
Water Content, %	78.17	Volume of Solids, cm ³	18.94
Wet Mass, g	93.79	Volume of Voids, cm ³	40.33
Dry Mass, g	52.64	Degree of Saturation, %	102.0

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t ₉₀ sec	cv. cm ² /s	mv m ² /kN	k cm/s
0.00	1.900	2.130	1.900				
6.48	1.903	2.135	1.902				
11.33	1.902	2.133	1.903	3	2.56E-01	1.09E-04	2.72E-06
21.23	1.900	2.130	1.901	10	7.66E-02	1.06E-04	7.98E-07
40.93	1.895	2.122	1.898	54	1.41E-02	1.34E-04	1.85E-07
21.23	1.899	2.128	1.897				
6.48	1.903	2.135	1.901				
21.23	1.897	2.125	1.900	10	7.65E-02	2.14E-04	1.61E-06
41.12	1.894	2.120	1.896	22	3.46E-02	7.94E-05	2.69E-07
80.34	1.877	2.091	1.885	86	8.76E-03	2.35E-04	2.02E-07
158.77	1.779	1.930	1.828	205	3.45E-03	6.55E-04	2.22E-07
315.56	1.488	1.451	1.633	913	6.20E-04	9.76E-04	5.93E-08
628.83	1.320	1.175	1.404	507	8.24E-04	2.82E-04	2.28E-08
1257.84	1.184	0.950	1.252	359	9.26E-04	1.14E-04	1.04E-08
2513.33	1.081	0.781	1.133	240	1.13E-03	4.30E-05	4.77E-09
1257.84	1.090	0.795	1.086				
315.56	1.128	0.858	1.109				
80.34	1.172	0.931	1.150				
21.23	1.217	1.005	1.195				
6.48	1.247	1.054	1.232				

Note:

Consolidation loading and unloading schedule assigned by the client.

Specimen taken 31-37 cm from bottom of the tube

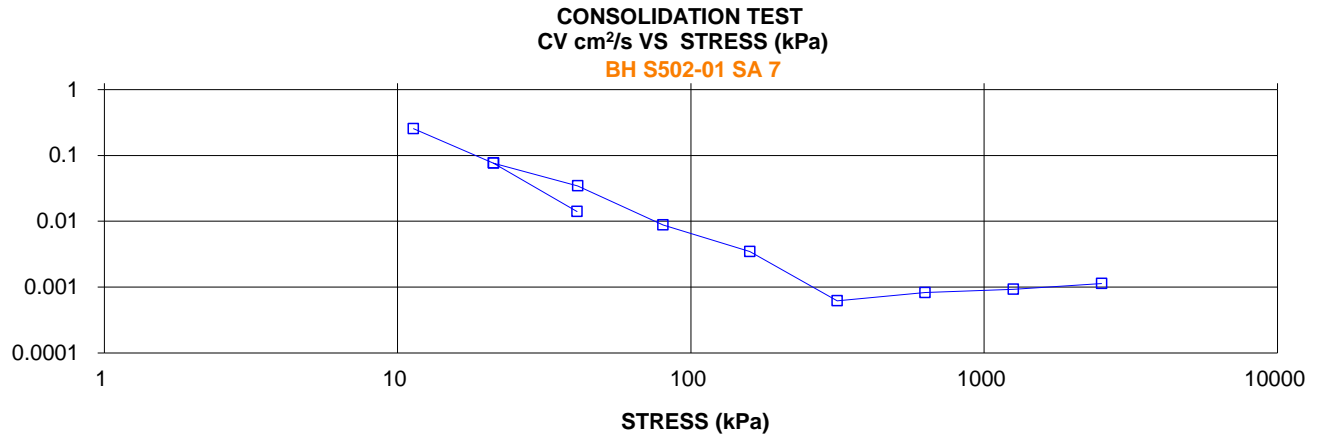
k calculated using cv based on t₉₀ values.**SAMPLE DIMENSIONS AND PROPERTIES - FINAL**

Sample Height, cm	1.25	Unit Weight, kN/m ³	18.49
Sample Diameter, cm	6.30	Dry Unit Weight, kN/m ³	13.27
Area, cm ²	31.19	Specific Gravity, measured	2.78
Volume, cm ³	38.90	Solids Height, cm	0.607
Water Content, %	39.32	Volume of Solids, cm ³	18.94
Wet Mass, g	73.34	Volume of Voids, cm ³	19.96
Dry Mass, g	52.64		

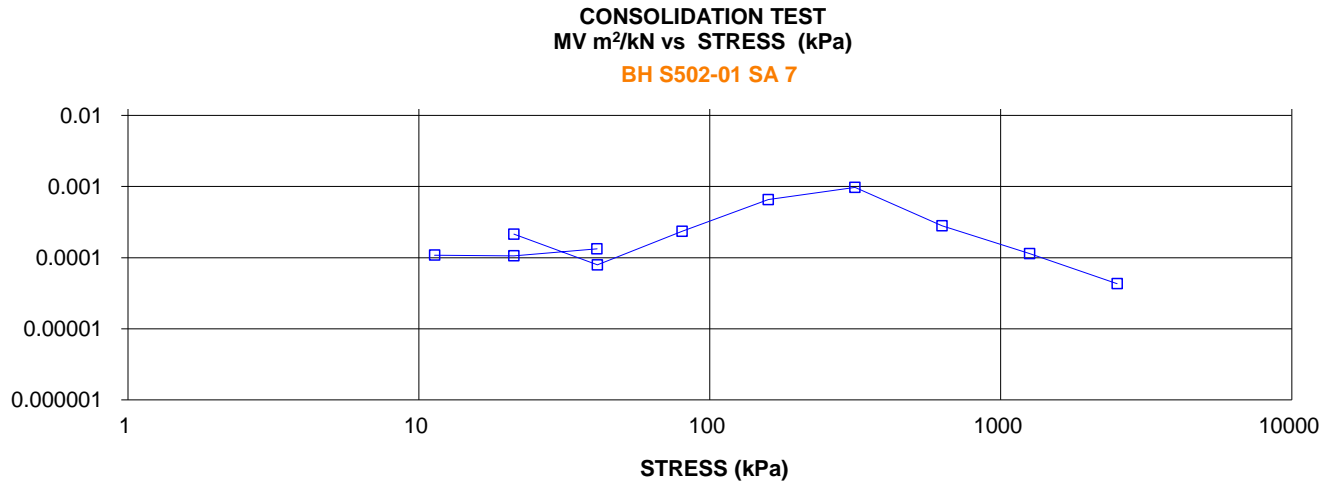
CONSOLIDATION TEST SUMMARY

Figure B.S502-08
Sheet 2 of 4

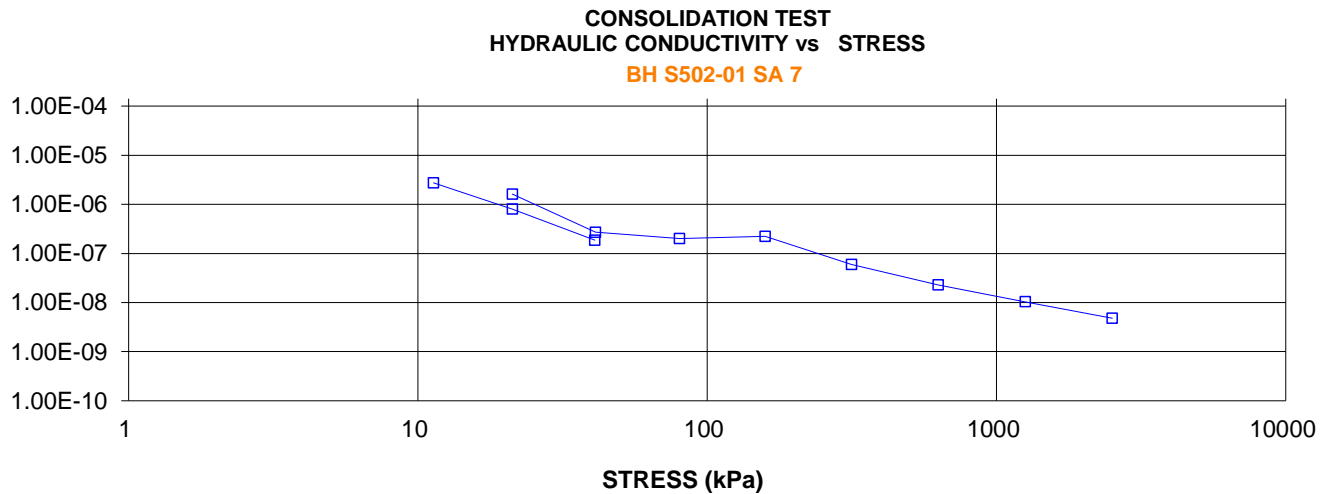
COEFFICIENT OF CONSOLIDATION,
cm²/s



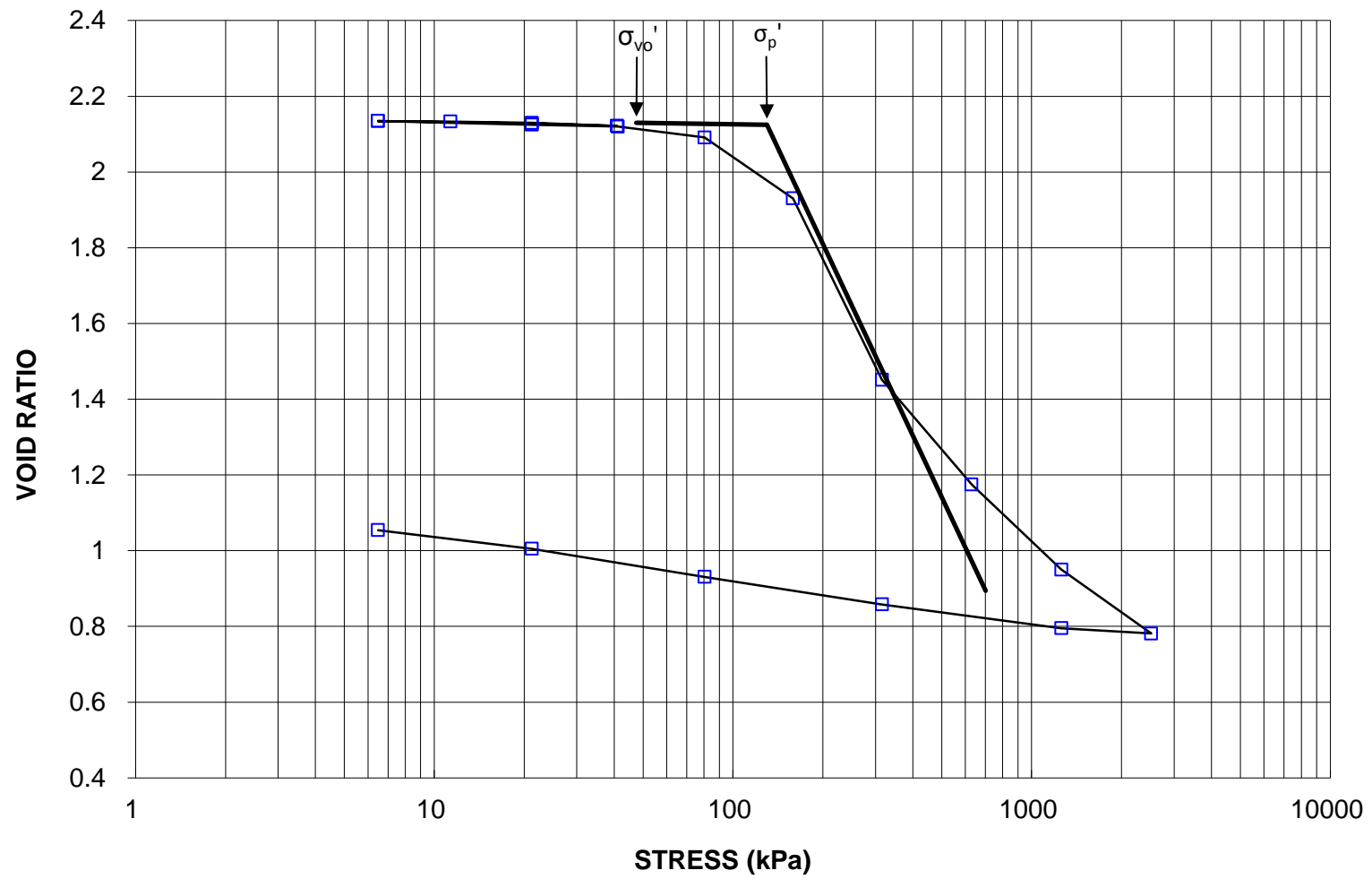
VOLUME COMPRESSIBILITY, m²/kN



HYDRAULIC CONDUCTIVITY, cm/s



CONSOLIDATION TEST
VOID RATIO vs STRESS
BH S502-01 SA 7



CONSOLIDATION TEST SUMMARY**FIGURE B.S502-09****Sheet 1 of 4****SAMPLE DIMENSIONS AND PROPERTIES - INITIAL**

Project Number	09-1111-6014	Sample Number	12
Borehole Number	S502-02	Sample Depth, m	12.2-12.8

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	9		
Date Started	8/21/2013		
Date Completed	9/10/2013		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.90	Unit Weight, kN/m ³	16.66
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m ³	10.80
Area, cm ²	31.55	Specific Gravity, measured	2.79
Volume, cm ³	60.04	Solids Height, cm	0.751
Water Content, %	54.30	Volume of Solids, cm ³	23.70
Wet Mass, g	102.02	Volume of Voids, cm ³	36.34
Dry Mass, g	66.12	Degree of Saturation, %	98.8

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t ₉₀ sec	cv. cm ² /s	mv m ² /kN	k cm/s
0	1.903	1.533	1.903				
6.38	1.903	1.533	1.903				
11.21	1.903	1.533	1.903	38	2.02E-02	2.18E-05	4.31E-08
21.15	1.901	1.531	1.902	25	3.07E-02	1.00E-04	3.02E-07
40.45	1.890	1.516	1.896	107	7.12E-03	2.91E-04	2.03E-07
79.39	1.874	1.495	1.882	98	7.66E-03	2.17E-04	1.63E-07
118.16	1.860	1.476	1.867	135	5.47E-03	1.95E-04	1.05E-07
79.39	1.868	1.487	1.864				
21.03	1.875	1.497	1.872				
6.38	1.883	1.507	1.879				
21.03	1.874	1.495	1.878	49	1.53E-02	3.23E-04	4.83E-07
79.39	1.864	1.482	1.869	43	1.72E-02	8.82E-05	1.49E-07
118.16	1.857	1.472	1.860	54	1.36E-02	1.00E-04	1.34E-07
156.88	1.845	1.456	1.851	1500	4.84E-04	1.62E-04	7.66E-09
312.13	1.751	1.331	1.798	919	7.46E-04	3.17E-04	2.32E-08
622.49	1.553	1.068	1.652	360	1.61E-03	3.35E-04	5.28E-08
1245.55	1.396	0.858	1.475	262	1.76E-03	1.33E-04	2.29E-08
2484.00	1.296	0.725	1.346	118	3.25E-03	4.25E-05	1.35E-08
1242.55	1.302	0.733	1.299				
312.13	1.335	0.778	1.319				
79.39	1.376	0.832	1.356				
21.03	1.410	0.877	1.393				
6.38	1.433	0.908	1.422				

Note:

Specimen taken 16 to 21cm from bottom of the tube

k calculated using cv based on t₉₀ values.**SAMPLE DIMENSIONS AND PROPERTIES - FINAL**

Sample Height, cm	1.43	Unit Weight, kN/m ³	18.98
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m ³	14.34
Area, cm ²	31.55	Specific Gravity, measured	2.79
Volume, cm ³	45.21	Solids Height, cm	0.751
Water Content, %	32.35	Volume of Solids, cm ³	23.70
Wet Mass, g	87.51	Volume of Voids, cm ³	21.51
Dry Mass, g	66.12		

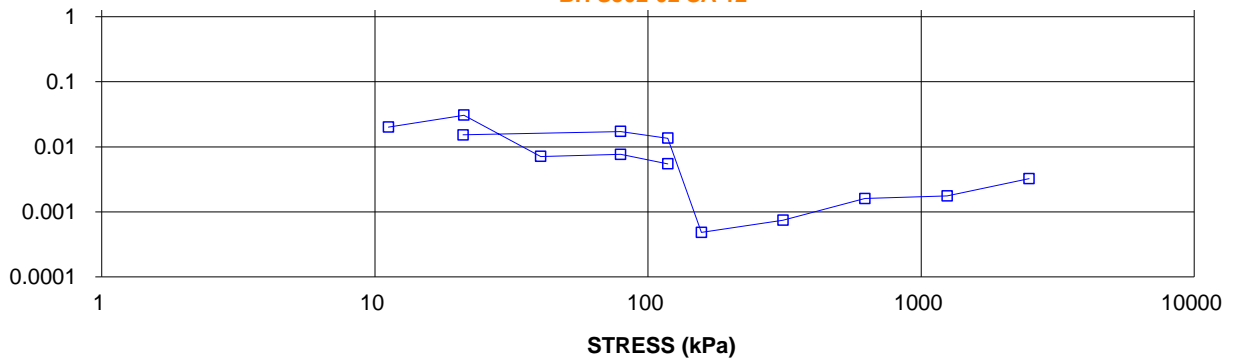
CONSOLIDATION TEST SUMMARY

FIGURE B.S502-09

Sheet 2 of 4

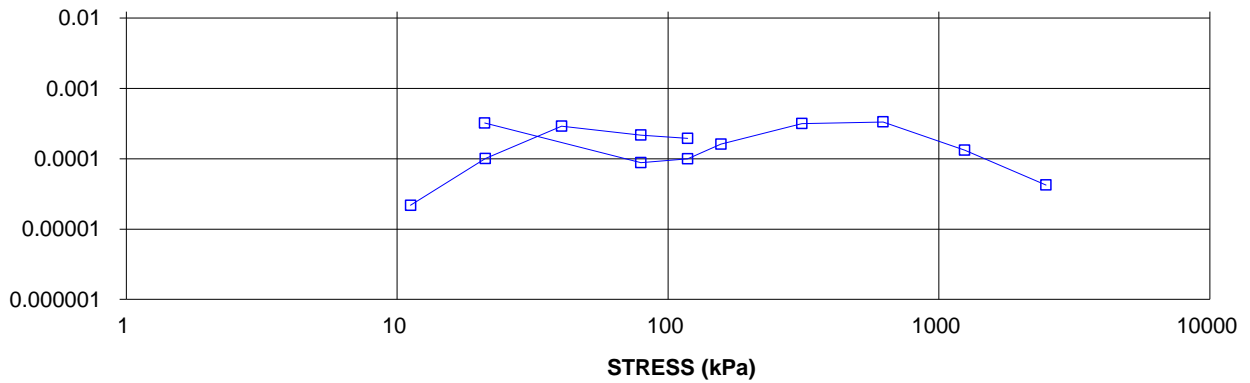
COEFFICIENT OF CONSOLIDATION,
cm²/s

CONSOLIDATION TEST
CV cm²/s VS STRESS (kPa)
BH S502-02 SA 12



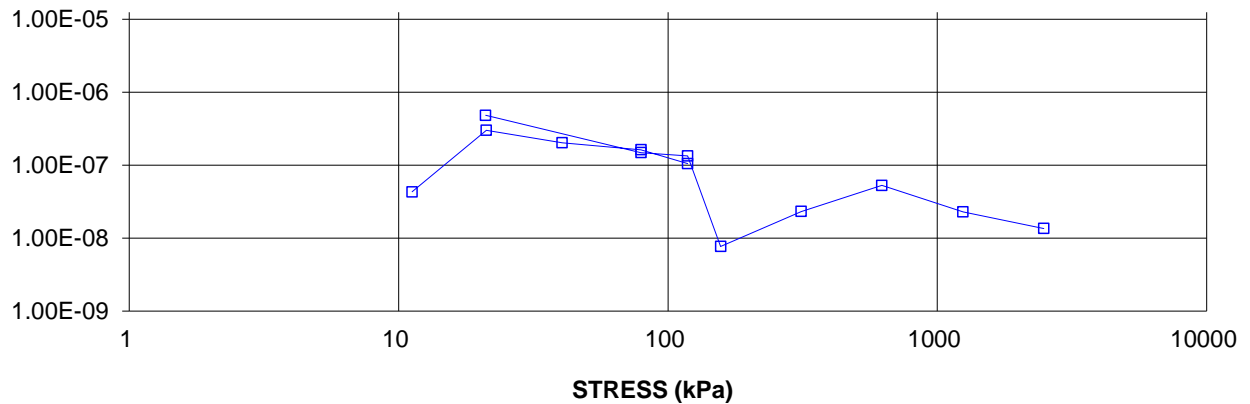
VOLUME COMPRESSIBILITY, m²/kN

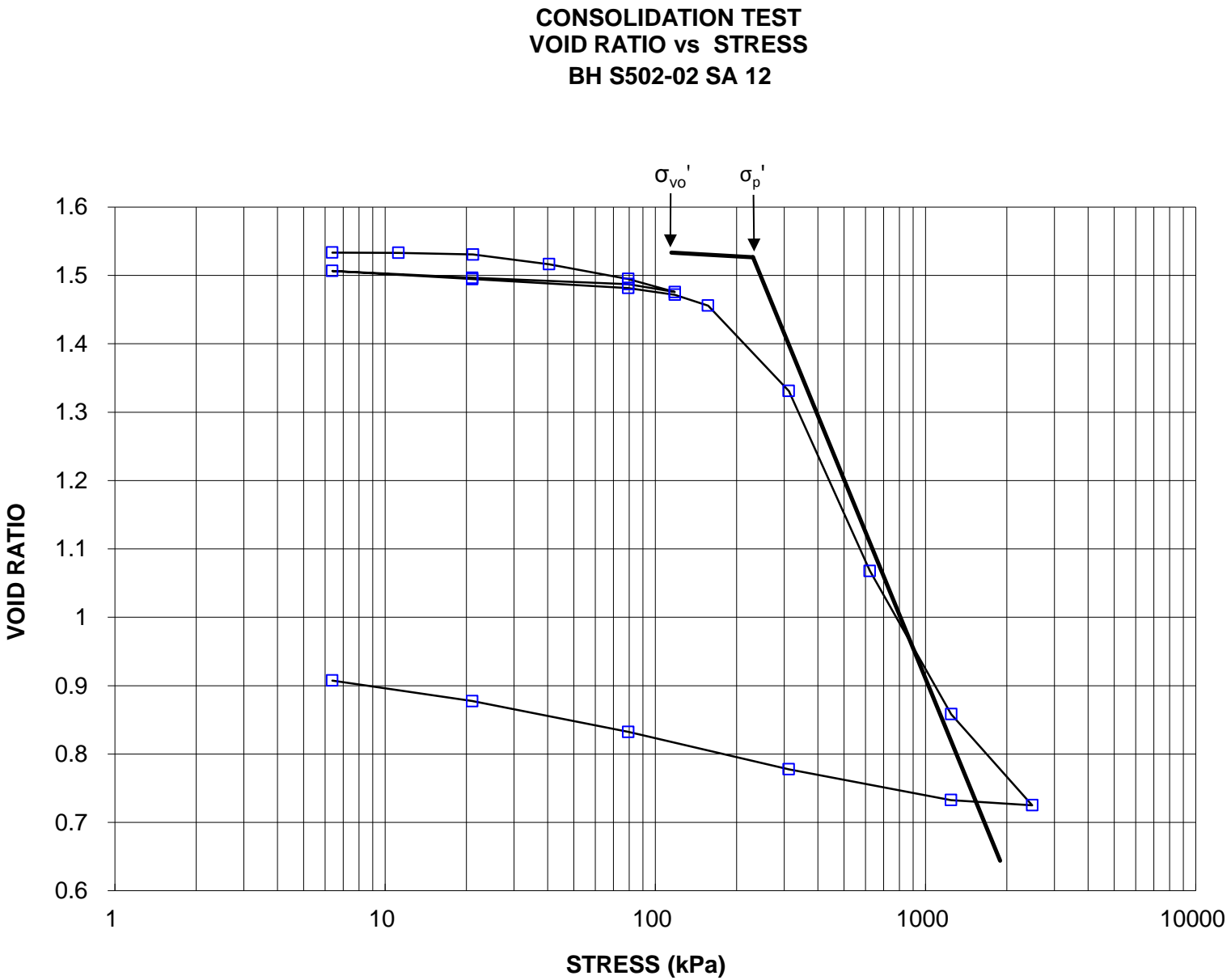
CONSOLIDATION TEST
MV m²/kN vs STRESS (kPa)
BH S502-02 SA 12



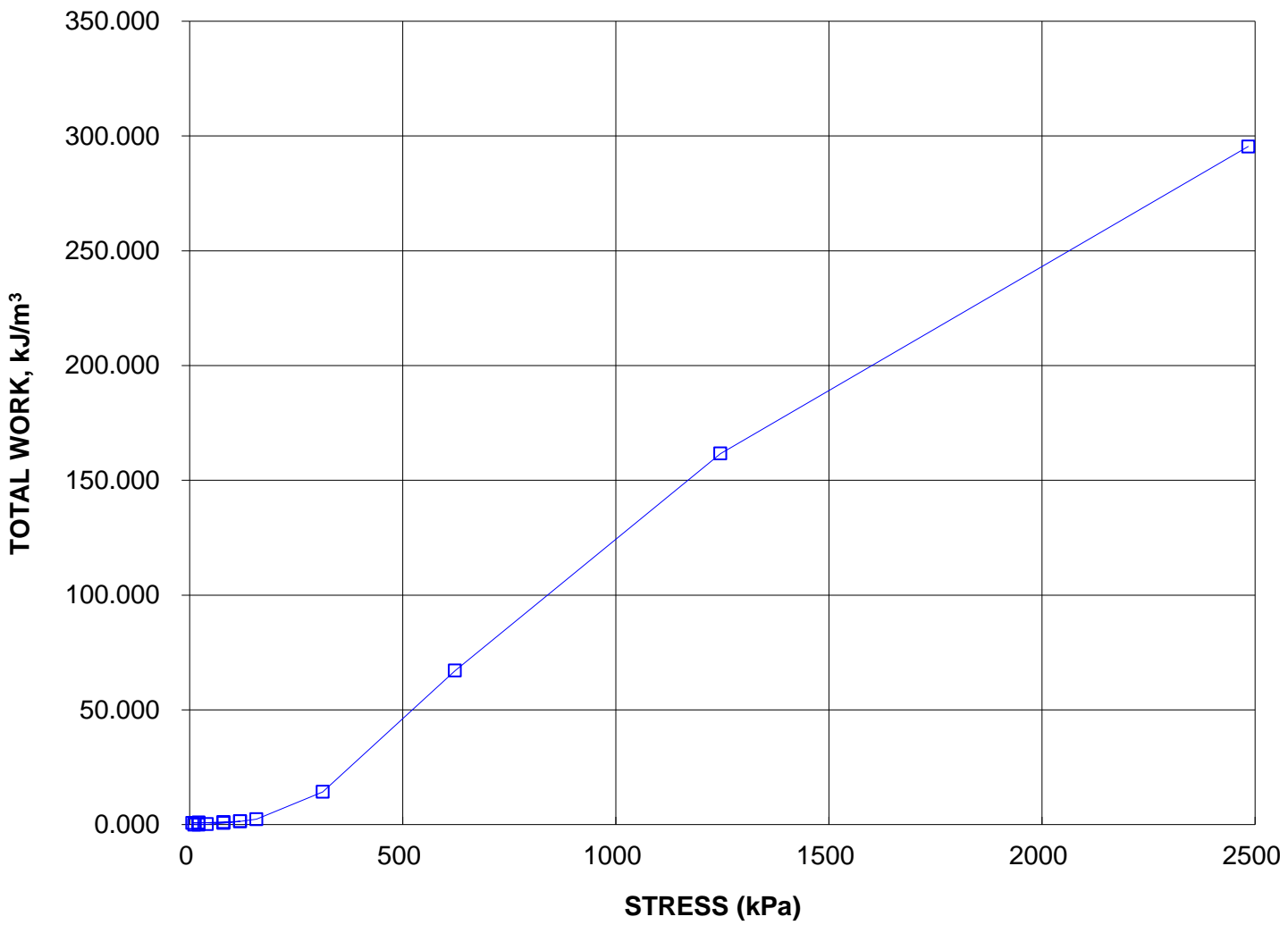
HYDRAULIC CONDUCTIVITY, cm/s

CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs STRESS
BH S502-02 SA 12





CONSOLIDATION TEST
TOTAL WORK, kJ/m^3 vs STRESS
BH S502-02 SA 12

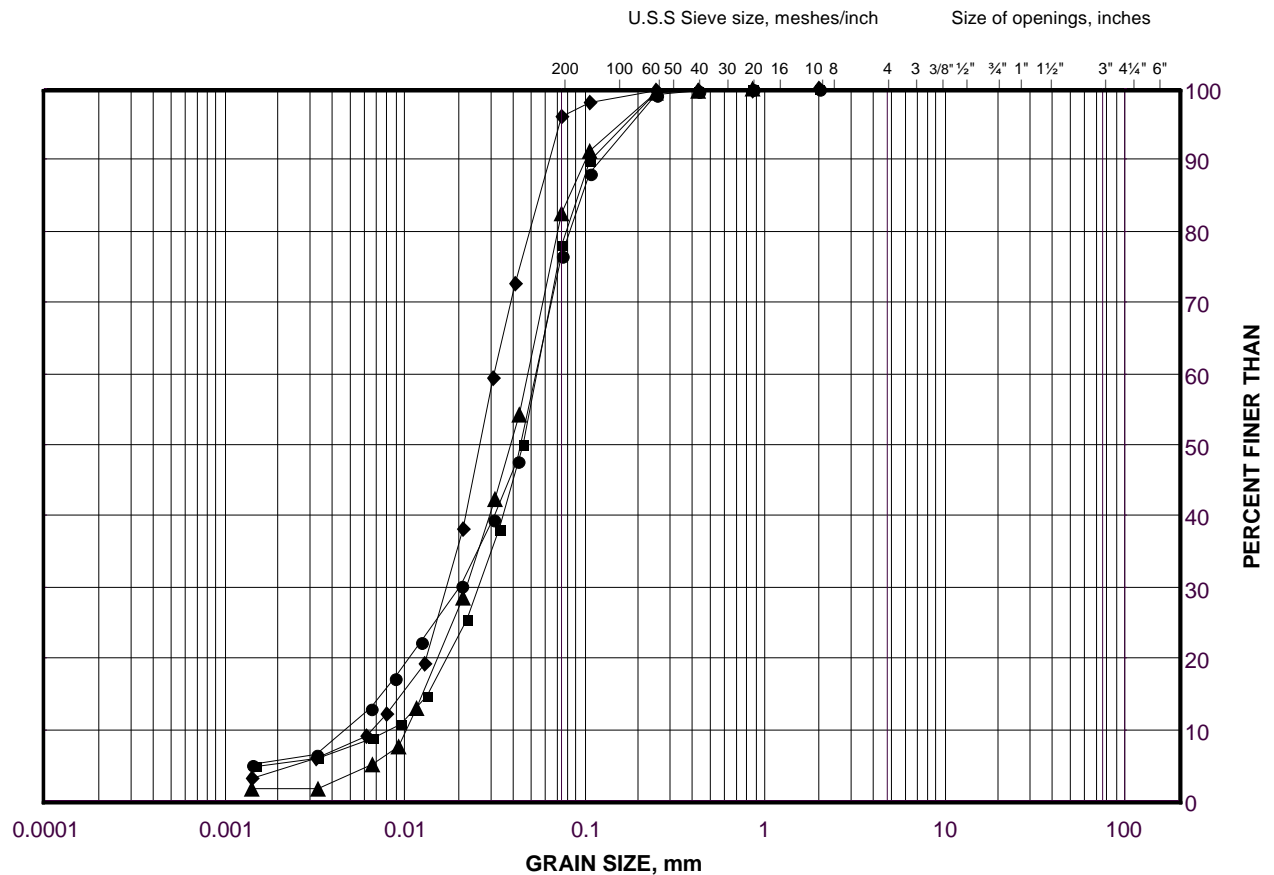


GRAIN SIZE DISTRIBUTION

Silt to Sandy Silt (Pockets)

Highway 69 (SBL) STA 20+980 to 21+180 (High Fill 502)

FIGURE B.S502-10



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

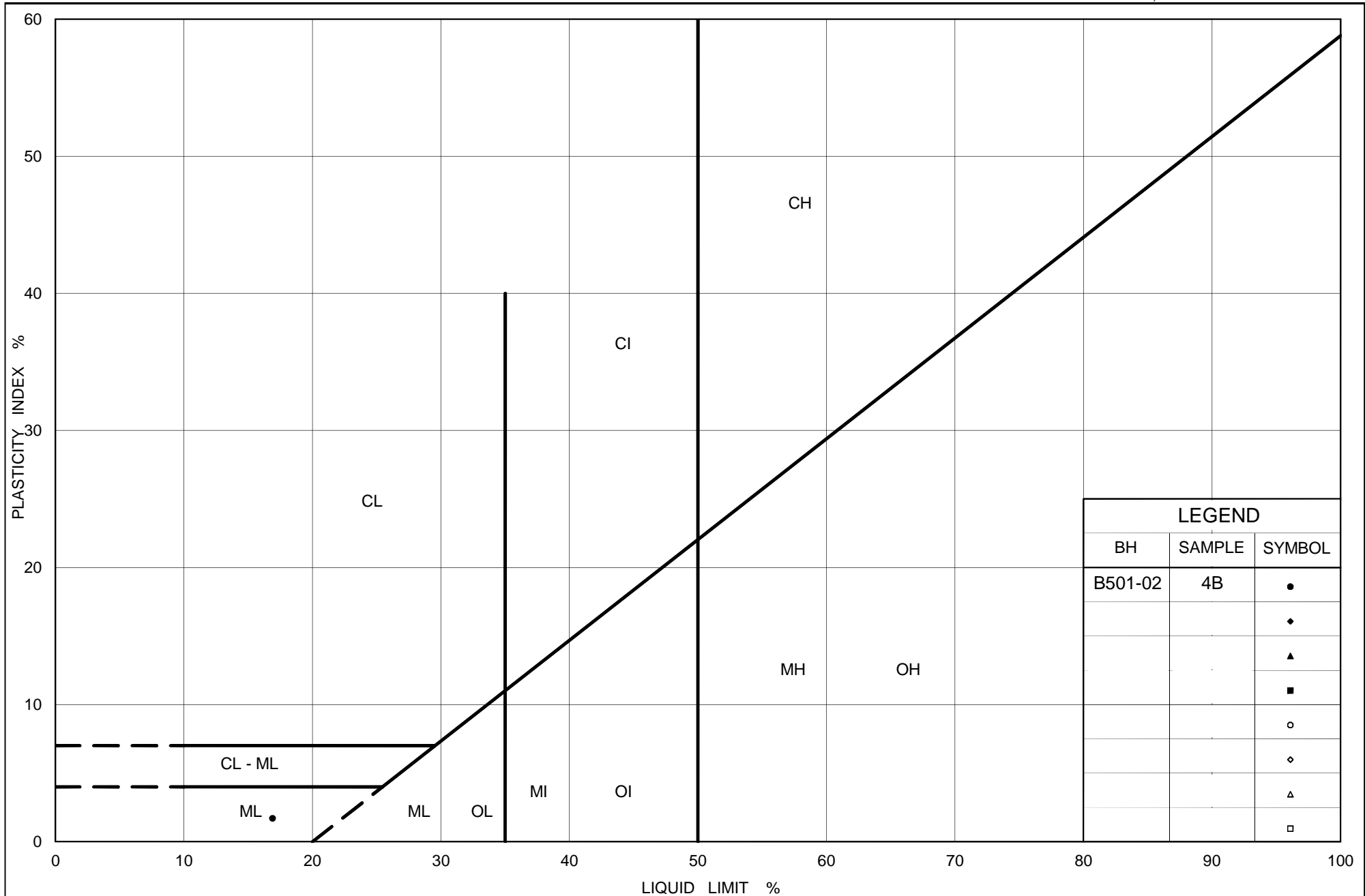
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S502-01	11	169.1
■	B501-12	12	168.9
◆	S502-02	15	165.5
▲	B501-02	9	166.3

Project Number: 09-1111-6014

Checked By: AV

Golder Associates

Date: 01-Oct-14



Ministry of Transportation

Ontario

PLASTICITY CHART

Silt (Pockets)

Highway 69 (SBL) STA 20+980 to 21+180 (High Fill 502)

Figure No. B.S502-11

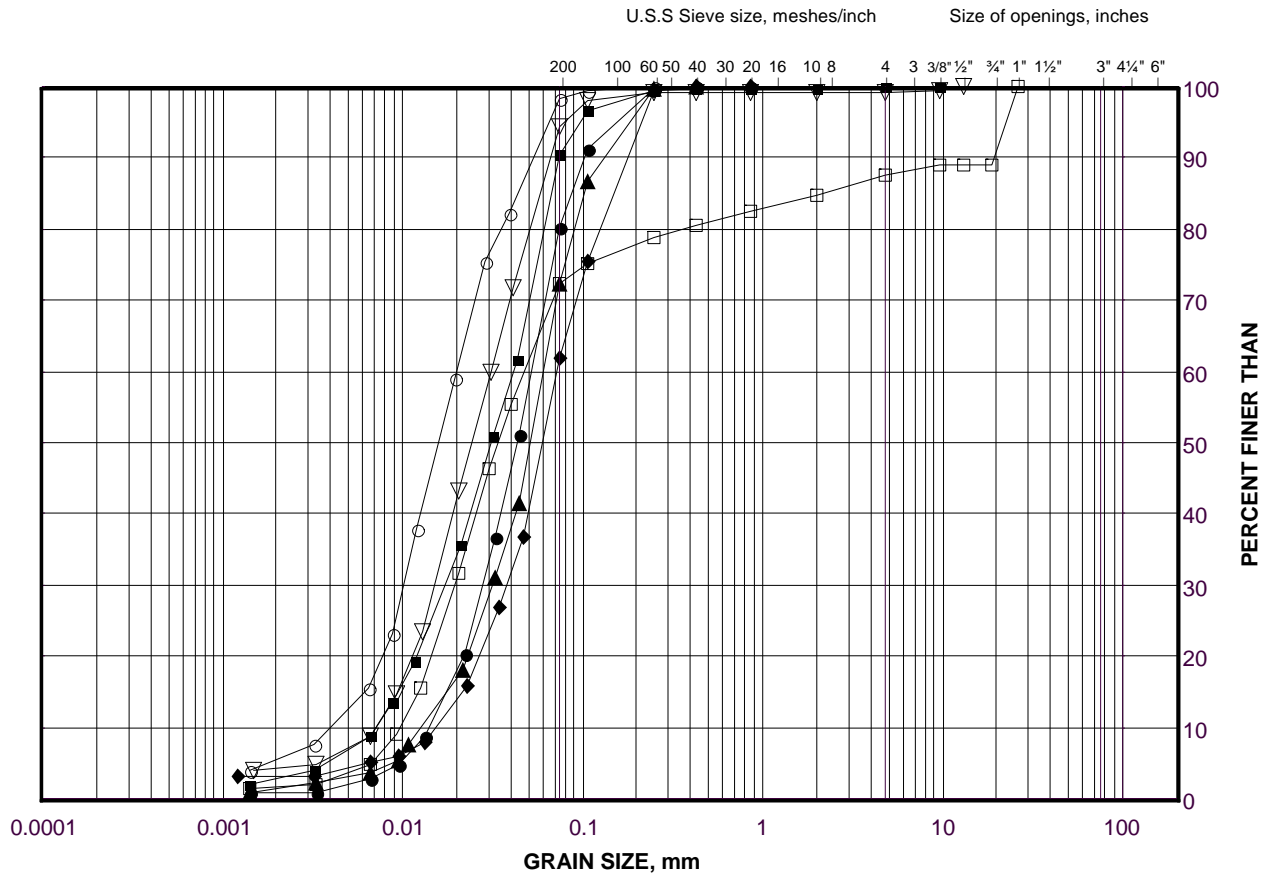
Project No. 09-1111-6014

Checked By: AV

GRAIN SIZE DISTRIBUTION

Silt to Silt and Sand (Lower Deposit)
Highway 69 (SBL) STA 20+980 to 21+180 (High Fill 502)

FIGURE B.S502-12



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S502-21	13	173.3
■	S502-08	14	175.1
◆	S502-08	16	172.0
▲	B501-02	16	154.3
▽	B501-12	18	158.2
○	S502-02	19	159.3
□	B501-02	21	141.9

Project Number: 09-1111-6014

Checked By: AV

Golder Associates

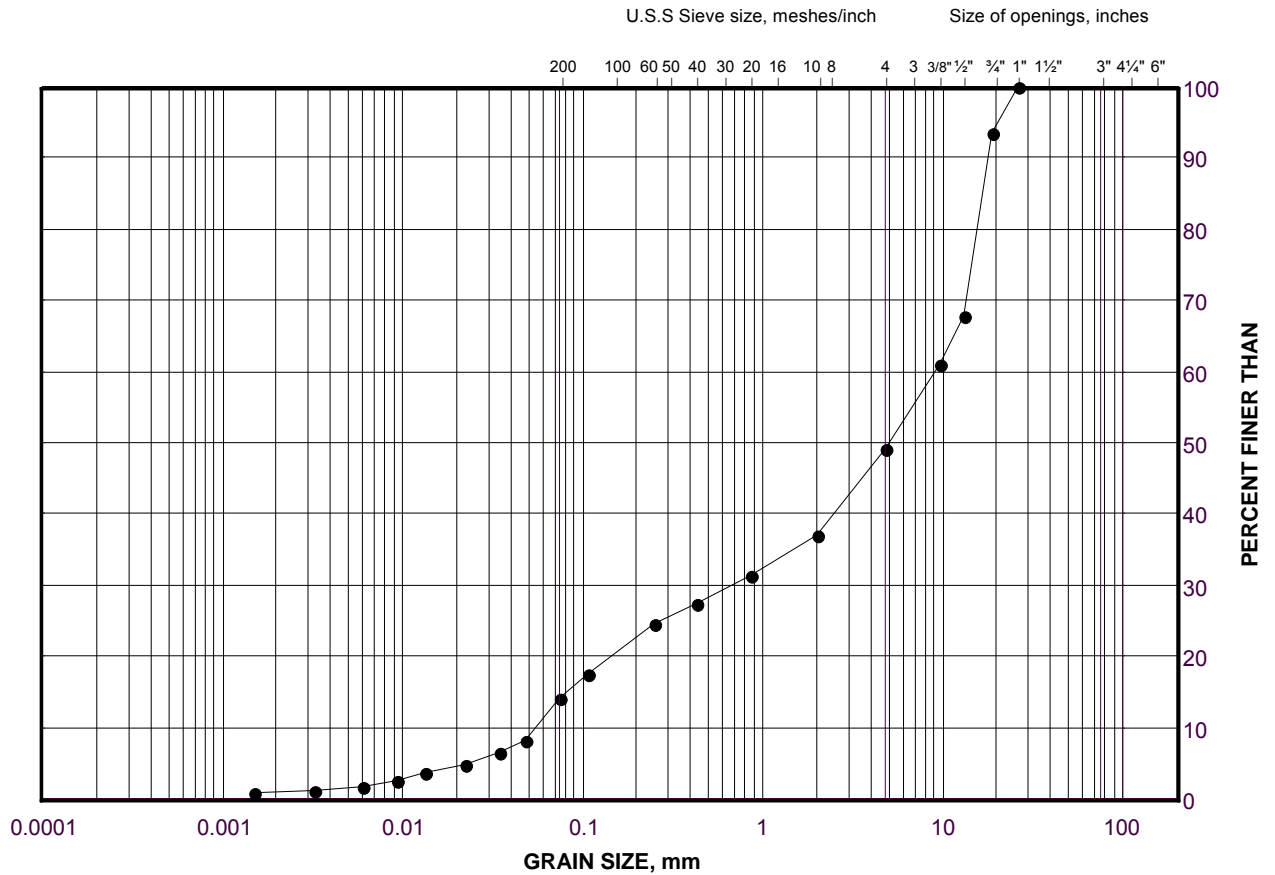
Date: 01-Oct-14

GRAIN SIZE DISTRIBUTION

Sand and Gravel

Highway 69 (SBL) STA 20+980 to 21+180 (High Fill 502)

FIGURE B.S502-13



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S502-14	5	185.9

Project Number: 09-1111-6014

Checked By: AV

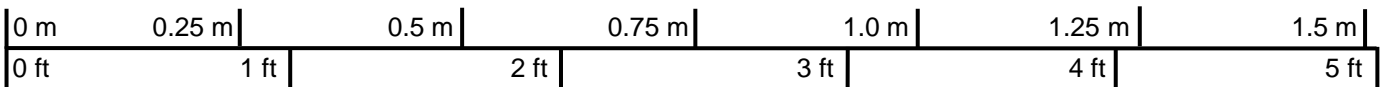
Golder Associates

Date: 08-Nov-13


Borehole B501-02



Box 1: 37.40 m – 40.60 m



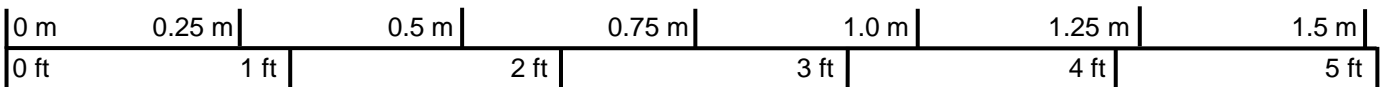
Scale

PROJECT				Swamp Crossing, High Fill Areas and Deep Cut Contract 5 Highway 69 Four-Laning GWP 5347-08-00; WP 5005-10-01			
TITLE				Bedrock Core Photograph – B501–02 Highway 69 (SBL)			
				PROJECT No. 09-1111-6014		FILE No. ----	
				DESIGN	AV	NOV 13	SCALE NTS
				CADD	--	--	REV.
				CHECK	CN	NOV 13	FIGURE B.S502-14
				REVIEW	JPD/JMAC	NOV 13	


Borehole B501-12



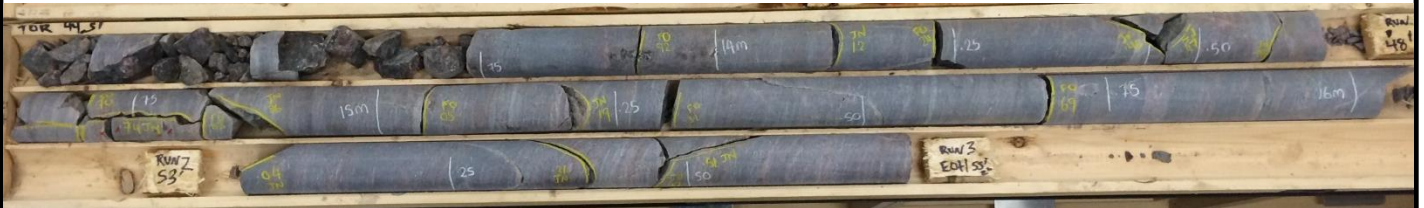
Box 1: 27.43 m – 30.85 m



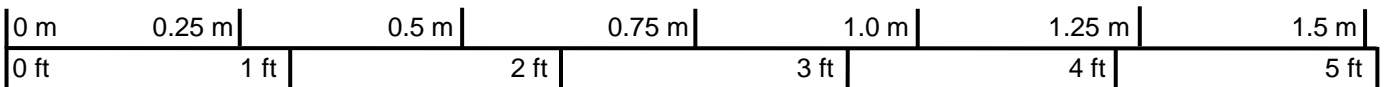
Scale

PROJECT		Swamp Crossing, High Fill Areas and Deep Cut Contract 5 Highway 69 Four-Laning GWP 5347-08-00; WP 5005-10-01			
TITLE		Bedrock Core Photograph – B501–12 Highway 69 (SBL)			
		PROJECT No. 09-1111-6014		FILE No. ----	
		DESIGN	AV	AUG 14	SCALE NTS
		CADD	--	--	REV.
		CHECK	CN	AUG 14	FIGURE B.S502-15
		REVIEW	JPD/JMAC	OCT 14	


Borehole B501-13



Box 1: 13.56 m – 16.80 m



Scale

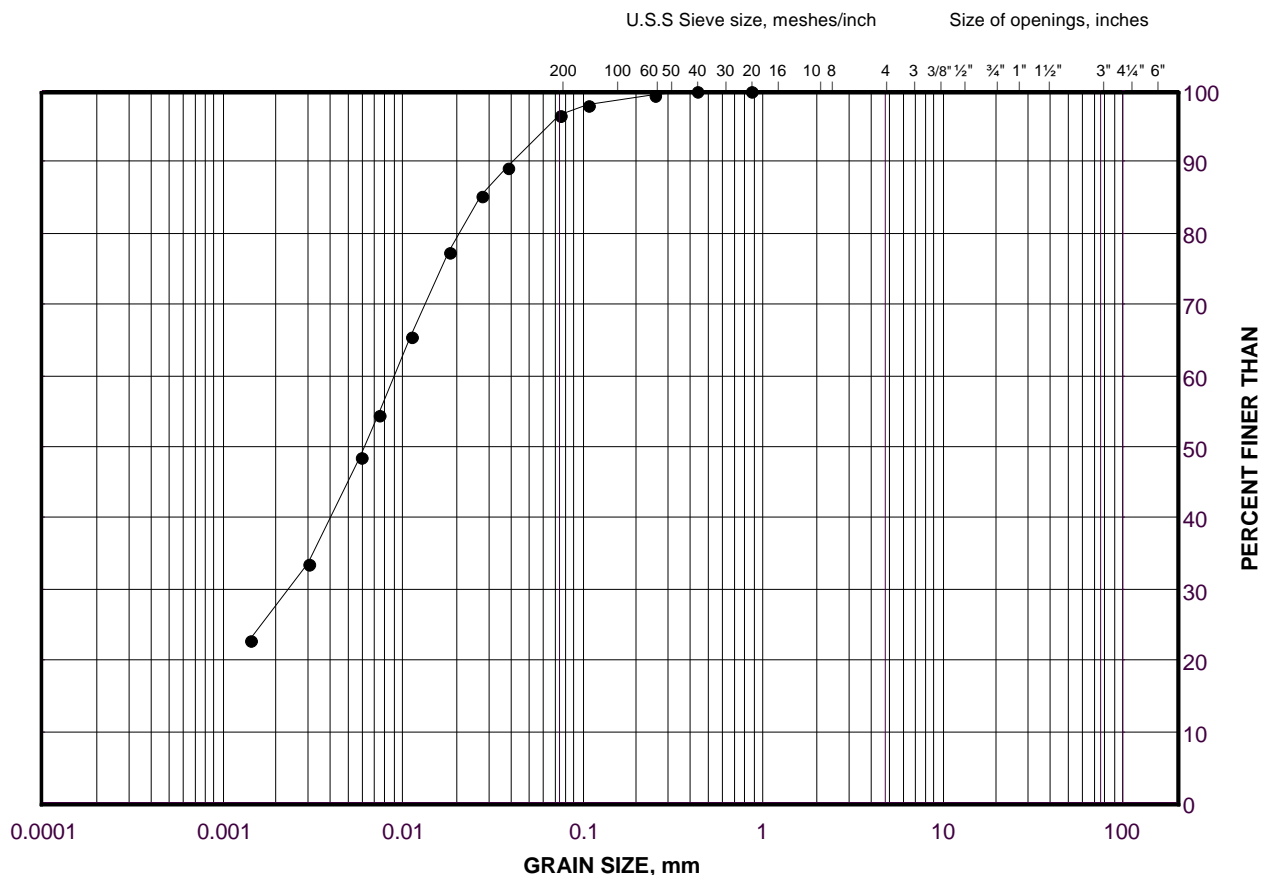
PROJECT		Swamp Crossing, High Fill Areas and Deep Cut Contract 5 Highway 69 Four-Laning GWP 5347-08-00; WP 5005-10-01			
TITLE		Bedrock Core Photograph – B501–13 Highway 69 (SBL)			
		PROJECT No. 09-1111-6014		FILE No. ----	
		DESIGN	AV	AUG 14	SCALE NTS
		CADD	--	--	REV.
		CHECK	CN	AUG 14	FIGURE B.S502-16
		REVIEW	JPD/JMAC	OCT 14	

