



JULY 2012

FOUNDATION INVESTIGATION AND DESIGN REPORT

**SWAMP CROSSINGS AND HIGH FILL AREAS – CONTRACT 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 5404-05-00; WP 5404-05-01**

Submitted to:
URS Canada Inc.
75 Commerce Valley Drive East
Markham, Ontario
L3T 7N9



REPORT



GEOCREs NO.: 41H-115
Report Number: 09-1111-6014-2520
Distribution:

- 5 Copies Ministry of Transportation, Ontario, North Bay, Ontario (Northeastern Region)
- 1 Copy Ministry of Transportation, Ontario, Downsview, Ontario (Foundation Section)
- 1 Copy URS Canada Inc., Markham, Ontario
- 2 Copies Golder Associates Ltd., Mississauga, Ontario



Table of Contents

PART A – FOUNDATION INVESTIGATION REPORT

1.0 INTRODUCTION.....	1
2.0 SITE DESCRIPTION.....	1
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	4
4.3 Highway 69 SBL – STA 17+750 to 17+775 (Swamp 201).....	5
4.4 Highway 69 NBL – STA 17+700 to 17+750 (Swamp 201).....	7
4.5 Highway 69 SBL – STA 11+175 to 11+275 (Swamp 202).....	9
4.6 Highway 69 NBL – STA 11+100 to 11+225 (Swamp 202).....	13
4.7 Highway 69 SBL – STA 11+350 to 11+375 (Swamp 203).....	17
4.8 Highway 69 NBL – STA 11+375 to 11+400 (Swamp 203).....	18
4.9 Highway 69 SBL – STA 11+725 to 11+825 (Swamp 204).....	19
4.10 Highway 69 NBL – STA 11+700 to 11+800 (Swamp 204).....	25
4.11 Highway 69 SBL – STA 12+200 to 12+375 (Swamp 205).....	31
4.12 Highway 69 NBL – STA 12+750 to 12+825 (Swamp 206).....	35
5.0 CLOSURE	37

PART B – FOUNDATION DESIGN REPORT

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS.....	38
6.1 General.....	38
6.2 High Fill Embankments and Embankments Over Swamps.....	38
6.2.1 Embankment Fill Types and Berm Requirements.....	39
6.2.2 Stability	40
6.2.2.1 Methodology	40
6.2.2.2 Parameter Selection	40
6.2.3 Settlement.....	41
6.2.3.1 Methodology	41



FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS - HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

6.2.3.2	Parameter Selection	42
6.2.3.3	Settlement of Embankment Fill	43
6.3	Settlement Performance Requirements	44
6.4	Stability and Settlement Mitigation Options	45
6.4.1	Full Sub-Excavation	45
6.4.2	Preloading (with Partial Sub-Excavation, Stability Berms and/or Staged Construction).....	47
6.4.3	Surcharging (with Stability Berms and/or Staged Construction).....	48
6.4.4	Wick Drains.....	49
6.4.5	Lightweight Fill	50
6.4.6	Instrumentation and Monitoring.....	51
6.5	Results of Analysis	51
6.5.1	Highway 69 SBL – STA 17+750 to 17+775 and Highway 69 NBL – STA 17+700 to 17+750 (Swamp 201).....	52
6.5.1.1	Stability	52
6.5.1.2	Settlement	52
6.5.2	Highway 69 SBL – STA 11+175 to 11+275 and Highway 69 NBL – STA 11+100 to 11+225 (Swamp 202).....	53
6.5.2.1	Stability	54
6.5.2.2	Settlement	54
6.5.2.3	Mitigation of Stability Issues and/or Time Dependent Settlements	55
6.5.3	Highway 69 SBL – STA 11+350 to 11+375 and Highway 69 NBL – STA 11+375 to 11+400 (Swamp 203).....	58
6.5.4	Highway 69 SBL – STA 11+725 to 11+825 and Highway 69 NBL – STA 11+700 to 11+800 (Swamp 204).....	59
6.5.4.1	Stability	59
6.5.4.2	Settlement	60
6.5.4.3	Mitigation of Stability Issues and/or Time Dependent Settlements	61
6.5.5	Highway 69 SBL – STA 12+200 to 12+375 (Swamp 205)	65
6.5.5.1	Stability	66
6.5.5.2	Settlement	66
6.5.5.3	Mitigation of Stability Issues and/or Time Dependent Settlements	67
6.5.6	Highway 69 NBL – STA 12+750 to 12+825 (Swamp 206)	70
6.5.6.1	Stability	71



FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS - HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

6.5.6.2	Settlement	71
6.6	Subgrade Preparation and Embankment Construction.....	72
6.6.1	Removal of Organic Materials.....	72
6.6.2	Excavation of Soft Soils	72
6.6.3	Groundwater and Surface Water Control	73
6.6.4	Backfilling.....	73
6.6.5	Embankment Fill Placement	73
6.7	Rock Excavation.....	74
6.7.1	Blasting	74
6.7.2	Rock Scaling and Bolting	75
6.8	Embankment Platform Widening	75
7.0	CLOSURE	75

References

Lists of Symbols and Abbreviations

Lithological and Geotechnical Rock Description Terminology

TABLES

Table 1	Summary of Swamp Crossings and High Fill Areas
Table 2	Summary of Consolidation Test Parameters
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

DRAWINGS

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

LIST OF APPENDICES

Appendix A Highway 69 SBL – STA 17+750 to 17+775 and Highway 69 NBL – STA 17+700 to 17+750 (Swamp 201)

Drawing A1	Borehole Locations and Soil Strata
Drawing A2	Soil Strata
Record of Boreholes	S201-01 to S201-10 and S201-05A
Record of DCPTs	S201-DC01 to S201-DC04 and S201-DC03A
Figure A.S201-01	Grain Size Distribution – Sand and Silt
Figure A.S201-02	Grain Size Distribution – Silty Sand
Figure A.S201-03	Plasticity Chart – Silty Clay



FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS - HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

Appendix B

Highway 69 SBL – STA 11+175 to 11+275 and Highway 69 NBL – STA 11+100 to 11+225 (Swamp 202)

Drawing B1	Borehole Locations and Soil Strata
Drawings B2 to B4	Soil Strata
Record of Boreholes	S202-01 to S202-20
Record of Drillhole	S202-04
Record of DCPTs	S202-DC01 to S202-DC07
Figure B.S202-01A	Grain Size Distribution – Clayey Silt to Clay
Figure B.S202-01B	Grain Size Distribution – Clayey Silt to Clay
Figure B.S202-01C	Grain Size Distribution – Clayey Silt to Clay
Figure B.S202-02A	Plasticity Chart – Clayey Silt to Clay
Figure B.S202-02B	Plasticity Chart – Clayey Silt to Clay
Figure B.S202-03	Consolidation Test Summary – Borehole S202-07 SA7
Figure B.S202-04	Grain Size Distribution – Silt (Interlayer)
Figure B.S202-05	Grain Size Distribution – Sand
Figure B.S202-06	Core Photo – Swamp 202
Figure B.S202-07A	Grain Size Distribution – Clayey Silt to Clay
Figure B.S202-07B	Grain Size Distribution – Clayey Silt to Clay
Figure B.S202-08A	Plasticity Chart – Clayey Silt to Clay
Figure B.S202-08B	Plasticity Chart – Clayey Silt and Clay
Figure B.S202-09	Consolidation Test Summary – Borehole S202-17 SA7
Figure B.S202-10	Consolidation Test Summary – Borehole S202-20 SA11
Figure B.S202-11	Grain Size Distribution – Silt (Interlayer)
Figure B.S202-12	Grain Size Distribution – Sand
Figure B.S202-13	Plasticity Chart – Silty Sand (Slight Plasticity)
Figure B.S202-14	Grain Size Distribution – Sand and Gravel
Figure B1	Summary Plot of Engineering Parameters for Cohesive Deposits
Figure B2	Slope Stability (Outside Toe Berms)
Figure B3	Slope Stability (2 m Surcharge and Outside Toe Berms/Median Infill)
Figure B4	Slope Stability (4.5 m of EPS Fill)
Table B1	Evaluation of Stability / Settlement Mitigation Options

Appendix C

Highway 69 SBL – STA 11+350 to 11+375 and Highway 69 NBL – STA 11+375 to 11+400 (Swamp 203)