GRAIN SIZE DISTRIBUTION

Clayey Silt (Pockets)

Highway 69 (NBL) STA 20+990 to 21+075 (High Fill 502)

FIGURE B.S502-17



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

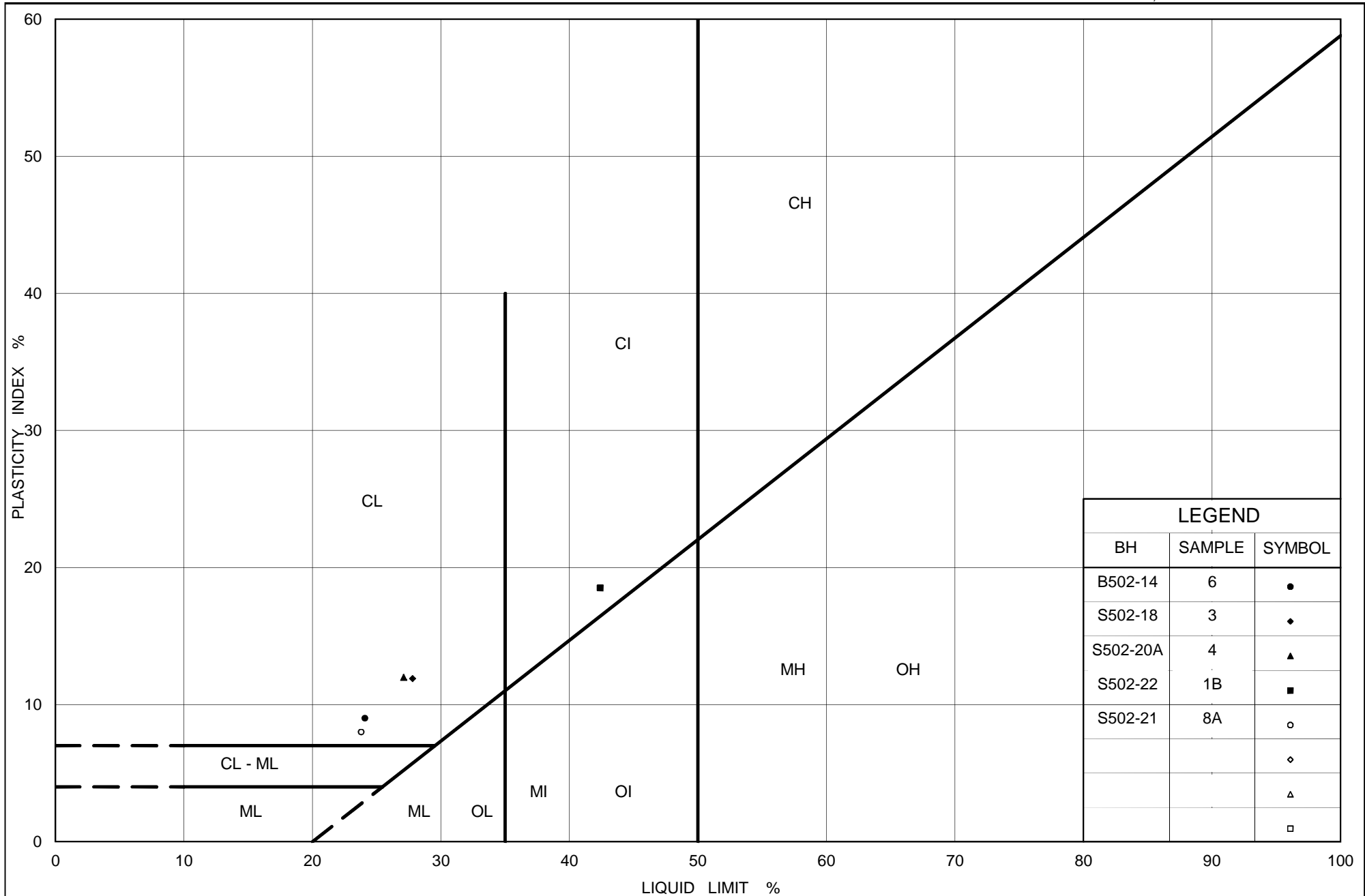
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S502-20A	4	181.8

Project Number: 09-1111-6014

Checked By: AV

Golder Associates

Date: 01-Oct-14



Ministry of Transportation

Ontario

PLASTICITY CHART
 Clayey Silt to Silty Clay (Pockets)
 Highway 69 (NBL) STA 21+990 to 20+075 (High Fill 502)

Figure No. B.S502-18

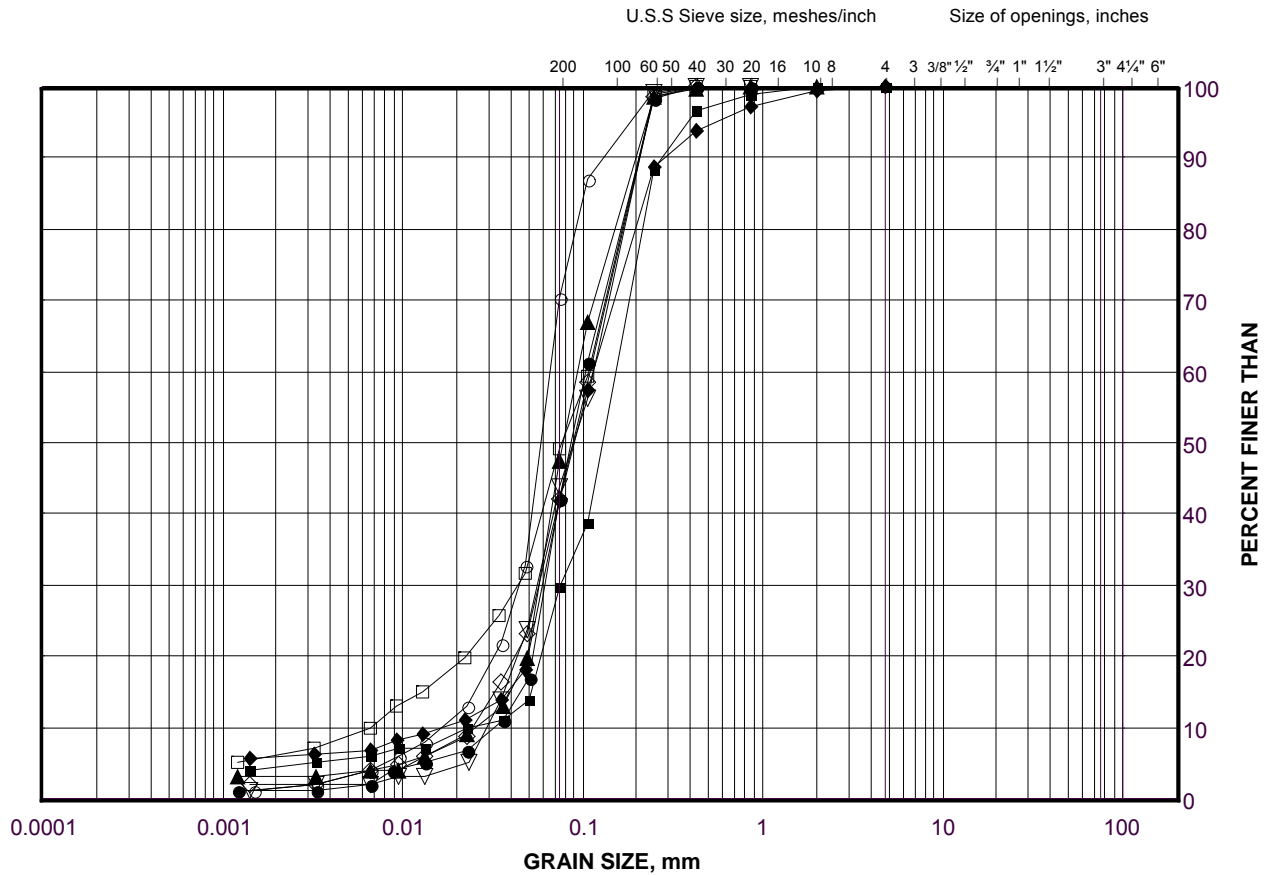
Project No. 09-1111-6014

Checked By: AV

GRAIN SIZE DISTRIBUTION

Silt and Sand to Silty Sand (Upper Deposit)
Highway 69 (NBL) STA 20+990 to 21+075 (High Fill 502)

FIGURE B.S502-19A



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	S502-23	10	179.3
■	S502-21	3	185.5
◆	S502-23	3	186.9
▲	S502-18	4	178.7
▽	S502-23	6	184.6
○	S502-20	6	180.0
□	S502-21	7	182.4
△	S502-21	8B	180.7

Project Number: 09-1111-6014

Checked By: AV

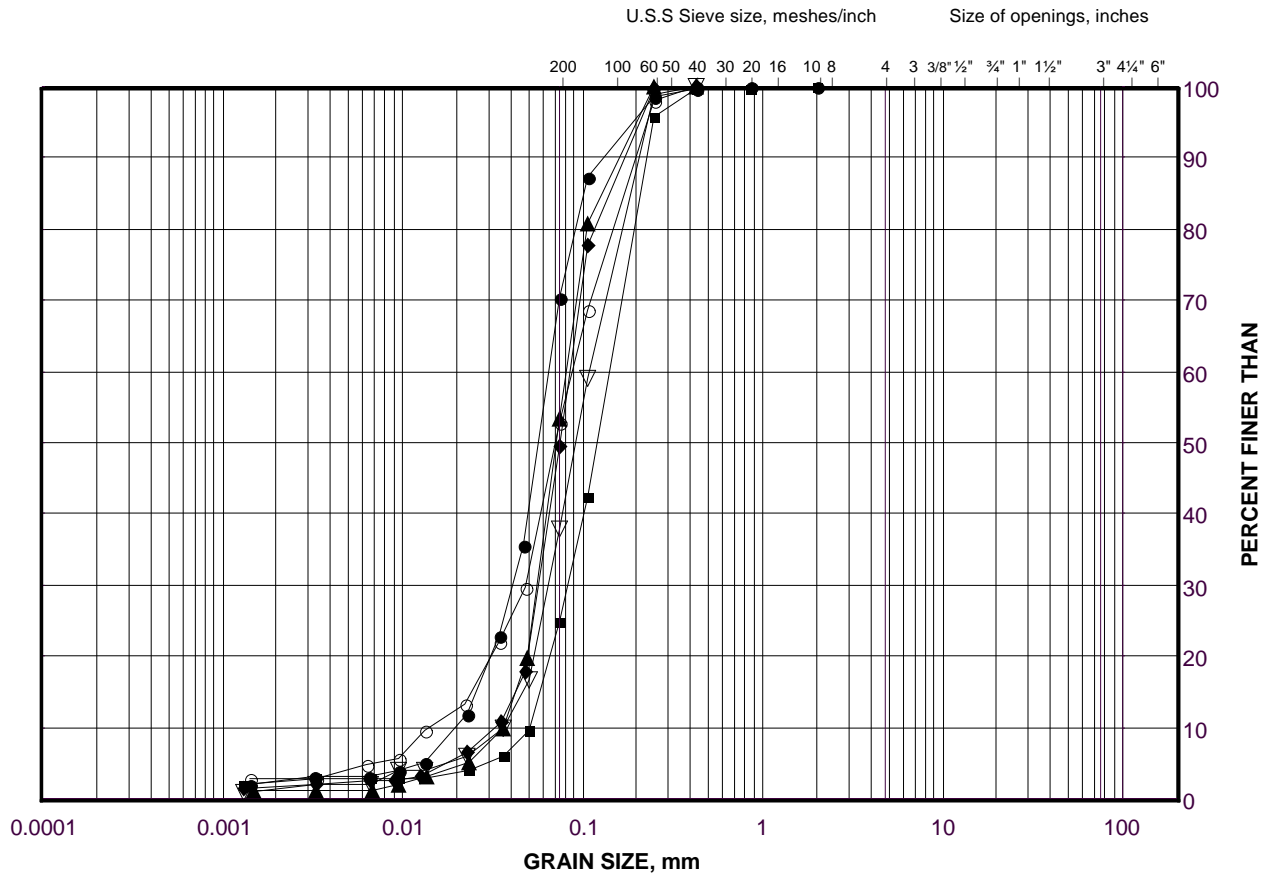
Golder Associates

Date: 05-Dec-13

GRAIN SIZE DISTRIBUTION

Silt and Sand to Silty Sand (Upper Deposit)
Highway 69 (NBL) STA 20+990 to 21+075 (High Fill 502)

FIGURE B.S502-19B



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B502-14	3	184.4
■	S502-22	4	185.4
◆	S502-22	5	184.6
▲	B502-14	8	178.3
▽	S502-24	8	183.9
○	S502-24	9	182.4

Project Number: 09-1111-6014

Checked By: AV

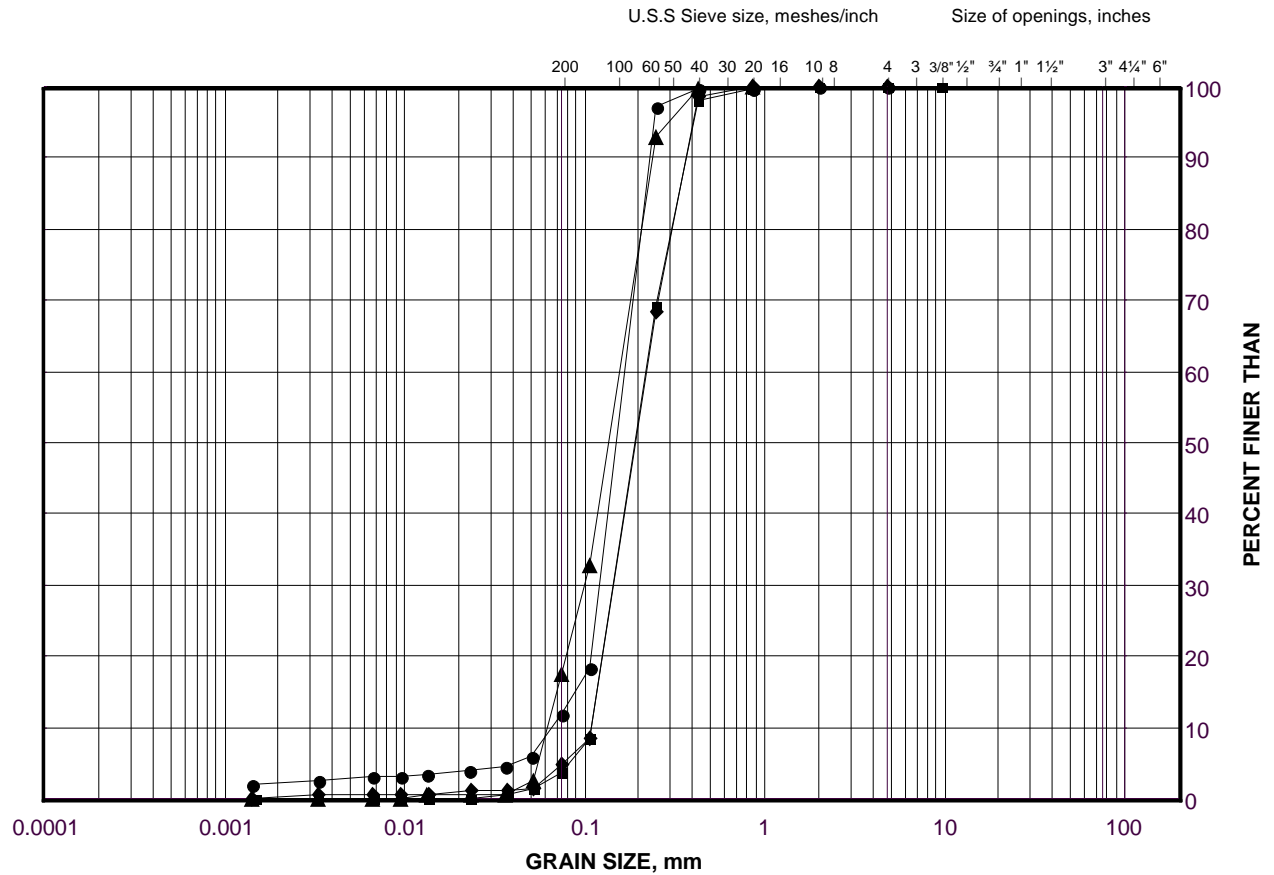
Golder Associates

Date: 17-Oct-14

GRAIN SIZE DISTRIBUTION

Sand (Upper Deposit)
Highway 69 (NBL) STA 20+990 to STA 21+075 (High Fill 502)

FIGURE B.S502-19C



SILT AND CLAY SIZES				FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED				SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

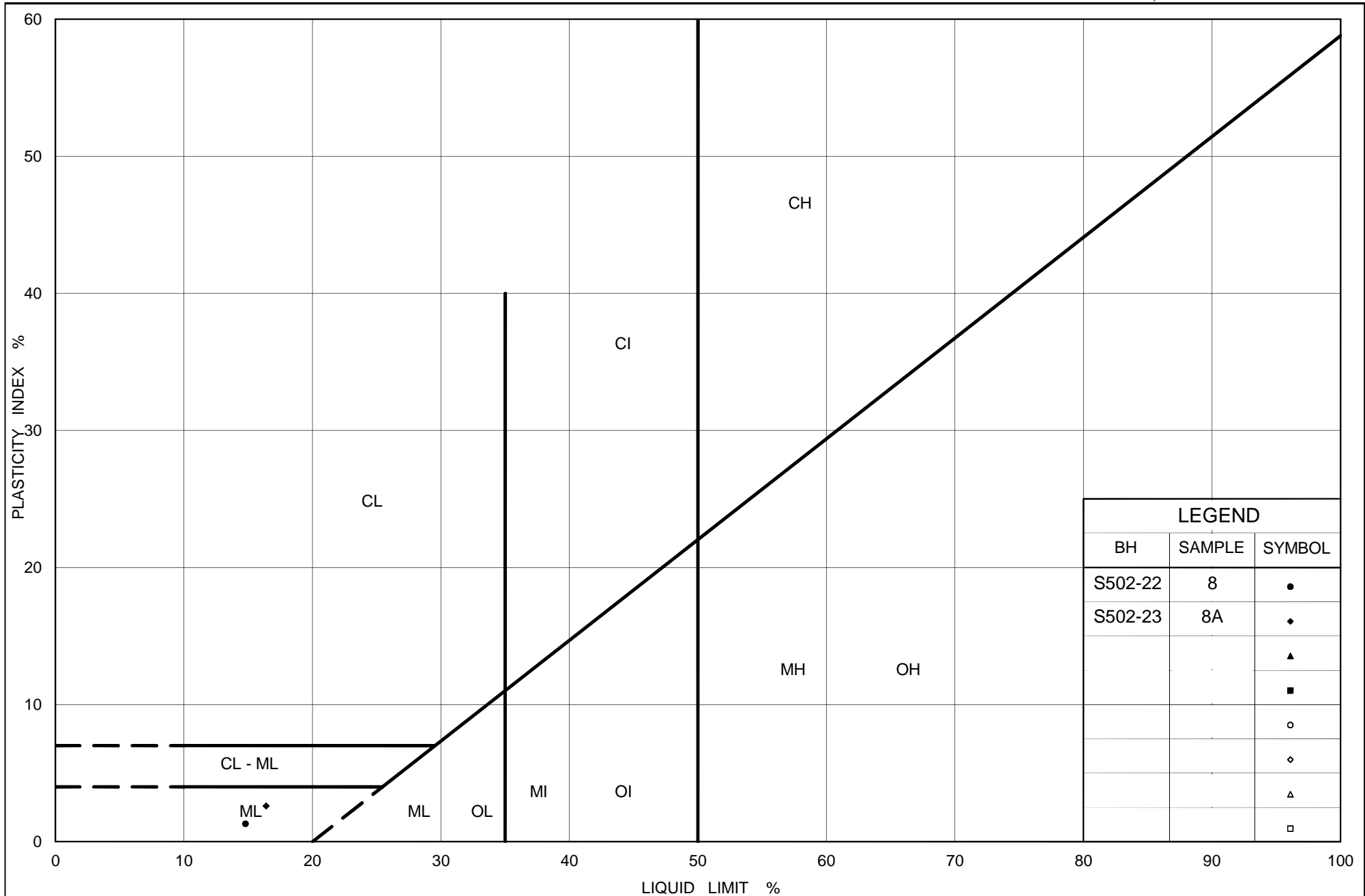
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S502-24	4	187.7
■	B502-13	5	180.9
◆	S502-20	5	180.7
▲	S502-23	7	183.8

Project Number: 09-1111-6014

Checked By: AV

Golder Associates

Date: 01-Oct-14



Ministry of Transportation

Ontario

PLASTICITY CHART
 Silt to Silt and Sand (Upper Deposit)
 Highway 69 (NBL) STA 20+990 to 21+075 (High Fill 502)

Figure No. B.S502-20

Project No. 09-1111-6014

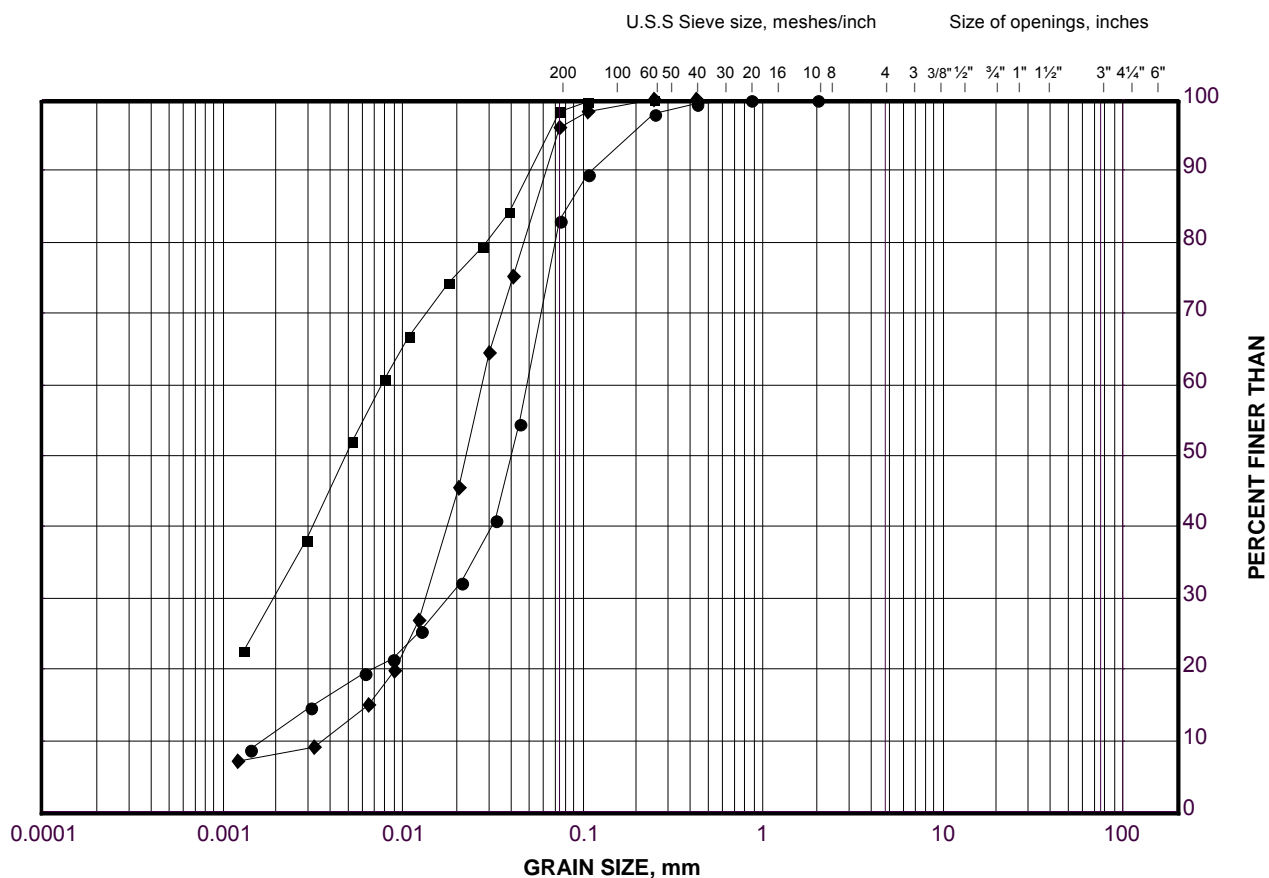
Checked By: AV

GRAIN SIZE DISTRIBUTION

Clayey Silt

Highway 69 (NBL) STA 20+990 to 21+075 (High Fill 502)

FIGURE B.S502-21



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

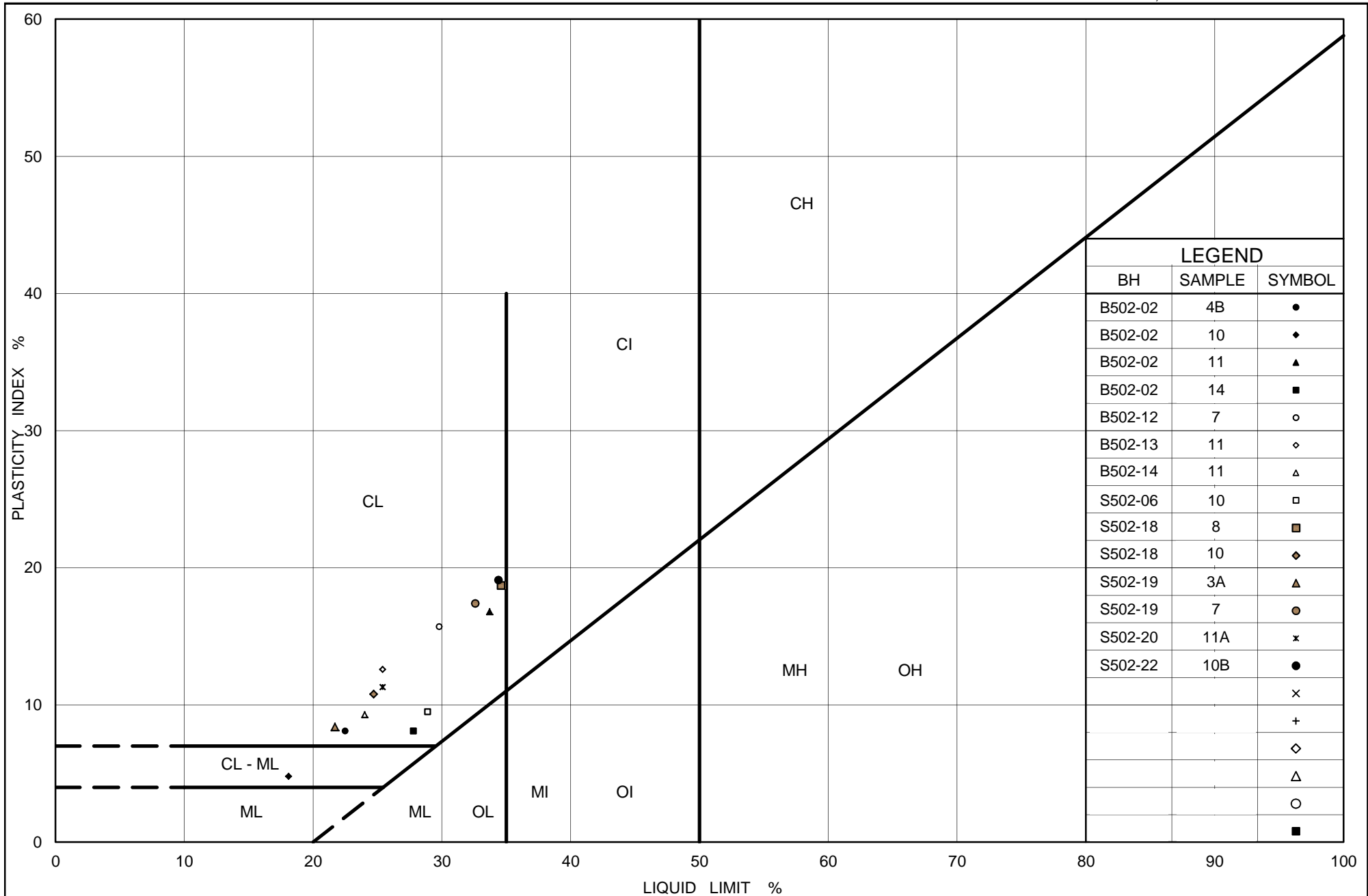
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B502-02	10	165.0
■	B502-02	11	163.6
◆	S502-18	11A	170.4

Project Number: 09-1111-6014

Checked By: AV

Golder Associates

Date: 01-Oct-14



Ministry of
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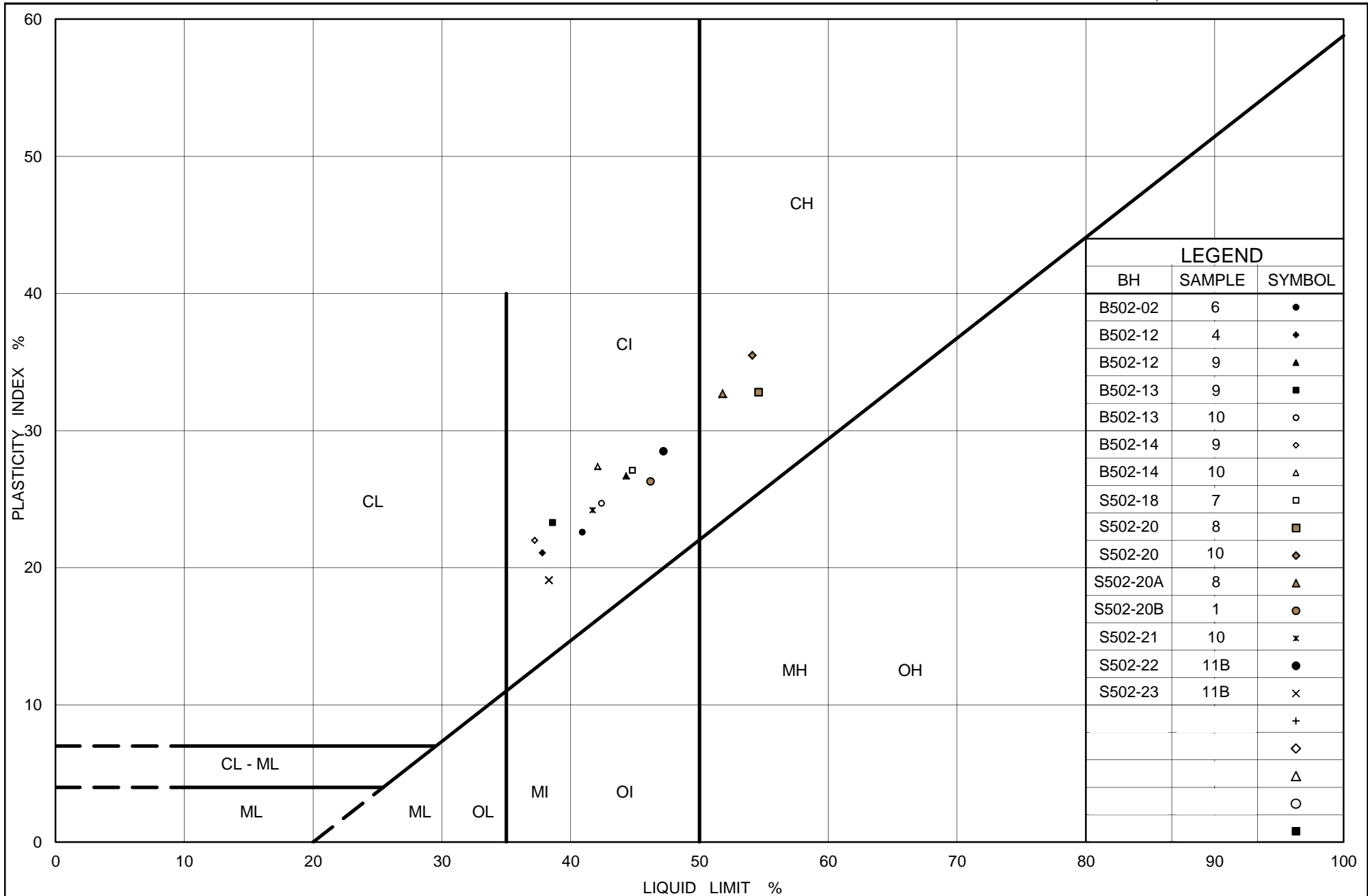
Ontario

PLASTICITY CHART
Clayey Silt
Highway 69 (NBL) STA 20+990 to 21+075 (High Fill 502)

Figure No. B.S502-22A

Project No. 09-1111-6014

Checked By: AV



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Ontario

PLASTICITY CHART
 Silty Clay to Clay
 Highway 69 (NBL) STA 20+990 to 21+075 (High Fill 502)

Figure No. B.S502-22B

Project No. 09-1111-6014

Checked By: AV

CONSOLIDATION TEST SUMMARY**FIGURE B.S502-23**

Sheet 1 of 4

SAMPLE IDENTIFICATION

Project Number	09-1111-6014	Sample Number	10
Borehole Number	B502-13	Sample Depth, m	7.47-7.92

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	8		
Date Started	3/18/2013		
Date Completed	3/31/2014		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.90	Unit Weight, kN/m ³	17.57
Sample Diameter, cm	6.30	Dry Unit Weight, kN/m ³	12.11
Area, cm ²	31.19	Specific Gravity, measured	2.76
Volume, cm ³	59.27	Solids Height, cm	0.850
Water Content, %	45.07	Volume of Solids, cm ³	26.51
Wet Mass, g	106.16	Volume of Voids, cm ³	32.75
Dry Mass, g	73.18	Degree of Saturation, %	100.7

TEST COMPUTATIONS

Stress	Corr. Height	Void	Average Height	t ₉₀	cv.	mv	k
kPa	cm	Ratio	cm	sec	cm ² /s	m ² /kN	cm/s
0.00	1.900	1.235	1.900				
6.35	1.903	1.238	1.901	11	6.97E-02		
11.33	1.902	1.238	1.902	231	3.32E-03	5.71E-05	1.86E-08
21.23	1.900	1.235	1.901	638	1.20E-03	1.06E-04	1.25E-08
40.93	1.891	1.224	1.895	1134	6.72E-04	2.56E-04	1.69E-08
80.23	1.874	1.204	1.882	1329	5.65E-04	2.24E-04	1.24E-08
158.60	1.846	1.171	1.860	1192	6.15E-04	1.90E-04	1.15E-08
319.05	1.697	0.997	1.772	3244	2.05E-04	4.86E-04	9.77E-09
632.89	1.547	0.820	1.622	1745	3.20E-04	2.52E-04	7.90E-09
1262.00	1.435	0.688	1.491	919	5.13E-04	9.39E-05	4.72E-09
2517.59	1.335	0.571	1.385	919	4.42E-04	4.18E-05	1.81E-09
1262.00	1.347	0.585	1.341				
319.05	1.368	0.609	1.357				
80.23	1.405	0.653	1.386				
21.23	1.436	0.689	1.421				
6.35	1.467	0.726	1.452				

Note:

Specimen taken 12-19 cm from bottom of the tube

k calculated using cv based on ϕ_0 values.**SAMPLE DIMENSIONS AND PROPERTIES - FINAL**

Sample Height, cm	1.47	Unit Weight, kN/m ³	19.91
Sample Diameter, cm	6.30	Dry Unit Weight, kN/m ³	15.68
Area, cm ²	31.19	Specific Gravity, measured	2.76
Volume, cm ³	45.76	Solids Height, cm	0.850
Water Content, %	26.93	Volume of Solids, cm ³	26.51
Wet Mass, g	92.89	Volume of Voids, cm ³	19.24
Dry Mass, g	73.18		

Prepared By: RD

Golder Associates

Checked By: AV

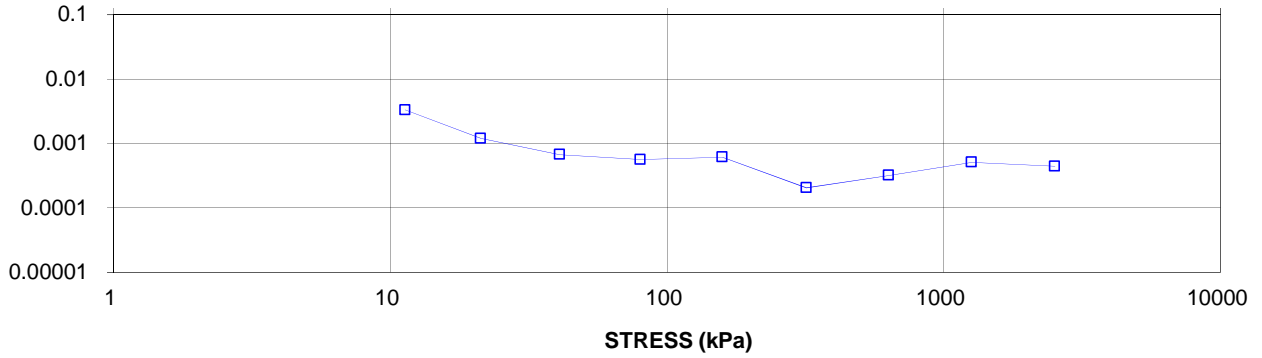
CONSOLIDATION TEST SUMMARY

FIGURE B.S502-23

Sheet 2 of 4

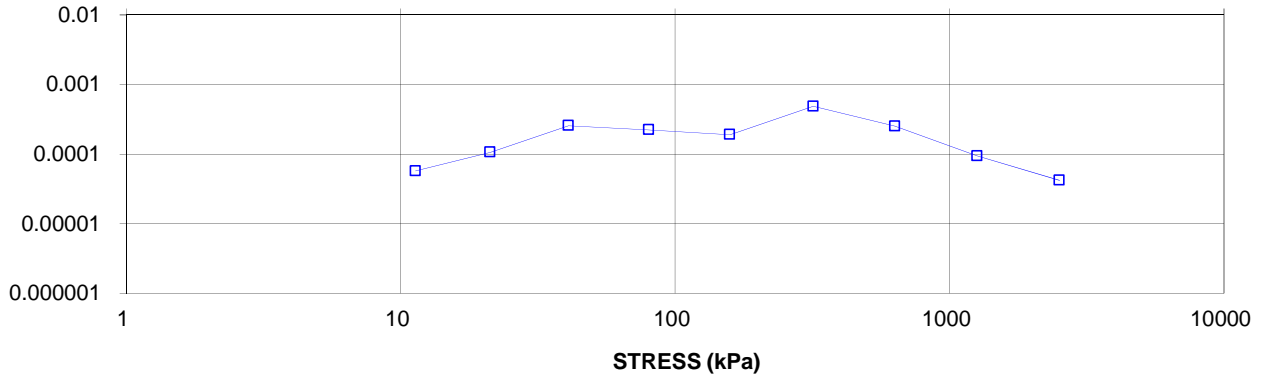
COEFFICIENT OF CONSOLIDATION,
cm²/s

CONSOLIDATION TEST
CV cm²/s VS STRESS (kPa)
BH B502-13 SA 10



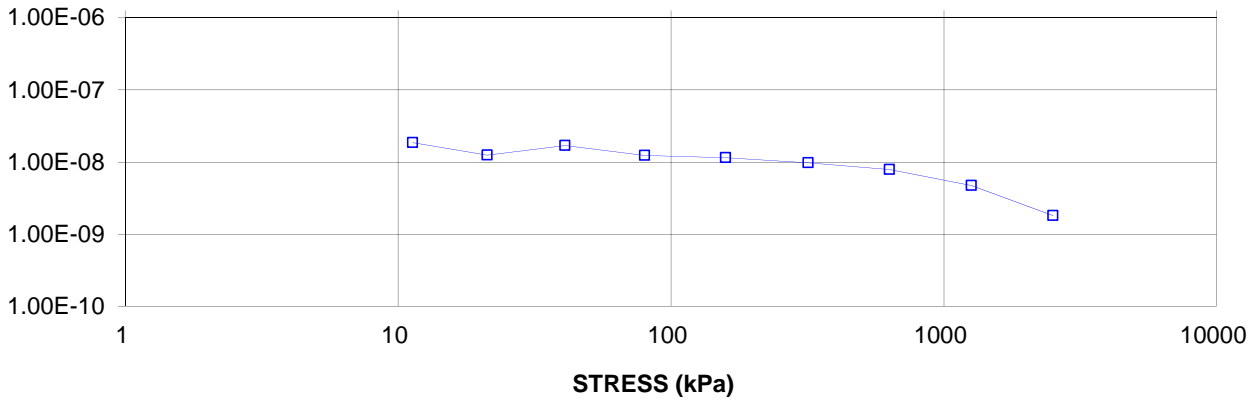
VOLUME COMPRESSIBILITY, m²/kN

CONSOLIDATION TEST
MV m²/kN vs STRESS (kPa)
BH B502-13 SA 10



HYDRAULIC CONDUCTIVITY,
cm/s

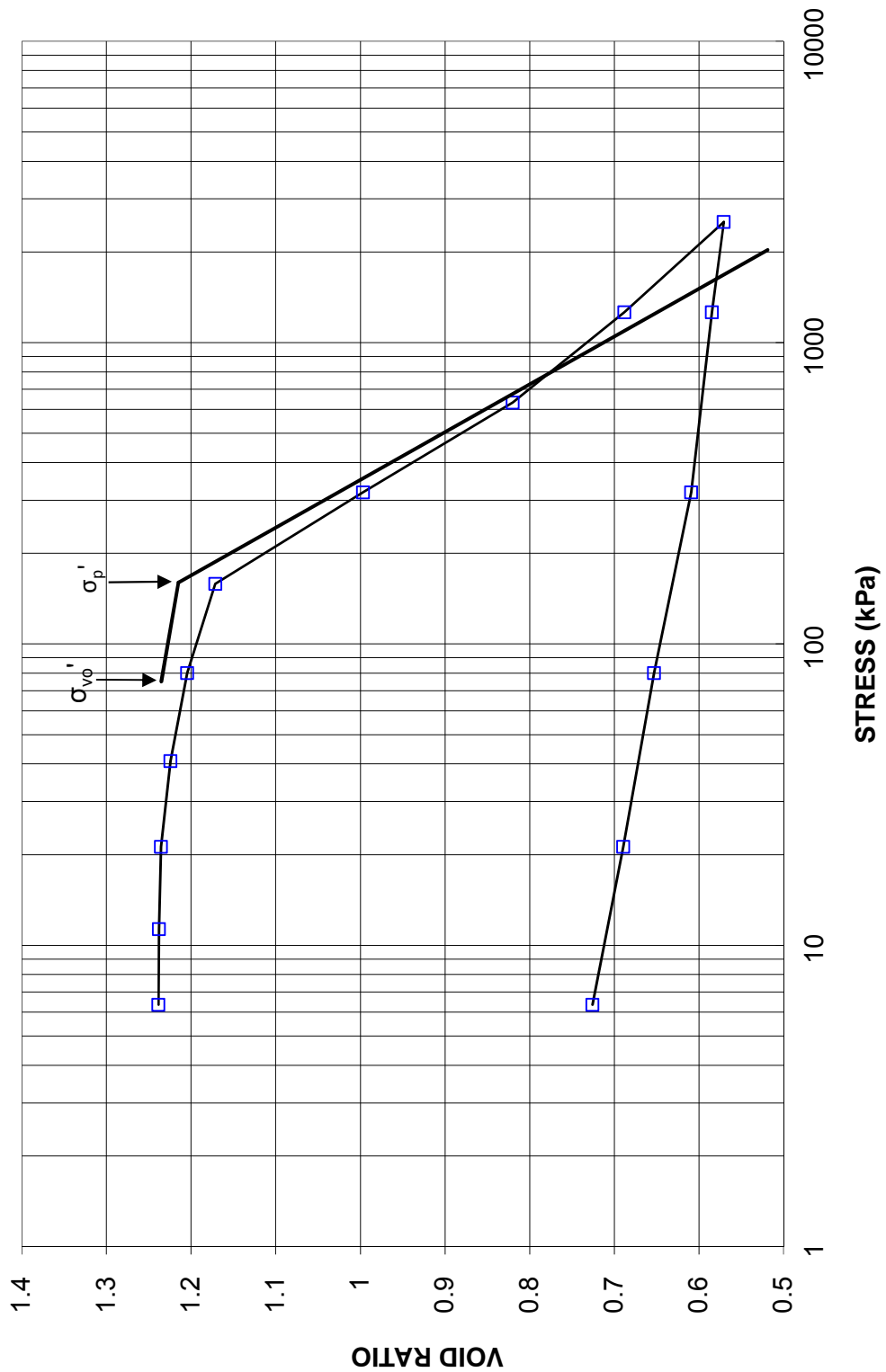
CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs STRESS
BH B502-13 SA 10



**CONSOLIDATION TEST
VOID RATIO VS LOG STRESS**

**FIGURE B.S502-23
Sheet 3 of 4**

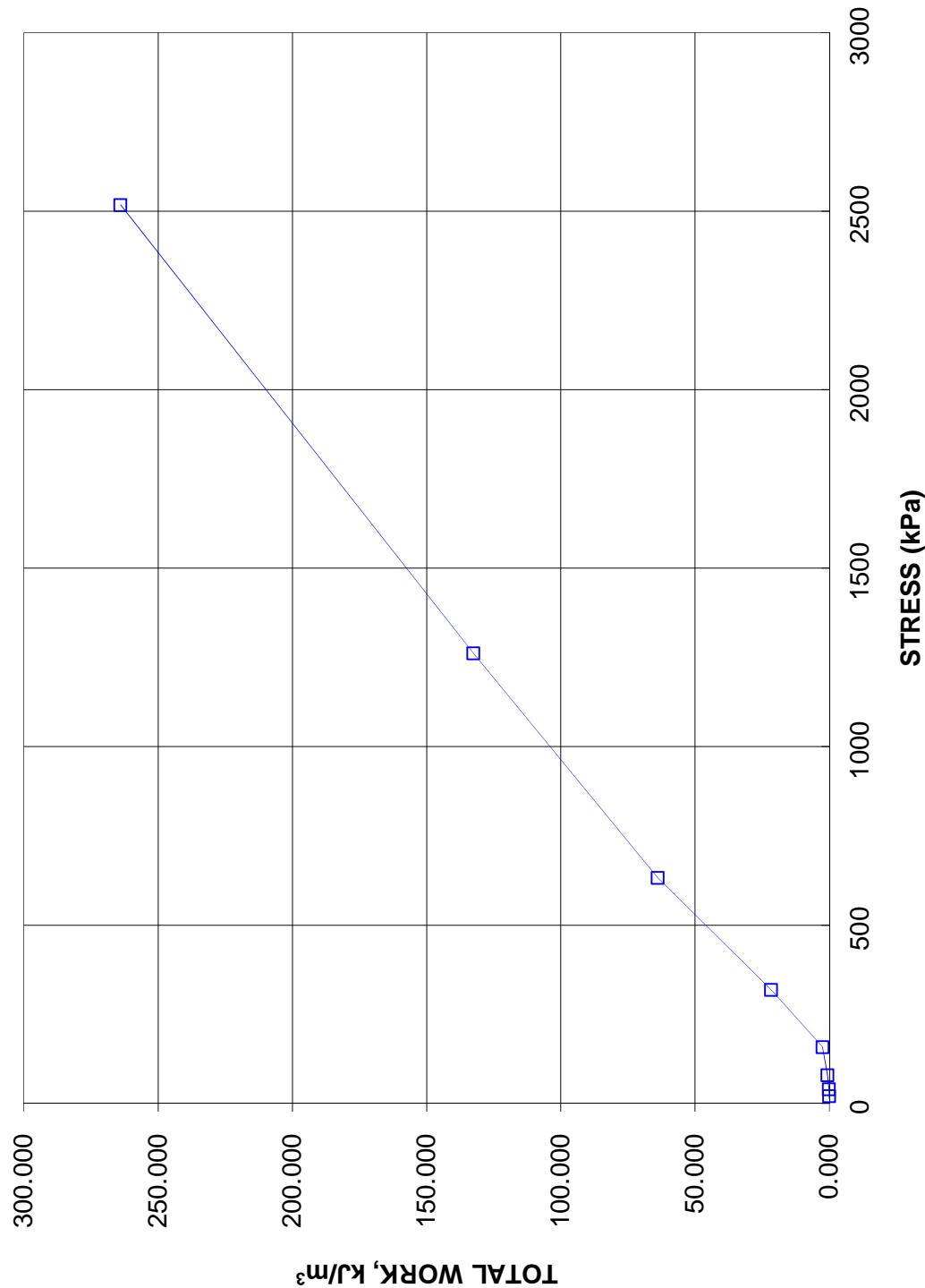
**CONSOLIDATION TEST
VOID RATIO vs STRESS
BH B502-13 SA 10**



CONSOLIDATION TEST
TOTAL WORK VS STRESS

FIGURE B.S502-23
Sheet 4 of 4

CONSOLIDATION TEST
TOTAL WORK, kJ/m^3 vs STRESS
BH B502-13 SA 10



CONSOLIDATION TEST SUMMARY**FIGURE B.S502-24**

Sheet 1 of 4

SAMPLE IDENTIFICATION

Project Number	09-1111-6014	Sample Number	10
Borehole Number	S502-20	Sample Depth, m	9.14-9.74

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	1		
Date Started	12/11/2013		
Date Completed	01/02/2014		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.56	Unit Weight, kN/m ³	16.91
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m ³	11.24
Area, cm ²	31.54	Specific Gravity, measured	2.75
Volume, cm ³	80.58	Solids Height, cm	1.065
Water Content, %	50.49	Volume of Solids, cm ³	33.57
Wet Mass, g	138.95	Volume of Voids, cm ³	47.01
Dry Mass, g	92.33	Degree of Saturation, %	99.2

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t ₉₀ sec	cv. cm ² /s	mv m ² /kN	k cm/s
0.00	2.555	1.400	2.555				
6.26	2.553	1.399	2.554	1	1.38E+00	1.00E-04	1.36E-05
10.91	2.551	1.396	2.552	34	4.06E-02	2.27E-04	9.04E-07
20.98	2.547	1.392	2.549	94	1.46E-02	1.63E-04	2.34E-07
40.45	2.535	1.382	2.541	167	8.20E-03	2.23E-04	1.79E-07
79.24	2.511	1.359	2.523	184	7.33E-03	2.49E-04	1.79E-07
98.58	2.499	1.348	2.505	1815	7.33E-04	2.37E-04	1.70E-08
40.45	2.507	1.355	2.503				
10.91	2.519	1.366	2.513				
40.45	2.510	1.358	2.515	42	3.19E-02	1.15E-04	3.61E-07
79.24	2.501	1.349	2.506	43	3.10E-02	9.79E-05	2.97E-07
98.58	2.495	1.344	2.498	2953	4.48E-04	1.15E-04	5.06E-09
156.82	2.462	1.313	2.478	1717	7.58E-04	2.24E-04	1.66E-08
311.93	2.232	1.097	2.347	1270	9.19E-04	5.80E-04	5.22E-08
622.63	2.000	0.878	2.116	508	1.87E-03	2.93E-04	5.36E-08
1246.39	1.855	0.742	1.927	227	3.47E-03	9.09E-05	3.09E-08
2491.36	1.728	0.623	1.791	194	3.51E-03	4.00E-05	1.37E-08
1246.39	1.733	0.628	1.730				
311.93	1.768	0.661	1.750				
98.58	1.796	0.687	1.782				
20.98	1.841	0.730	1.819				
6.26	1.878	0.764	1.859				

Note:

Specimen taken 19-29 cm from bottom of the tube
k calculated using cv based on $\dot{\epsilon}_0$ values.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	1.88	Unit Weight, kN/m ³	19.83
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m ³	15.29
Area, cm ²	31.54	Specific Gravity, measured	2.75
Volume, cm ³	59.22	Solids Height, cm	1.065
Water Content, %	29.69	Volume of Solids, cm ³	33.57
Wet Mass, g	119.74	Volume of Voids, cm ³	25.64
Dry Mass, g	92.33		

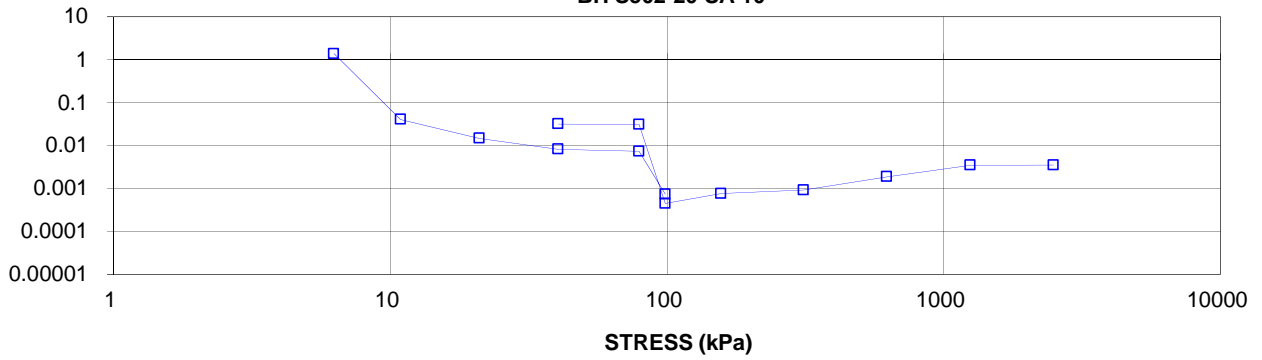
CONSOLIDATION TEST SUMMARY

FIGURE B.S502-24

Sheet 2 of 4

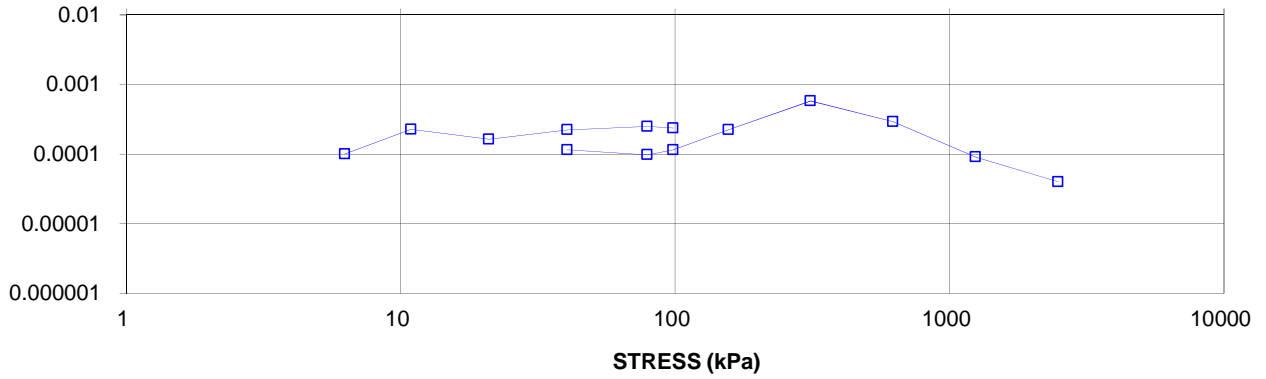
COEFFICIENT OF CONSOLIDATION,
cm²/s

CONSOLIDATION TEST
CV cm²/s VS STRESS (kPa)
BH S502-20 SA 10



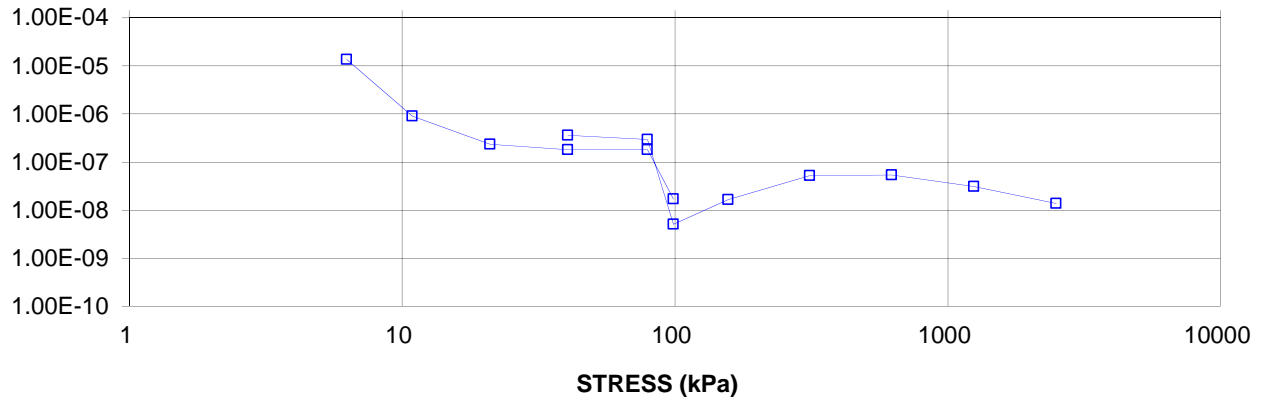
VOLUME COMPRESSIBILITY, m²/kN

CONSOLIDATION TEST
MV m²/kN vs STRESS (kPa)
BH S502-20 SA 10



HYDRAULIC CONDUCTIVITY,
cm/s

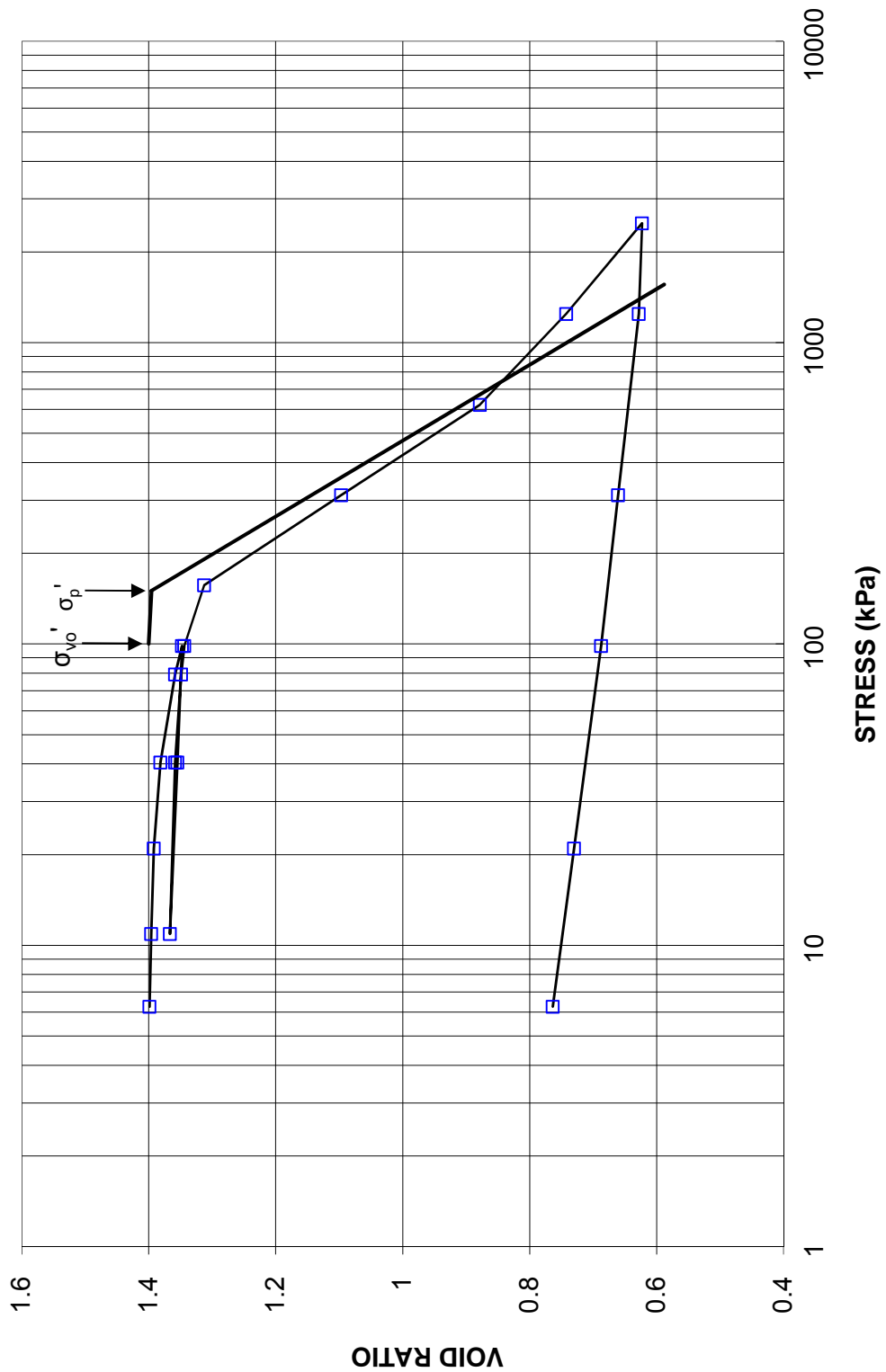
CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs STRESS
BH S502-20 SA 10



CONSOLIDATION TEST
VOID RATIO VS LOG STRESS

FIGURE B.S502-24
Sheet 3 of 4

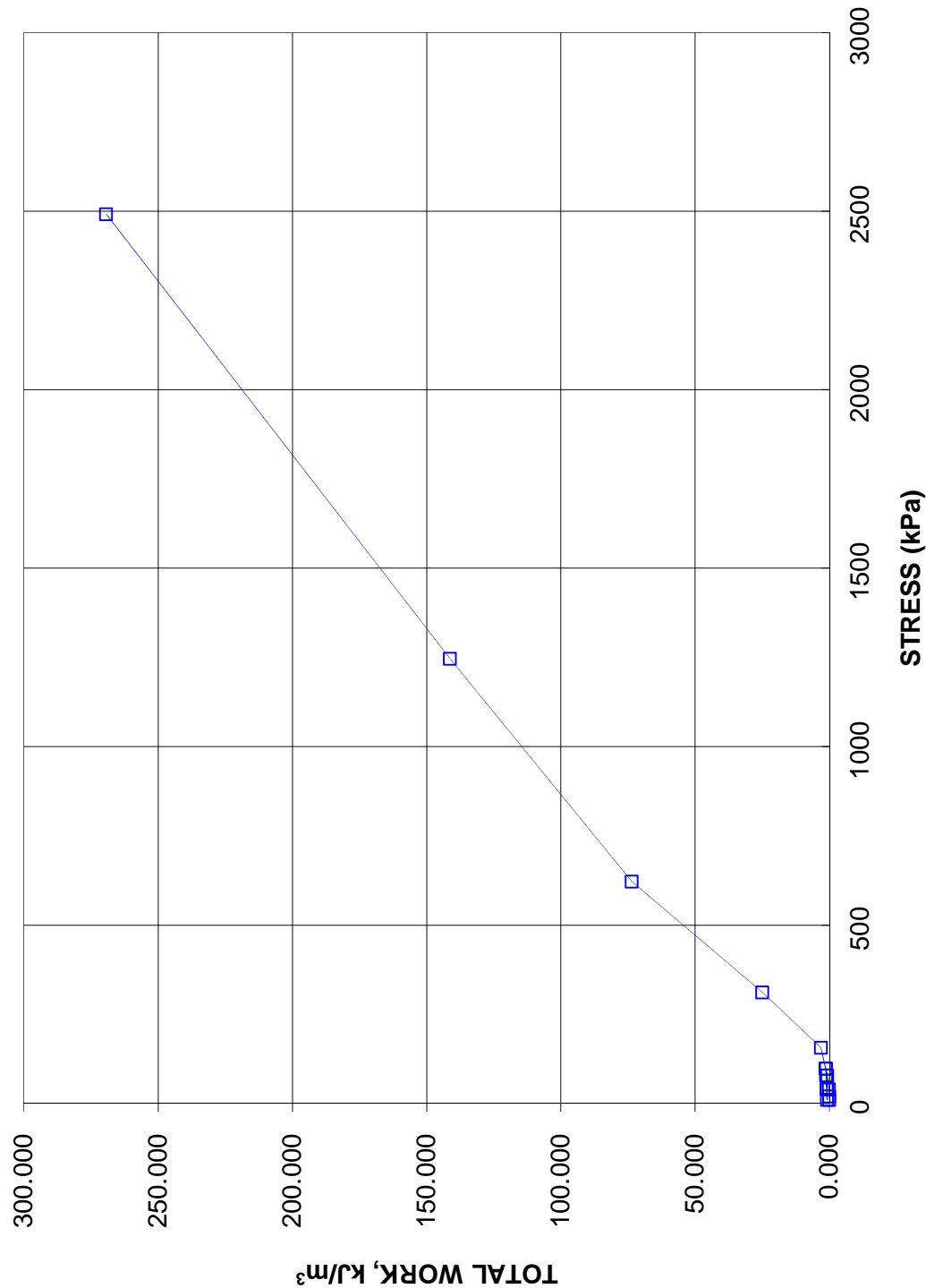
CONSOLIDATION TEST
VOID RATIO vs STRESS
BH S502-20 SA 10



CONSOLIDATION TEST
TOTAL WORK VS STRESS

FIGURE B.S502-24
Sheet 4 of 4

CONSOLIDATION TEST
TOTAL WORK, kJ/m³ vs STRESS
BH S502-20 SA 10



CONSOLIDATION TEST SUMMARY**FIGURE B.S502-25**

Sheet 1 of 4

SAMPLE IDENTIFICATION

Project Number	09-1111-6014	Sample Number	1
Borehole Number	S502-20B	Sample Depth, m	5.5-5.9

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	3		
Date Started	3/18/2013		
Date Completed	3/31/2014		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.54	Unit Weight, kN/m ³	16.95
Sample Diameter, cm	6.33	Dry Unit Weight, kN/m ³	11.13
Area, cm ²	31.43	Specific Gravity, measured	2.76
Volume, cm ³	79.77	Solids Height, cm	1.043
Water Content, %	52.30	Volume of Solids, cm ³	32.80
Wet Mass, g	137.86	Volume of Voids, cm ³	46.97
Dry Mass, g	90.52	Degree of Saturation, %	100.8

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average		t ₉₀ sec	cv. cm ² /s	mv m ² /kN	k cm/s
	Height cm		Height cm					
0.00	2.538	1.432	2.538					
5.85	2.541	1.435	2.540					
10.81	2.538	1.432	2.540	1220	1.12E-03	2.70E-04	2.97E-08	
20.59	2.531	1.425	2.534	1192	1.14E-03	2.90E-04	3.25E-08	
40.17	2.520	1.415	2.525	1250	1.08E-03	2.23E-04	2.37E-08	
79.16	2.497	1.393	2.508	1117	1.19E-03	2.32E-04	2.72E-08	
157.05	2.457	1.354	2.477	1024	1.27E-03	2.02E-04	2.52E-08	
312.87	2.311	1.215	2.384	2289	5.26E-04	3.68E-04	1.90E-08	
624.42	2.070	0.984	2.190	1745	5.83E-04	3.05E-04	1.74E-08	
1265.50	1.917	0.837	1.993	923	9.13E-04	9.43E-05	8.43E-09	
2513.86	1.786	0.712	1.851	638	1.14E-03	4.12E-05	4.60E-09	
1265.50	1.800	0.725	1.793					
312.87	1.833	0.756	1.816					
79.16	1.880	0.801	1.856					
20.59	1.918	0.838	1.899					
5.85	1.959	0.877	1.938					

Note:

Specimen taken 13-18 cm from bottom of the tube

k calculated using cv based on t₉₀ values.**SAMPLE DIMENSIONS AND PROPERTIES - FINAL**

Sample Height, cm	1.96	Unit Weight, kN/m ³	19.14
Sample Diameter, cm	6.33	Dry Unit Weight, kN/m ³	14.42
Area, cm ²	31.43	Specific Gravity, measured	2.76
Volume, cm ³	61.56	Solids Height, cm	1.043
Water Content, %	32.74	Volume of Solids, cm ³	32.80
Wet Mass, g	120.16	Volume of Voids, cm ³	28.77
Dry Mass, g	90.52		

Prepared By: RD

Golder Associates

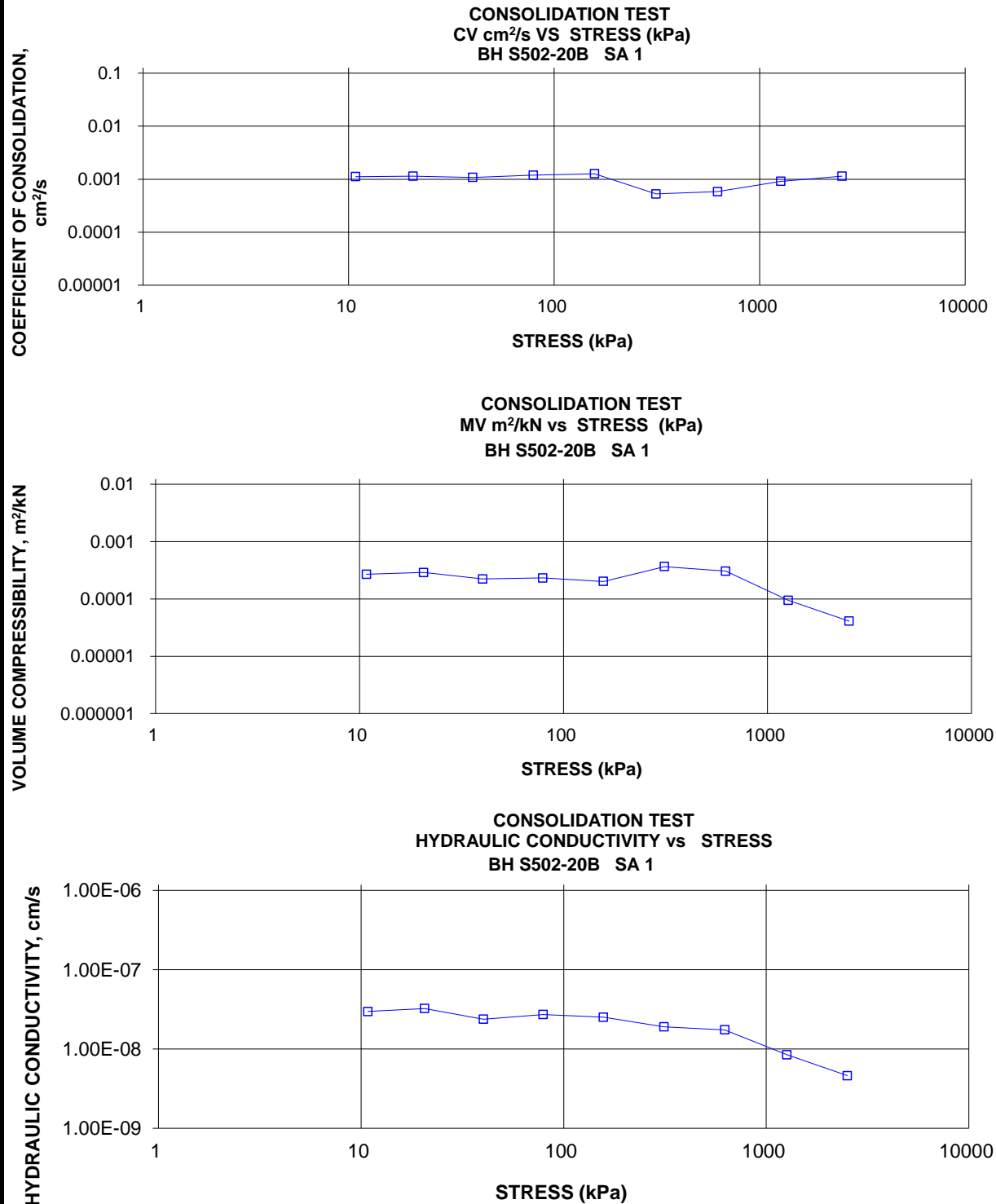
Checked By:

AV

CONSOLIDATION TEST SUMMARY

FIGURE B.S502-25

Sheet 2 of 4



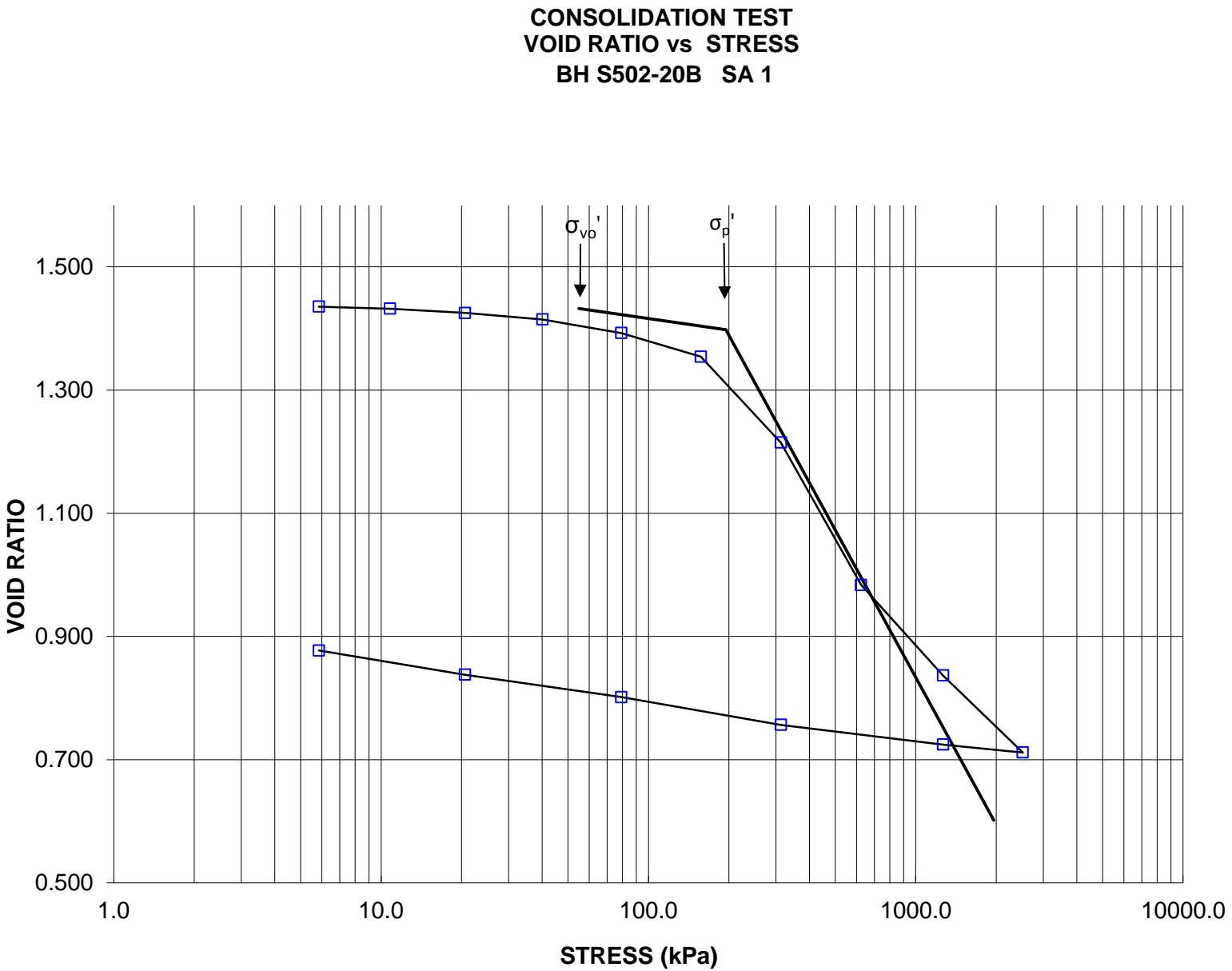
Project No. 09-1111-6014

Prepared By: RD

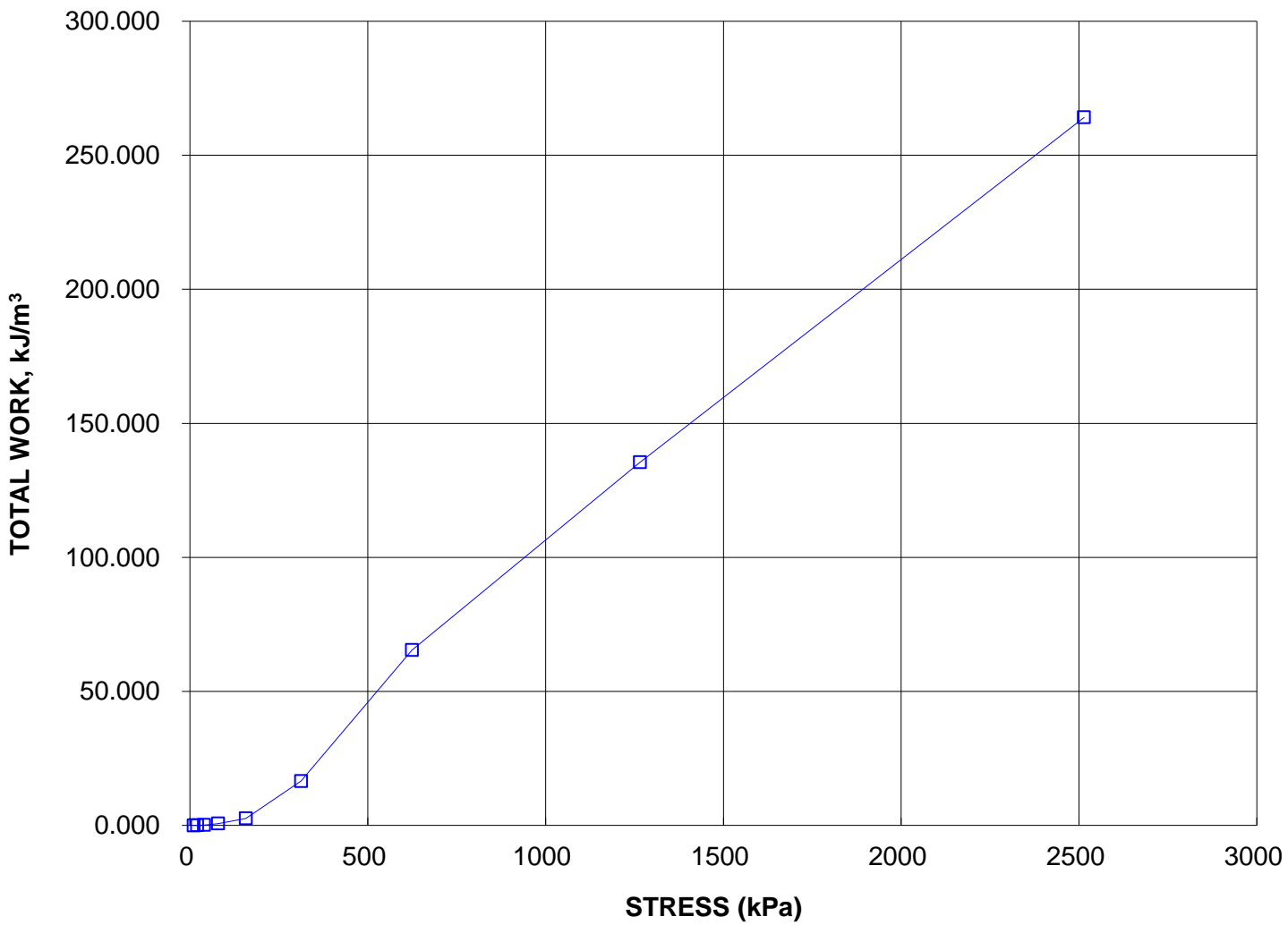
Golder Associates

Checked By:

AV



CONSOLIDATION TEST
TOTAL WORK, kJ/m^3 vs STRESS
BH S502-20B SA 1

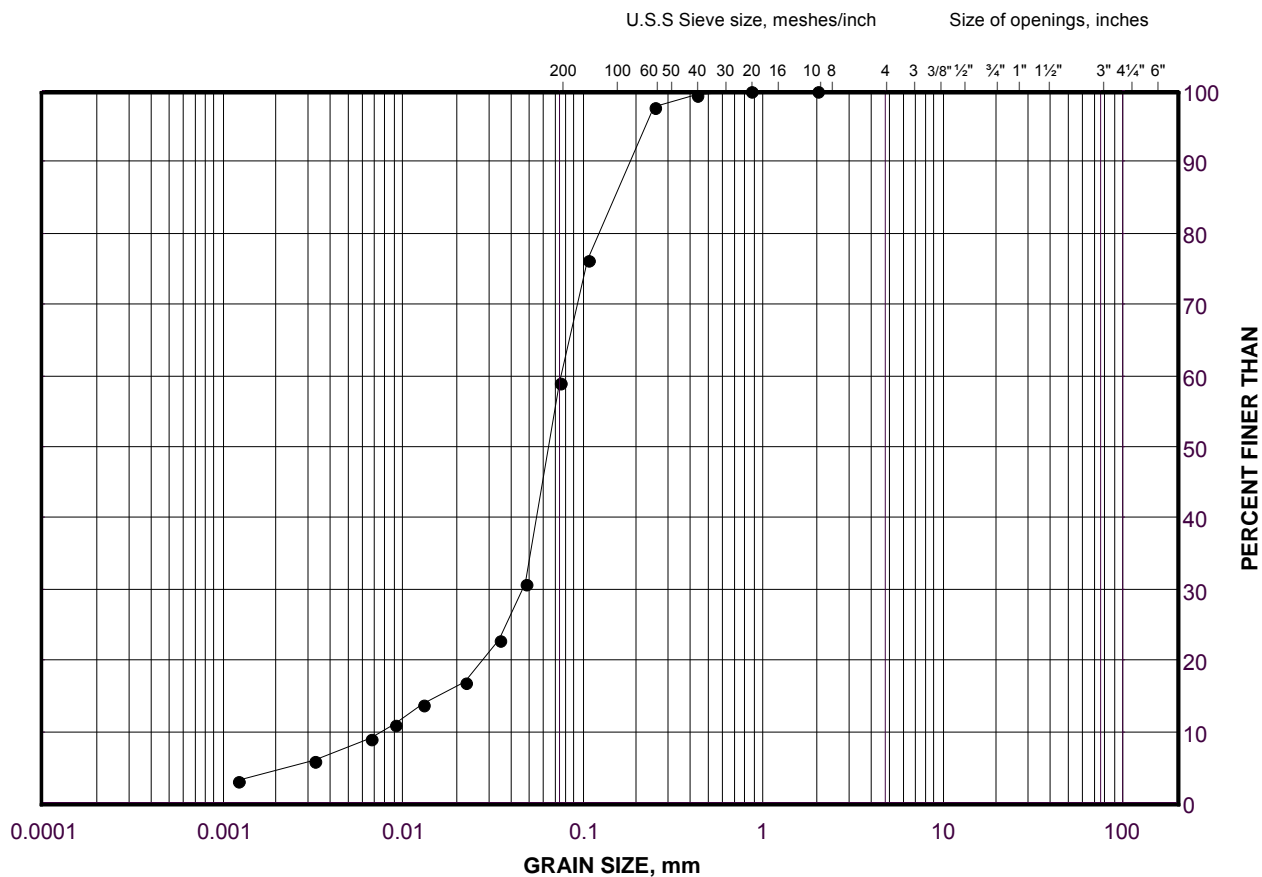


GRAIN SIZE DISTRIBUTION

Silt and Sand (Pocket)

Highway 69 (NBL) STA 20+990 to 21+075 (High Fill 502)

FIGURE B.S502-26



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

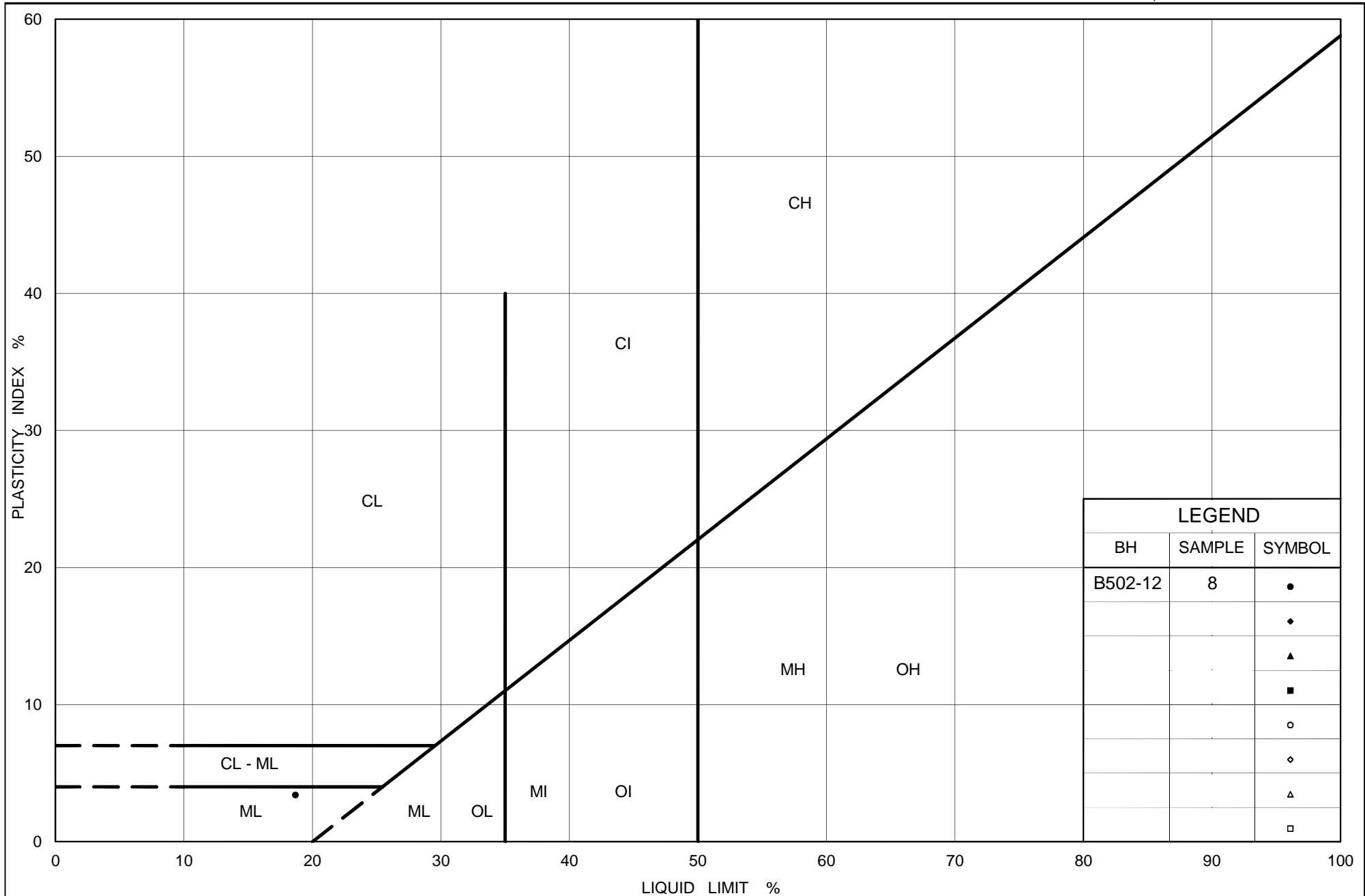
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	B502-02	8	168.1

Project Number: 09-1111-6014

Checked By: AV

Golder Associates

Date: 05-Dec-13



Ministry of Transportation

Ontario

PLASTICITY CHART

Silt (Pockets)

Highway 69 (NBL) STA 20+990 to 21+075 (High Fill 502)

Figure No. B.S502-27

Project No. 09-1111-6014

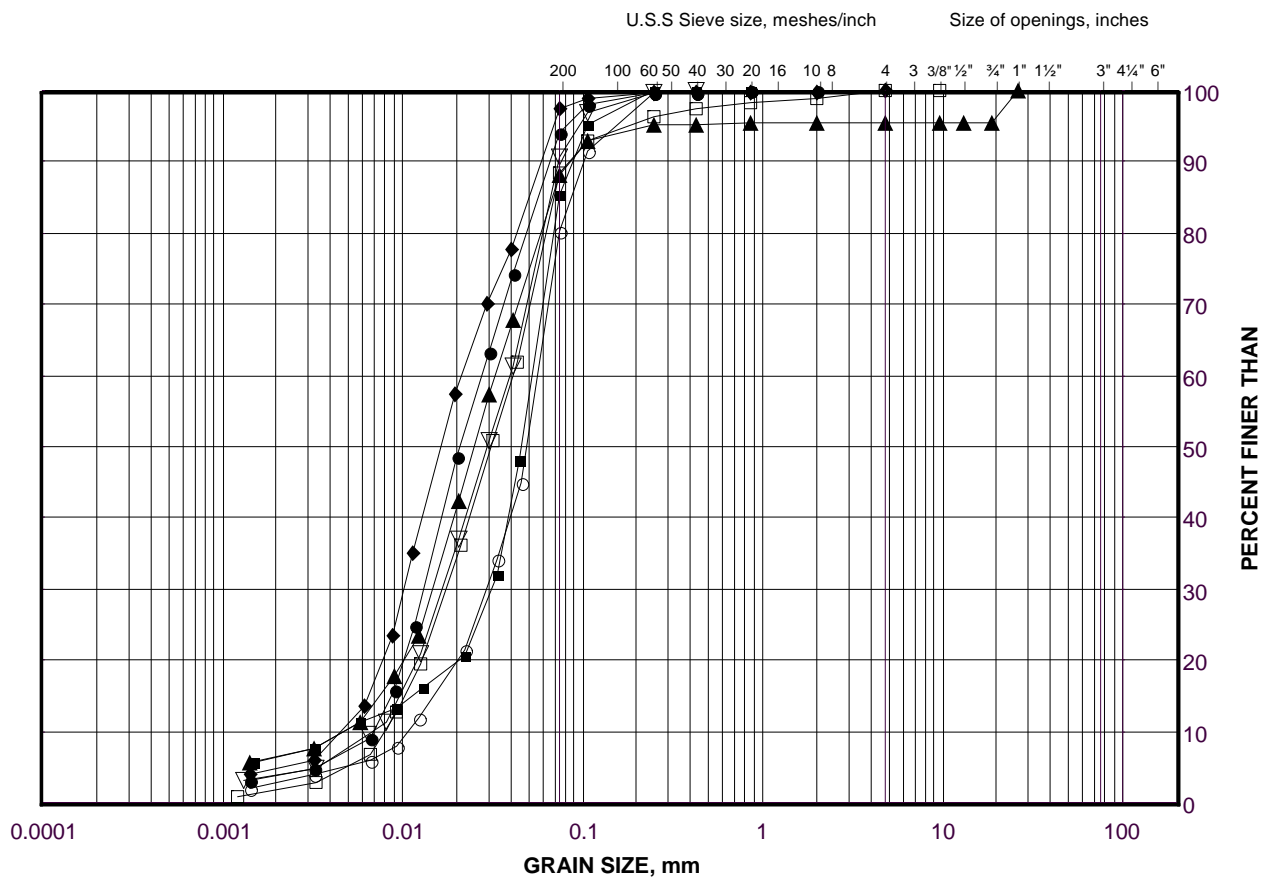
Checked By: AV

GRAIN SIZE DISTRIBUTION

Silt (Lower Deposit)

Highway 69 (NBL) STA 20+990 to 21+075 (High Fill 502)

FIGURE B.S502-28A



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S502-20A	10	175.2
■	S502-20	11B	172.9
◆	S502-18	12	168.8
▲	B502-13	13	171.2
▽	S502-22	13	174.0
○	S502-18	13	167.3
□	B502-02	16	154.4

Project Number: 09-1111-6014

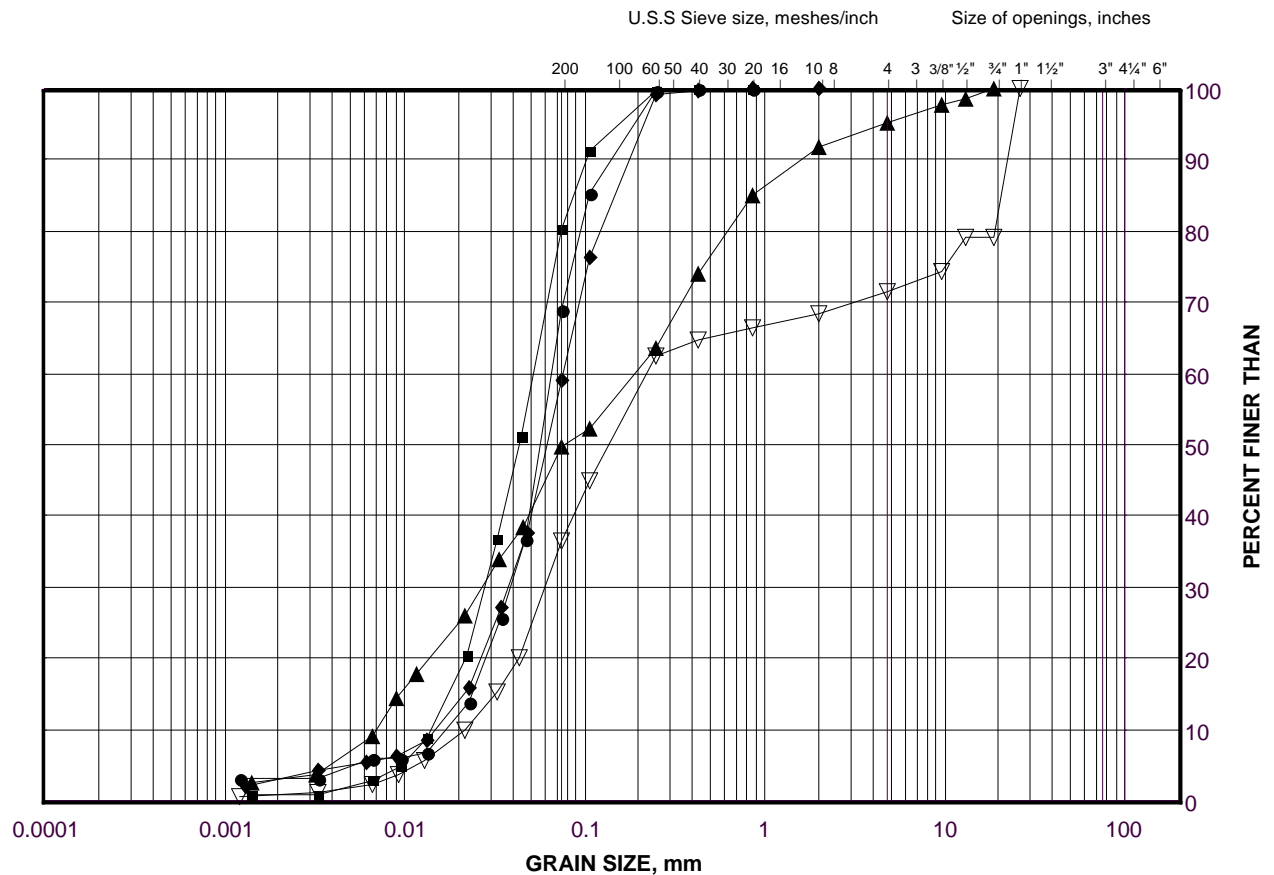
Checked By: AV

Golder Associates

Date: 17-Oct-14

GRAIN SIZE DISTRIBUTION
 Silt to Silt and Sand (Lower Deposit)
 Highway 69 (NBL) STA 20+990 to 21+075 (High Fill 502)

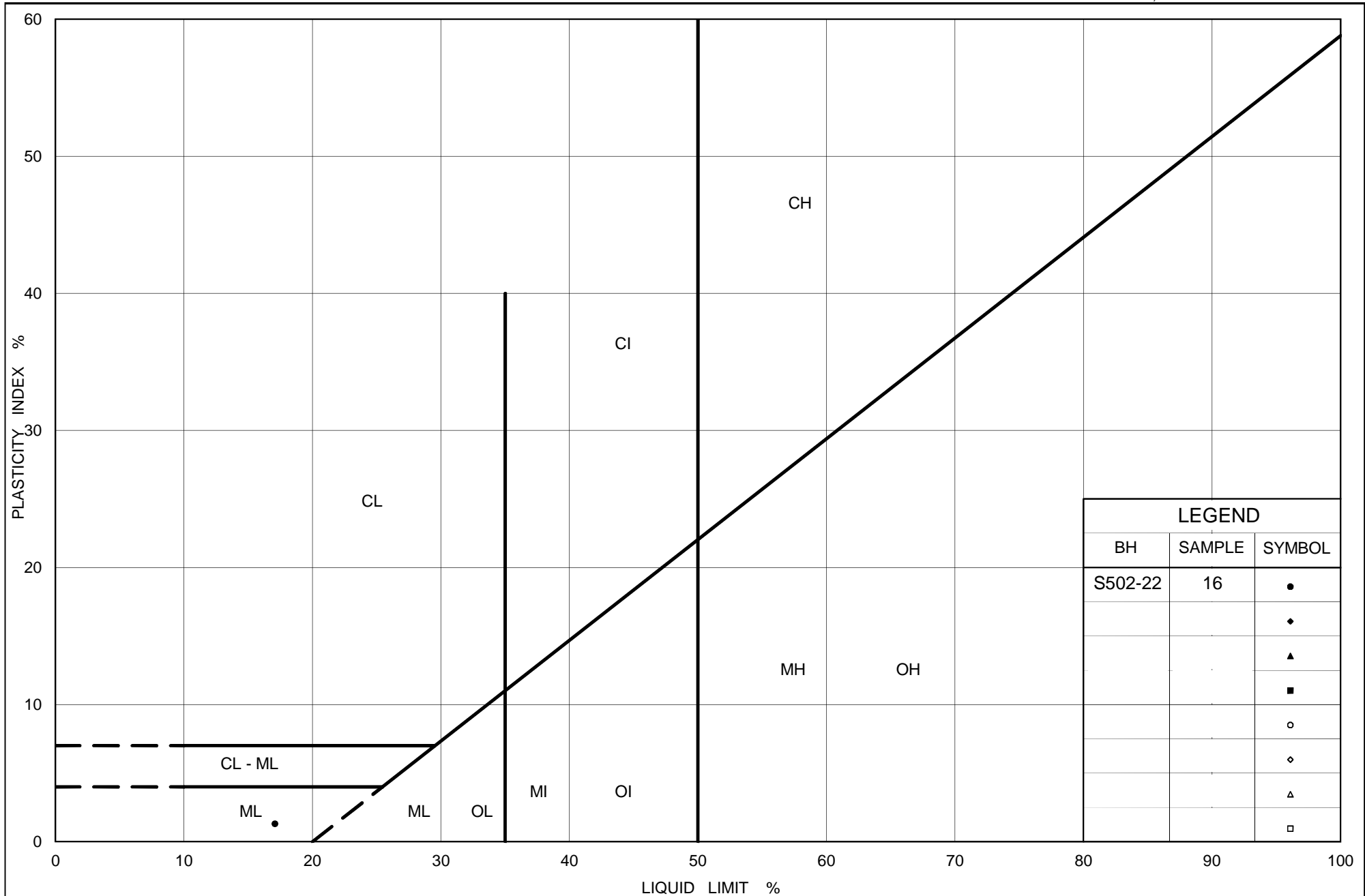
FIGURE B.S502-28B



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S502-20	12	171.6
■	S502-21	13	173.3
◆	S502-22	15	170.9
▲	S502-24	15	173.2
▽	B502-02	17	151.4