Drawing C1	Borehole Location and Soil Strata
Drawing C2	Soil Strata
Record of Boreholes	S203-01 to S203-06
Record of DCPTs	S203-DC01 to S203-DC03, S203-DC01A, S203-DC01B and S203-DC03A

Appendix D

Highway 69 SBL – STA 11+725 to 11+825 and Highway 69 NBL – STA 11+700 to 11+800 (Swamp 204)

Drawing D1	Borehole Locations and Soil Strata
Drawings D2 to D4	Soil Strata
Record of Boreholes	S204-01 to S204-18
Record of Drillhole	S204-12
Record of DCPTs	S204-DC01 to S204-DC08
Figure D.S204-01	Grain Size Distribution – Sandy Silt
Figure D.S204-02	Plasticity Chart – Silt (Slight Plasticity)
Figure D.S204-03	Grain Size Distribution – Silty Clay (Near Surface)
Figure D.S204-04	Plasticity Chart – Clayey Silt to Silty Clay (Near Surface)
Figure D.S204-05	Grain Size Distribution – Sand to Sandy Silt to Sand and Silt to Silty Sand (Upper)
Figure D.S204-06	Plasticity Chart – Clayey Silt to Clay (Upper)
Figure D.S204-07	Grain Size Distribution – Sandy Silt (Lower)
Figure D.S204-08	Plasticity Chart – Silt (Lower)
Figure D.S204-09	Grain Size Distribution – Silty Clay to Clay (Lower)
Figure D.S204-10A	Plasticity Chart – Silty Clay to Clay (Lower)



FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS - HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

Figure D.S204-10B	Plasticity Chart – Clay (Lower)
Figure D.S204-11	Consolidation Test Summary – Borehole S204-05 SA17
Figure D.S204-12	Consolidation Test Summary – Borehole S204-07 SA20
Figure D.S204-13	Grain Size Distribution – Sand and Silt (Interlayer)
Figure D.S204-14	Grain Size Distribution – Silt to Silty Sand to Sand and Silt
Figure D.S204-15	Plasticity Chart – Silt (Slight Plasticity)
Figure D.S204-16	Plasticity Chart – Clayey Silt to Clay (Near Surface)
Figure D.S204-17A	Grain Size Distribution – Sand and Silt to Silt (Upper)
Figure D.S204-17B	Grain Size Distribution – Sand and Silt to Silt to Silty Sand (Upper)
Figure D.S204-18	Plasticity Chart – Silt (Upper)
Figure D.S204-19	Plasticity Chart – Silt (Lower)
Figure D.S204-20	Grain Size Distribution – Silty Clay to Clay
Figure D.S204-21A	Plasticity Chart – Silty Clay to Clay
Figure D.S204-21B	Plasticity Chart – Silty Clay to Clay
Figure D.S204-22	Consolidation Test Summary – Borehole S204-14 SA13
Figure D.S204-23	Grain Size Distribution – Silt (Interlayer)
Figure D.S204-24	Plasticity Chart – Silt (Slight Plasticity)
Figure D.S204-25A	Grain Size Distribution – Silt to Sand and Silt to Silty Sand
Figure D.S204-25B	Grain Size Distribution – Sand
Figure D.S204-26	Core Photo – Swamp 204
Figure D1	Summary Plot of Engineering Parameters for Cohesive Deposits
Figure D2	Slope Stability (Outside Toe Berms)
Figure D3	Slope Stability (Localized Sub-Excavation Along Outside Toes)
Figure D4	Slope Stability – NBL STA 11+700 to 11+750 (Outside Toe Berms)
Figure D5	Slope Stability – NBL STA 11+700 to 11+750 (Sub-Excavation of Near Surface Cohesive Deposit)
Figure D6	Slope Stability (2 m Surcharge and Outside Toe Berms/Median Infill)
Figure D7	Slope Stability (2 m Surcharge and Localized Sub-Excavation Along Outside Toe Berms/Median Infill)
Figure D8	Slope Stability – NBL STA 11+700 to 11+750 (2 m Surcharge and Outside Toe Berms)
Figure D9	Slope Stability (5.5 m of EPS Fill)
Table D1	Evaluation of Stability / Settlement Mitigation Options

Appendix E

Highway 69 SBL – STA 12+200 to 12+375 (Swamp 205)