Ministry of Transportation

Ontario

PLASTICITY CHART Silt

Highway 69 (NBL) STA 20+990 to 21+075 (High Fill 502)

Figure No. B.S502-29

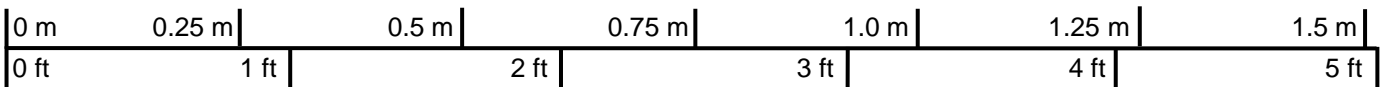
Project No. 09-1111-6014

Checked By: AV


Borehole B502-02



Box 1: 28.50 m – 31.80 m



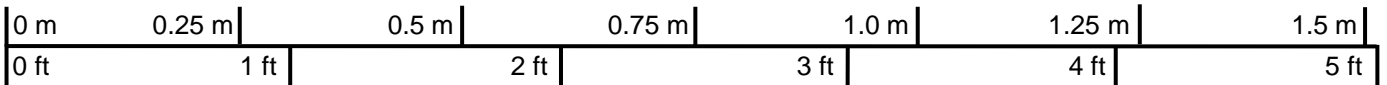
Scale

PROJECT		Swamp Crossing, High Fill Areas and Deep Cut Contract 5 Highway 69 Four-Laning GWP 5347-08-00; WP 5005-10-01			
TITLE		Bedrock Core Photograph – B502–02 Highway 69 (NBL)			
		PROJECT No. 09-1111-6014		FILE No. ----	
		DESIGN	AV	NOV 13	SCALE NTS
		CADD	--	--	REV.
		CHECK	CN	NOV 13	FIGURE B.S502-30
		REVIEW	JPD/JMAC	NOV 13	


Borehole B502-12



Box 1: 14.72 m – 18.04 m



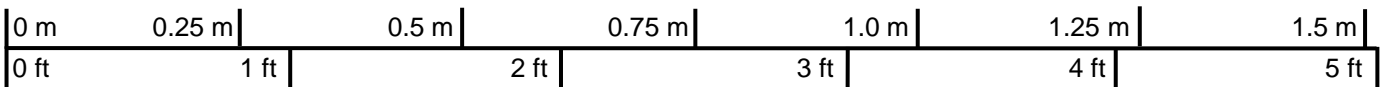
Scale

PROJECT		Swamp Crossing, High Fill Areas and Deep Cut Contract 5 Highway 69 Four-Laning GWP 5347-08-00; WP 5005-10-01			
TITLE		Bedrock Core Photograph – B502–12 Highway 69 (NBL)			
		PROJECT No. 09-1111-6014		FILE No. ----	
		DESIGN	AV	OCT 14	SCALE NTS
		CADD	--	--	REV.
		CHECK	CN	OCT 14	FIGURE B.S502-31
		REVIEW	JPD/JMAC	OCT 14	


Borehole B502-13



Box 1: 15.0 m – 18.04 m



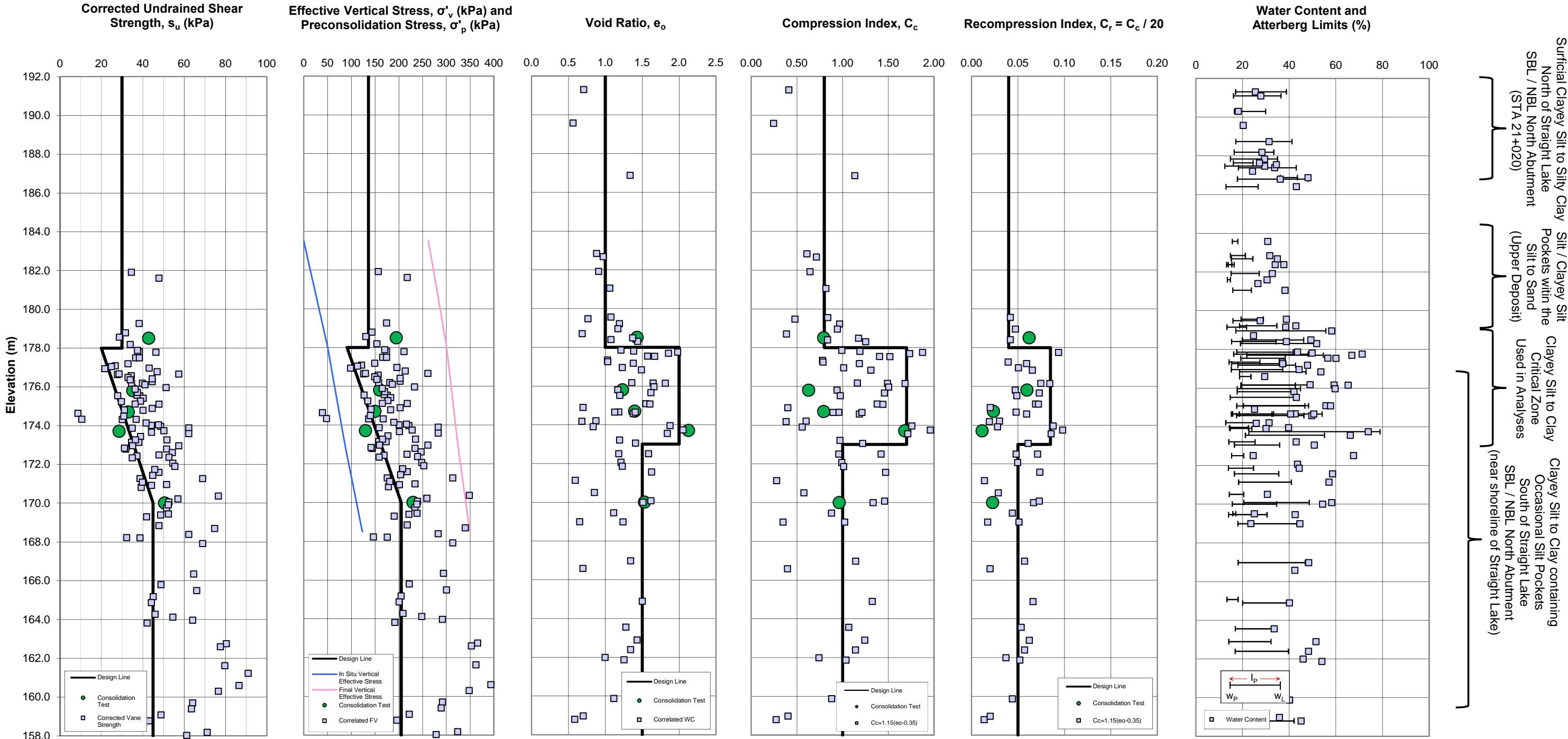
Scale

PROJECT		Swamp Crossing, High Fill Areas and Deep Cut Contract 5 Highway 69 Four-Laning GWP 5347-08-00; WP 5005-10-01			
TITLE		Bedrock Core Photograph – B502–13 Highway 69 (NBL)			
		PROJECT No. 09-1111-6014		FILE No. ----	
		DESIGN	AV	OCT 14	SCALE NTS
		CADD	--	--	REV.
		CHECK	CN	OCT 14	FIGURE B.S502-32
		REVIEW	JPD/JMAC	OCT 14	

SUMMARY PLOT OF ENGINEERING PARAMETERS FOR
COHESIVE DEPOSITS

Highway 69 SBL - STA 20+980 to 21+180 (Swamp 502)
Highway 69 NBL - STA 20+990 to 21+075 (Swamp 502)

FIGURE B1



Date: July 2016
Project No: 09-1111-6014

Prepared By: TZ
Checked By: JPD/JMAC

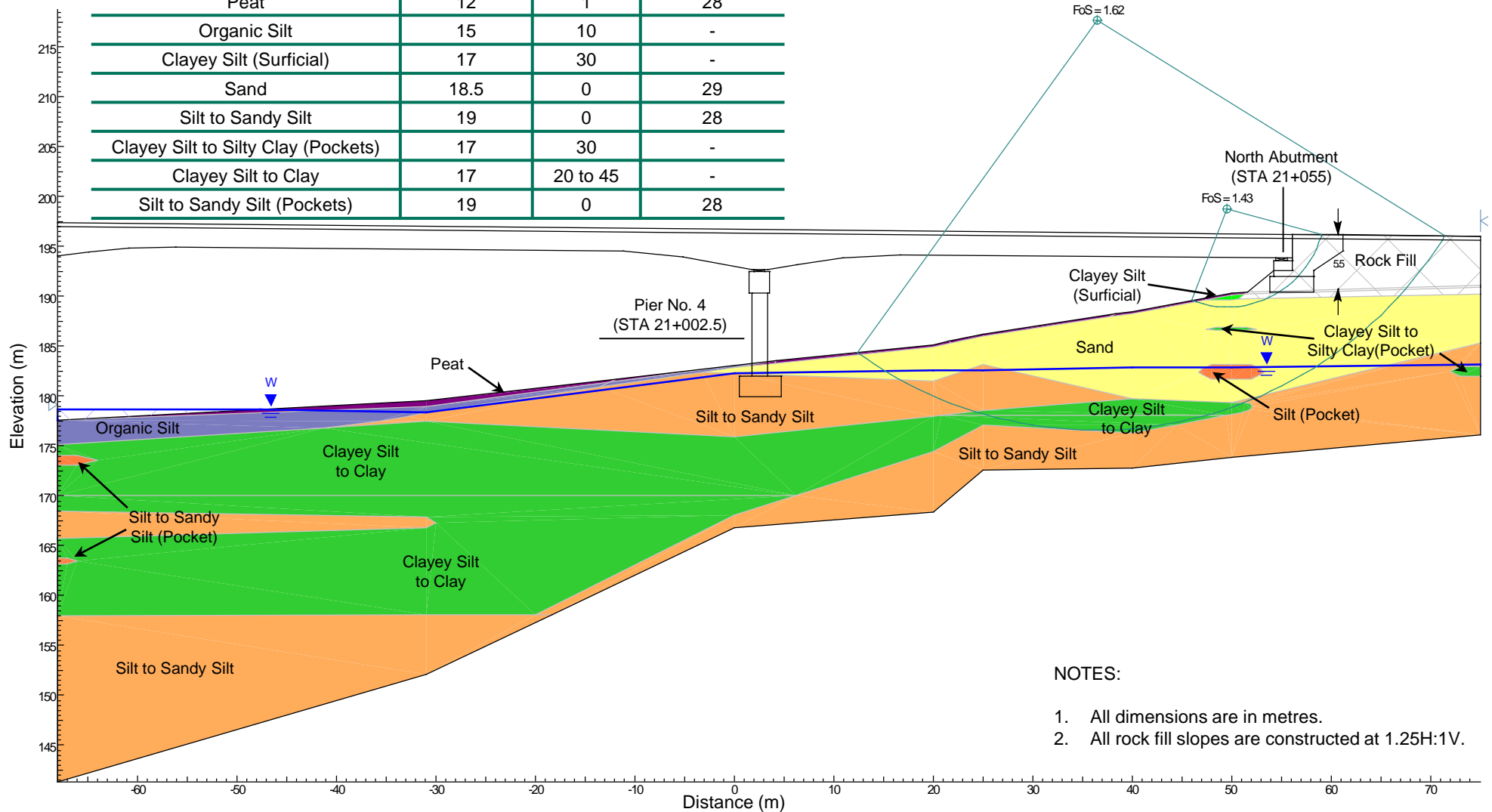




Highway 69 SBL – STA 20+980 to 21+180 (High Fill 502) Front Slope Stability – Base Case

Figure B2

Material Name	Unit Weight (kN/m ³)	Cohesion (kPa)	Friction Angle (degrees)
Rock Fill	19	0	40
Peat	12	1	28
Organic Silt	15	10	-
Clayey Silt (Surficial)	17	30	-
Sand	18.5	0	29
Silt to Sandy Silt	19	0	28
Clayey Silt to Silty Clay (Pockets)	17	30	-
Clayey Silt to Clay	17	20 to 45	-
Silt to Sandy Silt (Pockets)	19	0	28





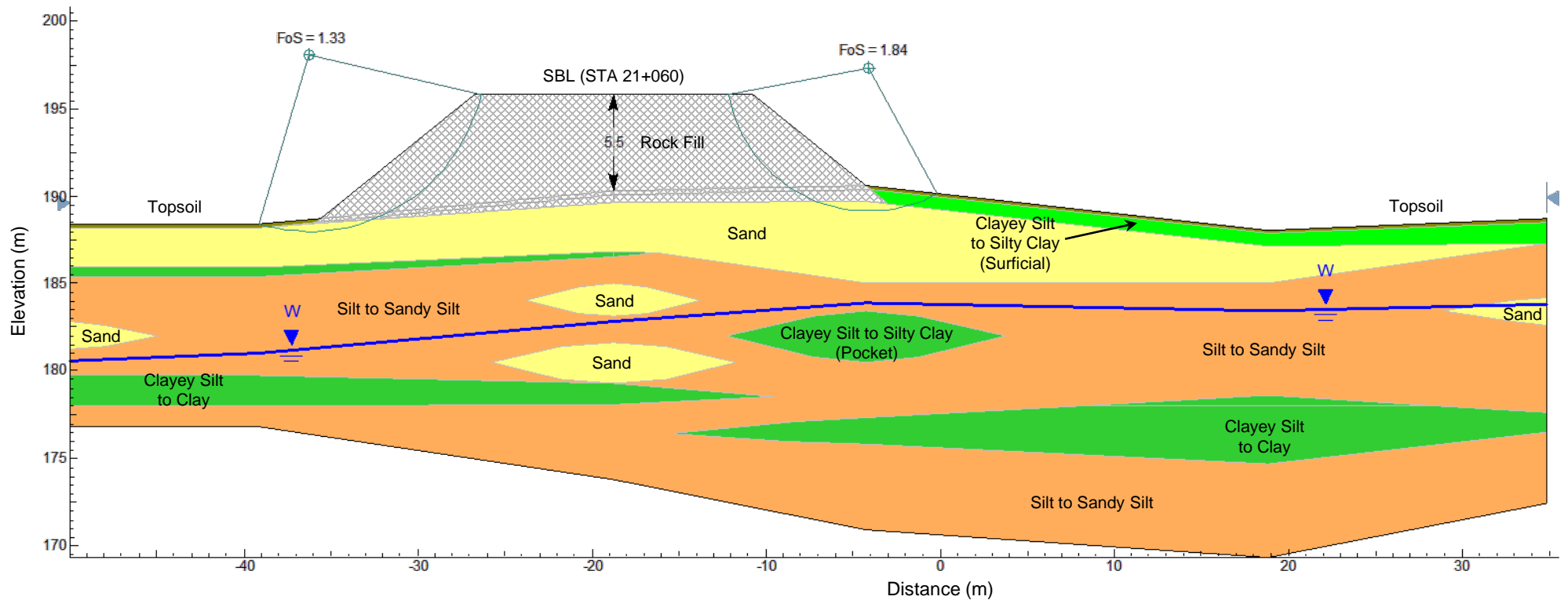
Highway 69 SBL – STA 20+980 to 21+180 (High Fill 502) Side Slope Stability – Base Case

Figure B3

NOTES:

1. All dimensions are in metres.
2. All rock fill slopes are constructed at 1.25H:1V.
3. Borehole S502-07 was utilized to model the stratigraphy below the centerline of the Highway 69 SBL embankment.

Material Name	Unit Weight (kN/m ³)	Cohesion (kPa)	Friction Angle (degrees)
Rock Fill	19	0	40
Topsoil	15	1	28
Clayey Silt to Silty Clay (Surficial)	17	30	-
Sand	18.5	0	29
Silt to Sandy Silt	19	0	28
Clayey Silt to Clay	17	20 to 45	-
Silt to Sandy Silt (Pocket)	19	0	28
Clayey Silt to Silty Clay (Pockets)	17	30	-

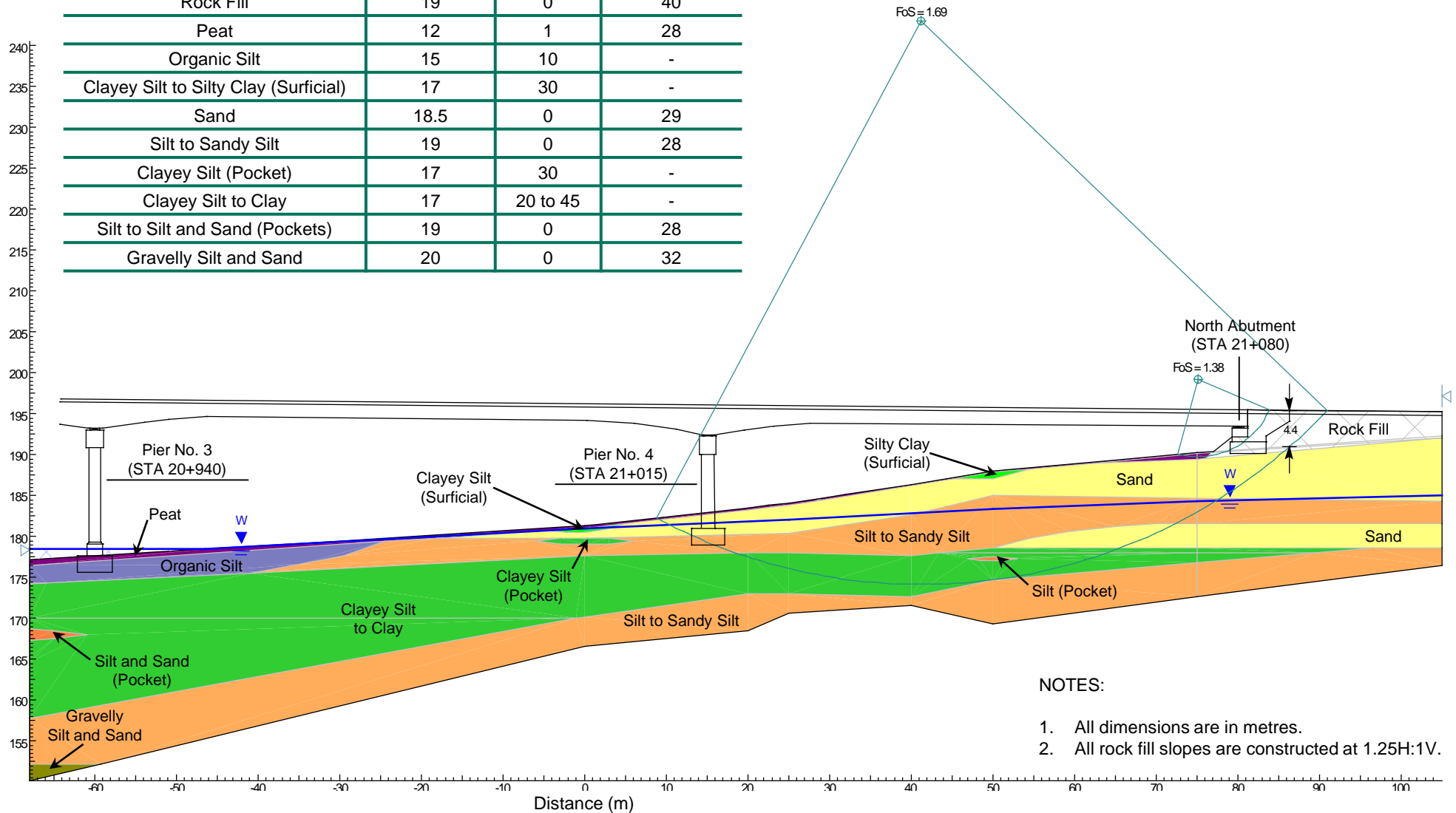




Highway 69 NBL – STA 20+990 to 21+075 (High Fill 502) Front Slope Stability – Base Case

Figure B4

Material Name	Unit Weight (kN/m ³)	Cohesion (kPa)	Friction Angle (degrees)
Rock Fill	19	0	40
Peat	12	1	28
Organic Silt	15	10	-
Clayey Silt to Silty Clay (Surficial)	17	30	-
Sand	18.5	0	29
Silt to Sandy Silt	19	0	28
Clayey Silt (Pocket)	17	30	-
Clayey Silt to Clay	17	20 to 45	-
Silt to Silt and Sand (Pockets)	19	0	28
Gravelly Silt and Sand	20	0	32





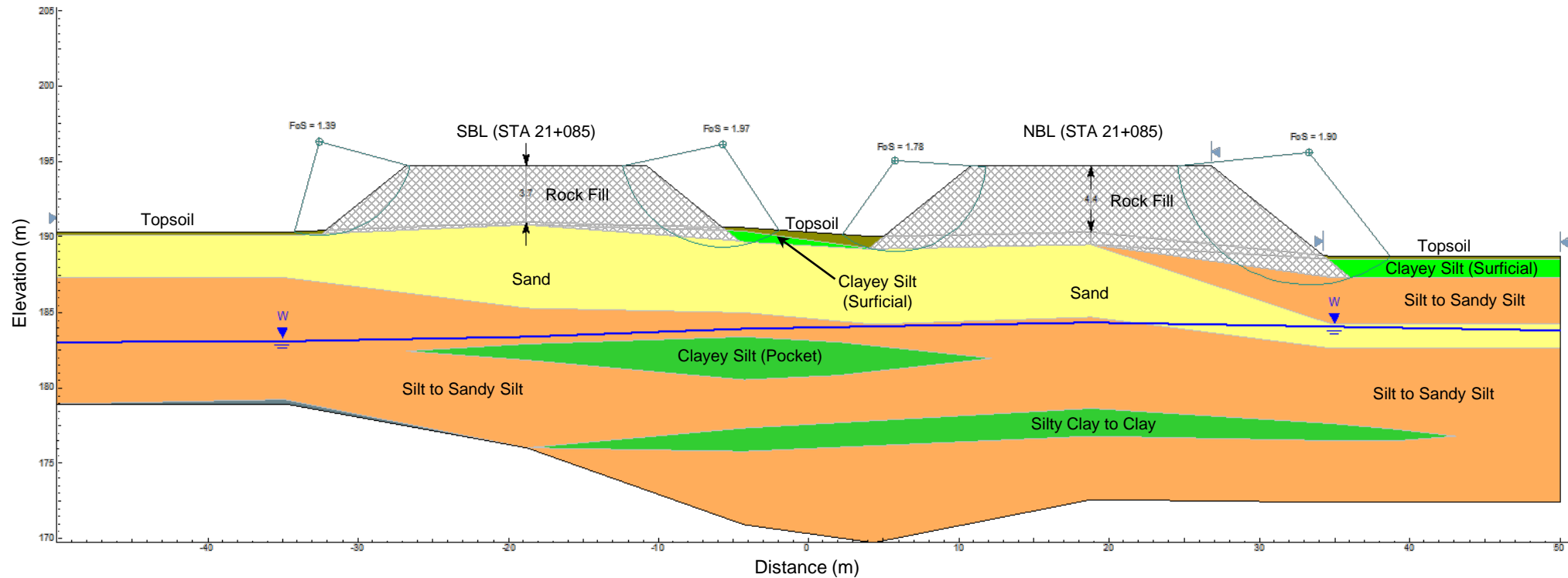
Highway 69 NBL – STA 20+990 to 21+075 (High Fill 502) Side Slope Stability – Base Case

Figure B5

NOTES:

1. All dimensions are in metres.
2. All rock fill slopes are constructed at 1.25H:1V.
3. Borehole S502-24 was utilized to model the stratigraphy below the centerline of the Highway 69 NBL embankment.

Material Name	Unit Weight (kN/m ³)	Cohesion (kPa)	Friction Angle (degrees)
Rock Fill	19	0	40
Topsoil	15	1	28
Clayey Silt (Surficial)	17	30	-
Sand	18.5	0	29
Silt to Sandy Silt	19	0	28
Clayey Silt to Clay	17	20 to 45	-

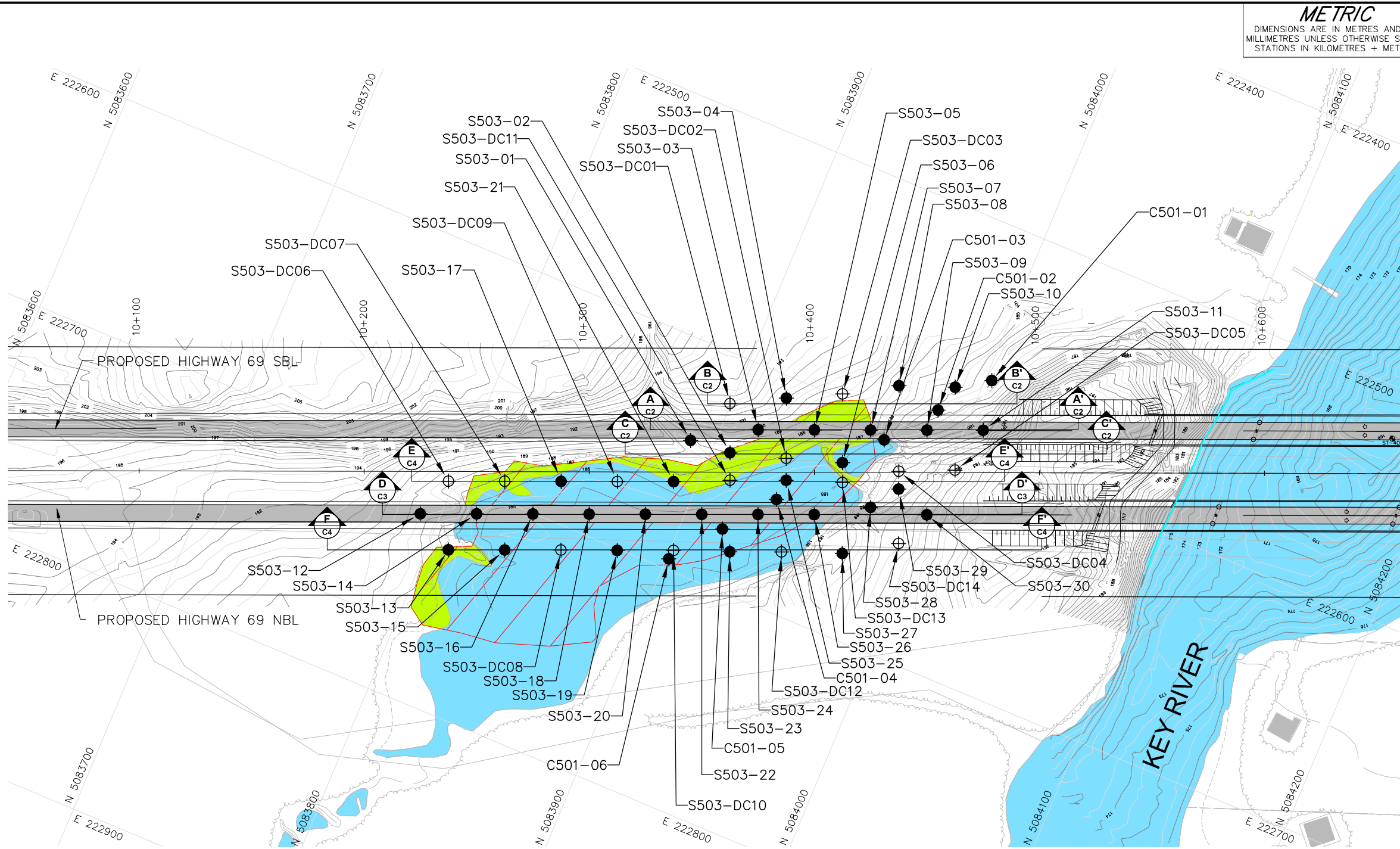




APPENDIX C

Highway 69 SBL – STA 10+350 to STA 10+470 (Swamp 503)

Highway 69 NBL – STA 10+230 to STA 10+445 (Swamp 503)



PLAN



DCPT CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
S503-DC01	193.0	5083899.5	222621.3
S503-DC02	186.3	5083931.9	222634.1
S503-DC03	190.3	5083944.0	222598.0
S503-DC04	187.8	5083980.3	222620.1
S503-DC05	192.0	5084003.1	222609.9
S503-DC06	188.3	5083797.5	222701.3
S503-DC07	185.9	5083820.5	222691.7
S503-DC08	185.8	5083855.3	222710.3
S503-DC09	185.9	5083866.7	222672.5
S503-DC10	185.8	5083901.5	222691.1
S503-DC11	186.4	5083912.6	222652.7
S503-DC12	185.8	5083946.0	222673.2
S503-DC13	185.8	5083959.1	222634.3
S503-DC14	191.9	5083992.6	222649.7

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
S503-12	188.9	5083791.5	222719.5
S503-13	186.1	5083809.2	222729.5
S503-14	185.6	5083814.6	222709.9
S503-15	185.8	5083832.3	222719.9
S503-16	185.8	5083837.7	222700.3
S503-17	185.9	5083843.6	222682.1
S503-18	185.8	5083860.7	222690.7
S503-19	185.8	5083878.5	222700.8
S503-20	185.8	5083883.8	222681.1
S503-21	186.4	5083889.8	222662.9
S503-22	185.8	5083906.9	222671.5
S503-23	185.8	5083924.8	222682.0
S503-24	185.8	5083930.0	222661.9
S503-25	185.8	5083935.7	222643.1
S503-26	185.8	5083953.1	222652.3
S503-27	188.3	5083971.2	222663.4
S503-28	188.4	5083974.9	222639.6
S503-29	188.8	5083983.3	222627.4
S503-30	192.6	5083999.2	222633.1

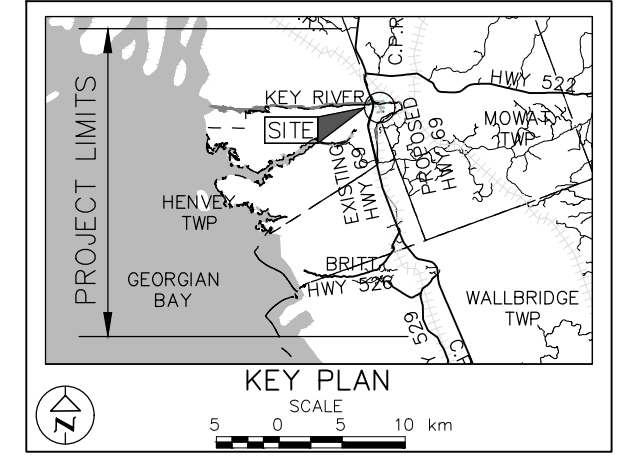


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 5005-10-01

HIGHWAY 69
STA 10+350 TO 10+470 (SBL)
STA 10+230 TO 10+445 (NBL)
BOREHOLE LOCATIONS

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



LEGEND

Borehole - Current Investigation

Dynamic Cone Penetration Test

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
C501-01	183.1	5084002.9	222566.9
C501-02	183.7	5083985.9	222588.3
C501-03	185.2	5083968.9	222609.7
C501-04	185.8	5083935.0	222652.6
C501-05	185.8	5083917.9	222673.9
C501-06	185.8	5083901.0	222695.4
S503-01	187.3	5083889.7	222643.1
S503-02	188.1	5083907.9	222641.4
S503-03	189.8	5083915.5	222627.2
S503-04	191.4	5083921.7	222609.4
S503-05	187.3	5083938.6	222617.6
S503-06	185.3	5083955.7	222626.2
S503-07	187.3	5083961.7	222608.0
S503-08	187.1	5083965.7	222585.0
S503-09	184.5	5083984.8	222598.4
S503-10	186.3	5083989.0	222575.9
S503-11	186.7	5084007.9	222588.8

NOTES

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

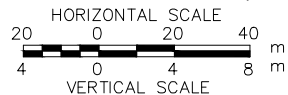
The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

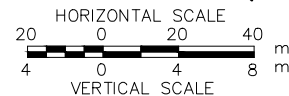
Base plans provided in digital format by URS, drawing file nos. Alignment and Contours from Hwy69_Contour-Plan_C3.dwg, received April 23, 2012 and , Existing Ground Surface cut from contour drawing file Hwy69_Contour-Plan_C5.dwg, received August 31, 2012 and the Existing and Proposed Grade obtained from drawing file Hwy69_profile March 2012.dwg, received March 14, 2012.

NO.	DATE	BY	REVISION	
Geocres No. 41H-164				
HWY. 69		PROJECT NO. 09-1111-6014		DIST.
SUBM'D. ARV		CHKD. ARV	DATE: Oct. 2014	SITE:
DRAWN: JFC		CHKD. ARV	APPD. JPD/JMAC	DWG. C1

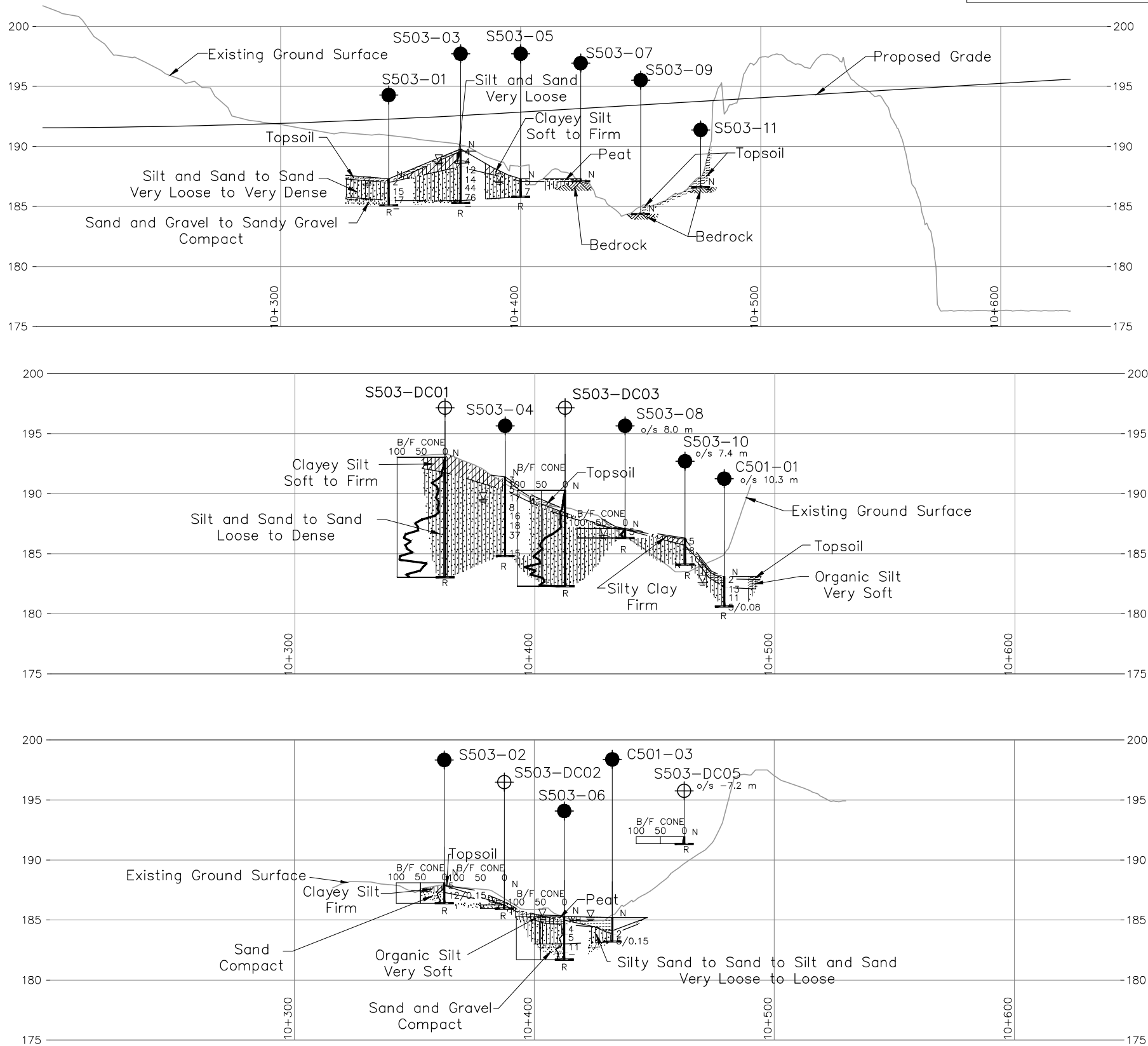
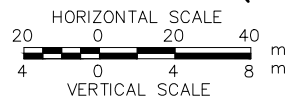
A-A'
C1
CENTRELINE PROFILE
HIGHWAY 69 (SBL)



B-B'
C1
EMBANKMENT TOE PROFILE
HIGHWAY 69 (SBL)



C-C'
C1
EMBANKMENT TOE PROFILE
HIGHWAY 69 (SBL)



NOTES

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METRIC

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

CONT No.
WP No. 5005-10-01

HIGHWAY 69

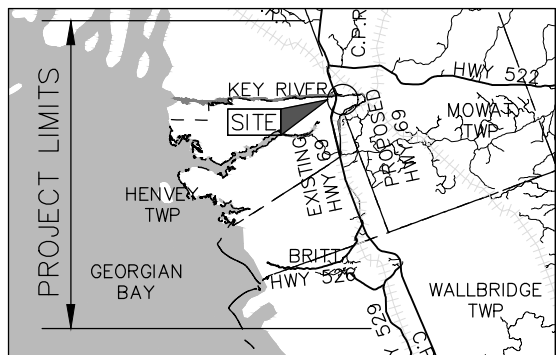
STA 10+290 TO 10+490 (SBL)

SOIL STRATA

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN



LEGEND

- Borehole - Current Investigation
- ⊕ Dynamic Cone Penetration Test
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ≡ WL upon completion of drilling
- R Refusal

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
C501-01	183.1	5084002.9	222566.9
C501-03	185.2	5083968.9	222609.7
S503-01	187.3	5083889.7	222643.1
S503-02	188.1	5083907.9	222641.4
S503-03	189.8	5083915.5	222627.2
S503-04	191.4	5083921.7	222609.4
S503-05	187.3	5083938.6	222617.6
S503-06	185.3	5083955.7	222626.2
S503-07	187.3	5083961.7	222608.0
S503-08	187.1	5083965.7	222585.0
S503-09	184.5	5083984.8	222598.4
S503-10	186.3	5083989.0	222575.9
S503-11	186.7	5084007.9	222588.8

DCPT CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
S503-DC01	193.0	5083899.5	222621.3
S503-DC02	186.3	5083931.9	222634.1
S503-DC03	190.3	5083944.0	222598.0
S503-DC05	192.0	5084003.1	222609.9

REFERENCE


Existing and Proposed Grade provided in digital format by URS, drawing file no. Hwy69_profile March 2012.dwg, received March 14, 2012 and Existing Ground Surface cut from contours provided in digital format by URS, drawing file no. drawing file Hwy69_Contour-Plan_C5.dwg, received August 31, 2012.

NO.	DATE	BY	REVISION
Geocres No. 41H-164			
HWY. 69			PROJECT NO. 09-1111-6014
SUBM'D. ARV	CHKD. ARV	DATE: Oct. 2014	SITE:
DRAWN: JFC	CHKD. ARV	APPD. JPD/JMAC	DWG. C2

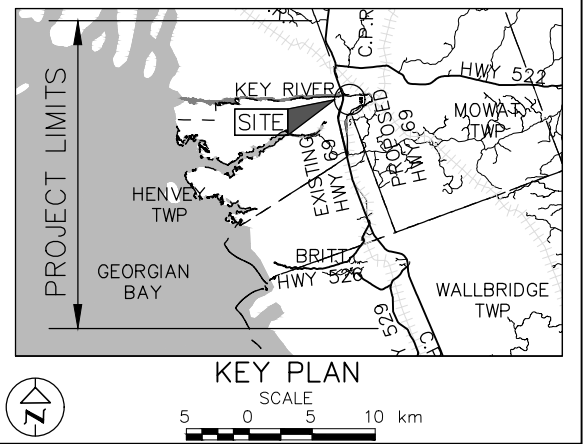
METRIC
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STATIONS IN KILOMETRES + METRES.

CONT No.
WP No.5005-10-01

HIGHWAY 69
STA 10+230 TO 10+445 (NBL)
SOIL STRATA



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



- LEGEND
- Borehole - Current Investigation
 - N Standard Penetration Test Value
 - 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
 - WL upon completion of drilling
 - R Refusal

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
S503-12	188.9	5083791.5	222719.5
S503-14	185.6	5083814.6	222709.9
S503-16	185.8	5083837.7	222700.3
S503-18	185.8	5083860.7	222690.7
S503-20	185.8	5083883.8	222681.1
S503-22	185.8	5083906.9	222671.5
S503-24	185.8	5083930.0	222661.9
S503-26	185.8	5083953.1	222652.3
S503-28	188.4	5083974.9	222639.6
S503-30	192.6	5083999.2	222633.1

NOTES

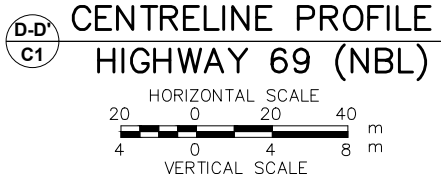
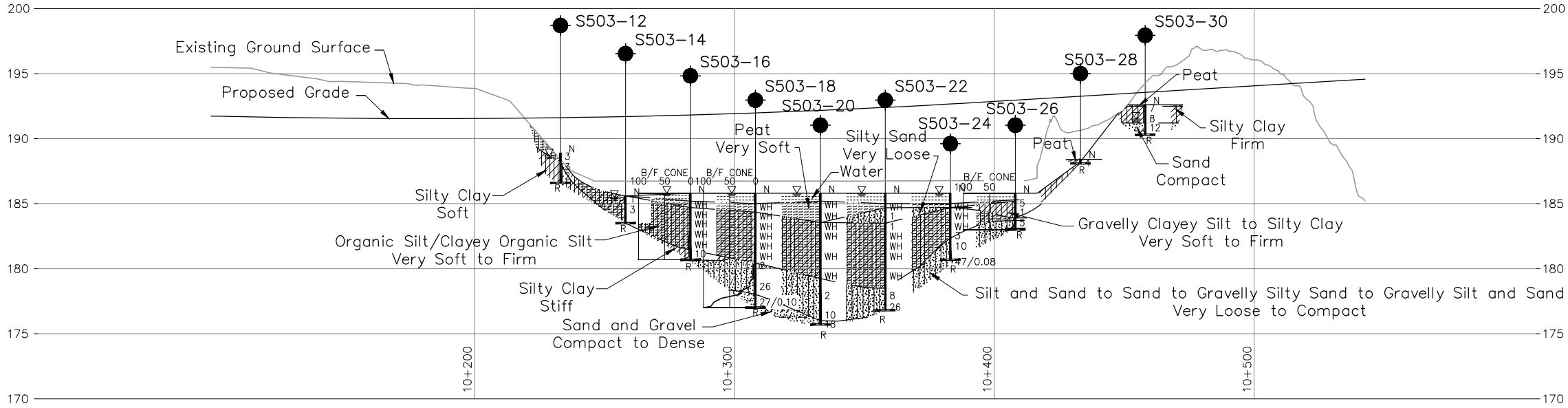
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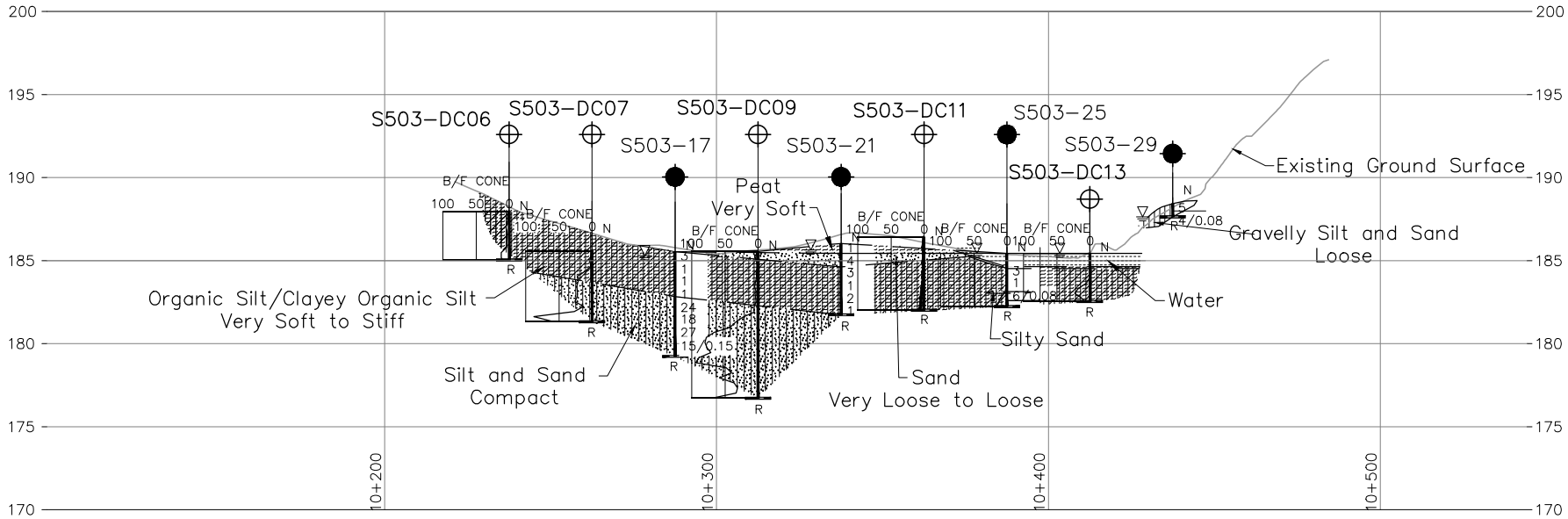
REFERENCE

Existing and Proposed Grade provided in digital format by URS, drawing file no. Hwy69_profile March 2012.dwg, received March 14, 2012.

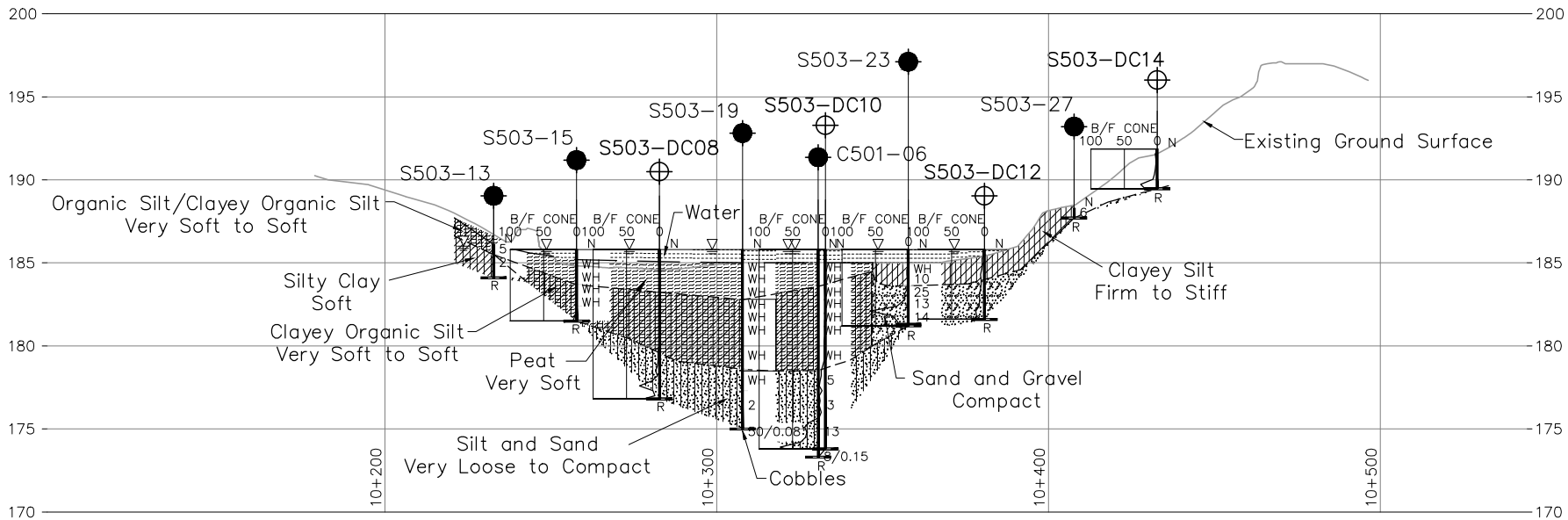
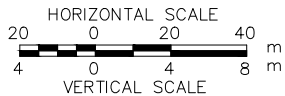


NO.	DATE	BY	REVISION	
Geocres No. 41H-164				
HWY. 69		PROJECT NO. 09-1111-6014		DIST.
SUBM'D. ARV		CHKD. ARV	DATE: Oct. 2014	SITE:
DRAWN: JFC		CHKD. ARV	APPD. JPD/JMAC	DWG. C3

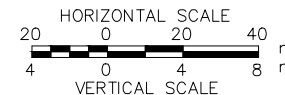
METRIC
DIMENSIONS ARE IN METRES AND/OR
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STATIONS IN KILOMETRES + METRES.



**EMBANKMENT TOE PROFILE
HIGHWAY 69 (NBL)**



**EMBANKMENT TOE PROFILE
HIGHWAY 69 (NBL)**



DCPT CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
S503-DC06	188.3	5083797.5	222701.3
S503-DC07	185.9	5083820.5	222691.7
S503-DC08	185.8	5083855.3	222710.3
S503-DC09	185.9	5083866.7	222672.5
S503-DC10	185.8	5083901.5	222691.1
S503-DC11	186.4	5083912.6	222652.7
S503-DC12	185.8	5083946.0	222673.2
S503-DC13	185.8	5083959.1	222634.3
S503-DC14	191.9	5083992.6	222649.7

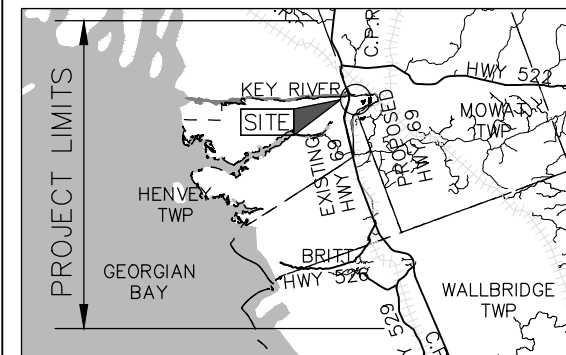
CONT No.
WP No. 5005-10-01

HIGHWAY 69
STA 10+230 TO 10+445 (NBL)
SOIL STRATA

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN
SCALE
5 0 5 10 km

LEGEND

- Borehole - Current Investigation
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ▽ WL upon completion of drilling
- R Refusal

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
C501-06	185.8	5083901.0	222695.4
S503-13	186.1	5083809.2	222729.5
S503-15	185.8	5083832.3	222719.9
S503-17	185.9	5083843.6	222682.1
S503-19	185.8	5083878.5	222700.8
S503-21	186.4	5083889.8	222662.9
S503-23	185.8	5083924.8	222682.0
S503-25	185.8	5083935.7	222643.1
S503-27	188.3	5083971.2	222663.4
S503-29	188.8	5083983.3	222627.4

NOTES

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REFERENCE

Existing Ground Surface cut from contours provided in digital format by URS, drawing file no. drawing file Hwy69_Contour-Plan_C5.dwg, received August 31, 2012.

NO.	DATE	BY	REVISION	
Geocres No. 41H-164				
HWY. 69		PROJECT NO. 09-1111-6014		DIST.
SUBM'D. ARV		CHKD. ARV	DATE: Oct. 2014	SITE:
DRAWN: JFC		CHKD. ARV	APPD. JPD/JMAC	DWG. C4

PROJECT		RECORD OF BOREHOLE		No S503-01		SHEET 1 OF 1		METRIC					
W.P.		LOCATION		ORIGINATED BY									
DIST		BOREHOLE TYPE		COMPILED BY									
DATUM		DATE		CHECKED BY									
09-1111-6014		N 5083889.7 ;E 222643.1		EHS									
5005-10-01		Portable Equipment, BW Casing, Wash Boring		GRL/AV									
Geodetic		March 14, 2013		CN									
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	GR SA SI CL
187.3	GROUND SURFACE												
0.0	TOPSOIL		1A	SS	2		187						
0.3	Black Wet		1B										
	SAND, trace organics		2	SS	15		186						
	Very loose to compact												
	Brown Wet												
185.5			3A	SS	17								
185.1	SAND and GRAVEL, some silt, trace clay		3B										
2.2	Compact Grey Wet		4	SS									32 46 20 2
END OF BOREHOLE SPLIT-SPOON AND CASING REFUSAL NOTE: 1. Water level in open borehole at a depth of 0.4 m below ground surface (Elev. 186.9 m) upon completion of drilling.													

PROJECT		RECORD OF BOREHOLE		No S503-02		SHEET 1 OF 1		METRIC										
W.P. 09-1111-6014		LOCATION		N 5083907.9; E 222641.4		ORIGINATED BY		EHS										
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, BW Casing, Wash Boring		COMPILED BY										
GRL/AV		DATE		March 13, 2013		CHECKED BY		CN										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40						60	80	100	20
188.1	GROUND SURFACE																	
0.0	TOPSOIL		1A															
0.2	Black Wet		1B	SS	5													
187.3	CLAYEY SILT, some sand																	
0.8	Firm Brown Wet		2	SS	12/0.15													
186.4	SAND, some silt																	
1.7	Compact Grey Wet																	
<p>A boulder was encountered at a depth of 1.1 m.</p> <p>END OF BOREHOLE SPLIT-SPOON REFUSAL</p> <p>NOTES:</p> <p>1. Open borehole dry upon completion of drilling.</p> <p>2. A Dynamic Cone Penetration Test was advanced 1.5 m South of Borehole S503-02 to confirm refusal.</p> <p>*Split-spoon and auger refusal was encountered at a depth of 1.1 m on inferred boulder. An additional borehole was advanced about 1 m East of Borehole S503-02 to obtain a split-spoon sample at a depth of 0.8 m below ground surface (Elev. 187.3 m).</p>																		

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PROJECT		RECORD OF BOREHOLE		No S503-03		SHEET 1 OF 1		METRIC					
W.P.		LOCATION		ORIGINATED BY									
DIST		BOREHOLE TYPE		COMPILED BY									
DATUM		DATE		CHECKED BY									
09-1111-6014		N 5083915.5 ; E 222627.2		EHS									
5005-10-01		Portable Equipment, BW Casing, Wash Boring		GRL/AV									
Geodetic		March 13, 2013		CN									
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	GR SA SI CL
189.8	GROUND SURFACE												
0.0	TOPSOIL		1A	SS	4		189						
0.2	Black Wet		1B	SS	4								
188.8	CLAYEY SILT, trace sand, containing silt seams Soft to firm Grey Moist		2A	SS	4								0 56 34 10
188.3	SILT and SAND, trace to some clay Very loose Brown Moist		2B	SS	4								
1.5	CLAYEY SILT Soft Grey Wet		2C	SS	4								0 59 36 5
	SILT and SAND, trace clay Compact to very dense Brown becoming grey below a depth of 3.0 m Wet		3	SS	12		188						
			4	SS	14		187						
			5	SS	44		186						
185.5	Sandy GRAVEL Grey Wet		6A	SS	76								
4.5	END OF BOREHOLE SPLIT-SPOON AND CASING REFUSAL		7	SS									
NOTE: 1. Water level in open borehole at a depth of 1.1 m below ground surface (Elev. 188.7 m) upon completion of drilling.													

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PROJECT 09-1111-6014		RECORD OF BOREHOLE No S503-04		SHEET 1 OF 1		METRIC											
W.P. 5005-10-01		LOCATION N 5083921.7 ; E 222609.4		ORIGINATED BY EHS													
DIST HWY 69		BOREHOLE TYPE Portable Equipment, BW Casing, Wash Boring		COMPILED BY GRL/AV													
DATUM Geodetic		DATE March 12 and 13, 2013		CHECKED BY CN													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ kN/m ³	GR SA SI CL
							20 40 60 80 100	20 40 60 80 100	20 40 60	W _p W W _L							
191.4	GROUND SURFACE																
0.0	TOPSOIL		1A	SS	3		191										
0.2	CLAYEY SILT		1B	SS													
	Soft to firm																
	Grey		2A	SS	5												
	Wet		2B	SS													
190.3	SILT and SAND, trace clay, containing silty clay seams between depths of 1.5 m and 2.1 m						190										
1.1	Loose to dense		3	SS	17												
	Brown becoming grey below a depth of 3.0 m																
	Wet		4	SS	8		189										0 59 39 2
			5	SS	16		188										
			6	SS	18		187										0 55 44 1
			7	SS	37		186										
			8	SS	15		185										
184.8	END OF BOREHOLE																
6.6	SPLIT-SPOON AND CASING REFUSAL																
	NOTE:																
	1. Water level in open borehole at a depth of 1.9 m below ground surface (Elev. 189.5 m) upon completion of drilling.																

PROJECT		RECORD OF BOREHOLE		No S503-05		SHEET 1 OF 1		METRIC						
W.P. 09-1111-6014		LOCATION		N 5083938.6 ; E 222617.6		ORIGINATED BY		MJR						
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, NW Casing, Wash Boring		COMPILED BY						
GRL/AV		DATE		March 18, 2013		CHECKED BY		CN						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
187.3	GROUND SURFACE							20	40	60	80	100		
0.0	CLAYEY SILT		1A		5		187							
0.2	Firm Grey Wet		1B	SS										
	SILT and SAND													
	Loose Grey Wet		2	SS	7		186							
185.8														
1.5	END OF BOREHOLE CASING REFUSAL													
NOTE: 1. Water level in open borehole at a depth of 0.2 m below ground surface (Elev. 187.1 m) upon completion of drilling.														

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PROJECT		RECORD OF BOREHOLE		No S503-06		SHEET 1 OF 1		METRIC	
W.P.		LOCATION		ORIGINATED BY		ID			
DIST		BOREHOLE TYPE		COMPILED BY		AV			
DATUM		DATE		CHECKED BY		CN			
09-1111-6014		N 5083955.7 ; E 222626.2							
5005-10-01		Portable Equipment, HQ Casing, Wash Boring							
HWY 69		August 2, 2013							
Geodetic									

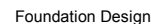
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _p W W _L	20 40 60			
185.3	GROUND SURFACE													
0.0	PEAT (Fibrous)		1A	SS	WH		185							
185.0	Very soft		1B	SS										
184.6	Dark brown													
0.7	Wet													
183.8	ORGANIC SILT		2	SS	4		184							
1.5	Very soft													
183.0	Grey													
1.5	Wet													
183.0	Silty SAND, trace clay, trace		3	SS	5									
2.3	organics													
182.3	Very loose to loose													
3.0	Grey		4	SS	11		183							
182.3	Wet													
3.0	SAND, trace to some silt, trace													
181.7	gravel													
3.6	Loose													
181.7	Grey													
3.6	Wet													
	SAND and GRAVEL, trace clay,													
	trace silt													
	Compact													
	Grey													
	Wet													
	END OF BOREHOLE													
	SPLIT-SPOON AND CASING													
	REFUSAL													
	END OF DCPT													
	Refusal to Further Penetration													
	(30 Blows / 0.0 m)													
	NOTES:													
	1. Water level in open borehole at													
	ground surface (Elev. 185.3 m)													
	upon completion of drilling.													
	2. A Dynamic Cone Penetration													
	Test was advanced 1.2 m East of													
	Borehole S503-06 to confirm													
	refusal.													

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PROJECT		RECORD OF BOREHOLE		No S503-07		SHEET 1 OF 1		METRIC								
W.P. 09-1111-6014		LOCATION		N 5083961.7 ; E 222608.0		ORIGINATED BY		MJR								
DIST		HWY 69		BOREHOLE TYPE		Hand Shovel Excavation		COMPILED BY								
GRL		DATE		March 19, 2013		CHECKED BY		CN								
Geodetic																
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
187.3	GROUND SURFACE															
0.0	PEAT (Fibrous)		1	CS	-											
0.2	Dark brown Wet															
	END OF EXCAVATION BEDROCK															
	NOTE: 1. Hand shovel excavation dry upon completion.															

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PROJECT		RECORD OF BOREHOLE		No S503-08		SHEET 1 OF 1		METRIC										
W.P. 5005-10-01		LOCATION		N 5083965.7 ; E 222585.0		ORIGINATED BY		MJR										
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, NW Casing, Wash Boring		COMPILED BY										
GRL/AV		DATE		March 20, 2013		CHECKED BY		CN										
DATUM		Geodetic																
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100						20
187.1	GROUND SURFACE																	
0.0	TOPSOIL		1A															
0.1	SAND, some silt, some gravel, trace to some clay, trace organics		1B	SS	5													
186.3	Loose Brown Wet																	
0.8	END OF BOREHOLE CASING REFUSAL																	
	END OF DCPT Refusal to Further Penetration																	
	NOTES: 1. Water level in open borehole at a depth of 0.6 m below ground surface (Elev. 186.5 m) upon completion of drilling. 2. A Dynamic Cone Penetration Test was advanced 1 m South of Borehole S503-08 to confirm refusal.																	






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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		RECORD OF BOREHOLE		No S503-10		SHEET 1 OF 1		METRIC							
W.P.		LOCATION		ORIGINATED BY		COMPILED BY		CHECKED BY							
DIST		BOREHOLE TYPE		DATE		DATE		DATE							
Geodetic		March 19, 2013		March 19, 2013		March 19, 2013		March 19, 2013							
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS		ELEVATION SCALE		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	20 40 60	W _p W W _L	γ	GR SA SI CL		
186.3	GROUND SURFACE														
0.0	TOPSOIL														
0.1	SILTY CLAY		1	SS	5		186								
185.7	Firm Brown Wet														
0.6	SAND, some silt Loose to compact Brown Wet		2	SS	8		185							0	86 14 0
			3	SS	10										
184.1	END OF BOREHOLE CASING REFUSAL														
2.2	NOTE: 1. Water level in open borehole at a depth of 1.4 m below ground surface (Elev. 184.9 m) upon completion of drilling.														

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S503-11				SHEET 1 OF 1		METRIC								
W.P. 5005-10-01		LOCATION N 5084007.9 ; E 222588.8				ORIGINATED BY MJR										
DIST _____ HWY 69		BOREHOLE TYPE Hand Shovel Excavation				COMPILED BY GRL										
DATUM Geodetic		DATE March 20, 2013				CHECKED BY CN										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
186.7	GROUND SURFACE															
0.0	TOPSOIL		1	CS												
0.1	END OF EXCAVATION BEDROCK															
NOTE: 1. Excavation dry upon completion.																

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PROJECT 09-1111-6014		RECORD OF BOREHOLE No S503-12				SHEET 1 OF 1		METRIC										
W.P. 5005-10-01		LOCATION N 5083791.5; E 222719.5				ORIGINATED BY MJR												
DIST _____ HWY 69		BOREHOLE TYPE Portable Equipment, NW Casing, Wash Boring				COMPILED BY GRL/AV												
DATUM Geodetic		DATE March 18, 2013				CHECKED BY CN												
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
188.9	GROUND SURFACE							20	40	60	80	100						
0.0	ORGANIC SILT Soft Dark brown Wet		1	SS	3		188											
188.2	SILTY CLAY, trace to some sand, trace organics to a depth of 1.4 m Soft Grey Wet		2	SS	3													
0.7			3	SS	2													
186.6	END OF BOREHOLE CASING REFUSAL																	
2.3	NOTE: 1. Water level in open borehole at a depth of 0.2 m below ground surface (Elev. 188.7 m) upon completion of drilling.																	

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PROJECT		RECORD OF BOREHOLE		No S503-13		SHEET 1 OF 1		METRIC						
W.P. 09-1111-6014		LOCATION		N 5083809.2 ; E 222729.5		ORIGINATED BY		MJR						
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, NW Casing, Wash Boring		COMPILED BY						
GRL/AV		DATE		March 18, 2013		CHECKED BY		CN						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
186.1	GROUND SURFACE							20 40 60 80 100	20 40 60					
0.0	ORGANIC SILT, some sand Firm Dark brown Wet		1	SS	5		186							
185.5														
0.6	SILTY CLAY, trace to some sand Soft Grey Wet		2	SS	2		185							
184.1														
2.0	END OF BOREHOLE CASING REFUSAL													
NOTE: 1. Water level in open borehole at a depth of 0.1 m below ground surface (Elev. 186.0 m) upon completion of drilling.														

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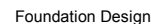
PROJECT 09-1111-6014		RECORD OF BOREHOLE No S503-14				SHEET 1 OF 1		METRIC								
W.P. 5005-10-01		LOCATION N 5083814.6 ; E 222709.9				ORIGINATED BY MJR										
DIST _____ HWY 69		BOREHOLE TYPE Portable Equipment, NW Casing, Wash Boring				COMPILED BY GRL/AV										
DATUM Geodetic		DATE March 15, 2013				CHECKED BY CN										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
185.6	GROUND SURFACE															
0.0	Clayey ORGANIC SILT, trace sand Very soft to soft Dark grey Wet	1	1	SS	1											
			2	SS	3											
183.5	END OF BOREHOLE CASING REFUSAL															
2.1	NOTE: 1. Water level in open borehole at a depth of 0.1 m below ground surface (Elev. 185.5 m) upon completion of drilling.															

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S503-15				SHEET 1 OF 1		METRIC								
W.P. 5005-10-01		LOCATION N 5083832.3 ; E 222719.9				ORIGINATED BY GM										
DIST _____ HWY 69		BOREHOLE TYPE Portable Equipment, HQ Casing, Wash Boring				COMPILED BY AV										
DATUM Geodetic		DATE July 24, 2013				CHECKED BY CN										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
185.8 0.0	WATER SURFACE WATER															
185.2 0.6	PEAT (Fibrous) Very soft Dark brown Wet		1	SS	WH											
183.7 2.1	Clayey ORGANIC SILT, containing pieces of wood Very soft Wet		2	SS	WH											
182.4 3.4	END OF BOREHOLE SPLIT-SPOON REFUSAL		3	SS	WH											
181.5 4.3	END OF DCPT (Refusal to Further Penetration) NOTE: 1. A Dynamic Cone Penetration Test was advanced 1 m North Borehole S503-15.		4	SS	WH											

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PROJECT 09-1111-6014		RECORD OF BOREHOLE No S503-16		SHEET 1 OF 1		METRIC												
W.P. 5005-10-01		LOCATION N 5083837.7 ; E 222700.3		ORIGINATED BY GM														
DIST HWY 69		BOREHOLE TYPE Portable Equipment, NQ Casing, Wash Boring		COMPILED BY MCK/AV														
DATUM Geodetic		DATE July 14, 2013		CHECKED BY CN														
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)					
185.8	WATER SURFACE							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W _p W W _L 20 40 60			GR SA SI CL		
0.0	WATER																	
185.2	0.6 PEAT (Fibrous)		1A	SS	WH		185											
184.7	1.1 Very soft Dark brown Wet		1B															
	Clayey ORGANIC SILT, containing wood fragments to a depth of 2.7 m		2	SS	WH		184											
	Very soft Dark brown to grey Wet		3	SS	WH		183											
			4	SS	WH		182											
			5	SS	WH		181											
181.4	4.4 SILTY CLAY, some sand, some gravel		6	SS	10													
180.8	Stiff Grey Wet																	
5.1	END OF BOREHOLE SPLIT-SPOON REFUSAL END OF DCPT (Refusal of Further Penetration)																	
NOTE: 1. A Dynamic Cone Penetration Test was carried out 0.5 m North of Borehole S503-16 to confirm refusal.																		

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

PROJECT		09-1111-6014		RECORD OF BOREHOLE No S503-18		SHEET 1 OF 1		METRIC					
W.P.		5005-10-01		LOCATION		N 5083860.7 ; E 222690.7		ORIGINATED BY					
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, HQ Casing, Wash Boring		COMPILED BY					
DATUM		Geodetic		DATE		July 14, 2013		CHECKED BY					
								CN					
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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		ELEVATION SCALE	SHEAR STRENGTH kPa					
185.8 0.0	WATER SURFACE WATER							20 40 60 80 100					
185.0 0.8	PEAT (Fibrous) Very soft Dark brown Wet		1	SS	WH		185						
184.4 1.5	Clayey ORGANIC SILT, some sand Very soft Brown Wet		2	SS	WH		184					OC = 12.1%	
			3	SS	WH		183					280	
			4	SS	WH		182					163	
			5	SS	WH		181					OC = 10.6%	
			6	SS	WH		180					147.6	
180.5 5.3	SAND, trace to some silt, trace to some clay Very loose to compact Grey Wet		7	SS	2		179						0 85 9 6
			8	SS	26		178						
178.0 7.8	SAND and GRAVEL Dense Grey Wet		9	SS	54/0.10		177						
177.3 8.8	END OF BOREHOLE SPLIT-SPOON AND CASING REFUSAL END OF DCPT (100 blows per 0.0 m) NOTE: 1. A Dynamic Cone Penetration Test was advanced 1 m North of Borehole S503-18 to confirm refusal.												

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S503-19		SHEET 1 OF 1		METRIC															
W.P. 5005-10-01		LOCATION N 5083878.5 ; E 222700.8		ORIGINATED BY ID																	
DIST HWY 69		BOREHOLE TYPE Portable Equipment, HQ Casing, Wash Boring		COMPILED BY AV																	
DATUM Geodetic		DATE July 25, 2013		CHECKED BY CN																	
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)								
								20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W _p W W _L 20 40 60			γ kN/m ³			GR SA SI CL		
185.8 0.0	WATER SURFACE WATER																				
185.0 0.8	PEAT (Fibrous) Very soft Dark brown Wet		1	SS	WH		185														
			2	SS	WH		184														
			3	SS	WH		183						873.5								
182.8 3.0	Clayey ORGANIC SILT Soft Grey Wet		4	SS	WH		182	4					184.7			OC = 14.9%					
			5	SS	WH		181	+5					192.4								
			6	SS	WH		180	+5					169								
			7	SS	WH		179	5													
178.2 7.6	SILT and SAND, trace gravel, trace clay, trace organics Very loose Grey Wet		8	SS	WH		178	5					OC = 3.5%								
			9	SS	2		177									5 58 36 1					
175.0 10.8	Cobbles at a depth of 10.7 m END OF BOREHOLE SPLIT-SPOON AND CASING REFUSAL NOTE: 1. An additional borehole was advanced 1.5 m South of Borehole S503-19 to carry out in situ field vanes between a depth of 4.2 m and 4.5 m below ground surface (Elev. 180.8 and 108.5 m) and to obtain a Shelby tube sample at a depth of 3.2 m below ground surface (Elev. 181.8 m).		10	SS	50/108		175														

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		RECORD OF BOREHOLE		No S503-20		SHEET 1 OF 1		METRIC					
W.P. 09-1111-6014		LOCATION		N 5083883.8 ; E 222681.1		ORIGINATED BY		ID					
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, HQ Casing, Wash Boring		COMPILED BY					
DATUM		Geodetic		DATE		July 26, 2013		CHECKED BY					
								CN					
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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa						
185.8 0.0	WATER SURFACE WATER												
185.2 0.6	PEAT (Fibrous) Very soft Brown Wet		1	SS	WH								
			2	SS	WH								
183.6 2.2	Clayey ORGANIC SILT Soft Grey Wet		3	SS	WH								
			4	SS	WH								
			5	SS	WH								
179.2 6.6	SILT and SAND, trace to some gravel, trace clay, trace organics to a depth of 8.2 m Very loose to loose Grey Wet		6A 6B	SS	WH								
			7	SS	2								
			8	SS	10								
176.0 10.1	SAND and GRAVEL Compact Brown and grey Wet END OF BOREHOLE SPLIT SPOON AND AUGER REFUSAL		9	SS	10/0.15								

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S503-22		SHEET 1 OF 1		METRIC												
W.P. 5005-10-01		LOCATION N 5083906.9 ; E 222671.5		ORIGINATED BY ID														
DIST HWY 69		BOREHOLE TYPE Portable Equipment, HQ Casing, Wash Boring		COMPILED BY MCK/AV														
DATUM Geodetic		DATE July 30, 2013		CHECKED BY CN														
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ		
185.8	WATER SURFACE							20 40 60 80 100	○ UNCONFINED + FIELD VANE	W _p	W	W _L						
0.0	WATER							20 40 60 80 100	● QUICK TRIAXIAL × REMOULDED	20 40 60								
185.0																		
184.7	PEAT (Fibrous) Very soft Dark brown Wet		1A	SS	WH													
1.1			1B															
	SILTY SAND, trace clay Very loose Dark grey Wet		2	SS	1													
183.6																		
2.2	Clayey ORGANIC SILT, trace to some sand Soft to firm Dark grey Wet		3	SS	1													
			4	SS	WH													
			5	SS	WH													
			6	SS	WH													
180.2																		
5.6	ORGANIC SILT Very soft to soft Dark-grey Wet		7	SS	WH													
178.5																		
7.3	Gravelly SILT and SAND, trace clay Loose to compact Grey Wet		8	SS	8													
176.8			9	SS	26													
9.0	END OF BOREHOLE SPLIT-SPOON AND CASING REFUSAL																	
	NOTE: 1. An additional borehole was advanced 1.5 m South-East of Borehole S503-22 to carry out in situ field vane between depths of 1.5 m and 5.1 m below ground surface (Elev. 183.5 and 179.9 m) and to obtain Shelby tube samples at depths of 1.9 m and 3.8 m below ground surface (Elev. 183.1 m and 181.2 m).																	

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PROJECT 09-1111-6014		RECORD OF BOREHOLE No S503-23		SHEET 1 OF 1		METRIC															
W.P. 5005-10-01		LOCATION N 5083924.8 ; E 222682.0		ORIGINATED BY ID																	
DIST HWY 69		BOREHOLE TYPE Portable Equipment, HQ Casing, Wash Boring		COMPILED BY AV																	
DATUM Geodetic		DATE July 29, 2013		CHECKED BY CN																	
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)								
185.8	WATER SURFACE							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W _p W W _L 20 40 60			γ kN/m ³			GR SA SI CL		
0.0	WATER																				
184.9	CLAYEY SILT, trace to some sand, trace to some gravel, trace organics Firm to stiff Grey Wet		1	SS	WH		185	3					OC = 2.8%								
			2	SS	10		184														
183.6	SAND and GRAVEL, some silt, trace clay Compact Grey Wet		3	SS	25		183														
2.2			4	SS	13		182														
			5	SS	14																
181.2	END OF BOREHOLE CASING REFUSAL END OF DCPT Refusal to Further Penetration (30 Blows / 0.0 m)																				
4.6	NOTES: 1. A Dynamic Cone Penetration Test was advanced 1 m North of Borehole S503-23. 2. An additional borehole was advanced 1 m South of Borehole S503-23 to carry out in situ field vane at a depth of 0.3 m below ground surface (Elev. 184.6 m).																				


GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		RECORD OF BOREHOLE		No S503-24		SHEET 1 OF 1		METRIC							
W.P. 09-1111-6014		LOCATION		N 5083930.0; E 222661.9		ORIGINATED BY		ID							
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, HQ Casing, Wash Boring		COMPILED BY							
DATUM		Geodetic		DATE		July 30, 2013		CHECKED BY							
								CN							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
185.8 0.0	WATER SURFACE WATER														
185.0															
184.7 1.1	PEAT (Fibrous) Very soft Brown Wet		1A	SS	WH										
	Clayey ORGANIC SILT, some sand Very soft to soft Grey Wet		1B												
			2	SS	WH										
			3	SS	WH										
182.4 3.4	SAND, some gravel, trace to some silt, trace clay Very loose to compact Grey Wet		4A	SS	3										
			4B												
			5	SS	10										
180.7 5.1	END OF BOREHOLE SPLIT-SPOON REFUSAL		6	SS	47/0.08										

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		RECORD OF BOREHOLE		No S503-25		SHEET 1 OF 1		METRIC							
W.P. 09-1111-6014		LOCATION		N 5083935.7 ; E 222643.1		ORIGINATED BY		ID							
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, HQ Casing, Wash Boring		COMPILED BY							
DATUM		Geodetic		DATE		July 31, 2013		CHECKED BY							
								CN							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
185.8	WATER SURFACE														
0.0	WATER														
185.0															
0.9	PEAT (Fibrous) Very soft Grey Wet		1A	SS	3										
	Clayey ORGANIC SILT, containing wood fragments and rootlets Soft to stiff Dark brown Wet		1B	SS	1										
183.5			2	SS	1										
2.4	Silty SAND Grey Wet		3	SS	6/0.08										
182.6															
3.2	END OF BOREHOLE SPLIT-SPOON REFUSAL END OF DCPT Refusal to Further Penetration END OF BOREHOLE														
NOTES: 1. An additional borehole was advanced to carry out in situ field vane at depths of 0.7 m and 1 m below ground surface (Elev. 184.3 and 184.0 m). 2. A Dynamic Cone Penetration Test was advanced 1.5 m North-East of Borehole S503-25.															

PROJECT		09-1111-6014		RECORD OF BOREHOLE No S503-26		SHEET 1 OF 1		METRIC						
W.P.		5005-10-01		LOCATION		N 5083953.1 ; E 222652.3		ORIGINATED BY ID						
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, HQ Casing, Wash Boring		COMPILED BY MCK/AV						
DATUM		Geodetic		DATE		July 31, 2013		CHECKED BY CN						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
185.8	WATER SURFACE													
0.0	WATER													
185.3														
0.6	PEAT (Fibrous) Very soft Dark brown Wet		1A 1B	SS	5		185							
	SILTY CLAY, trace sand, trace organics, containing wood fragments and rootlets Very soft to firm Dark brown Wet		2	SS	1		184						OC = 4.4%	
183.9														
2.1	ORGANIC SILT, containing wood fragments Very soft Dark brown Wet		3A 3B	SS	5								95.7	
183.0														23 49 24 4
2.8	Gravelly Silty SAND, trace clay Loose Dark brown Wet						183							
	END OF BOREHOLE CASING REFUSAL													
	END OF DCPT Refusal to Further Penetration													
	NOTE: 1. A Dynamic Cone Penetration Test was advanced 2 m East of Borehole S503-26.													

PROJECT		09-1111-6014		RECORD OF BOREHOLE No S503-27		SHEET 1 OF 1		METRIC														
W.P.		5005-10-01		LOCATION		N 5083971.2 ; E 222663.4		ORIGINATED BY		MJR												
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, NW Casing, Wash Boring		COMPILED BY		GRL												
DATUM		Geodetic		DATE		March 19, 2013		CHECKED BY		CN												
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)				
188.3	GROUND SURFACE							20	40	60	80	100										
0.0	CLAYEY SILT		1	SS	6		188															
187.7	Firm Grey Wet																					
0.6	END OF BOREHOLE CASING REFUSAL																					
NOTE: 1. Open borehole dry upon completion of drilling.																						



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PROJECT		RECORD OF BOREHOLE		No S503-28		SHEET 1 OF 1		METRIC								
W.P. 09-1111-6014		LOCATION		N 5083974.9 ; E 222639.6		ORIGINATED BY		MJR								
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment		COMPILED BY								
GRL		DATE		March 19, 2013		CHECKED BY		CN								
DATUM		Geodetic														
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
188.4	GROUND SURFACE															
0.0	PEAT		1A	SS	4											
0.3	Gravelly CLAYEY SILT, some sand Soft Brown Wet END OF BOREHOLE SPLIT-SPOON REFUSAL NOTE: 1. Open borehole dry upon completion of drilling.		1B													

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		RECORD OF BOREHOLE		No S503-29		SHEET 1 OF 1		METRIC								
W.P. 09-1111-6014		LOCATION		N 5083983.3 ; E 222627.4		ORIGINATED BY		MJR								
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, NW Casing, Wash Boring		COMPILED BY								
GRL/AV		DATE		March 19, 2013		CHECKED BY		CN								
DATUM		Geodetic														
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
188.8	GROUND SURFACE															
0.0	Gravelly SILT and SAND, trace to some clay Loose Brown Wet		1	SS	5											21 38 32 9
188.0	END OF BOREHOLE SPLIT-SPOON AND CASING REFUSAL		2	SS	4/0.00	▽	188									
0.8	NOTE: 1. Water level in open borehole at a depth of 0.7 m below ground surface (Elev. 188.1 m) upon completion of drilling.															

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		09-1111-6014		RECORD OF BOREHOLE No S503-30		SHEET 1 OF 1		METRIC									
W.P.		5005-10-01		LOCATION		N 5083999.2 ; E 222633.1		ORIGINATED BY									
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, NW Casing, Wash Boring		COMPILED BY									
DATUM		Geodetic		DATE		March 19, 2013		CHECKED BY									
								CN									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
192.6	GROUND SURFACE																
0.0	PEAT		1A				192										
0.1	SILTY CLAY, trace organics Firm Grey Wet		1B	SS	7												
191.2		2	SS	8													
1.4	SAND, trace to some silt, trace gravel Compact Brown Wet		3	SS	12		191										
190.3																	
2.3	END OF BOREHOLE CASING REFUSAL NOTE: 1. Water level in open borehole at a depth of 1.1 m below ground surface (Elev. 191.5 m) upon completion of drilling.																

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		RECORD OF BOREHOLE		No C501-01		SHEET 1 OF 1		METRIC									
G.W.P. 09-1111-6014		LOCATION		N 5084002.9 ; E 222566.9		ORIGINATED BY		ID									
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, NQ Casing, Wash Boring		COMPILED BY									
AV		DATE		August 6, 2013		CHECKED BY		CN									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)	
183.1	GROUND SURFACE							20	40	60	80	100					
0.0	TOPSOIL		1A	SS	2	▽	183										
0.2	Dark brown		1B														
	ORGANIC SILT, some sand, roots																
182.2	Very soft		2A	SS	13		182										
0.9	Dark brown to grey		2B														
	Wet																
	SAND, trace to some silt, trace to some gravel, trace clay		3	SS	11		181										
	Compact																
	Grey																
	Wet																
180.6	END OF BOREHOLE		4	SS	5/0.08												
2.5	SPLIT-SPOON AND CASING REFUSAL																
NOTE: 1. Water level in open borehole at a depth of 0.5 m below ground surface (Elev. 182.6 m) upon completion of drilling.																	

PROJECT		09-1111-6014		RECORD OF BOREHOLE No C501-02				SHEET 1 OF 1		METRIC								
G.W.P.		5005-10-00		LOCATION		N 5083985.9 ; E 222588.3		ORIGINATED BY		ID								
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, HQ Casing, Wash Boring		COMPILED BY		AV								
DATUM		Geodetic		DATE		August 6, 2013		CHECKED BY		CN								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
183.7	GROUND SURFACE																	
0.0 183.4	TOPSOIL Dark brown		1A	SS	1	▽	183											
0.3	SAND, trace to some gravel, some silt, trace to some clay, trace organics Very loose		1B															
182.6	Grey Wet		2A	SS	3													
1.1	SAND and GRAVEL Very loose to compact Grey Wet		2B				182											
181.7			3	SS	12													
2.0	END OF BOREHOLE SPLIT-SPOON AND CASING REFUSAL																	
NOTE: 1. Water level in open borehole at a depth of 0.5 m below ground surface (Elev. 183.2 m) upon completion of drilling.																		

PROJECT		09-1111-6014		RECORD OF BOREHOLE No C501-03		SHEET 1 OF 1		METRIC										
G.W.P.		5005-10-00		LOCATION		N 5083970.7 ; E 222610.0		ORIGINATED BY										
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, HQ Casing, Wash Boring		COMPILED BY										
DATUM		Geodetic		DATE		August 7, 2013		CHECKED BY										
								CN										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60						80	100	20
185.2 0.0	WATER SURFACE WATER																	
184.1																		
183.8 1.4	PEAT (Fibrous) Very soft Dark brown Wet		1A 1B	SS	2													
183.2 2.0	Gravelly SILT and SAND, trace clay Very loose to loose Grey Wet END OF BOREHOLE SPLIT-SPOON AND CASING REFUSAL		2	SS	5/0.15													21 33 43 3

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		RECORD OF BOREHOLE		No C501-04		SHEET 1 OF 1		METRIC							
G.W.P. 09-1111-6014		LOCATION		N 5083935.0 ; E 222652.6		ORIGINATED BY		ID							
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, HQ Casing, Wash Boring		COMPILED BY							
DATUM		Geodetic		DATE		July 30, 2013		CHECKED BY							
								CN							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
185.8 0.0	WATER SURFACE WATER														
184.9															
184.6	PEAT (Fibrous) Very soft Dark brown Wet		1A 1B	SS	1										
183.4	CLAYEY SILT, trace organics, trace wood fragments and rootlets Very soft Dark grey Wet		2	SS	1										
182.8	CLAYEY ORGANIC SILT Very soft Grey Wet		3	SS	1										
180.3	SAND and GRAVEL Compact to very dense Grey Wet		4 5 6	SS	10 15 62										
180.3 5.5	END OF BOREHOLE SPLIT-SPOON AND CASING REFUSAL														

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PROJECT 09-1111-6014		RECORD OF BOREHOLE No C501-05		SHEET 1 OF 1		METRIC												
G.W.P. 5005-10-00		LOCATION N 5083918.0 ; E 222673.9		ORIGINATED BY ID														
DIST _____ HWY 69		BOREHOLE TYPE Portable Equipment, HQ Casing, Wash Boring		COMPILED BY AV														
DATUM Geodetic		DATE July 29 and 30, 2013		CHECKED BY CN														
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)					
185.8 0.0	WATER SURFACE WATER							20 40 60 80 100	20 40 60 80 100	20 40 60	20 40 60	20 40 60	20 40 60	20 40 60	20 40 60	20 40 60	20 40 60	
185.0							185											
184.7 1.1	PEAT (Fibrous) Very soft Brown Wet		1A 1B	SS	1													
	ORGANIC SILT, trace to some sand, trace wood fragments and roots to a depth of 2.1 m Very soft to soft Dark grey Wet		2	SS	3		184											
			3	SS	1		183											
			4	SS	1		182											
			5	SS	1													
181.3 4.5	SAND and GRAVEL Very dense Grey Wet		6	SS	61		181											
180.8 5.0	END OF BOREHOLE SPLIT-SPOON REFUSAL																	
NOTE: 1. An additional borehole was advanced South of Borehole C501-05 to carry out in situ field vanes between depths of 2.4 m and 3.9 m below ground surface (Elev. 182.6 m and 181.1 m) and to obtain Shelby tube samples at depths of 1.3 m and 3.0 m below peat surface (Elev. 183.7 m and 182.0 m).																		

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PROJECT 09-1111-6014		RECORD OF BOREHOLE No C501-06		SHEET 1 OF 2		METRIC															
G.W.P. 5005-10-00		LOCATION N 5083901.0 ; E 222695.4		ORIGINATED BY ID																	
DIST _____ HWY 69		BOREHOLE TYPE Portable Equipment, HQ Casing, Wash Boring		COMPILED BY MCK/AV																	
DATUM Geodetic		DATE July 29, 2013		CHECKED BY CN																	
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ			GR SA SI CL		
185.8 0.0	WATER SURFACE WATER							20 40 60 80 100	20 40 60 80 100	20 40 60	W _p W W _L										
185.0 0.8	PEAT (Fibrous) Very soft Dark brown Wet		1	SS	WH		185														
			2	SS	WH		184														
183.6 2.2	Clayey ORGANIC SILT Soft Grey Wet		3	SS	WH		183														
			4	SS	WH		182														
			5	SS	WH		181														
			6	SS	WH		180														
			7	SS	WH		179														
178.5 7.3	SILT and SAND, trace gravel, trace clay Very loose to compact Grey Wet		8	SS	5		178														
			9	SS	3		177														
			10	SS	13		176														
173.3 12.5	END OF BOREHOLE SPLIT-SPOON AND CASING REFUSAL		11	SS	8/0.15		175														
							174														

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT 09-1111-6014		RECORD OF BOREHOLE No C501-06				SHEET 2 OF 2		METRIC															
G.W.P. 5005-10-00		LOCATION N 5083901.0 ; E 222695.4				ORIGINATED BY ID																	
DIST _____ HWY 69		BOREHOLE TYPE Portable Equipment, HQ Casing, Wash Boring				COMPILED BY MCK/AV																	
DATUM Geodetic		DATE July 29, 2013				CHECKED BY CN																	
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa															
	--- CONTINUED FROM PREVIOUS PAGE ---						<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> ○ UNCONFINED + FIELD VANE </div> <div style="display: flex; justify-content: space-between;"> ● QUICK TRIAXIAL × REMOULDED </div>					<div style="display: flex; justify-content: space-between;"> 20 40 60 20 40 60 </div>											
	NOTE: 1. An additional borehole was advanced about 1.5 m South of Borehole C501-06 to carry out in situ field vane at depths of 2.9 m and 3.2 m below ground surface (Elev. 182.1 m and Elev. 181.8 m) and to obtain a Shelby tube sample at a depth of 1.8 m below ground surface (Elev. 183.2 m).																						

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16



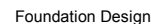
+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT 09-1111-6014		RECORD OF DCPT No S503-DC02				SHEET 1 OF 1		METRIC								
W.P. 5005-10-01		LOCATION N 5083931.9;E 222634.1				ORIGINATED BY EHS										
DIST _____ HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test				COMPILED BY AV										
DATUM Geodetic		DATE March 13, 2013				CHECKED BY JPD										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
186.3	GROUND SURFACE															
0.0 186.0 0.3	Dynamic Cone Penetration Test (DCPT)						186									
	END OF DCPT Refusal to Further Penetration (10 Blows / 0.0 m)															
	NOTE: 1. Bedrock was exposed by hand shovel excavation in the vicinity of DCPT S503-DC02.															

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



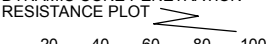
+3, ×3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>09-1111-6014</u>		RECORD OF DCPT No S503-DC05				SHEET 1 OF 1		METRIC								
W.P. <u>5005-10-01</u>		LOCATION <u>N 5084003.1 ; E 222609.9</u>				ORIGINATED BY <u>MJR</u>										
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Portable Equipment, Dynamic Cone Penetration Test</u>				COMPILED BY <u>AV</u>										
DATUM <u>Geodetic</u>		DATE <u>March 18, 2013</u>				CHECKED BY <u>JPD</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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
192.0	GROUND SURFACE															
0.0	Dynamic Cone Penetration Test (DCPT)															
191.4	END OF DCPT															
0.6	Refusal to Further Penetration															

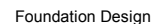
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PROJECT <u>09-1111-6014</u>				RECORD OF DCPT No S503-DC06				SHEET 1 OF 1				METRIC					
W.P. <u>5005-10-01</u>				LOCATION <u>N 5083797.5 ; E 222701.3</u>				ORIGINATED BY <u>MJR</u>									
DIST <u> </u> HWY <u>69</u>				BOREHOLE TYPE <u>Portable Equipment, Dynamic Cone Penetration Test</u>				COMPILED BY <u>AV</u>									
DATUM <u>Geodetic</u>				DATE <u>March 18, 2013</u>				CHECKED BY <u>JPD</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	SHEAR STRENGTH kPa					W _p W W _L				
188.3 0.0	GROUND SURFACE Dynamic Cone Penetration Test (DCPT)					188	<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> ○ UNCONFINED + FIELD VANE </div> <div style="display: flex; justify-content: space-between;"> ● QUICK TRIAXIAL × REMOULDED </div>					<div style="display: flex; justify-content: space-between;"> 20 40 60 20 40 60 </div>					
185.4 2.9	END OF DCPT Refusal to Further Penetration (10 Blows / 0.15 m)					186											

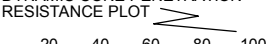
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PROJECT		RECORD OF DCPT No S503-DC07		SHEET 1 OF 1		METRIC				
W.P. 09-1111-6014		LOCATION N 5083820.5 ; E 222691.7		ORIGINATED BY MJR						
DIST _____ HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test		COMPILED BY AV						
DATUM Geodetic		DATE March 14, 2013		CHECKED BY JPD						
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT  SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE						
185.9 0.0	GROUND SURFACE Dynamic Cone Penetration Test (DCPT)									
181.6 4.3	END OF DCPT Refusal to Further Penetration									

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16



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

PROJECT		RECORD OF DCPT No S503-DC09		SHEET 1 OF 1		METRIC				
W.P. 09-1111-6014		LOCATION N 5083866.7 ;E 222672.5		ORIGINATED BY MJR						
DIST HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test		COMPILED BY AV						
DATUM Geodetic		DATE March 14, 2013		CHECKED BY JPD						
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT  SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE						
185.9 0.0	GROUND SURFACE Dynamic Cone Penetration Test (DCPT)									
177.1 8.8	END OF DCPT Refusal to Further Penetration (69 Blows / 0.23 m)									

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT <u>09-1111-6014</u>				RECORD OF DCPT No S503-DC10				SHEET 1 OF 1		METRIC				
W.P. <u>5005-10-01</u>		LOCATION <u>N 5083901.5 ; E 222691.1</u>				ORIGINATED BY <u>ID</u>								
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Portable Equipment, Dynamic Cone Penetration Test</u>				COMPILED BY <u>AV</u>								
DATUM <u>Geodetic</u>		DATE <u>July 29, 2013</u>				CHECKED BY <u>JPD</u>								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
185.8 0.0	WATER SURFACE						<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> ○ UNCONFINED + FIELD VANE </div> <div style="display: flex; justify-content: space-between;"> ● QUICK TRIAXIAL × REMOULDED </div>					<div style="display: flex; justify-content: space-between;"> W_p W W_L </div> <div style="display: flex; justify-content: space-between;"> PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT </div>		
184.9 0.9	Dynamic Cone Penetration Test (DCPT)						<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> W_p W W_L </div> <div style="display: flex; justify-content: space-between;"> PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT </div>							
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+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

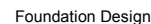


+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

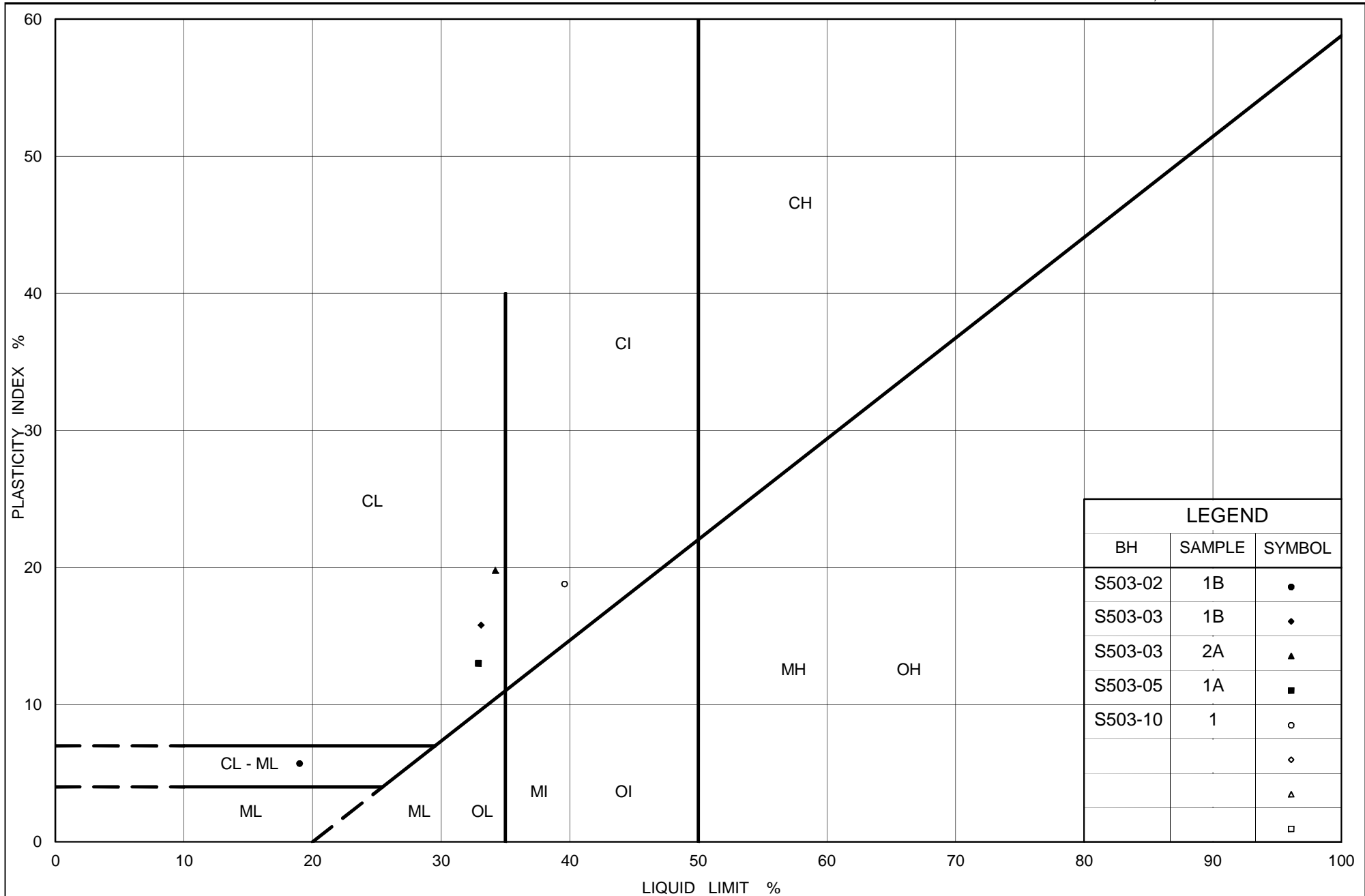
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W.P. 5005-10-01				LOCATION N 5083959.1 ; E 222634.3				ORIGINATED BY ID									
DIST HWY 69				BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test				COMPILED BY AV									
DATUM Geodetic				DATE July 31, 2013				CHECKED BY JPD									
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			SHEAR STRENGTH kPa					WATER CONTENT (%)				
185.8 0.0	WATER SURFACE							20	40	60	80	100					
184.6 1.2	Dynamic Cone Penetration Test (DCPT)							20	40	60	80	100					
182.9 2.9	END OF DCPT Refusal to Further Penetration (30 Blows / 0.0 m)							20	40	60	80	100					

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16



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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16



Ministry of Transportation

Ontario

PLASTICITY CHART
 Clayey Silt to Silty Clay
 Highway 69 (SBL) STA 10+350 to 10+470 (Swamp 503)

Figure No. C.S503-01

Project No. 09-1111-6014

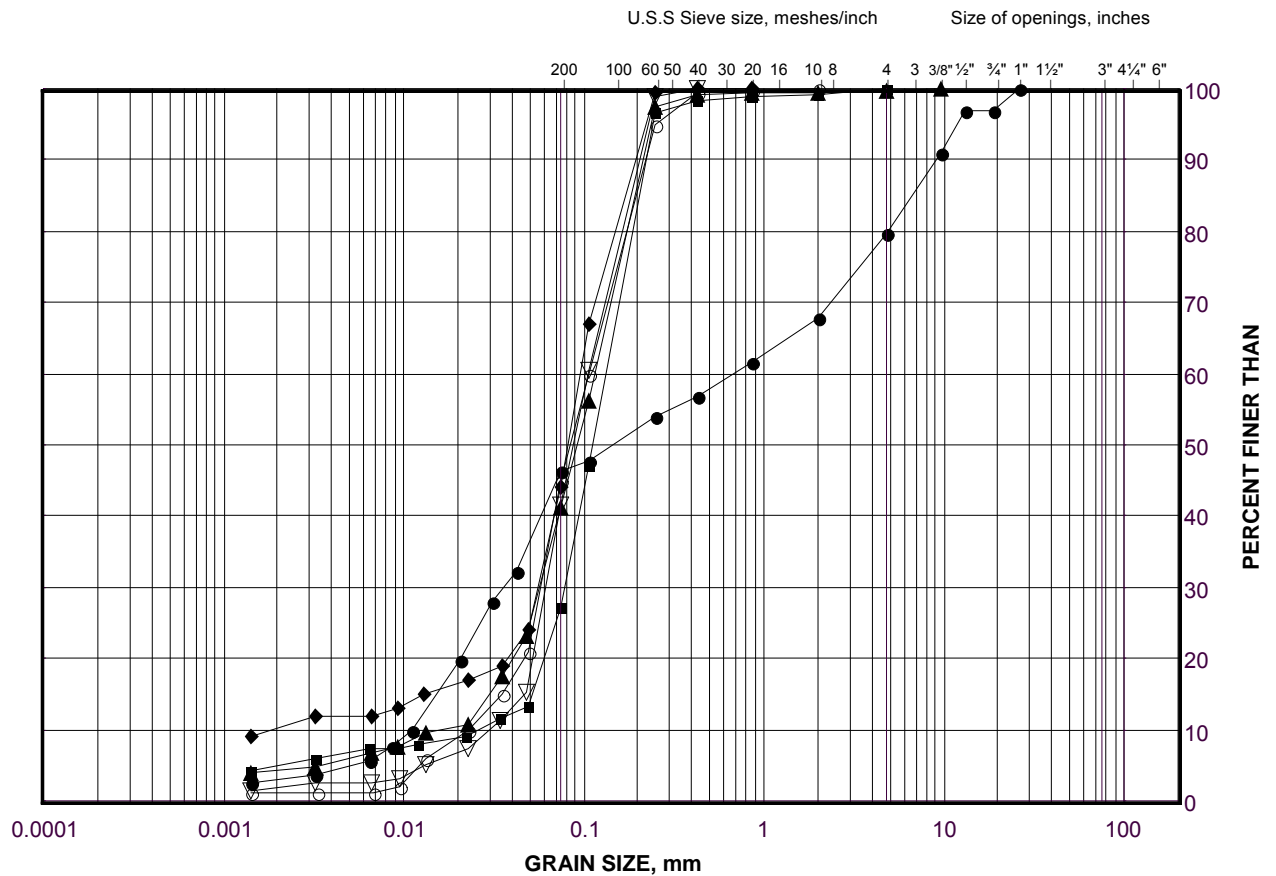
Checked By: AV

GRAIN SIZE DISTRIBUTION

Silt and Sand to Silty Sand

Highway 69 (SBL) STA 10+350 to 470 (Swamp 503)