Drawing E1	Borehole Locations and Soil Strata
Record of Boreholes	S205-01 to S205-15
Record of DCPTs	S205-DC01 to S205-DC07, S205-DC05A and S205-DC06A
Figure E.S205-01	Grain Size Distribution – Sand
Figure E.S205-02A	Plasticity Chart – Silty Clay to Clay
Figure E.S205-02B	Plasticity Chart – Clayey Silt
Figure E.S205-03	Consolidation Test Summary – Borehole S205-07 SA4
Figure E.S205-04	Grain Size Distribution – Silt
Figure E.S205-05	Grain Size Distribution – Gravelly Silty Sand
Figure E1	Summary Plot of Engineering Parameters for Cohesive Deposits
Figure E2	Slope Stability (Outside Toe Berm)
Figure E3	Slope Stability (Partial Sub-Excavation and Backfill)
Figure E4	Slope Stability (2 m Surcharge and Outside Toe Berm)
Figure E5	Slope Stability (3 m of EPS Fill)
Table E1	Evaluation of Stability / Settlement Mitigation Options

Appendix F

Highway 69 NBL – STA 12+750 to 12+825 (Swamp 206)

Drawing F1	Borehole Locations and Soil Strata
Record of Boreholes	S206-01 to S206-07
Record of DCPTs	S206-DC01 to S206-DC04, S206-DC01A and S206-DC03A
Figure F.S206-01	Grain Size Distribution – Sand and Silt
Figure F.S206-02	Plasticity Chart – Clayey Silt



**FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL
AREAS - HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01**

Appendix G Non-Standard Special Provisions

Requirements for Expanded Polystyrene Embankment Fill



PART A

FOUNDATION INVESTIGATION REPORT
SWAMP CROSSINGS AND HIGH FILL AREAS – CONTRACT 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 5404-05-00; WP 5404-05-01



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 five (5) swamp crossing/high fill embankments and one (1) deep cut area within the Contract 2 limits of the new Highway 69 alignment to the north of the junction with Highway 529. The proposed work in Contract 2 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 the engineering of: high fill embankments and embankments over swamps; the Canadian National Railway (CNR) re-alignment; the Bekanon 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 2 extend from approximately 1.7 km north of the junction of the existing Highway 529 and Highway 69 northerly for a total distance of about 4.5 km. The general location of this section of the new Highway 69 four-laning alignment is 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 January 2009. Golder's proposal for foundation engineering services is contained in Section 6.8 of URS's Technical Proposal for this assignment. The work has been carried out in accordance with Golder's Supplementary Specialty Quality Control Plan for foundation engineering services for this project, dated April 19, 2010. The Base Plan showing the proposed horizontal alignment and a drawing showing the proposed vertical alignment for the Contract 2 section of Highway 69 four-laning was provided to Golder by URS on December 16, 2009 and November 28, 2011, respectively.

This report addresses the investigation carried out for the Contract 2 swamp crossings and high fill areas only. A detailed list of the Contract 2 swamp crossing/high fill areas is presented in Table 1. Separate reports address the foundation investigations for the related swamp crossing/high fill areas, culverts and other bridge structures for the project.

The purpose of this investigation is to establish the subsurface conditions along the new highway alignment at the proposed Contract 2 swamp crossing/high fill areas 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 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 as defined in the terms of reference. The investigation areas are shown in 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, GEOCRESS No. 41H-51, dated September 2005, by Trow Associates Inc.

2.0 SITE DESCRIPTION

The new four-lane Highway 69 alignment is oriented generally in a south-north direction spanning the Township of Wallbridge to the south and the Township of Henvey to the north. The section of the new highway alignment addressed in this report is approximately 4.5 km long extends northerly from about 1.7 km north of the junction between existing Highway 69 and Highway 529. The proposed new alignment within this section is located



approximately 0.5 km to 2.5 km east of the existing Highway 69 alignment. The proposed highway alignment associated with the four-laning of the new Highway 69 in this area also includes the proposed Still River bridge structures.