FIGURE C.S503-02A



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C501-03	2	183.2
■	S503-06	2	184.2
◆	S503-03	2B	188.8
▲	S503-03	4	187.2
▽	S503-04	4	188.8
○	S503-04	6	187.3

Project Number: 09-1111-6014

Checked By: AV

Golder Associates

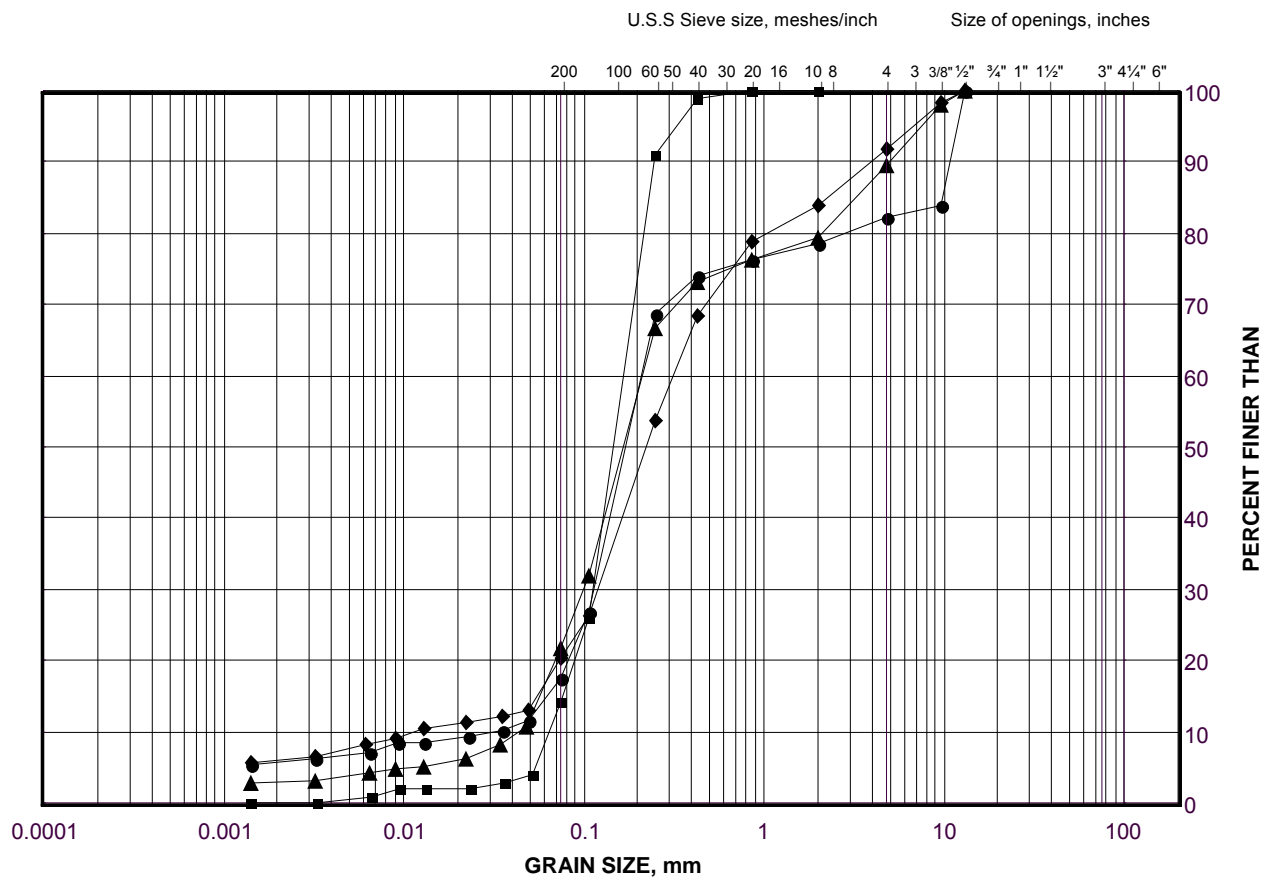
Date: 22-Oct-13

GRAIN SIZE DISTRIBUTION

Sand

Highway 69 9SBL) STA 10+350 to 10+470 (Swamp 503)

FIGURE C.S503-02B



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S503-08	1B	186.7
■	S503-10	2	185.2
◆	C501-02	2A	182.9
▲	C501-01	2B	181.9

Project Number: 09-1111-6014

Checked By: AV

Golder Associates

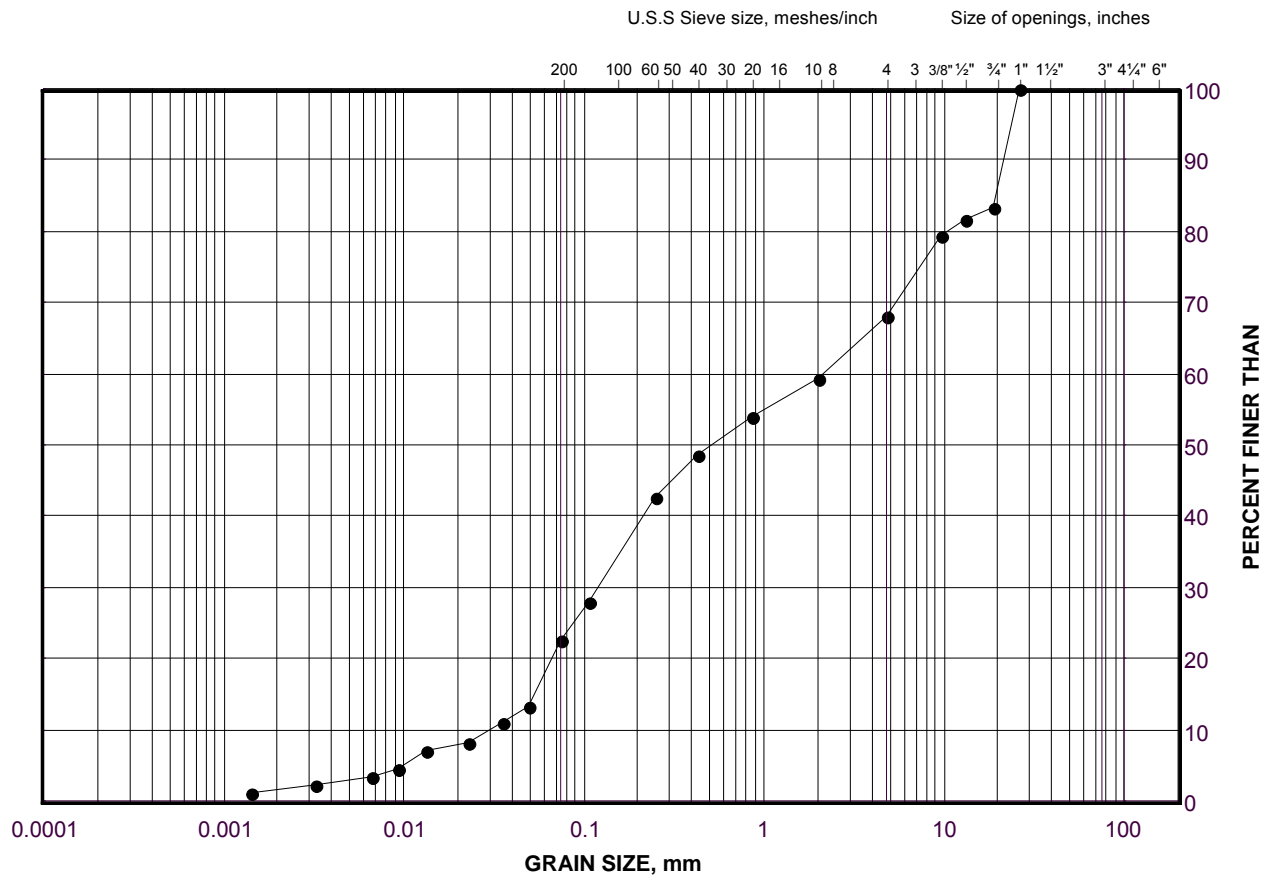
Date: 22-Oct-13

GRAIN SIZE DISTRIBUTION

Sand and Gravel

Highway 69 (SBL) STA 10+350 to 10+470 (Swamp 503)

FIGURE C.S503-03



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		

LEGEND

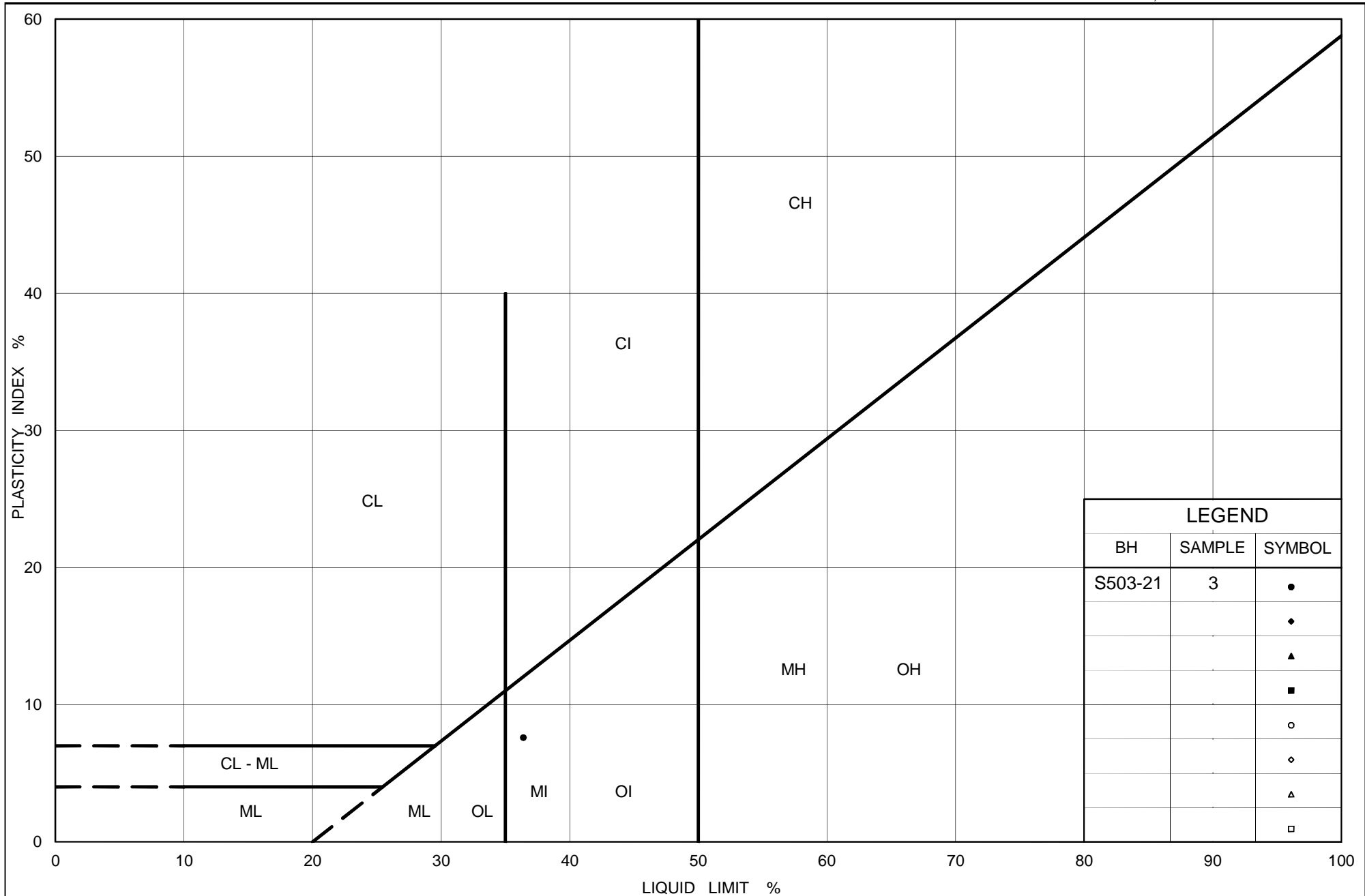
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S503-01	3B	185.4

Project Number: 09-1111-6014

Checked By: AV

Golder Associates

Date: 22-Oct-13



Ministry of Transportation

Ontario

PLASTICITY CHART

Organic Silt

Highway 69 (NBL) STA 10+230 to 10+445 (Swamp 503)

Figure No. C.S503-04

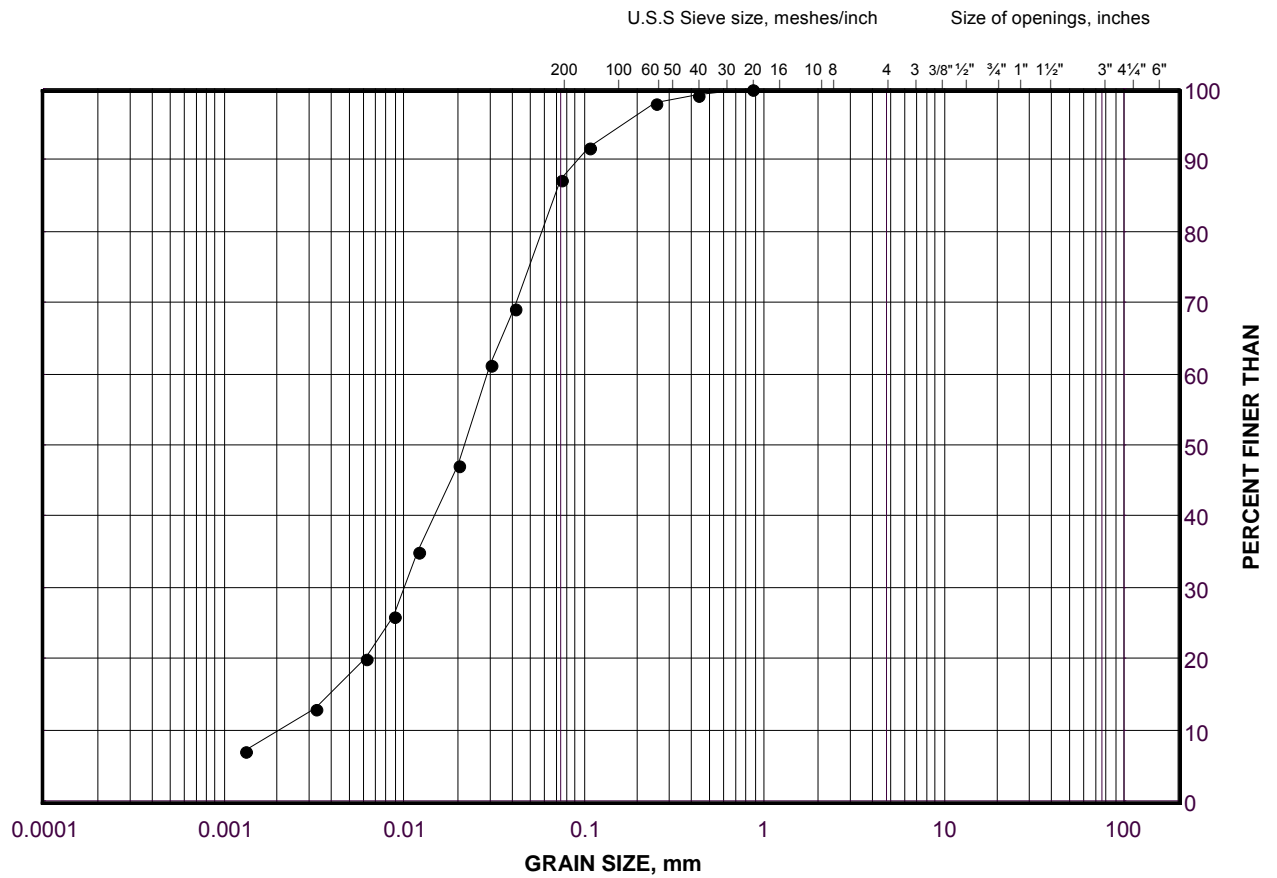
Project No. 09-1111-6014

Checked By: AV

GRAIN SIZE DISTRIBUTION

Clayey Organic Silt
Highway 69 (NBL) STA 10+230 to 10+445 (Swamp 503)

FIGURE C.S503-05



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

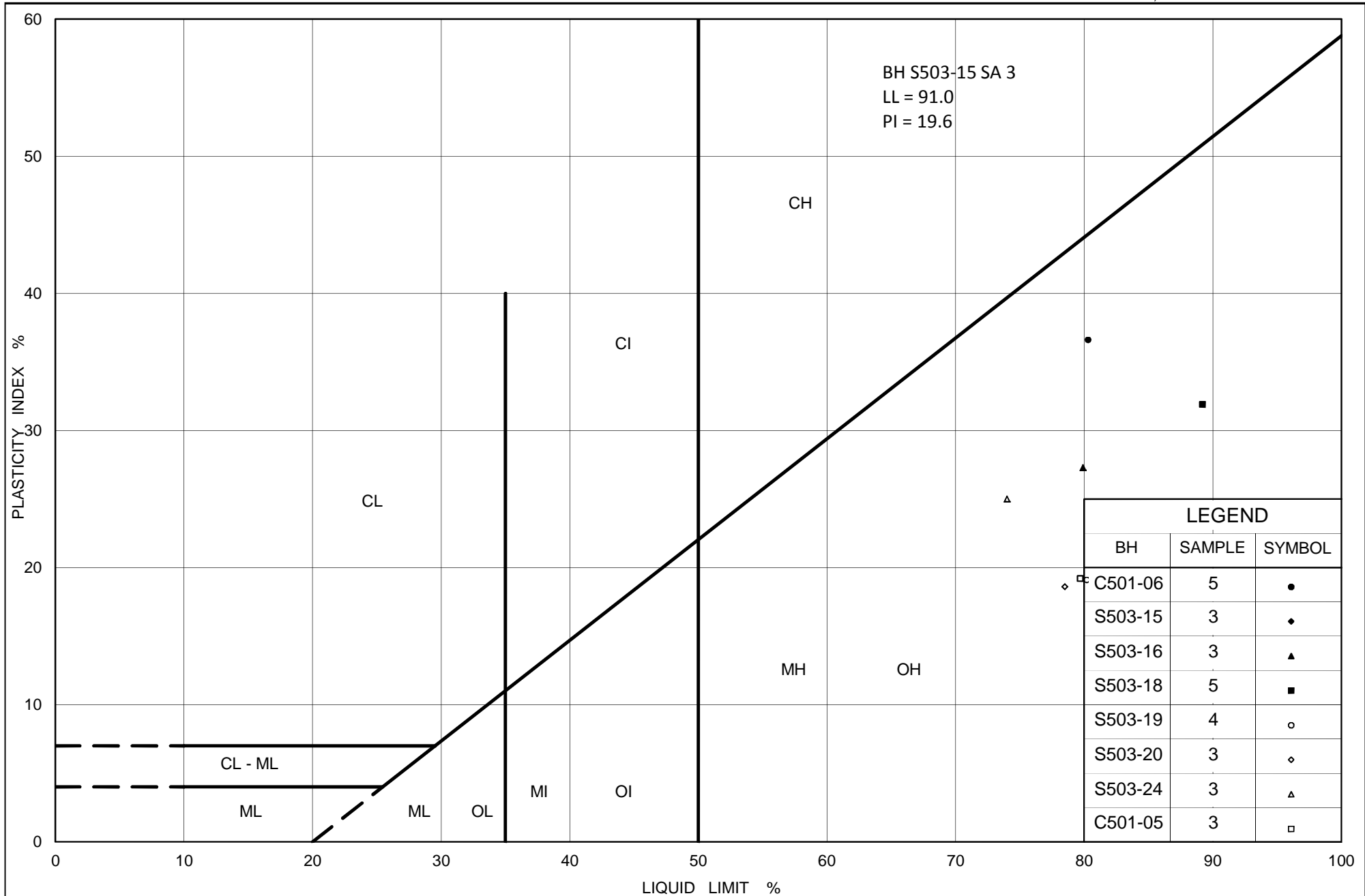
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S503-24	3	183.2

Project Number: 09-1111-6014

Checked By: AV

Golder Associates

Date: 28-Oct-13



Ministry of Transportation

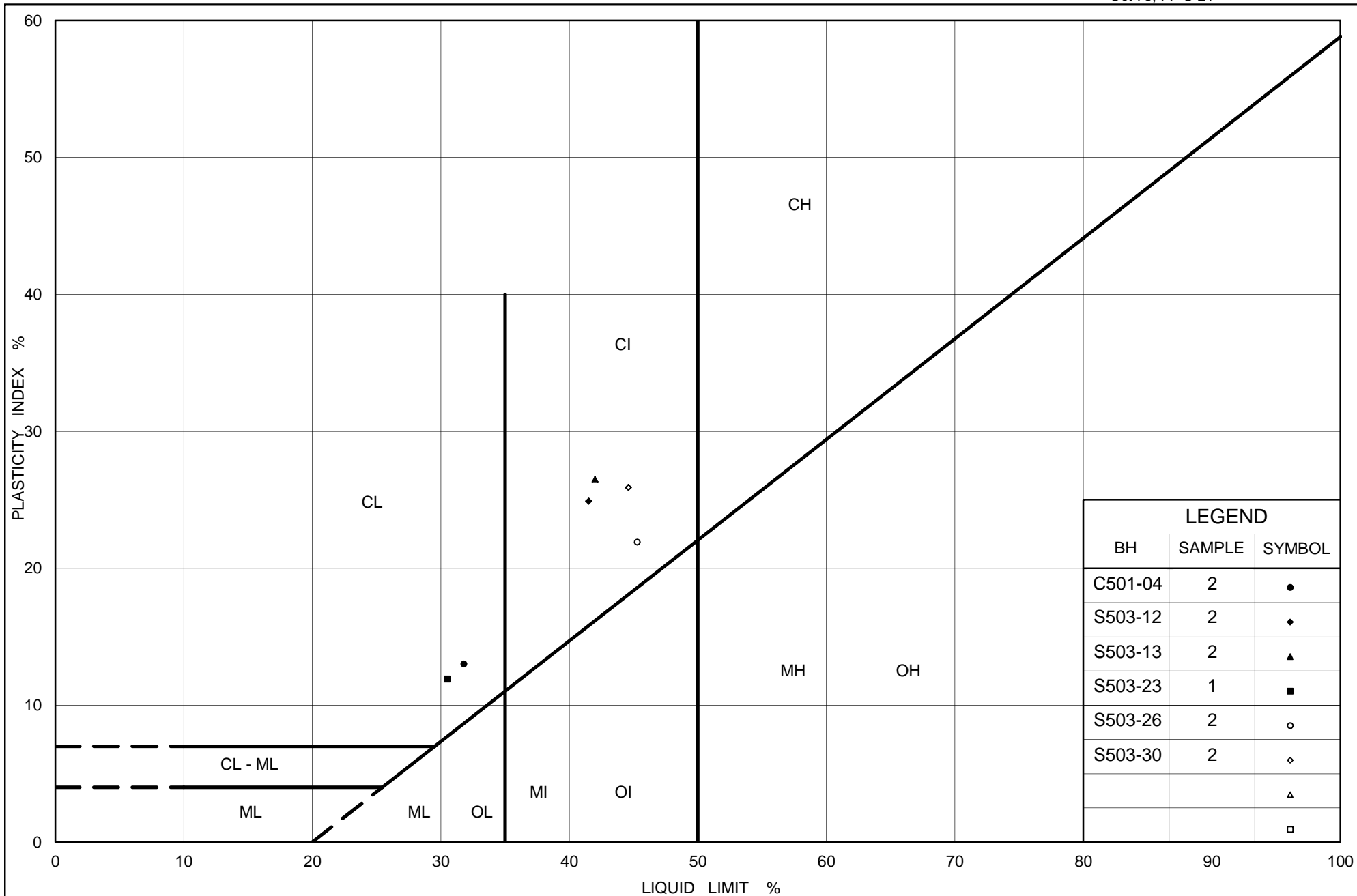
Ontario

PLASTICITY CHART
 Clayey Organic Silt
 Highway 69 (NBL) STA 10+230 to 10+445 (Swamp 503)

Figure No. C.S503-06

Project No. 09-1111-6014

Checked By: AV



Ministry of Transportation

Ontario

PLASTICITY CHART
 Clayey Silt to Silty Clay
 Highway 69 (NBL) STA 10+230 to 10+445 (Swamp 503)

Figure No. C.S503-07

Project No. 09-1111-6014

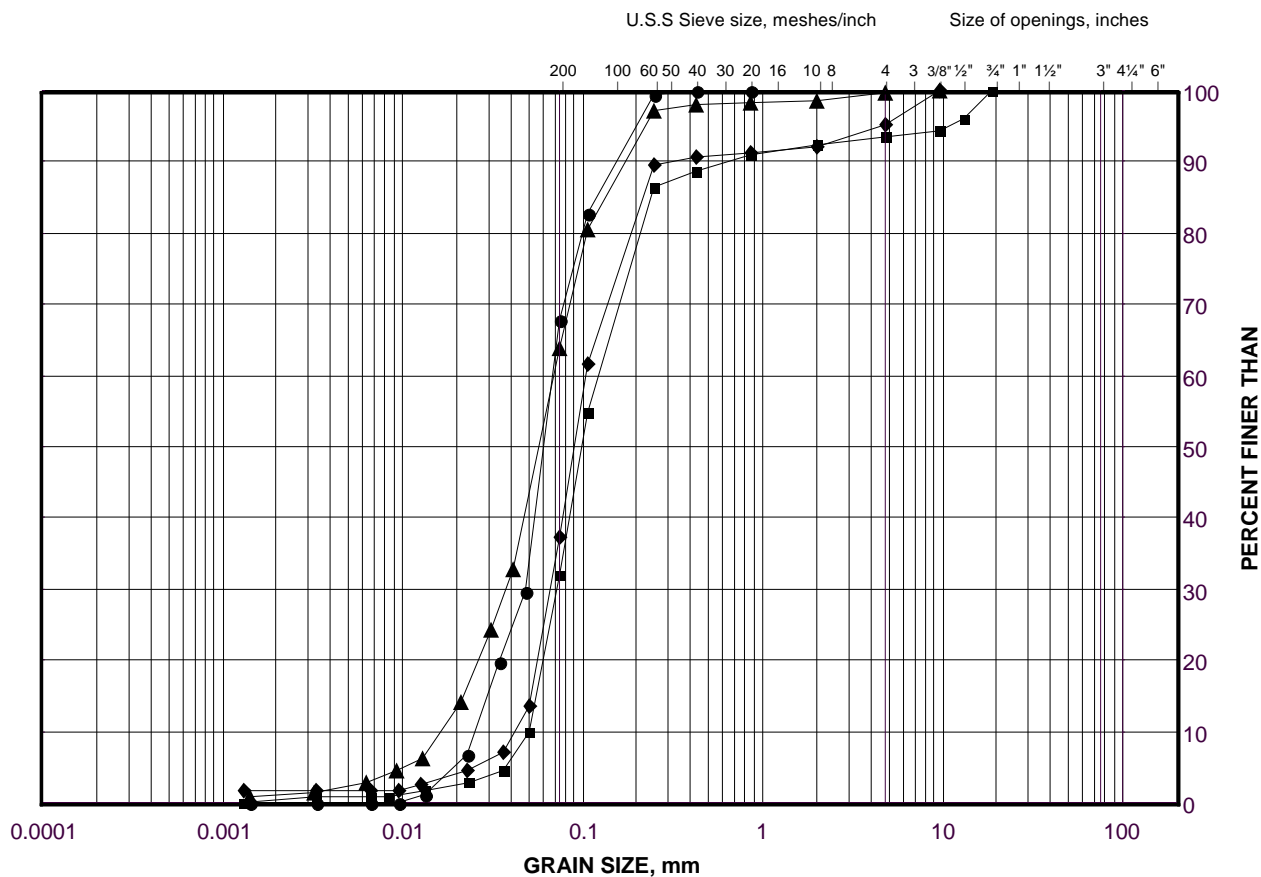
Checked By: AV

GRAIN SIZE DISTRIBUTION

Silt and Sand

Highway 69 (NBL) STA 10+230 to 10+445 (Swamp 503)

FIGURE C.S503-08A



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S503-17	5	182.5
■	S503-20	8	176.3
◆	S503-19	9	176.4
▲	C501-06	9	176.4

Project Number: 09-1111-6014

Checked By: AV

Golder Associates

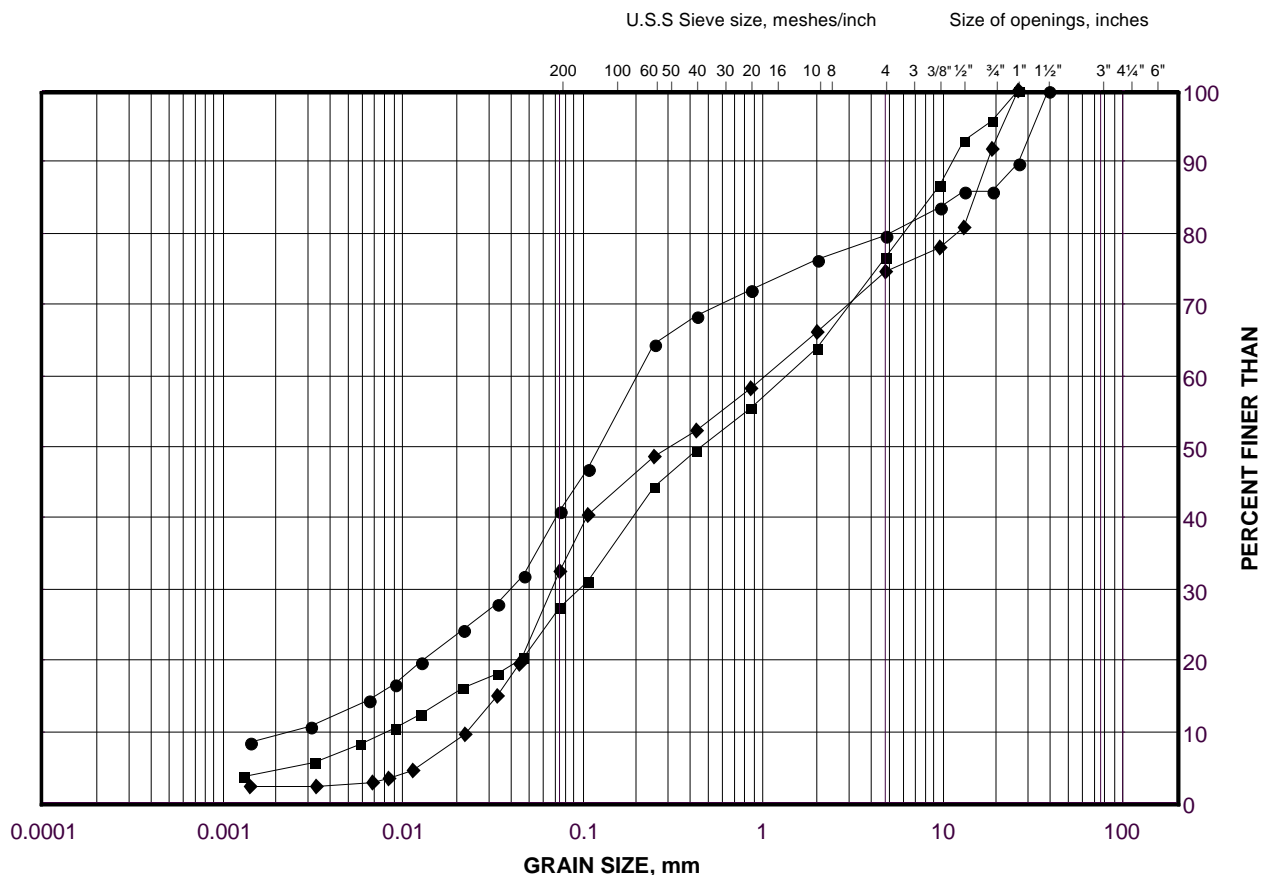
Date: 17-Oct-14

GRAIN SIZE DISTRIBUTION

Gravelly Silty Sand

(Highway 69 (NBL) STA 10+230 to 10+445 (Swamp 503))

FIGURE C.S503-08C



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

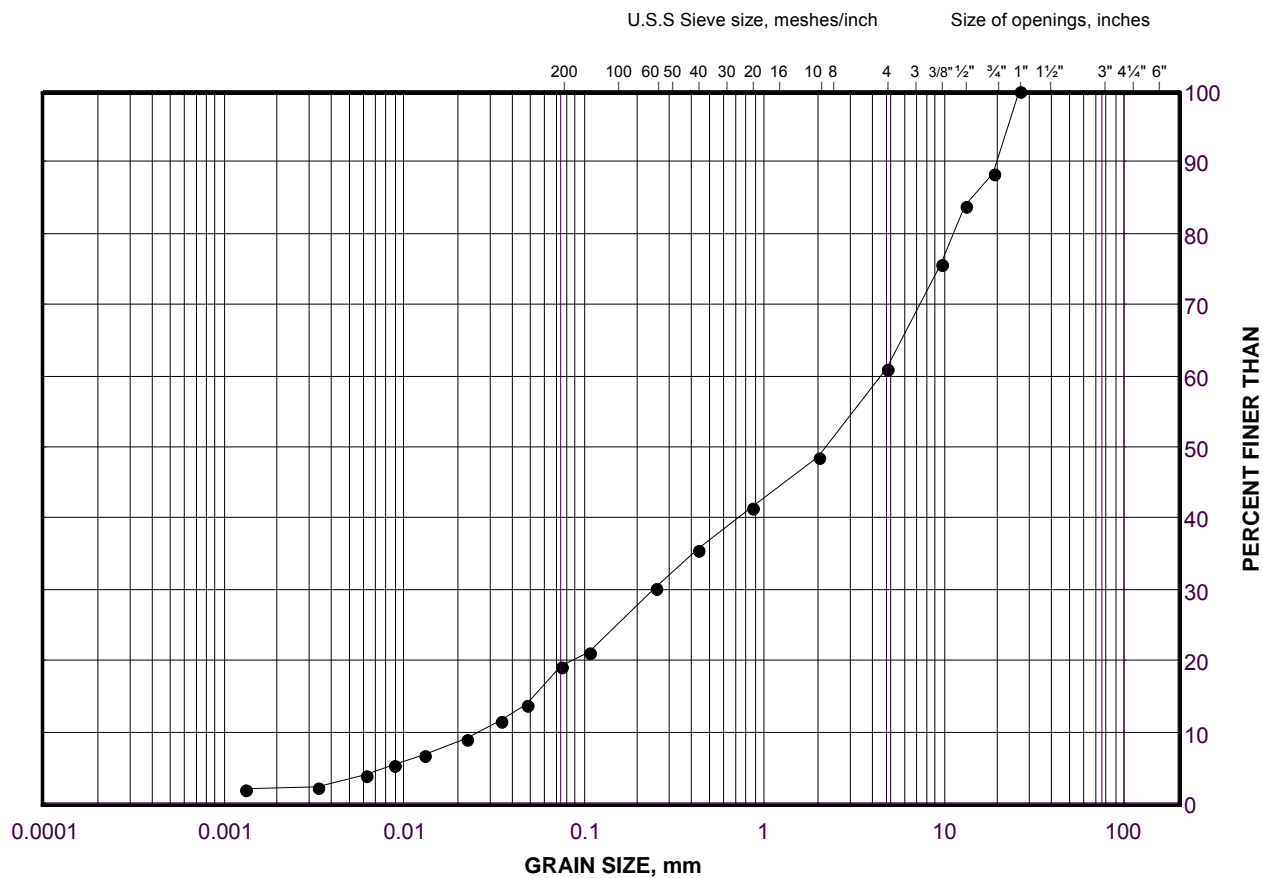
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S503-29	1	188.5
■	S503-26	3B	183.3
◆	S503-22	9	177.1

GRAIN SIZE DISTRIBUTION

Sand and Gravel

Highway 69 (NBL) STA 10+230 to 10+445 (Swamp 503)

FIGURE C.S503-09



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S503-23	5	181.8

Project Number: 09-1111-6014

Checked By: AV

Golder Associates

Date: 28-Oct-13



**FOUNDATION REPORT – SWAMP CROSSING, HIGH FILL
AREAS AND DEEP CUT - HIGHWAY 69 GWP 5347-08-00; WP 5005-10-01**

**Table C1: Evaluation of Stability/Settlement Mitigation Options
Highway 69 SBL – STA 10+350 to STA 10+470 (Swamp 503)**

Stability/Settlement Mitigation Option	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
Full Sub-Excavation (up to about 3.5 m deep) and Preloading of Rock Fill (5 days)	1	<ul style="list-style-type: none"> ■ Toe berms are not required. ■ Reduced time to achieve the post-construction settlement criteria as compared with preloading option. 	<ul style="list-style-type: none"> ■ Generation of excess excavation spoil. ■ Additional quantity of rock fill will be required for backfilling. Delay in construction associated with up to 3.5 m deep sub-excavation and replacement with rock fill operation. ■ Additional post-construction settlement of rock fill itself due to increased thickness of fill. 	<ul style="list-style-type: none"> ■ Additional costs associated with sub-excavation, disposal and replacement of weak/soft, compressible deposits. 	<ul style="list-style-type: none"> ■ Preloading of rock fill itself will be required to reduce post-construction settlement of the rock fill embankment. ■ Will achieve/ maintain stability of proposed embankment.
Preloading (15 days), including localized sub-excavation of clayey organic silt / organic silt below the east side slope (up to about 3.5 m deep in localized area)	2	<ul style="list-style-type: none"> ■ Toe berms are not required. ■ Slight reduction in the generation of excess excavation spoils as compared with the full sub-excavation option. ■ Lesser quantity of rock fill will be required for backfilling. 	<ul style="list-style-type: none"> ■ Delay in construction associated with up to 3.5 m deep sub-excavation and replacement with rock fill operation. ■ Increased period of preloading. ■ Additional post-construction settlement of rock fill itself. 	<ul style="list-style-type: none"> ■ Additional costs associated with sub-excavation, disposal and replacement of weak/soft, compressible deposits. 	<ul style="list-style-type: none"> ■ Preloading of rockfill itself would be required to reduce post-construction settlement of the cohesive deposit and the rock fill embankment. ■ Low risk with respect to maintaining stability of proposed embankments.
Surcharging	NR ¹	<ul style="list-style-type: none"> ■ Given the short duration recommended for the preloading option and given that localized sub-excavation of the clayey organic silt / organic silt deposit encountered below the east side slope would still be required, surcharging is not expected to offer any significant advantages and is not recommended. 			
Wick Drains and Preloading or Surcharging	Not practical	<ul style="list-style-type: none"> ■ Given that the cohesive deposit is relatively thin below the SBL embankment (up to about 1.3 m thick), the installation of wick drains will not appreciably increase the rate of consolidation. Considering the additional costs associated with a detailed wick drain investigation and design, as well as the requirement for foundation monitoring during construction, the use of wick drains is not considered economical or practical at this location. 			
Lightweight Fill	Not practical	<ul style="list-style-type: none"> ■ Given the short duration recommended for the preloading option, the limited amount of excavation required for the full sub-excavation option, absence of stability issues along the west side of the SBL embankment, and the relatively short length of the swamp crossing, and the presence of bedrock outcrops and shallow deposits overlying bedrock near the northern limit of the swamp crossing, the use of expensive lightweight fill (i.e. expanded polystyrene (EPS)) is not considered economical or practical at this location. 			
Aggregate Piers	Not practical	<ul style="list-style-type: none"> ■ Given the localized extent and limited thickness of the cohesive deposit (varying between 0.2 m and 1.3 m) and the high cost associated with the construction of aggregate piers, the use of aggregate piers is not considered economical or practical for this area. 			
Deep Soil Mixing	Not practical	<ul style="list-style-type: none"> ■ Given the localized extent and limited thickness of the cohesive deposit (varying between 0.2 m and 1.3 m) and the high cost associated with deep soil mixing construction, the use of deep soil mixing is not considered economical or practical for this area. 			

Note: 1. NR – not recommended.



**FOUNDATION REPORT – SWAMP CROSSING, HIGH FILL
AREAS AND DEEP CUT - HIGHWAY 69 GWP 5347-08-00; WP 5005-10-01**

**Table C2: Evaluation of Stability/Settlement Mitigation Options
Highway 69 NBL – STA 10+230 to STA 10+445 (Swamp 503)**

Stability/Settlement Mitigation Option	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
Full Sub-Excavation (up to 6.5 m deep) and Preloading of Rock Fill (95 days)	1	<ul style="list-style-type: none"> ■ Reduced total settlement. ■ Toe berms are not required. ■ Reduced time period to achieve the settlement criterion. 	<ul style="list-style-type: none"> ■ Generation of larger volume of excess excavation spoil. ■ Larger quantity of rock fill will be required for backfilling. Some delay in construction associated with up to 6.5 m deep sub-excavation and replacement with rock fill operation. ■ Additional effort required for sub-excavation and replacement. ■ Additional post-construction settlement of rock fill itself. 	<ul style="list-style-type: none"> ■ Additional costs associated with sub-excavation, disposal and replacement of weak/soft, compressible deposits. 	<ul style="list-style-type: none"> ■ Preloading would be required to reduce the magnitude of post-construction settlement of rock fill. ■ Will achieve/ maintain stability of proposed embankments.
Preloading (800 days) and Toe Berm (3 m high by 16 m wide along the outside toe) and Median Infill (1.5 m high)	5	<ul style="list-style-type: none"> ■ Standard construction operation. ■ Avoids generation of large volume of excess excavation spoil. 	<ul style="list-style-type: none"> ■ Large toe berm (hence, large quantity of rock fill) is required. ■ Very long delay in construction period to achieve post-construction settlement criterion. ■ Instrumentation and monitoring program required to assess end of preload period. 	<ul style="list-style-type: none"> ■ Schedule impacts may increase overall project costs. ■ Additional costs associated with construction of toe berm and median infill. ■ Additional cost for the installation of instrumentation and associated monitoring program. 	<ul style="list-style-type: none"> ■ Potential for instability of preload embankment on weak/soft foundation soils. ■ Subject to the monitoring data collected during the preload period, the embankment may need to be preloaded for a further extended period of time.
Surcharging (200 days) and Toe Berm (3 m high by 21 m wide along the outside toe) and Median Infill (1.5 m high)	2	<ul style="list-style-type: none"> ■ Standard construction operation. ■ Reduced time to reach post-construction settlement criteria as compared with preloading alternative. ■ Avoids generation of large volume of excess excavation spoil. 	<ul style="list-style-type: none"> ■ Increased handling of surcharge fills (Granular 'B') upon completion of surcharge period. ■ Large toe berm is required to maintain stability of surcharge embankments. ■ Additional right-of-way may be required to accommodate large toe berm. ■ Delay in construction to reach post-construction settlement criteria. ■ Instrumentation and monitoring program required to assess end of surcharge period. 	<ul style="list-style-type: none"> ■ Schedule impacts may increase overall project costs. ■ Additional cost associated with construction for 2 m high surcharge and large toe berms. ■ Potential cost for acquiring additional right-of-way to accommodate large berms. ■ Additional cost for the installation of instrumentation and associated monitoring program. 	<ul style="list-style-type: none"> ■ Greater potential for instability of embankment with surcharge on weak/soft foundation soils. ■ Additional right-of-way may be required for large toe berm. ■ Subject to the monitoring data collected during the surcharge period, the embankment may need to be surcharged for an extended period of time.



**FOUNDATION REPORT – SWAMP CROSSING, HIGH FILL
AREAS AND DEEP CUT - HIGHWAY 69 GWP 5347-08-00; WP 5005-10-01**

**Table C2: Evaluation of Stability/Settlement Mitigation Options
Highway 69 NBL – STA 10+230 to STA 10+445 (Swamp 503)**

Stability/Settlement Mitigation Option	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
Wick Drains	Not practical	<ul style="list-style-type: none"> Given the low coefficient of horizontal consolidation (estimated based on empirical correlations and engineering experience with similar soils); considering the effects of smearing during wick drain installation (i.e. reduced horizontal permeability of the organic deposit immediately adjacent to the wick drains); given the relatively high creep rate of the organic deposits, preliminary analyses indicate that wick drains are not expected to offer any significant advantages in terms of the preload/surcharge times to satisfy the settlement performance criterion following completion of construction. 			
Lightweight Fill (4.5 m thick EPS core) and Preloading (175 days)	4	<ul style="list-style-type: none"> Improved stability – toe berms are not required. Reduced total settlement of foundation soils. 	<ul style="list-style-type: none"> Very high cost of EPS construction materials. Requires embankments to be constructed with 2H:1V side slopes given the need for granular fill for levelling pad and conventional soil cover on side slopes. Not feasible to install below the groundwater table (due to buoyancy forces) and requirement for minimum conventional soil cover on top of the EPS. Requires 125 mm thick reinforced concrete pad to be constructed on top of the EPS. Delay in construction required to reach post-construction settlement criteria. Instrumentation and monitoring program required to assess end of preload period. 	<ul style="list-style-type: none"> Relative cost of EPS fill is at least an order of magnitude higher than fill required for the other options. Additional costs associated with the construction of a protective concrete cap on top of the EPS. Reduced costs for disposal / management of excavation spoils as compared with partial sub-excavation or full sub-excavation option. Schedule impacts may increase overall project costs. Additional cost for the installation of instrumentation and associated monitoring program. 	<ul style="list-style-type: none"> Ensures that stability of the embankment is achieved. Reduces post-construction settlement of foundation soils. Subject to the monitoring data collected during the preload period, the embankment may need to be left in place for an extended period of time.
Aggregate Piers (on 2.5 m triangular pattern) and Preloading (65 days)	3	<ul style="list-style-type: none"> Improved stability. Reduced time to achieve the time-dependent settlement criterion. Reduced total settlement of foundation soils. 	<ul style="list-style-type: none"> Detail aggregate pier design will be required. Additional time required for construction of aggregate piers. Generation of some excess excavation spoil. Temporary casing will likely be required due to low strength of organic deposits encountered below the water table, unless displacement-type aggregate piers can be utilized. 	<ul style="list-style-type: none"> Schedule impacts may increase overall project costs. Additional costs associated with detail aggregate pier design. Additional cost for the construction of aggregate piers. 	<ul style="list-style-type: none"> Would achieve/ maintain stability of the embankment. Would achieve the long-term settlement performance of the embankment. Complex aggregate pier design to balance between spacing of piers/preloading period/costs. If the preload period can easily be recommended into the construction schedule, costs could be reduced.



**FOUNDATION REPORT – SWAMP CROSSING, HIGH FILL
AREAS AND DEEP CUT - HIGHWAY 69 GWP 5347-08-00; WP 5005-10-01**

**Table C2: Evaluation of Stability/Settlement Mitigation Options
Highway 69 NBL – STA 10+230 to STA 10+445 (Swamp 503)**

Stability/Settlement Mitigation Option	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
			<ul style="list-style-type: none"> Delay in construction schedule to allow for sufficient settlement to occur to meet post-construction settlement criteria. 		
Deep Soil Mixing	Not practical	<ul style="list-style-type: none"> Improved strength of soft/weak strata and long-term stability of embankment. Improved stiffness of soft/weak strata and long-term settlement performance of embankment. Reduced construction schedule following completion of soil mixing. Treatment of poor foundation soils in-situ greatly reduces or eliminates excavation spoil. 	<ul style="list-style-type: none"> Detailed soil mixing design will be required including bench scale laboratory testing to optimize mix design. Additional time for construction of deep soil mix panels. 	<ul style="list-style-type: none"> Additional costs associated with detail soil mixing design. High additional costs associated with construction of soil mix panels. 	<ul style="list-style-type: none"> Would achieve/maintain stability of the embankment. Would achieve the long-term settlement performance of the embankment. Soil mix design may require high cement content given high organic content of foundation soils requiring treatment which could increase costs.



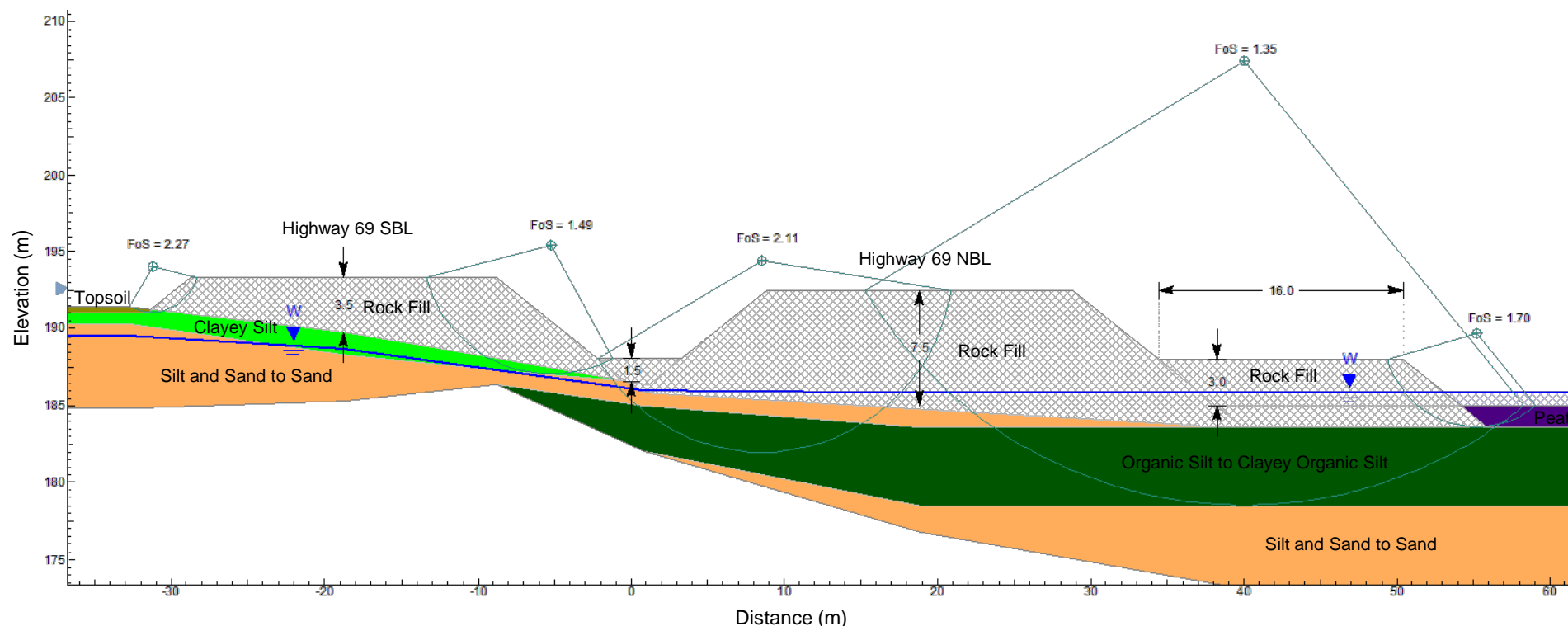
Highway 69 SBL – STA 10+350 to STA 10+470 (Swamp 503) Highway 69 NBL – STA 10+230 to STA 10+445 (Swamp 503) Slope Stability (Median Infill / Outside Toe Berm)

Figure C1

Material Name	Unit Weight (kN/m ³)	Cohesion (kPa)	Friction Angle (degrees)
Rock Fill	19	0	40
Topsoil	15	1	28
Peat	12	1	28
Clayey Silt	17	25	0
Silt and Sand to Sand	19	0	31
Organic Silt to Clayey Organic Silt	16	20	0

NOTES:

1. All dimensions are in metres.
2. All rock fill slopes are at 1.25H:1V.





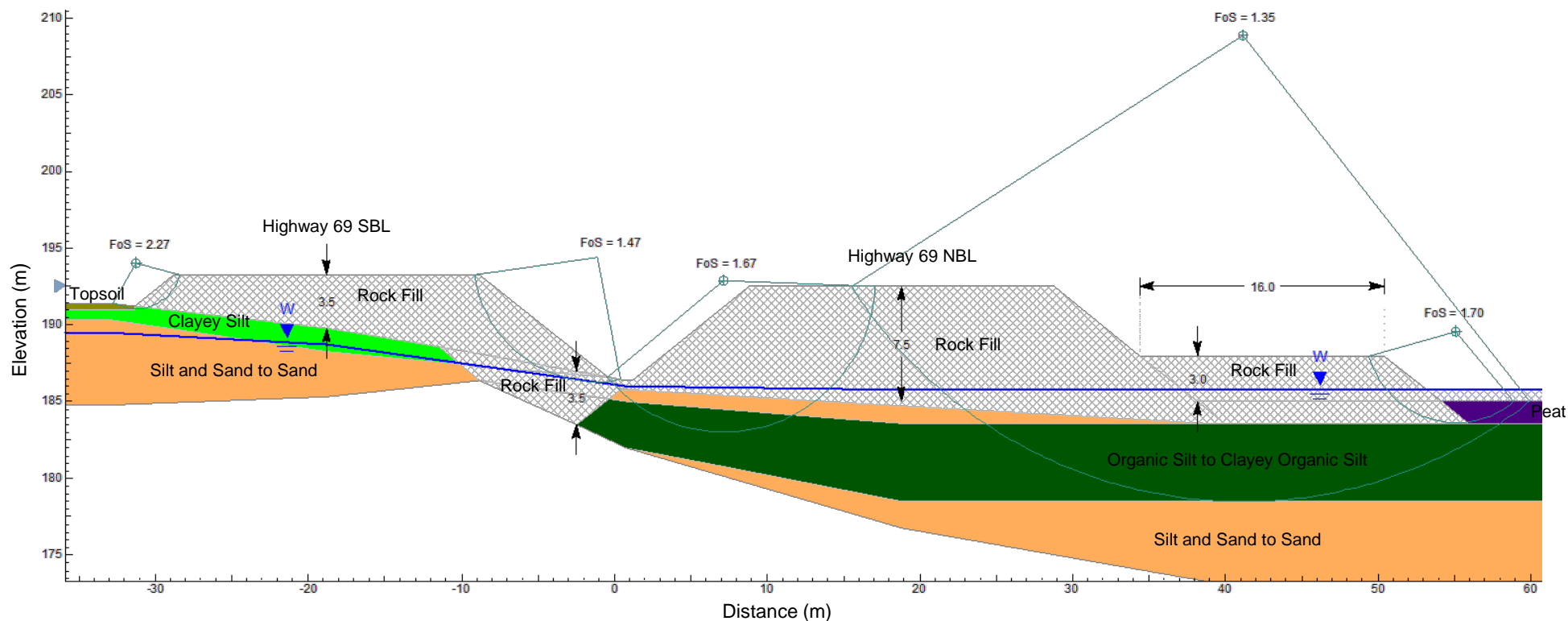
Highway 69 SBL – STA 10+350 to STA 10+470 (Swamp 503) Highway 69 NBL – STA 10+230 to STA 10+445 (Swamp 503) Slope Stability (Localized Sub-Excavation and Outside Toe Berm)

Figure C2

Material Name	Unit Weight (kN/m ³)	Cohesion (kPa)	Friction Angle (degrees)
Rock Fill	19	0	40
Topsoil	15	1	28
Peat	12	1	28
Clayey Silt	17	25	0
Silt and Sand to Sand	19	0	31
Organic Silt to Clayey Organic Silt	16	20	0

NOTES:

1. All dimensions are in metres.
2. All rock fill slopes are at 1.25H:1V.





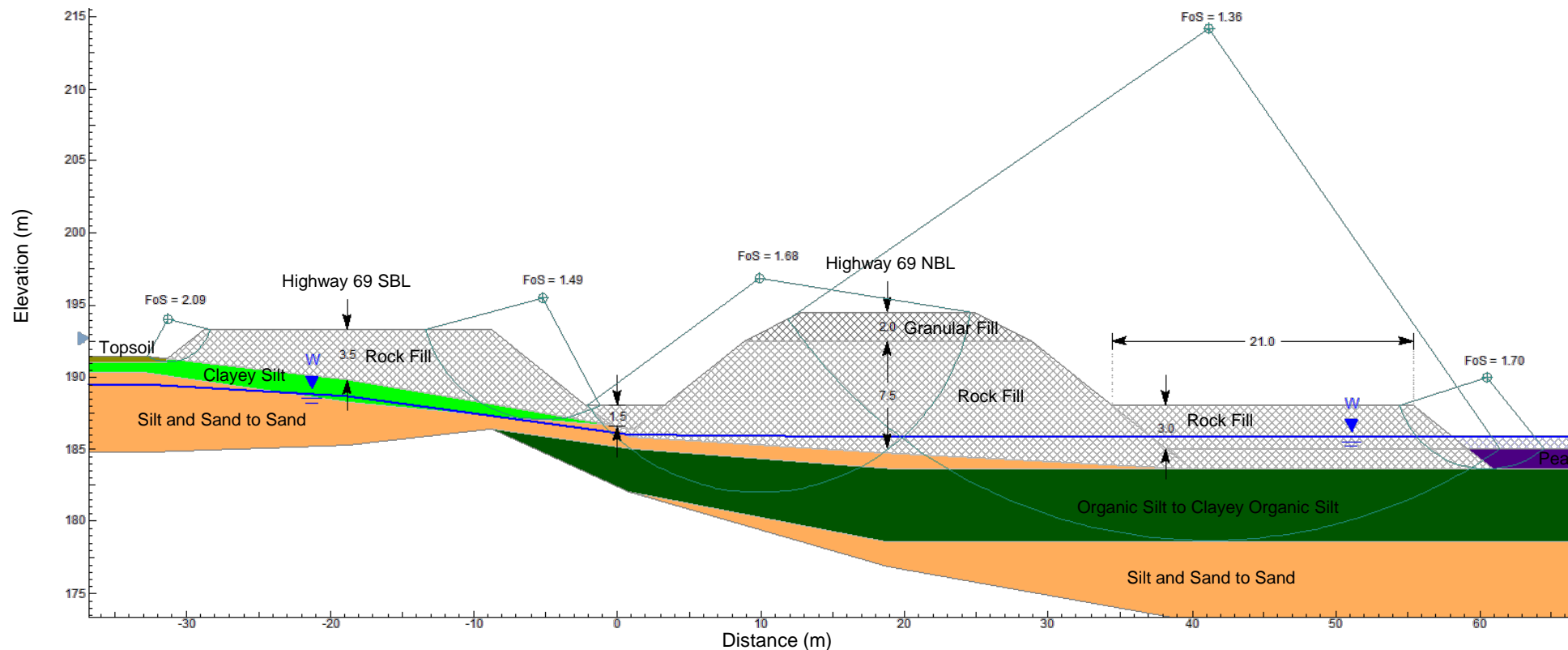
Highway 69 SBL – STA 10+350 to STA 10+470 (Swamp 503)
Highway 69 NBL – STA 10+230 to STA 10+445 (Swamp 503)
Slope Stability (2 m Surcharge at NBL and Median Infill / Outside Toe Berm)

Figure C3

Material Name	Unit Weight (kN/m ³)	Cohesion (kPa)	Friction Angle (degrees)
Rock Fill	19	0	40
Granular Fill	21	0	34
Topsoil	15	1	28
Peat	12	1	28
Clayey Silt	17	25	0
Silt and Sand to Sand	19	0	31
Organic Silt to Clayey Organic Silt	16	20	0

NOTES:

1. All dimensions are in metres.
2. All rock fill slopes are at 1.25H:1V.
3. All granular fill slopes are at 2H:1V.





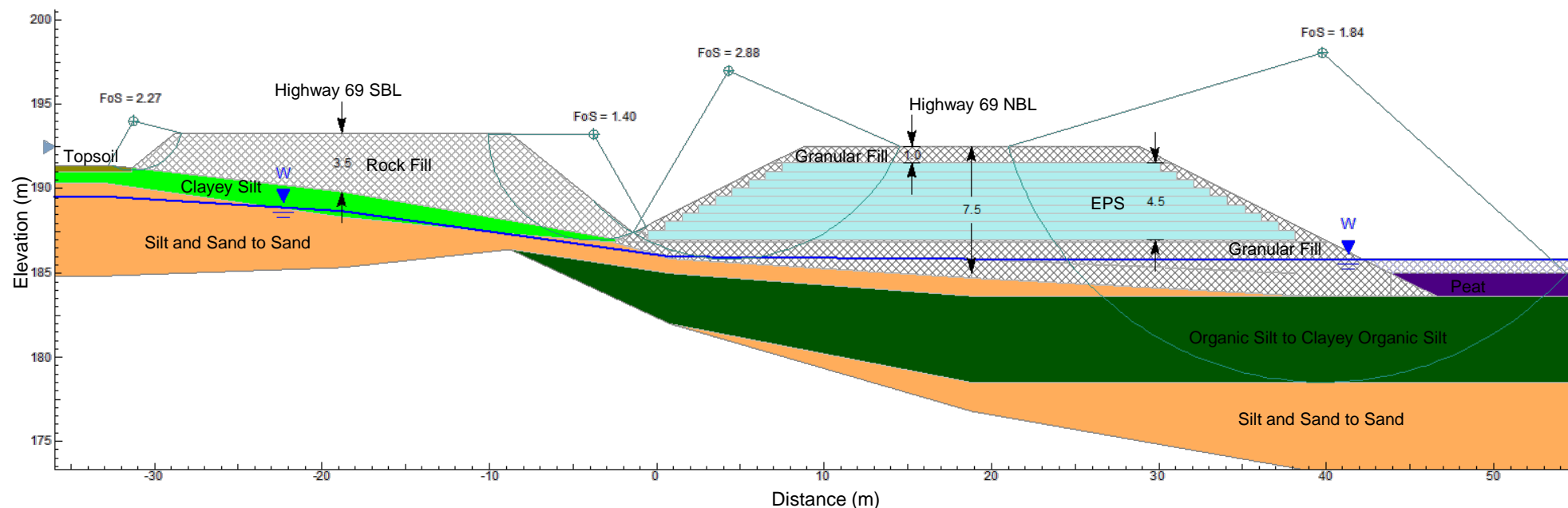
Highway 69 SBL – STA 10+350 to STA 10+470 (Swamp 503) Highway 69 NBL – STA 10+230 to STA 10+445 (Swamp 503) Slope Stability (4.5 m EPS Fill at NBL)

Figure C4

Material Name	Unit Weight (kN/m ³)	Cohesion (kPa)	Friction Angle (degrees)
Rock Fill	19	0	40
Granular Fill	21	0	34
Lightweight Fill (EPS)	0.5	15	0
Topsoil	15	1	28
Peat	12	1	28
Clayey Silt	17	25	0
Silt and Sand to Sand	19	0	31
Organic Silt to Clayey Organic Silt	16	20	0

NOTES:

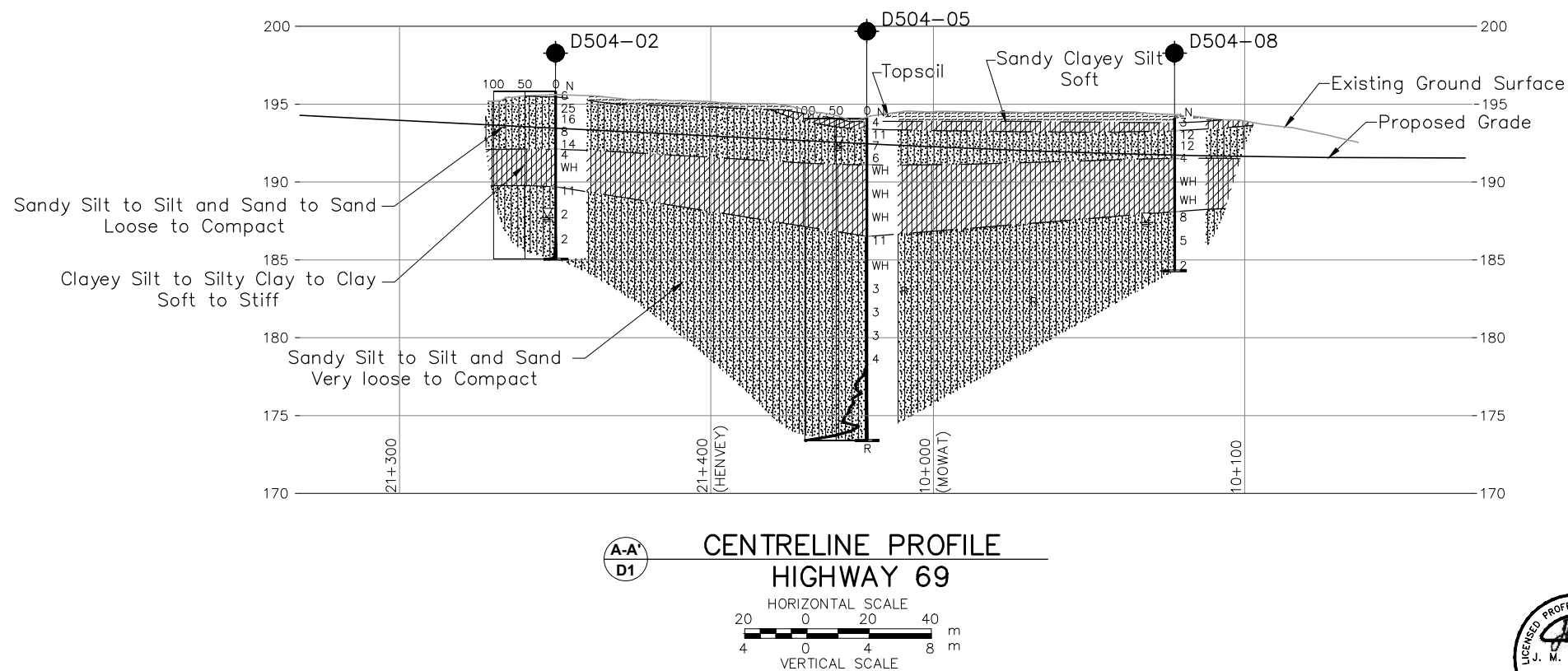
1. All dimensions are in metres.
2. All rock fill slopes are at 1.25H:1V.
3. All granular fill slopes are at 2H:1V.





APPENDIX D

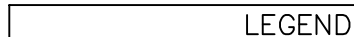
Highway 69 NBL – STA 21+300 (Henvey) to STA 10+140 (Mowat)
(Deep Cut 504)



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



SHEET



- | | Borehole – Current Investigation |
|----------|--|
| N | Standard Penetration Test Value |
| 16 | Blows/0.3m unless otherwise stated
(Std. Pen. Test, 475 j/blow) |
| ∇ | WL upon completion of drilling |
| R | Refusal |

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
D504-01	195.1	5083431.2	222885.2
D504-02	195.8	5083471.8	222852.8
D504-03	195.5	5083510.7	222816.2
D504-04	194.8	5083524.0	222848.0
D504-05	194.1	5083564.1	222814.2
D504-06	195.8	5083599.6	222779.0
D504-07	194.4	5083612.7	222810.4
D504-08	194.1	5083655.3	222776.2
D504-09	194.0	5083691.9	222740.6

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by URS, drawing file nos. Alignment and Contours from Hwy69_Contour-Plan_C3.dwg, received April 23, 2012 and the Existing and Proposed Grade obtained from drawing file Hwy69_profile March 2012.dwg, received March 14, 2012.

NO.	DATE	BY	REVISION		
Geocres No. 41H-164					
HWY. 69		PROJECT NO. 09-1111-6014		DIST.	
SUBM'D. ARV	CHKD. ARV	DATE: Oct. 2014		SITE:	
DRAWN: JFC	CHKD. ARV	APPD. JPD/JMAC		DWG. D1	

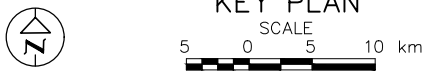
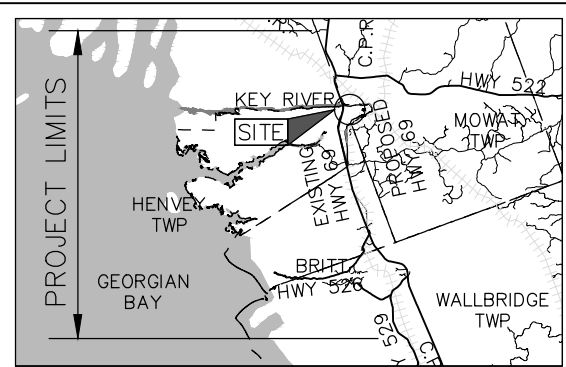


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 5005-10-01

HIGHWAY 69
STA 21+300 (MOWAT) TO STA 10+140 (HENVEY)

SOIL STRATA



LEGEND

- Borehole - Current Investigation
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL in piezometer, measured on July 25, 2013
- WL upon completion of drilling
- R Refusal

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
D504-01	195.1	5083431.2	222885.2
D504-03	195.5	5083510.7	222816.2
D504-04	194.8	5083524.0	222848.0
D504-06	195.8	5083599.6	222779.0
D504-07	194.4	5083612.7	222810.4
D504-09	194.0	5083691.9	222740.6

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

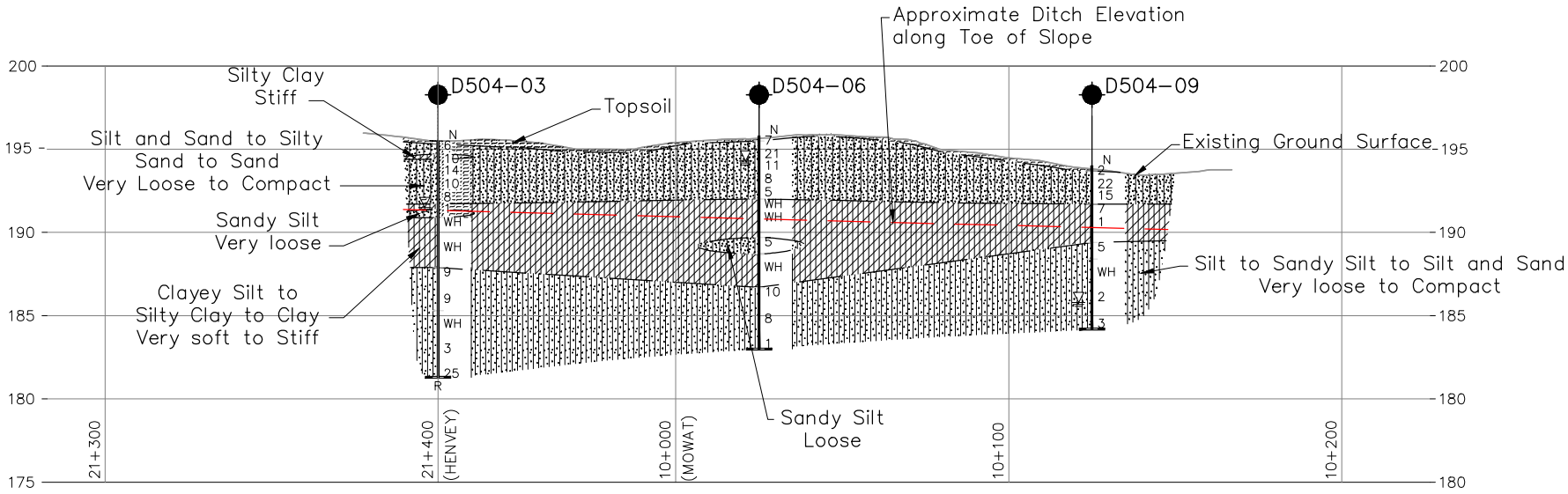
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

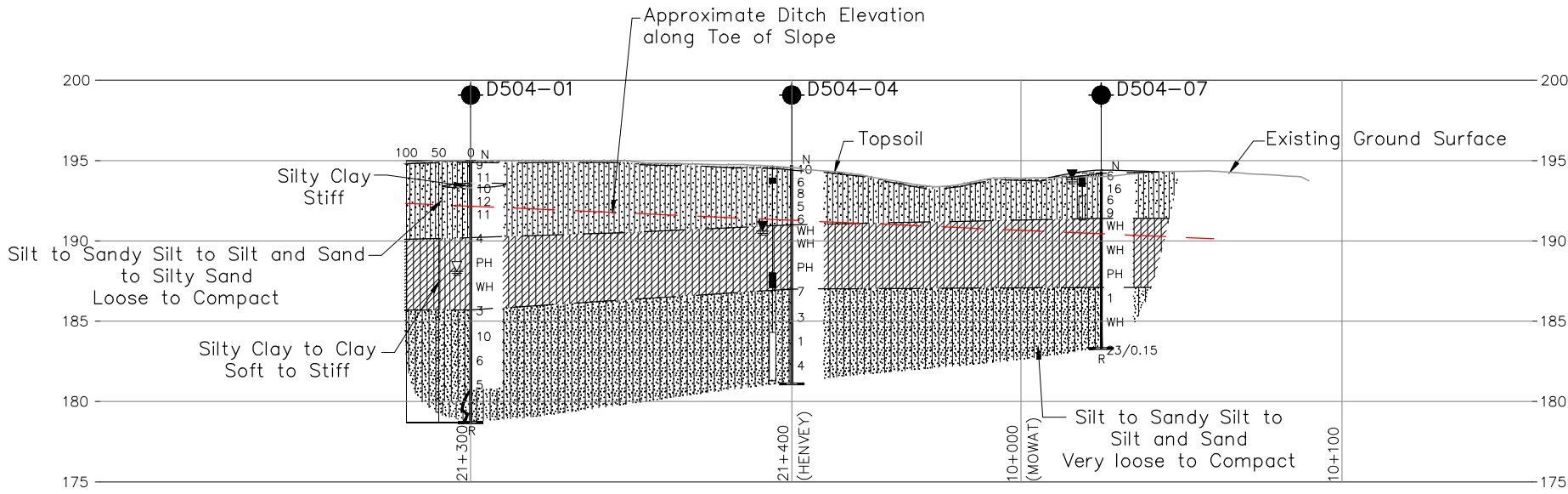
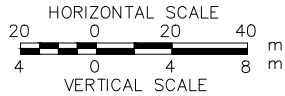
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Existing Ground Surface cut from contour drawing provided in digital format by URS, drawing file no. Hwy69_Contour-Plan_C5.dwg, received August 31, 2012.

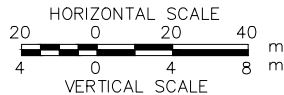
NO.	DATE	BY	REVISION	
Geocres No. 41H-164				
HWY. 69			PROJECT NO. 09-1111-6014	DIST.
SUBM'D. ARV		CHKD. ARV	DATE: Oct. 2014	SITE:
DRAWN: JFC		CHKD. ARV	APPD. JPD/JMAC	DWG. D2



WEST FACE PROFILE
HIGHWAY 69 (NBL)

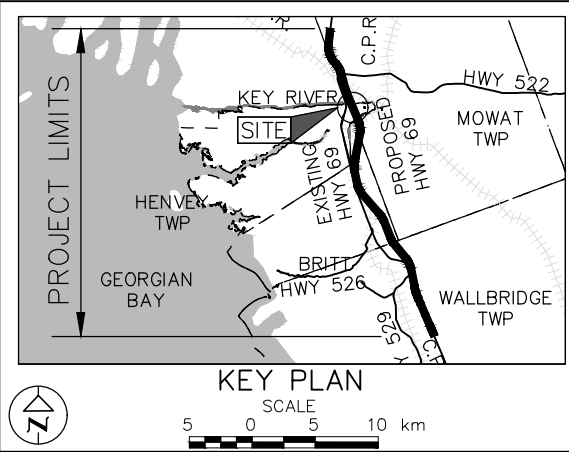


EAST FACE PROFILE
HIGHWAY 69 (NBL)





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


CONT No. WP No. 5005-10-01		
HIGHWAY 69 CROSS SECTION STA. 10+060 (NBL)		SHEET
SOIL STRATA		





LEGEND



Borehole – Current Investigation



Seal



Piezometer


N Standard Penetration Test Value


Blows/0.3m unless otherwise stated
(Std. Pen. Test, 475 j/blow)


WL in piezometer, measured on July 25, 2013


WL upon completion of drilling


Refusal

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
D504-06	195.8	5083599.6	222779.0
D504-07	194.4	5083612.7	222810.4
D504-08	194.1	5083655.3	222776.2

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

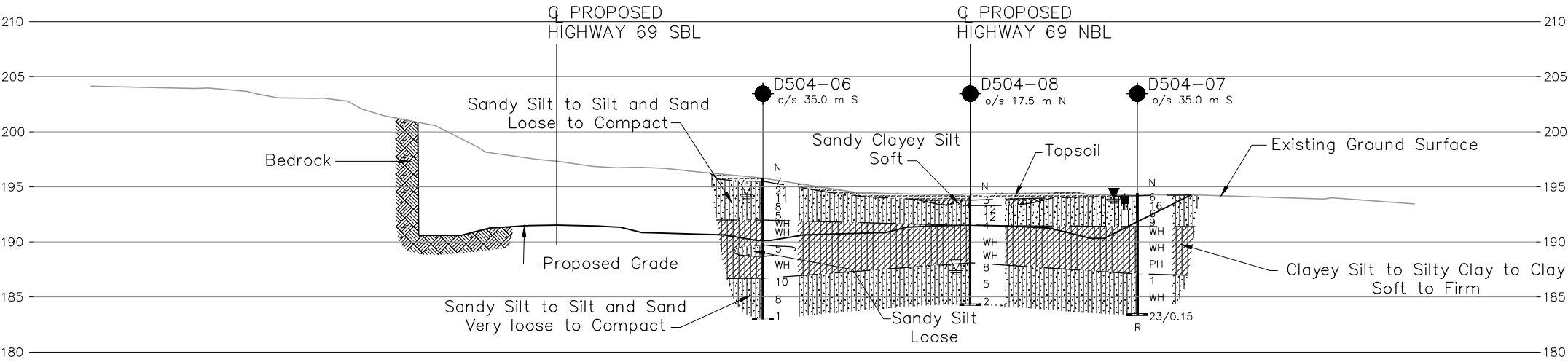
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Cross section drawing provided in digital format by URS, drawing file no. xs_Hwy69_Contract4_2013-01-22-for-golder.dwg, received February 1, 2013 .

NO.	DATE	BY	REVISION	
Geocres No. 41H-164				
HWY. 69		PROJECT NO. 09-1111-6014		DIST.
SUBM'D. AV	CHKD. AV	DATE: Oct. 2013	SITE:	
DRAWN: JFC	CHKD. AV	APPD. JPD/JMAC	DWG. D3	



**CROSS SECTION
STATION 10+060**

SCALE
5 0 5 10 m




PROJECT 09-1111-6014			RECORD OF BOREHOLE No D504-01			SHEET 1 OF 2			METRIC				
W.P. 5005-10-01			LOCATION N 5083431.2 ; E 222885.2			ORIGINATED BY ID							
DIST _____ HWY 69			BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers			COMPILED BY MCK/AV							
DATUM Geodetic			DATE July 24, 2013			CHECKED BY JPD							
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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa						
195.1	GROUND SURFACE						20	40	60	80	100		
0.0	TOPSOIL		1A		9								
	SILT and SAND, trace clay Loose to compact Brown Wet		1B	SS									
			2	SS	11								
193.6													
193.3	SILTY CLAY		3A	SS	10								
1.8	Stiff Grey Wet		3B										
	SILT and SAND, trace clay Loose to compact Brown Wet		4	SS	12								
			5	SS	11								
			6A	SS	4								
190.2	SILTY CLAY to CLAY		6B										
4.9	Firm to stiff Grey Wet												
	Thinly silt laminated		7	TO	PH								
			8	SS	WH								
			9A	SS	3								
185.7	SILT, some sand		9B										
9.4	Very loose to compact Grey Wet												
			10	SS	10								
			11	SS	6								
			12	SS	5								
180.8	END OF BOREHOLE												
14.3													

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT 09-1111-6014		RECORD OF BOREHOLE No D504-01				SHEET 2 OF 2		METRIC								
W.P. 5005-10-01		LOCATION N 5083431.2 ; E 222885.2				ORIGINATED BY ID										
DIST HWY 69		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers				COMPILED BY MCK/AV										
DATUM Geodetic		DATE July 24, 2013				CHECKED BY JPD										
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								
	--- CONTINUED FROM PREVIOUS PAGE ---						<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED </div>									
178.8						180										
16.3	END OF DCPT Refusal to Further Penetration (30 Blows / 0.0 m) NOTE: 1. Water level in open borehole at a depth of 6.9 m below ground surface (Elev. 188.2 m) upon completion of drilling.					179										

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		RECORD OF BOREHOLE		No D504-02		SHEET 1 OF 1		METRIC								
W.P. 09-1111-6014		LOCATION		N 5083471.8 ; E 222852.8		ORIGINATED BY		ID								
DIST		HWY 69		BOREHOLE TYPE		108 mm I.D. Hollow Stem Augers		COMPILED BY								
MCK/AV		DATE		July 24, 2013		CHECKED BY		JPD								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
195.8	GROUND SURFACE		1A													
0.0	TOPSOIL		1B	SS	6											
0.2	SILT and SAND, trace organics, containing wood fragments to a depth of 2.1 m Loose to compact Brown Wet		2	SS	25											
			3	SS	16											
			4	SS	8											
			5	SS	14											
192.1	SILTY CLAY to CLAY Firm to stiff Grey Wet		6	SS	4											
3.7			7	SS	WH											
189.7	Sandy SILT, trace clay Very loose to compact Grey Wet		8	SS	11											
6.1			9	SS	2											
			10	SS	2											
186.0	END OF BOREHOLE															
9.8																
185.1	END OF DCPT Refusal to Further Penetration (30 Blows / 0.0 m)															
10.7	NOTE: 1. Water level in open borehole at a depth of 8.1 m below ground surface (Elev. 187.7 m) upon completion of drilling.															

PROJECT		09-1111-6014		RECORD OF BOREHOLE No D504-03		SHEET 1 OF 2		METRIC									
W.P.		5005-10-01		LOCATION		N 5083510.7 ; E 222816.2		ORIGINATED BY ID									
DIST		HWY 69		BOREHOLE TYPE		108 mm I.D. Hollow Stem Augers		COMPILED BY MCK/AV									
DATUM		Geodetic		DATE		July 15 and 16, 2013		CHECKED BY JPD									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS		ELEVATION SCALE		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES												
195.5	GROUND SURFACE																
0.0	TOPSOIL		1A		6												
0.2	Silty SAND, containing rootlets and wood fragments		1B	SS													
194.7	Loose Brown																
194.4	Wet		2A	SS	10												
1.1	SILTY CLAY		2B														
	Stiff Grey Wet																
	Silty SAND		3	SS	14												
	Loose to compact Brown Wet																
			4	SS	10												
			5	SS	8												
191.7																	
191.4	SILTY CLAY		6A	SS	1												
4.1	Very soft Grey Wet		6B														
190.9	Sandy SILT																
4.6	Very loose Grey Wet		7	SS	WH												
	CLAYEY SILT																
	Soft to firm Grey Wet																
			8	SS	WH												
187.9																	
7.6	SILT, trace clay, trace sand		9	SS	9												
	Loose Grey Wet																
			10	SS	9												
185.3																	
10.2	SILT and SAND, trace clay																
	Very loose to compact Grey Wet		11	SS	WH												
			12	SS	3												
181.3																	
14.2	END OF BOREHOLE		13	SS	25												

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT 09-1111-6014		RECORD OF BOREHOLE No D504-03				SHEET 2 OF 2		METRIC								
W.P. 5005-10-01		LOCATION N 5083510.7 ; E 222816.2				ORIGINATED BY ID										
DIST HWY 69		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers				COMPILED BY MCK/AV										
DATUM Geodetic		DATE July 15 and 16, 2013				CHECKED BY JPD										
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								
	<div style="text-align: center;">--- CONTINUED FROM PREVIOUS PAGE ---</div> SPLIT-SPOON AND AUGER REFUSAL NOTE: 1. Water level in open borehole at a depth of 4.0 m below ground surface (Elev. 191.5 m) upon completion of drilling.															

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT		RECORD OF BOREHOLE		No D504-04		SHEET 1 OF 2		METRIC						
W.P. 5005-10-01		LOCATION		N 5083524.0 ; E 222848.0		ORIGINATED BY		ID						
DIST		HWY 69		BOREHOLE TYPE		108 mm I.D. Hollow Stem Augers		COMPILED BY						
DATUM		Geodetic		DATE		July 18, 2013		CHECKED BY						
								JPD						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
194.8	GROUND SURFACE													
0.0	TOPSOIL		1A		10									
0.2	SILT, containing rootlets		1B	SS										
194.0	Compact Brown Moist													
0.8	Silty SAND, trace to some clay, containing silty clay lenses		2	SS	6									
	Loose Brown Wet		3	SS	8									
			4	SS	5									
			5	SS	6									
191.0	SILTY CLAY		6	SS	WH									
3.8	Soft to firm Grey Wet		7	SS	WH									
	containing silty sand seams between depths of 4.3 m and 4.4 m.		8	TO	PH									
			9A											
187.0	Sandy SILT		9B	SS	7									
7.8	Very loose to loose Grey Wet													
			10	SS	3									
			11	SS	1									
			12	SS	4									
181.2	END OF BOREHOLE													
13.6														

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16



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


GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT 09-1111-6014			RECORD OF BOREHOLE No D504-05			SHEET 1 OF 2			METRIC			
W.P. 5005-10-01			LOCATION N 5083564.1 ; E 222814.2			ORIGINATED BY ID						
DIST HWY 69			BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers			COMPILED BY MCK/AV						
DATUM Geodetic			DATE July 18, 2013			CHECKED BY JPD						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa					
194.1	GROUND SURFACE		1A				<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 </div>					
0.0	TOPSOIL		1B	SS	4		<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 </div>					
0.2	Sandy CLAYEY SILT											
193.4	Mottled brown and grey											
0.7	Soft											
	Wet											
	SAND, trace silt, trace gravel		2	SS	11							
	Loose to compact											
	Brown becoming grey below a depth of 1.5 m											
	Wet		3	SS	7							
			4	SS	6							
191.1	CLAYEY SILT, trace to some sand											
3.0	Soft to firm		5	SS	WH							
	Grey											
	Wet											
			6	SS	WH							
			7	SS	WH							
			8	SS	11							
			9	SS	WH							
			10	SS	3							
			11	SS	3							
			12	SS	3							
179.5												
14.6												

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT 09-1111-6014				RECORD OF BOREHOLE No D504-05				SHEET 2 OF 2				METRIC					
W.P. 5005-10-01				LOCATION N 5083564.1 ; E 222814.2				ORIGINATED BY ID									
DIST HWY 69				BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers				COMPILED BY MCK/AV									
DATUM Geodetic				DATE July 18, 2013				CHECKED BY JPD									
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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
	--- CONTINUED FROM PREVIOUS PAGE ---						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W _p W W _L 20 40 60					
178.3	SILT and SAND, trace clay Loose Grey Wet		13	SS	4		179										0 60 38 2
15.8	END OF BOREHOLE						178										
							177										
							176										
							175										
							174										
173.4	END OF DCPT Refusal to Further Penetration (100 Blows / 0.0 m)																
20.7	NOTE: 1. Water level in open borehole at a depth of 1.8 m below ground surface (Elev. 192.3 m) upon completion of drilling.																

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 07/25/16

PROJECT 09-1111-6014		RECORD OF BOREHOLE No D504-06		SHEET 1 OF 1		METRIC														
W.P. 5005-10-01		LOCATION N 5083599.6 ; E 222779.0		ORIGINATED BY ID																
DIST HWY 69		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers		COMPILED BY MCK/AV																
DATUM Geodetic		DATE July 22, 2013		CHECKED BY JPD																
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ	GR SA SI CL			
							20 40 60 80 100	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W _p — W — W _L 20 40 60					OC=4.5%		
195.8	GROUND SURFACE		1A		7		195													
0.0	TOPSOIL		1B	SS																
0.3	SILT and SAND, trace clay, trace organics to a depth of 1.4 m Loose to compact Brown Wet		2	SS	21		194										0 60 36 4			
			3	SS	11		193													
			4	SS	8		192													
			5	SS	5		191													
192.0	SILTY CLAY to CLAY Soft to firm Grey Wet		6	SS	WH		190													
3.8			7	SS	WH		189													
							188													
189.7	Sandy SILT Loose Grey Wet		8	SS	5		187													
6.1							186													
188.7	CLAYEY SILT Soft Grey Wet		9	SS	WH		185													
7.1							184													
186.7	Sandy SILT Very loose to compact Grey Wet		10	SS	10		183													
9.1																				
			11	SS	8															
183.0			12	SS	1															
12.8	END OF BOREHOLE																			
	NOTE: 1. Water level in open borehole at a depth of 1.5 m below ground surface (Elev. 194.3 m) upon completion of drilling.																			

PROJECT		RECORD OF BOREHOLE		No D504-07		SHEET 1 OF 1		METRIC						
W.P. 5005-10-01		LOCATION		N 5083612.7 ; E 222810.4		ORIGINATED BY		ID						
DIST		HWY 69		BOREHOLE TYPE		108 mm I.D. Hollow Stem Augers		COMPILED BY						
DATUM		Geodetic		DATE		July 23, 2013		CHECKED BY						
								JPD						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
194.4	GROUND SURFACE		1A											
0.0	TOPSOIL		1B	SS	6									
0.2	Sandy SILT Loose to compact Grey Wet		2	SS	16									
			3	SS	6									
			4	SS	9									
191.4			5	SS	WH									
3.0	SILTY CLAY Soft to firm Grey Wet		6	SS	WH									
			7	TO	PH									
	Sandy silt seams between depths of 6.1 m and 6.7 m		8	SS	1									
187.1			9	SS	WH									
7.3	SILT and SAND Very loose to compact Grey Wet		10	SS	23/0.15									
183.4														
11.0	END OF BOREHOLE SPLIT-SPOON AND AUGER REFUSAL													
	NOTES: 1. Water level in piezometer at a depth of 0.5 m below ground surface (Elev. 193.9 m) on July 25, 2013. 2. Piezometer decommissioned on July 25, 2013.													

GTA-MTO 001 T:\PROJECTS\200909-1111-6014 (URS, HWY 69, HENVEY)\LOG09-1111-6014.GPJ GAL-GTA-GDT 07/25/16



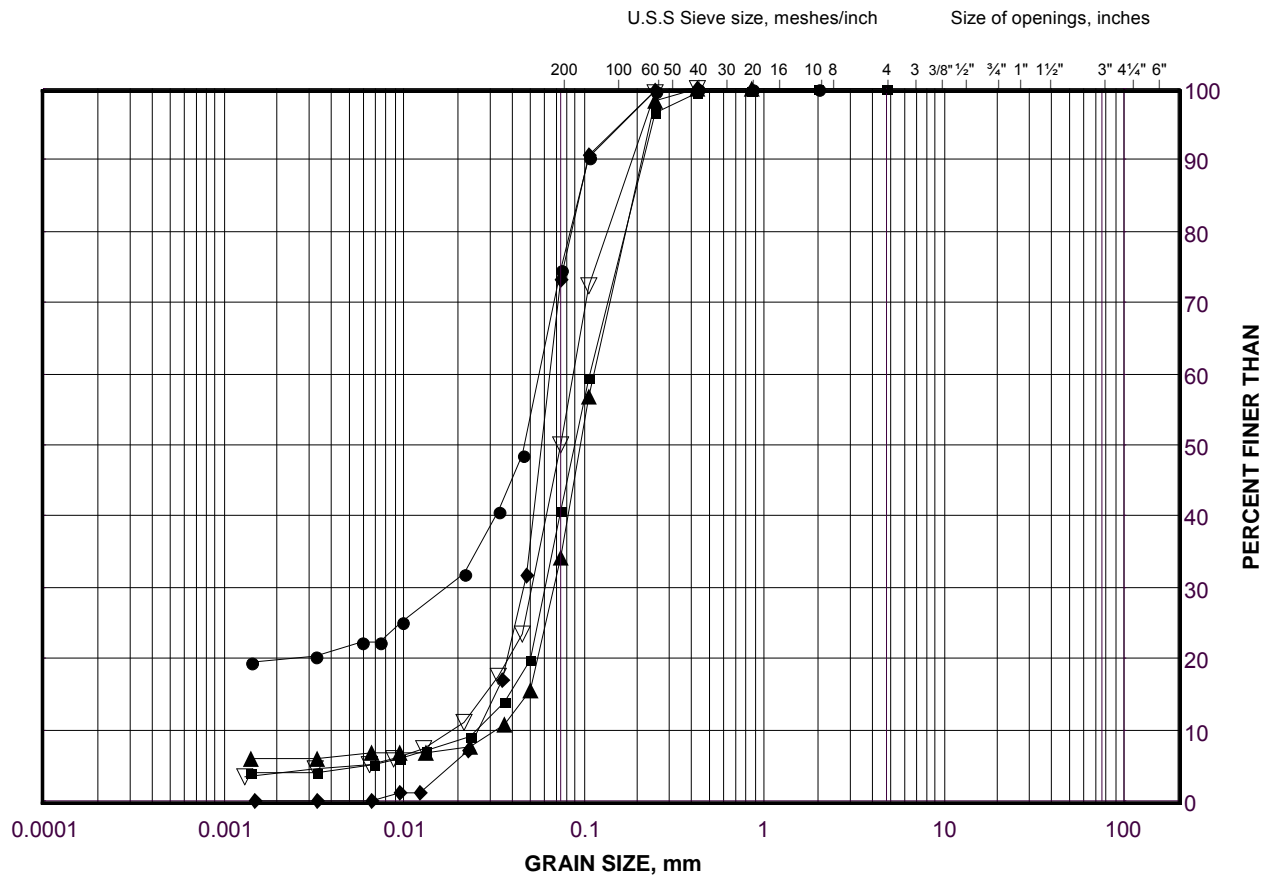
+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT 09-1111-6014		RECORD OF BOREHOLE No D504-09		SHEET 1 OF 1		METRIC					
W.P. 5005-10-01		LOCATION N 5083691.9; E 222740.6		ORIGINATED BY ID							
DIST HWY 69		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers		COMPILED BY MCK/AV							
DATUM Geodetic		DATE July 23, 2013		CHECKED BY JPD							
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID UNIT REMARKS		
ELEV	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W _p W W _L	γ	GRAIN SIZE DISTRIBUTION (%)
194.0	GROUND SURFACE										
193.7	TOPSOIL		1A	SS	2						
0.3	SAND, trace organics Very loose to compact Brown Moist to wet		1B								
			2	SS	22		193				
			3	SS	15		192				
191.7	SILTY CLAY Stiff Grey Wet		4	SS	7		191				
2.3			5	SS	1		190				
189.4	SILT Loose Grey Wet		6	SS	5		189				
188.4	Sandy SILT, trace silt Very loose Grey Wet		7	SS	WH		188				
5.6			8	SS	2		187				
			9	SS	3		186				
184.2	END OF BOREHOLE						185				
9.8	NOTES: 1. Water level in open borehole at a depth of 8.2 m below ground surface (Elev. 185.8 m) upon completion of drilling. 2. An additional borehole was advanced 1.2 m South of Borehole D504-09 to carry out field in situ vane tests between depths of 2.6 m and 2.9 m below ground surface (Elev. 191.4 m and 191.1 m).										