In general, the topography of this section of the project consists of rolling terrain, including sparsely or densely populated treed areas and numerous bedrock outcrops separated by valleys, pasture lands and swamps containing areas of standing water and various types of vegetation and organic soils. The ground surface within the limits of the Contract 2 swamp crossing/high fill areas varies between about Elevation 203.8 m and Elevation 181.0 m, referenced to Geodetic datum, and is gently sloping downward from southeast to northwest towards Georgian Bay. A detailed description of each investigated swamp crossing/high fill area 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 2 swamp crossing/high fill areas was carried out between January 18 and March 4, 2010, and between February 25 and March 14, 2011, during which time a total of seventy-seven (77) boreholes and forty-one (41) Dynamic Cone Penetration Tests (DCPTs) were advanced at the locations of the swamp crossing/high fill areas. The locations of the boreholes and DCPTs are summarized in Table 1 and are shown on Drawings A1 to F1 in Appendices A to F. In general, boreholes and DCPTs were advanced along the centreline and the toes of the proposed embankment alignment (in accordance with the terms of reference).

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 2 project limits. The details of the drilling equipment and suppliers are listed below. Hand excavation methods were used where appropriate depending on the terrain.

Drilling Equipment	Supplied and Operated By
Track Mounted CME-55	Walker Drilling Ltd. of Utopia, Ontario
Track Mounted D-50	Walker Drilling Ltd. of Utopia, Ontario
Track Mounted D-25	Walker Drilling Ltd. of Utopia, Ontario
Portable Equipment	Walker Drilling Ltd. of Utopia, Ontario and OGS Inc. of Almonte, Ontario

The boreholes were advanced through the overburden using 108 mm inner diameter (I.D.) hollow-stem augers, 127 mm or 165 mm outer diameter (O.D.) solid-stem augers, and/or 'BW', 'NW' or 'HW' casing with wash boring techniques. In general, soil samples were advanced at intervals of depth of about 0.75 m and 1.5 m, using a 50 mm O.D. split-spoon sampler driven by automatic hammers on the track-mounted drill rigs, and carried out in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586, Standard Test Method for Standard Penetration Test). Boreholes advanced by portable equipment employed full-weight hammers or half-weight hammers lifted manually and dropped from the SPT height. Where a half-weight hammer was used, the 'N'-values were corrected for the lower energy drive. Samples of the 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. Samples of the bedrock were obtained using an 'NQ' size rock core barrel. All boreholes were backfilled with bentonite upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The boreholes and DCPTs were advanced to depths up to 45.9 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, 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 0.1 m), the bedrock was exposed by hand shovel excavation to confirm the refusal condition. In two (2) boreholes, bedrock was cored for a depth of about 3 m and photographs of the recovered rock 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 F. 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. Furthermore, groundwater elevations will vary depending on seasonal fluctuations, precipitation and local soil permeability.

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 detailed 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, Atterberg limits and grain size distribution) was carried out on selected samples. In addition, one-dimensional consolidation (oedometer) tests were carried out on select samples of the cohesive deposits and the summary of the consolidation test results is presented in Table 2. The results of the laboratory classification testing are included in the associated appendices.

Classification of the rock mass quality of the bedrock 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.

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

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.



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 F1 in Appendices A to F 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 very 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.

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 attached Record of Borehole sheets and the laboratory test sheets provided in Appendices A to F. 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 F.

The inferred soil stratigraphy as encountered in the boreholes and DCPTs advanced for the Contract 2 swamp crossing/high fill areas are shown in profile and cross-section on Drawings A1 to F1, inclusive. The orientation (i.e. north, south, east, west) stated in the text of the 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 north-south.

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



In general, the stratigraphy encountered at the various borehole locations typically consists of alternating layers of cohesive and cohesionless soils. The overburden (soil material) thickness is variable, ranging from no cover (i.e. bedrock outcrops exposed at ground surface at the edges of the swamps) up to about 45.9 m below ground surface upon borehole termination. The stratigraphy generally consists of:

- Surficial layers of topsoil, silty sand to sand to sand and gravel fill, fibrous and amorphous peat or organic root mat;
- Cohesionless deposits of silty sand to sand to sandy silt, interlayered with clayey silt to clay deposits in some areas;
- Cohesive deposits of clayey silt to clay, interbedded with sand and silt seams and layers in some areas; and,
- Cohesionless deposits of sand to silt deposits below the cohesive deposits and over the inferred bedrock surface.