GRAIN SIZE DISTRIBUTION

Sandy Silt to Silty Sand to Silt and Sand
Highway 69 (NBL) STA 21+300 to STA 10+140

FIGURE D.D504-01



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

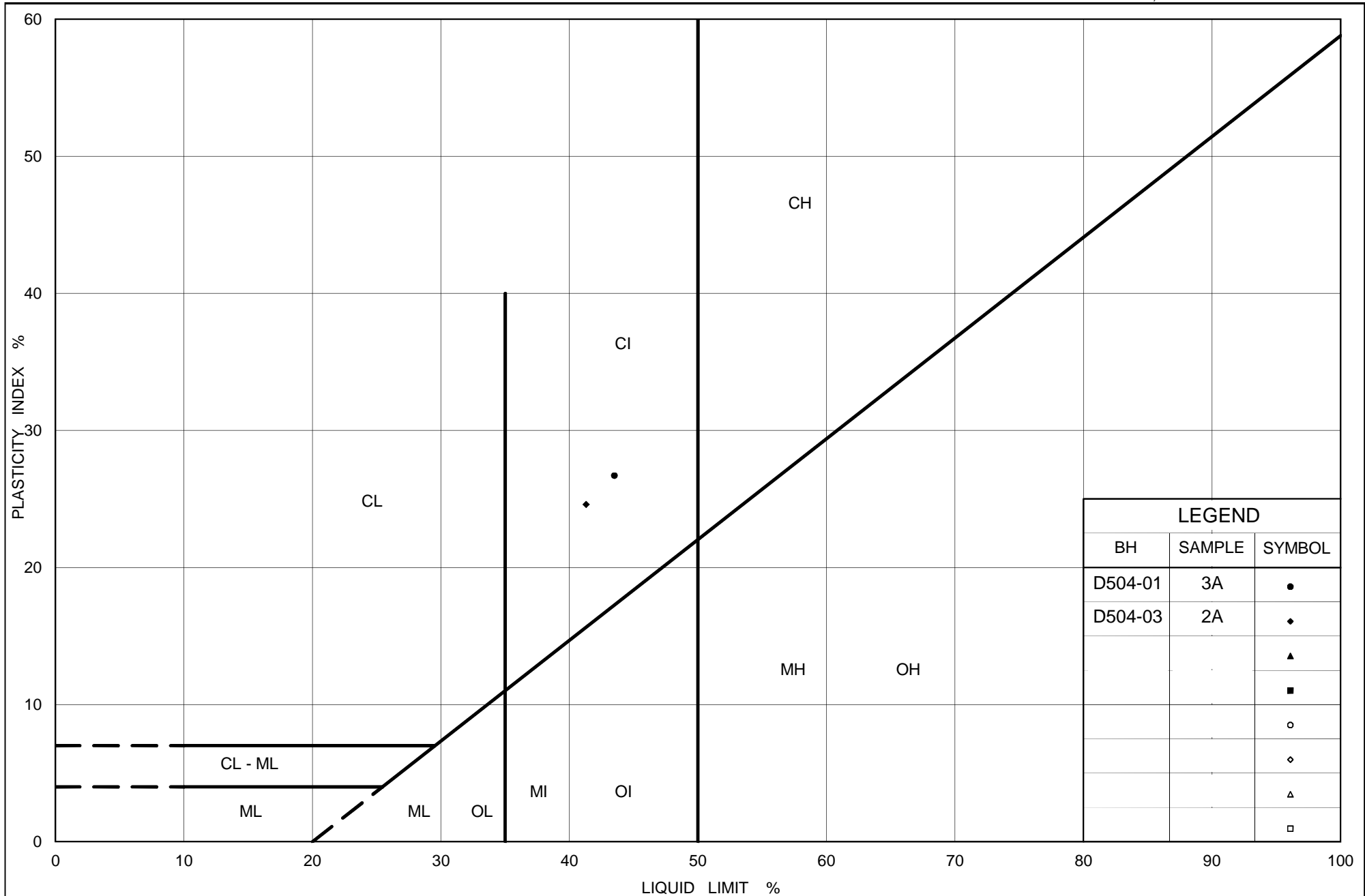
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	D504-08	2	193.0
■	D504-06	3	194.0
◆	D504-07	4	191.8
▲	D504-04	4	192.2
▽	D504-01	5	191.7

Project Number: 09-1111-6014

Checked By: AV

Golder Associates

Date: 08-Nov-13



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PLASTICITY CHART
 Silty Clay (Pockets)
 Highway 69 (NBL) STA 21+300 to 10+140

Figure No. D.D504-02

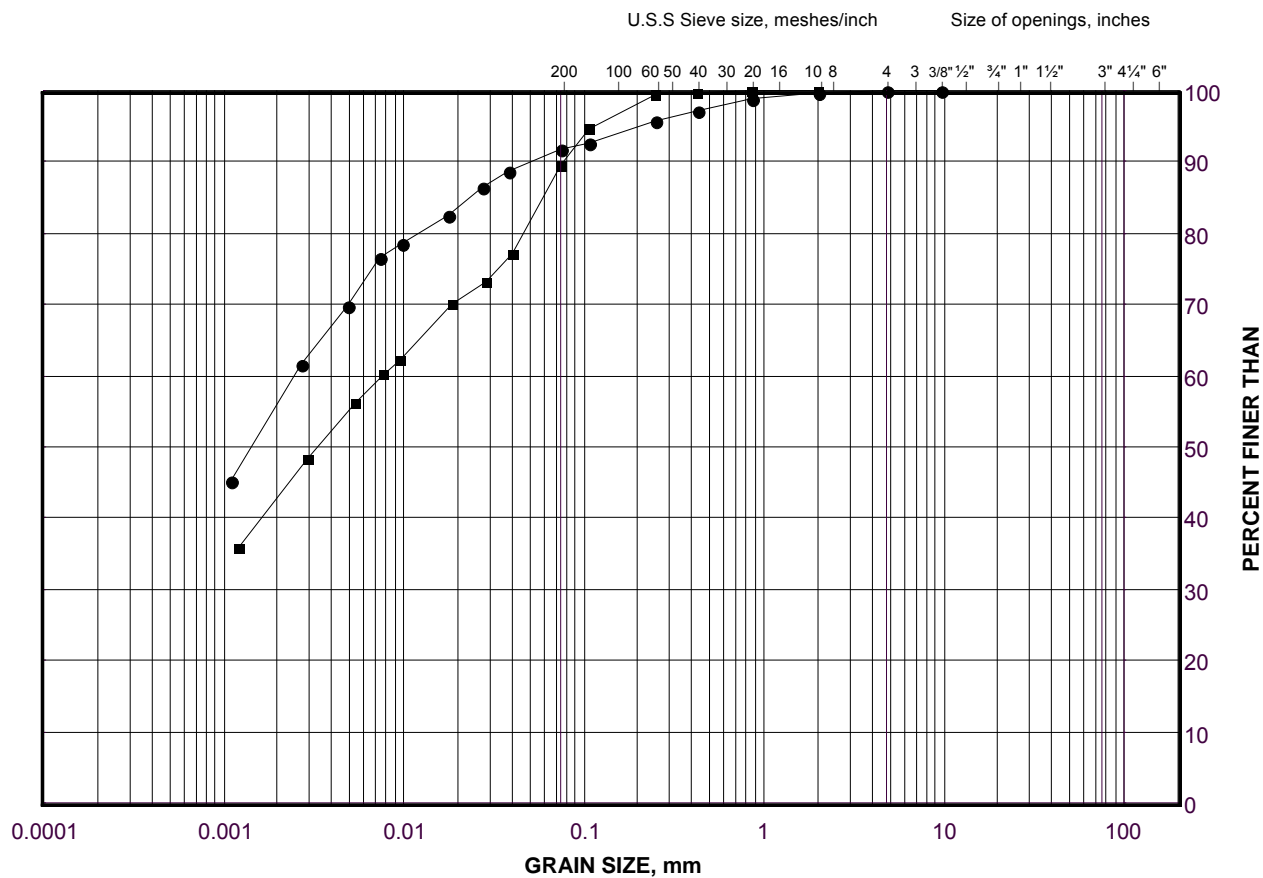
Project No. 09-1111-6014

Checked By: AV

GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay
Highway 69 (NBL) STA 21+300 to STA 10+140

FIGURE D.D504-03



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

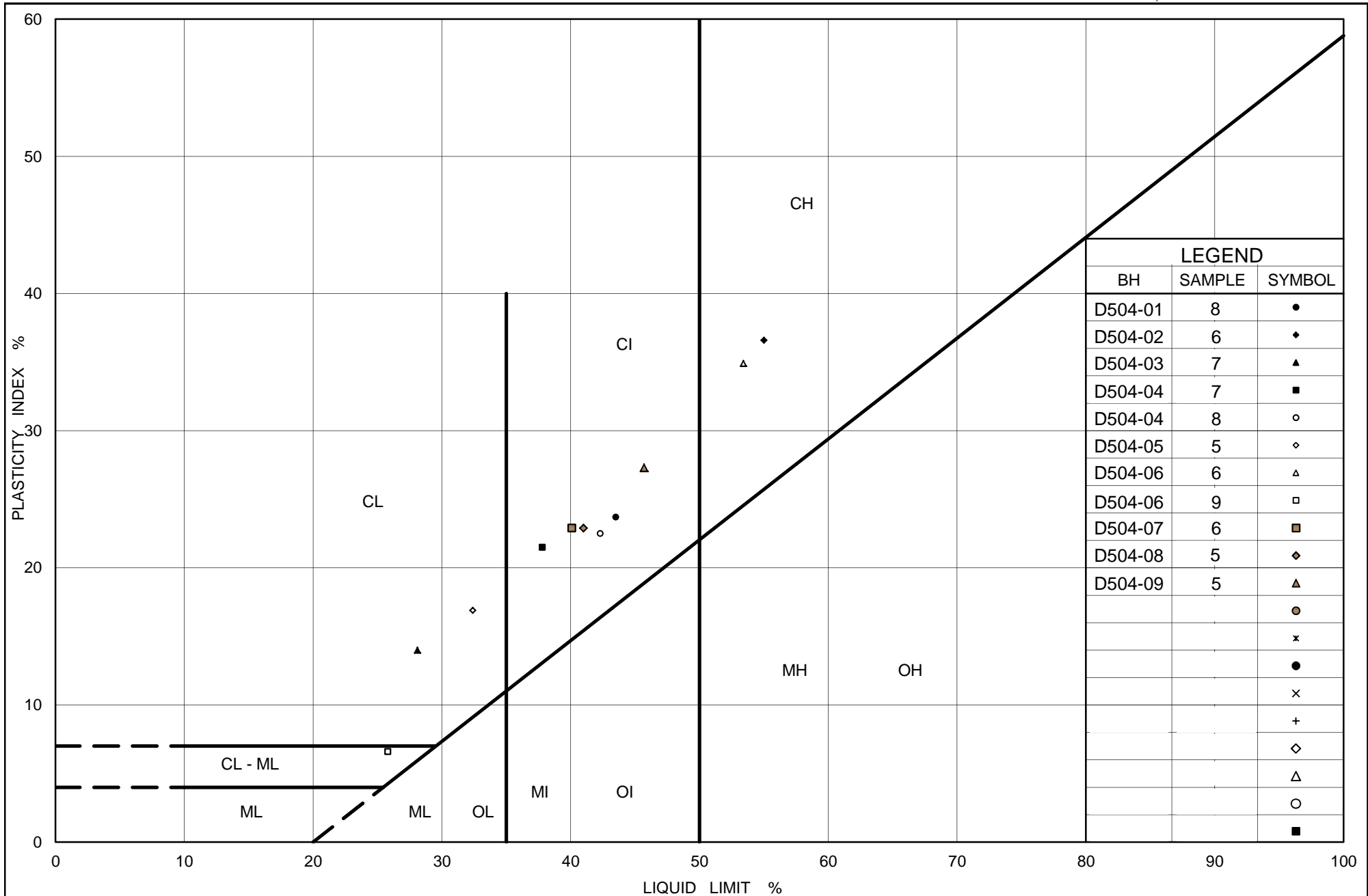
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	D504-09	5	190.6
■	D504-05	5	190.7

Project Number: 09-1111-6014

Checked By: AV

Golder Associates

Date: 08-Nov-13



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PLASTICITY CHART
Clayey Silt to Clay
Highway 69 (NBL) STA 21+300 to STA 10+140

Figure No. D.D504-04

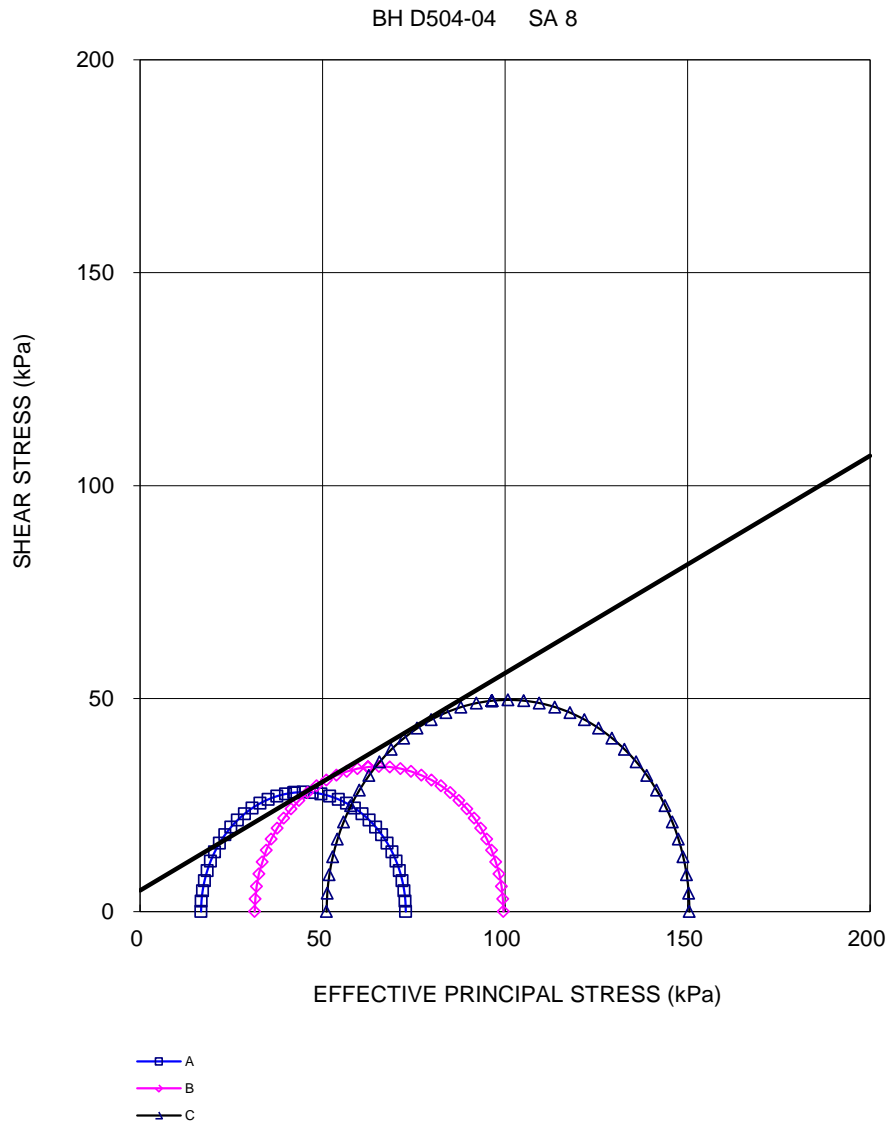
Project No. 09-1111-6014

Checked By: AV

CONSOLIDATED UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENTS SHEET 1 OF 4			FIGURE D.D504-05
TEST STAGE	A	B	C
BOREHOLE NUMBER	D504-04	D504-04	D504-04
SAMPLE	8	8	8
DEPTH, m	-	-	-
SPECIMEN DIAMETER, cm	5.01	5.02	5.04
SPECIMEN HEIGHT, cm	10.07	10.03	10.07
NATURAL WATER CONTENT, %	59.4	57.9	61.1
DRY DENSITY, Mg/m ³	1.06	1.07	1.03
WATER CONTENT AFTER SATURATION, %	60.7	61.2	61.8
CELL PRESSURE, σ_3 , kPa	230.0	350.0	425.0
BACK PRESSURE, kPa	205.0	275.0	275.0
PORE PRESSURE PARAMETER "B"	0.98	0.96	0.99
CONSOLIDATION PRESSURE, σ_c , kPa	25.0	75.0	150.0
VOLUMETRIC STRAIN DURING CONSOLIDATION, %	1.1	8.1	15.7
WATER CONTENT AFTER CONSOLIDATION, %	59.7	53.7	46.6
AVERAGE RATE OF STRAIN, %/hr	0.5	0.5	0.5
TIME TO FAILURE, HOURS	8.4	8.6	9.2
WATER CONTENT AFTER TEST, %	56.9	49.4	47.3
MAX. DEVIATOR STRESS, $(\sigma_1 - \sigma_3)$, kPa	56.1	67.9	99.3
AXIAL STRAIN AT $(\sigma_1 - \sigma_3)$ maximum, %	4.2	4.3	4.6
MAX EFFECTIVE PRINCIPAL STRESS RATIO, (σ'_1 / σ'_3) maximum	4.4	3.6	3.1
DEVIATOR STRESS AT (σ'_1 / σ'_3) maximum, kPa	52.7	57.3	98.9
AXIAL STRAIN AT (σ'_1 / σ'_3) maximum, %	2.3	12.5	5.5
PORE PRESSURE PARAMETER, Af, AT $(\sigma_1 - \sigma_3)$ maximum	0.15	0.65	1.00
PORE PRESSURE PARAMETER, Af, AT (σ'_1 / σ'_3) maximum	0.18	0.92	1.04
FILTER DRAINS USED, y/n	y	y	y
TEST NOTES:			
FAILURE PLANE NUMBER	1.0	-	-
ANGLE OF FAILURE, DEGREES	50.0	Bulged	Bulged
<div> <div>Date: 09/23/2013</div> <div>Project No. 09-1111-6014</div> </div> <div> Golder Associates </div> <div> <div>Prepared By: LH</div> <div>Checked By: AV</div> </div>			

CONSOLIDATED UNDRAINED TRIAXIAL
WITH PORE PRESSURE MEASUREMENTS
SHEET 2 OF 4

FIGURE D.D504-05



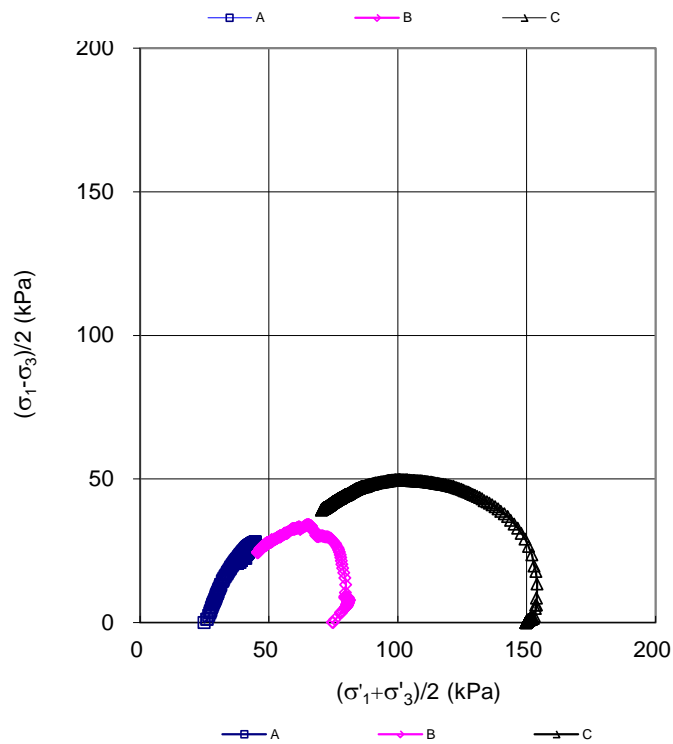
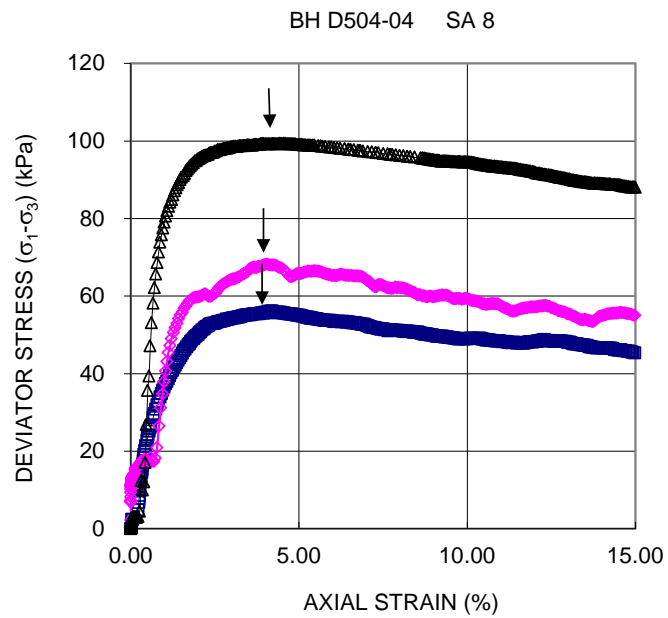
Date: 09/23/2013
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Checked By: AV

**CONSOLIDATED UNDRAINED TRIAXIAL
WITH PORE PRESSURE MEASUREMENTS
SHEET 3 OF 4**

FIGURE D.D504-05



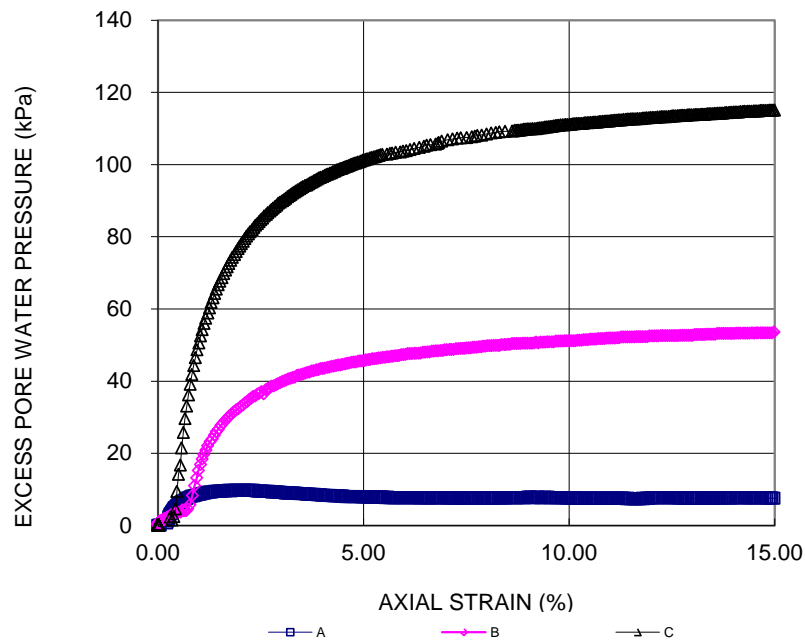
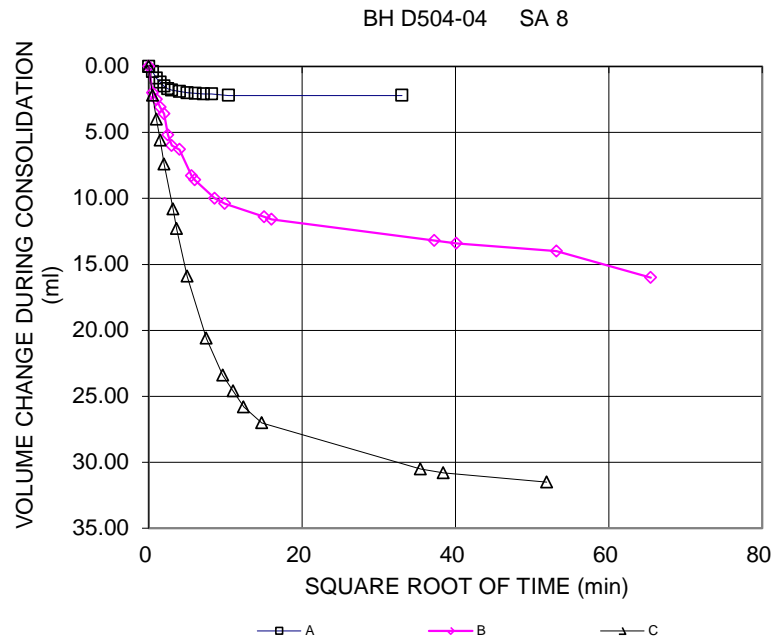
Date: 09/23/2013
Project No. 09-1111-6014

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**CONSOLIDATED UNDRAINED TRIAXIAL
WITH PORE PRESSURE MEASUREMENTS
SHEET 4 OF 4**

FIGURE D.D504-05



Date: 09/23/2013
Project No. 09-1111-6014

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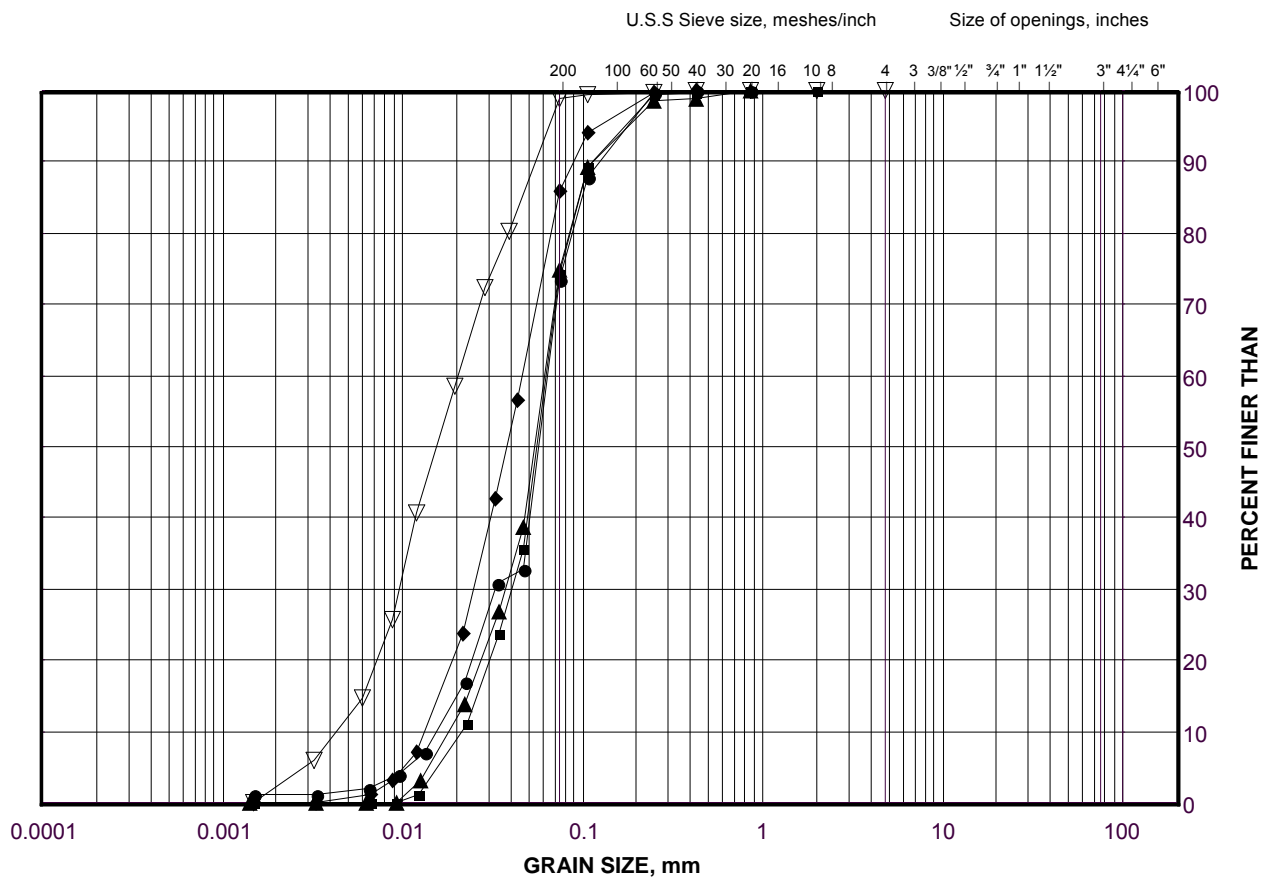
Prepared By: LH
Checked By: AV

GRAIN SIZE DISTRIBUTION

Silt to Sandy Silt

Highway 69 (NBL) STA 21+300 to STA 10+140

FIGURE D.D504-06A



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	D504-02	10	186.4
■	D504-04	11	183.8
◆	D504-01	11	182.6
▲	D504-05	9	184.7
▽	D504-03	9	187.6

Project Number: 09-1111-6014

Checked By: AV

Golder Associates

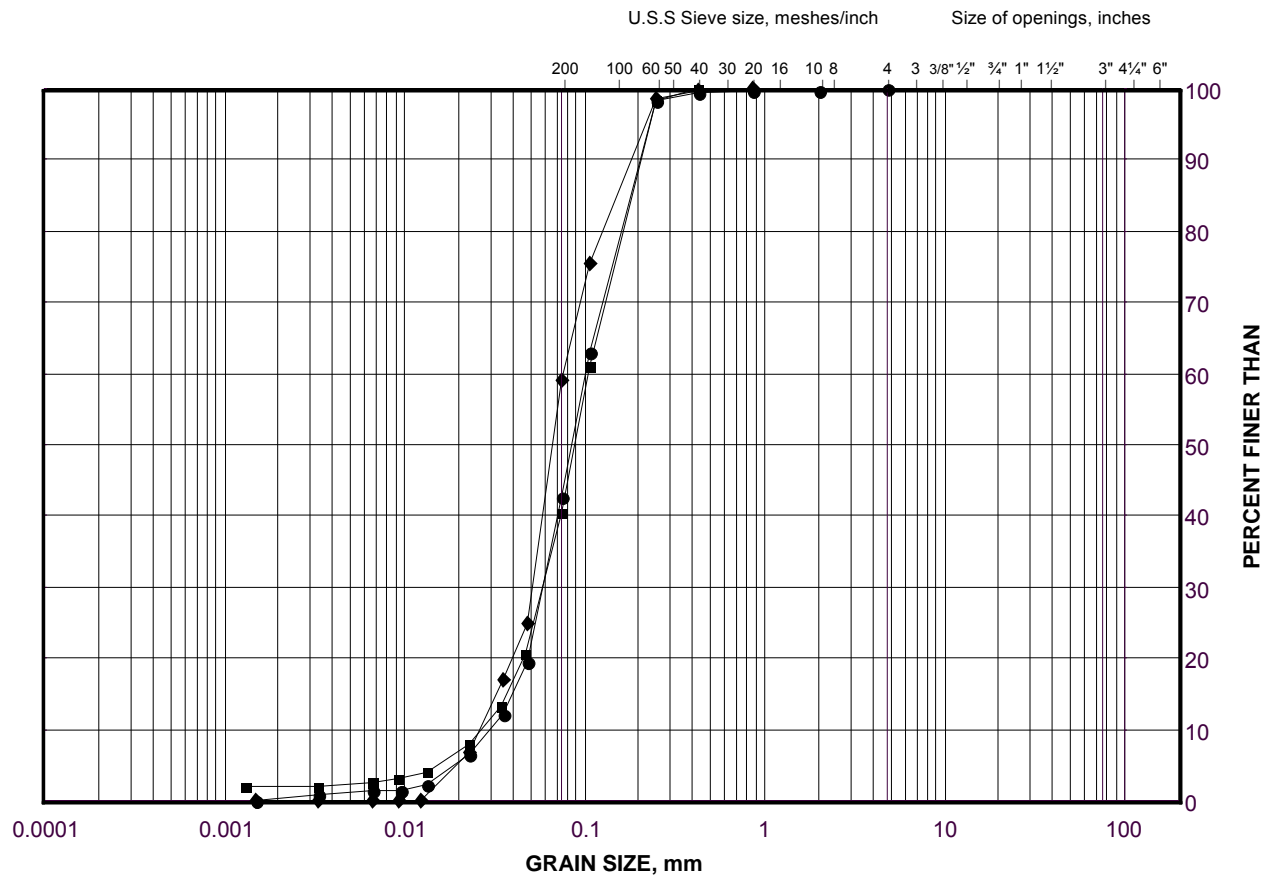
Date: 05-Dec-13

GRAIN SIZE DISTRIBUTION

Silt and Sand

Highway 69 (NBL) STA 21+300 to STA 10+140

FIGURE D.D504-06B



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

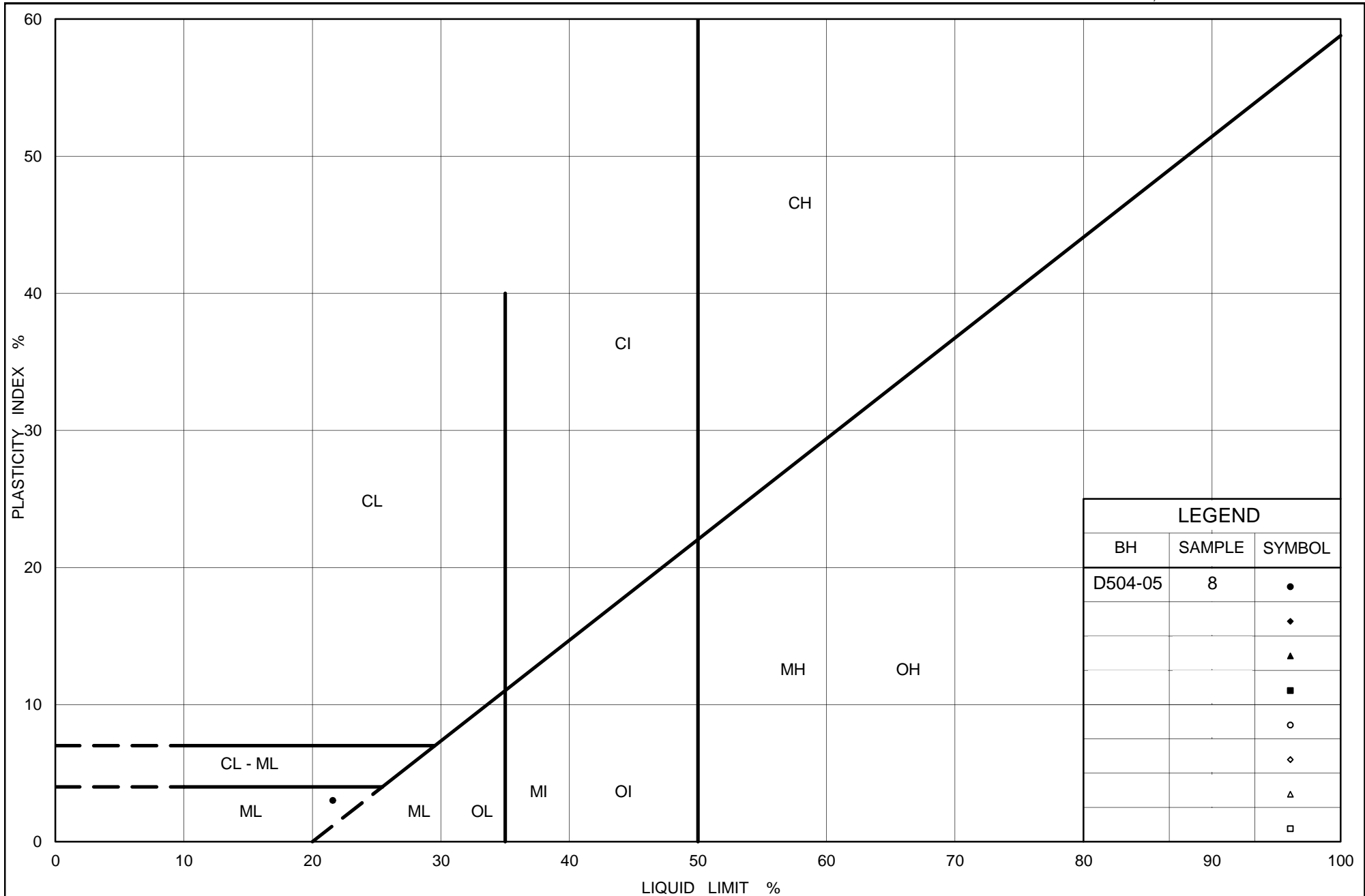
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	D504-03	11	184.5
■	D504-05	13	178.6
◆	D504-07	9	185.0

Project Number: 09-1111-6014

Checked By: AV

Golder Associates

Date: 05-Dec-13



Ministry of Transportation

Ontario

PLASTICITY CHART
Sandy Silt
Highway 69 NBL STA 21+300 to STA 10+140

Figure No. D.D504-07

Project No. 09-1111-6014

Checked By: AV



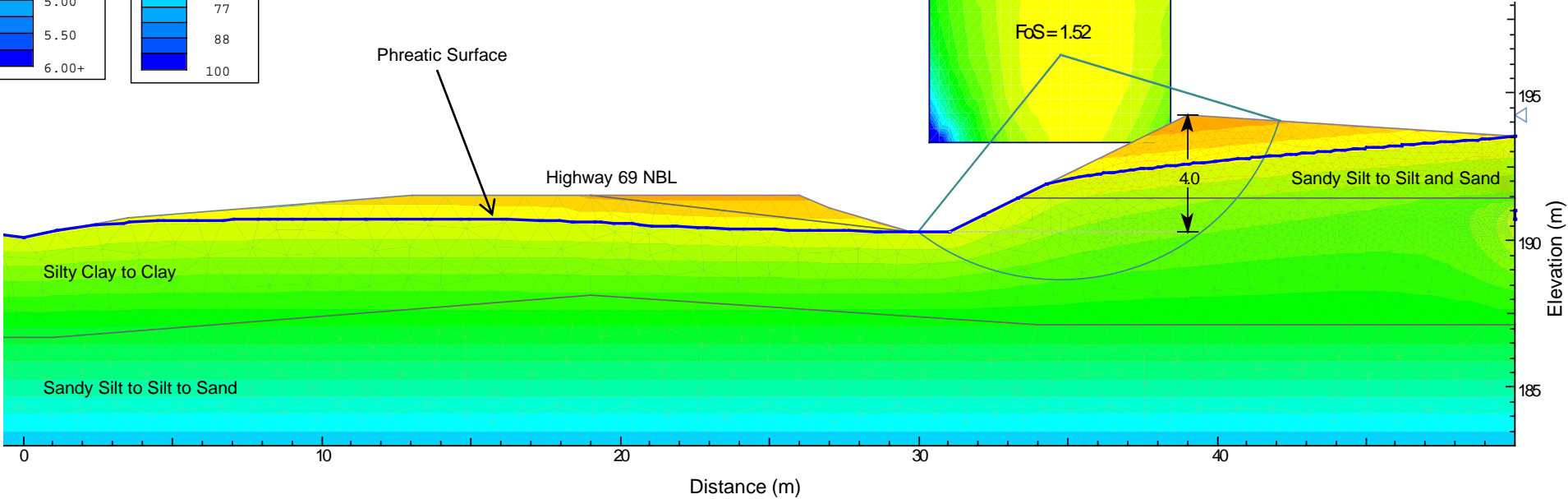
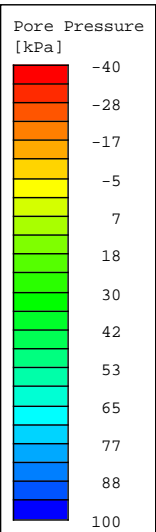
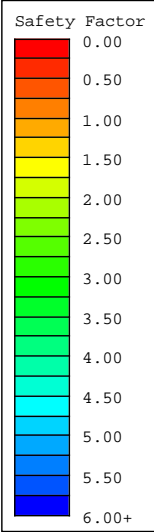
Highway 69 NBL – STA 21+300 to 10+140 (Deep Cut 504) Slope Stability (2H:1V Earth Cut Slope) Total Stress Analysis

Figure D1

NOTE:

- 1. All dimensions are in metres.

Material Name	Unit Weight (kN/m³)	Cohesion (kPa)	Friction Angle (degrees)
Sandy Silt to Silt and Sand	19	0	33
Silty Clay to Clay	17	20	-
Sandy Silt to Silt and Sand	19	0	33



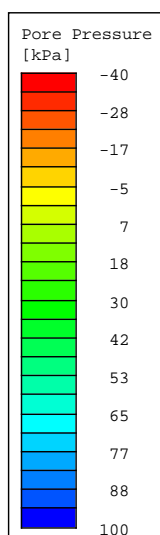
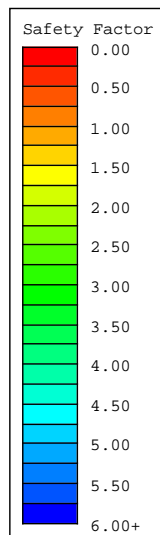


Highway 69 NBL – STA 21+300 to 10+140 (Deep Cut 504) Slope Stability (2H:1V Earth Cut Slope) Effective Stress Analysis

Figure D2

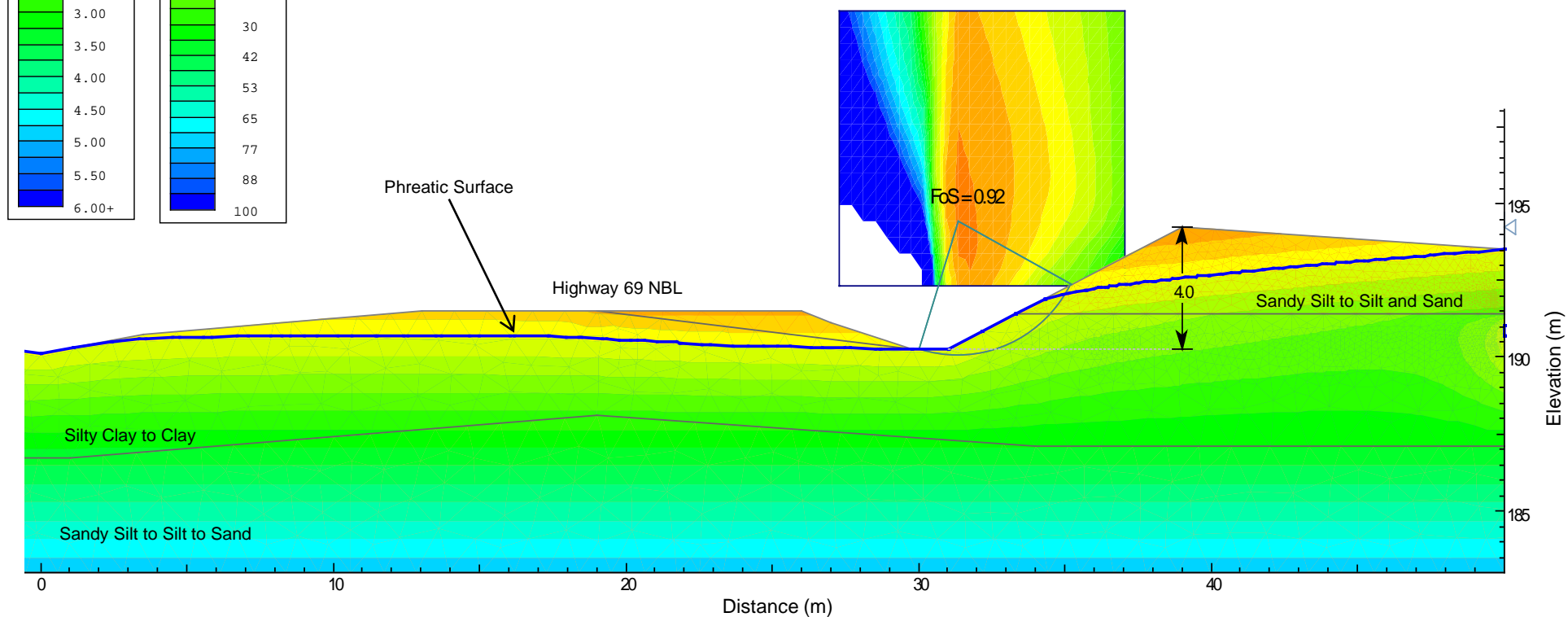
NOTE:

1. All dimensions are in metres.



Material Name	Unit Weight (kN/m³)	Cohesion (kPa)	Friction Angle (degrees)
Sandy Silt to Silt and Sand	19	0	33
Silty Clay to Clay	17	*	
Sandy Silt to Silt and Sand	19	0	33

* Refer to Table 3 for the fully defined shear-normal strength function.





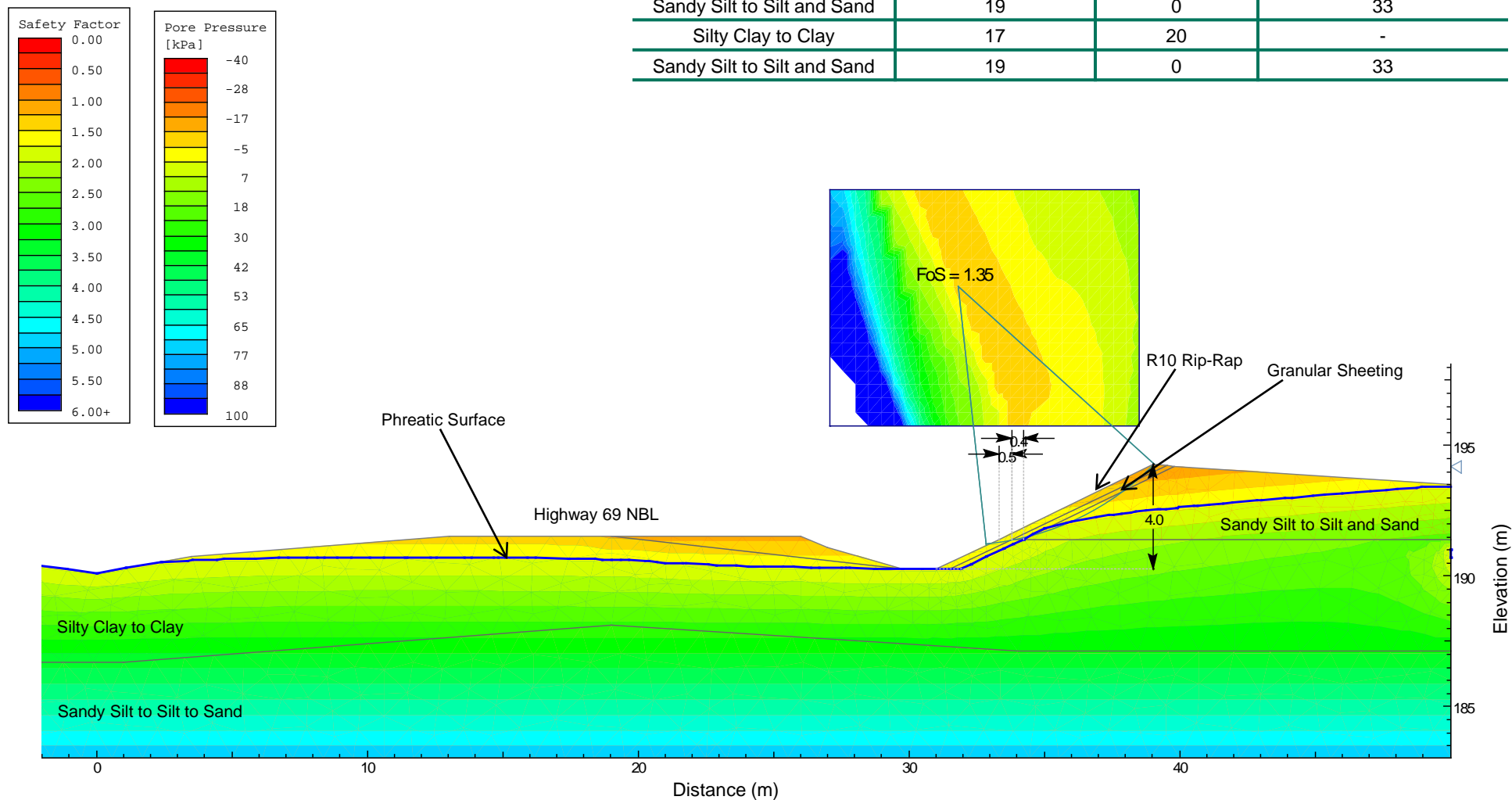
Highway 69 NBL – STA 21+300 to 10+140 (Deep Cut 504) Slope Stability (2H:1V Earth Cut Slope and 0.4 m Thick Granular Sheeting Covered by 0.5 m Thick Rip-Rap) Total Stress Analysis

Figure D3

NOTE:

1. All dimensions are in metres.

Material Name	Unit Weight (kN/m ³)	Cohesion (kPa)	Friction Angle (degrees)
Rock Fill	19	0	40
Sandy Silt to Silt and Sand	19	0	33
Silty Clay to Clay	17	20	-
Sandy Silt to Silt and Sand	19	0	33



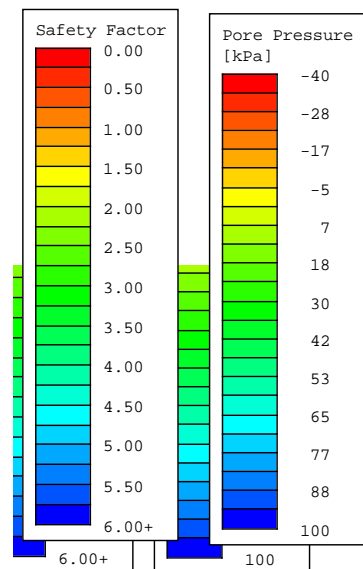


Highway 69 NBL – STA 21+300 to 10+140 (Deep Cut 504) Slope Stability (2H:1V Earth Cut Slope and 0.4 m Thick Granular Sheeting Covered by 0.5 m Thick Rip-Rap) Effective Stress Analysis

Figure D4

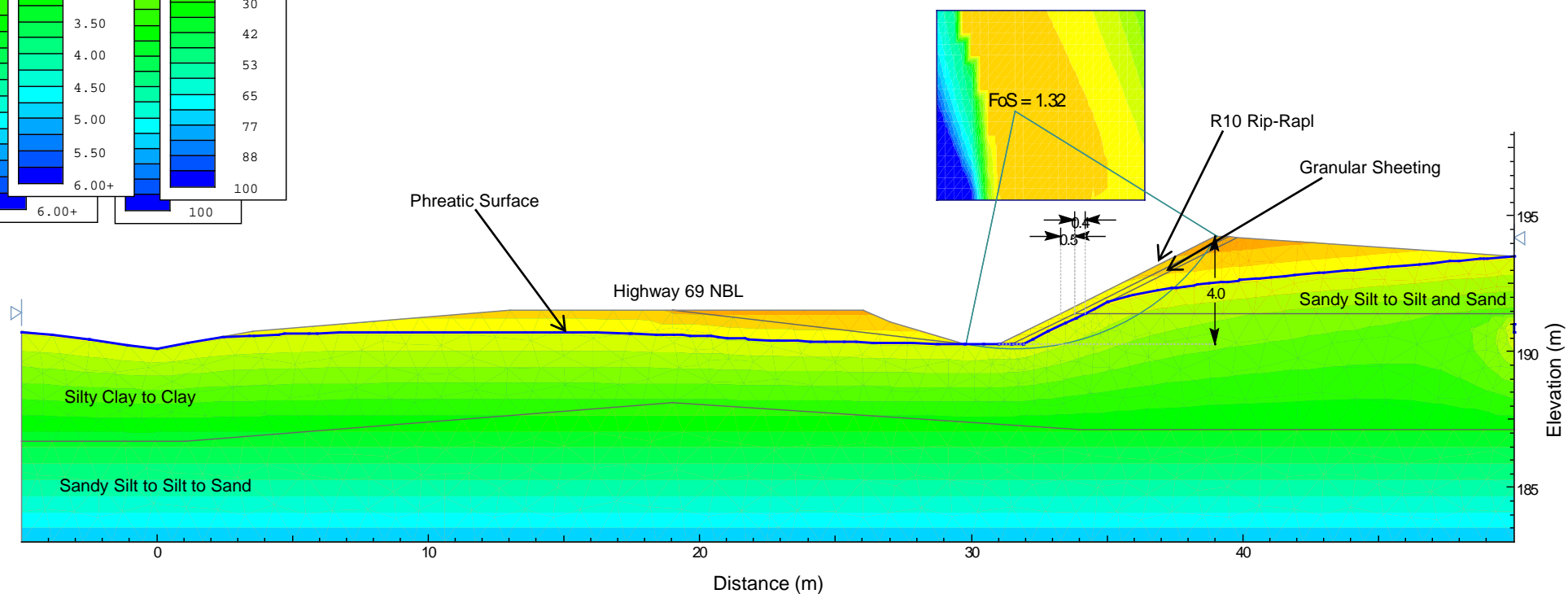
NOTE:

1. All dimensions are in metres.



Material Name	Unit Weight (kN/m ³)	Cohesion (kPa)	Friction Angle (degrees)
Rock Fill	19	0	40
Granular Sheeting	21	0	34
Sandy Silt to Silt and Sand	19	0	33
Silty Clay to Clay	17	*	
Sandy Silt to Silt and Sand	19	0	33

* Refer to Table 3 for the fully defined shear-normal strength function.





APPENDIX E

Non-Standard Special Provisions

OPERATIONAL CONSTRAINT – Dewatering at Deep Cuts.

Special Provision

Deep Cut Area – The deep cut area (between STA 21+300 (Henvey) to STA 10+140 (Mowat)) was measured to be at about 0.5 m below ground surface as measured in the piezometer installed in selected boreholes in this area. It is estimated that the Highway 69 subgrade profile will be constructed by excavation to depths of up to about 3.5 m below the groundwater level. The excavation to form the cut slopes will be made through deposits of silt to sand and clayey silt to clay containing silty / sandy seams and pockets. Dewatering ahead of the deep cut excavation at this location will be required and the excavation shall be kept stable during the work.

END OF SECTION

[https://capws.golder.com/sites/0911116014highway69fourlaning/contract 5/reporting/swamp and high fills/draft/appendix e/09-1111-6014-5520 sp dewatering at deep cut area.docx](https://capws.golder.com/sites/0911116014highway69fourlaning/contract%205/reporting/swamp%20and%20high%20fills/draft/appendix%20e/09-1111-6014-5520%20sp%20dewatering%20at%20deep%20cut%20area.docx)

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