Detailed descriptions of the subsurface conditions at each investigated swamp crossing/high fill area 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 SBL – STA 17+750 to 17+775 (Swamp 201)

The plan and profile along the centreline of the embankment and a cross-section at a selected station of the proposed embankment of the new Highway 69 SBL alignment showing the borehole locations and interpreted stratigraphy between about STA 17+750 and 17+775 in the Township of Wallbridge are shown on Drawing A1 in Appendix A. The alignment extends across a low-lying swamp area with the proposed embankment up to about 4 m high above the existing ground surface.

A total of three (3) boreholes (Boreholes S201-01 to S201-03, inclusive) and one (1) DCPT (DCPT S201-DC01) were completed to investigate the subsurface conditions within this swamp area. The topography in this section of the proposed highway is a relatively flat low-lying area between gently sloping bedrock ridges to the north and south limits of the investigated area, and the ground is moderately tree covered encompassing a wet grassy area.

The subsurface soils along the SBL alignment in Swamp 201 generally consist of surficial layers of root mat, amorphous peat and topsoil at the ground surface, underlain by deposits of sand and silt to sand and gravel, underlain by inferred bedrock. Resistance to dynamic cone penetration, shovel excavation and borehole advancement, was encountered at depths of up to about 1.2 m, being deepest in the vicinity of about STA 17+775. A bedrock outcrop is present in the vicinity of the proposed alignment, at about STA 17+765 along the west toe of the proposed embankment.

Peat / Topsoil

An approximately 0.2 m thick layer of black amorphous peat containing rootlets and 0.1 m thick root mat was encountered at the ground surface at about Elevation 202.8 m and 203.8 m in Boreholes S201-01 and S201-02, respectively. In Borehole S201-02, bedrock was exposed by shovel (hand) excavation to confirm refusal at the



bottom of this deposit and in Borehole S201-01, the bottom of this deposit was defined by refusal to further split-spoon advancement and also inferred by refusal to cone penetration.

One SPT 'N'-value of 25 blows per 0.08 m of penetration was measured at the bottom of Borehole S201-01 (split-spoon refusal on inferred bedrock), however, it is estimated that the peat layer has a very soft consistency.

The natural water content measured on this sample of the peat is about 212 per cent.

A 0.3 m thick layer of topsoil was encountered at the ground surface at about Elevation 202.9 m in Borehole S201-03.

Sand and Silt to Sand and Gravel

A deposit of brown sand and silt, trace gravel and trace clay, underlain by a deposit of grey sand and gravel, trace to some silt, generally containing wood fragments, organics and rootlets were encountered underlying the topsoil in Borehole S201-03. The top of the sand and silt deposit is at about Elevation 202.6 m and the thickness of the deposit is about 0.3 m, and the top of the sand and gravel deposit is at about Elevation 202.3 m and the thickness of the deposit is about 0.6 m. The bottom of the sand and gravel deposit was defined by refusal to further split-spoon advancement in Borehole S201-03 and inferred by refusal to cone penetration in DCPT S201-DC01.

The SPT 'N'-values measured within these deposits are 4 blows and 7 blows per 0.3 m of penetration, indicating a loose relative density.

The natural water content measured on a sample of the sand and silt deposit is about 65 per cent.

A grain size distribution of one (1) sample from the sand and silt deposit is shown on Figure A.S201-01 in Appendix A.

Bedrock / Refusal

Bedrock outcrops are present in the vicinity of the swamp area, and along the west toe of the proposed embankment at the location of Borehole S201-02, at about STA 17+765. The bedrock surface at the boreholes and DCPT as inferred by refusal to further split-spoon advancement and shovel excavation or dynamic cone penetration was encountered at depths of between about 0.1 m and 1.6 m below ground surface, corresponding to Elevation 203.7 m and 201.4 m. In general, refusal was encountered at greater depth towards the northern limit of the swamp between about STA 17+765 and 17+775.

Groundwater Conditions

In general, the soil samples taken in the boreholes were wet. Water levels observed in Boreholes S201-01 and S201-03 upon completion of drilling are at about Elevation 202.8 m and 202.5 m, measured at ground surface and at a depth of about 0.4 m below the ground surface, while in Borehole S201-02, the excavation was dry upon completion.



4.4 Highway 69 NBL – STA 17+700 to 17+750 (Swamp 201)

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 17+700 and 17+750 in the Township of Wallbridge are shown on Drawings A1 and A2. The alignment extends across a low-lying swamp area with the proposed embankment up to about 4 m high above the existing ground surface.

A total of eight (8) boreholes (Boreholes S201-04 to S201-10 and S201-05A) and four (4) DCPTs (DCPT S201-DC02 to S201-DC04 and S201-DC03A) were completed to investigate the subsurface conditions within this swamp area. The topography in this section of the proposed highway is relatively flat with a low-lying area between gently sloping bedrock ridges beyond the north and south limits of the investigated area, and the ground is moderately tree covered encompassing an open, wet, grassy area and shallow open water in places.

Ice and water was encountered at the surface in some of the boreholes advanced within this swamp. The subsurface soils along the NBL alignment in Swamp 201 generally consist of surficial layers of root mat, amorphous peat and topsoil at the ground surface or below the ice cover, underlain by deposits of silty sand to sand and silty clay, which in turn is underlain by inferred bedrock. Resistance to dynamic cone penetration, shovel excavation and borehole advancement, was encountered at depths of up to about 3.4 m below ground surface, being deepest near the south end of the swamp in the vicinity of about STA 17+700. A bedrock outcrop was observed in the vicinity of the proposed alignment at about STA 17+735 along the west toe of the proposed embankment.

Ice / Water

Ice and water to depths of 0.2 m and 0.3 m was encountered at the ground surface in Boreholes S201-04, S201-05 and S201-09.

Peat / Topsoil

An approximately 0.1 m thick root mat and 0.6 m to 0.7 m thick layer of dark brown amorphous peat and trace sand, containing rootlets and wood fragments, was encountered at the ground surface or under the ice and water cover in Boreholes S201-04 to S201-07 and S201-09. The top of the peat deposit varies between about Elevation 203.4 m and 202.6 m. In Boreholes S201-06 and S201-07, bedrock was exposed by shovel (hand) excavation to confirm refusal at the bottom of this deposit.

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

The natural water content measured on two (2) samples of the peat is about 389 per cent and 685 per cent.

An approximately 0.2 m thick layer of topsoil was encountered at the ground surface at about Elevation 203.3 m and 203.4 m in Boreholes S201-08 and S201-10, respectively. The bottom of the topsoil deposit is defined by refusal to split-spoon advancement and dynamic cone penetration in Borehole S201-08 and bedrock was exposed by shovel (hand) excavation to confirm refusal at the bottom of this deposit.



Silty Sand to Sand

A deposit of grey silty sand to sand, trace to some silt, trace to some gravel and trace to some clay containing rootlets was encountered below the peat deposit in Boreholes S201-04, S201-05 and S201-09. The top of this deposit is at about Elevation 202.0 m and its thickness ranges from about 0.3 m to 0.9 m.

The SPT 'N'-values recorded within this deposit are 3 blows and 4 blows per 0.3 m of penetration, indicating a very loose to loose relative density.

The natural water content measured on two (2) samples of this deposit is about 26 per cent and 33 per cent.

A grain size distribution of one (1) sample from the silty sand portion of this deposit is shown on Figure A.S201-02 in Appendix A.

Silty Clay

A deposit of brown to grey silty clay trace to some sand and containing rootlets was encountered below the deposit of silty sand to sand in Boreholes S201-04, S201-05, S201-05A and S201-09. The top of this deposit ranges from about Elevation 201.7 m to 201.1 m and its thickness ranges from about 0.9 m to 1.9 m. The bottom of this deposit is defined by refusal to further split-spoon advancement in Boreholes S201-04, S201-05A and S201-09, and Borehole S201-05 was terminated within this deposit.

The SPT 'N'-values measured within this deposit are 2 blows and 3 blows per 0.3 m of penetration. In situ field vane tests carried out within the silty clay deposit measured undrained shear strengths ranging from about 52 kPa to 63 kPa and the sensitivity is calculated to be about 4 and 5. The field vane tests results indicate that the silty clay deposit has a firm to stiff consistency.

The natural water content measured on two (2) samples of this deposit is about 35 per cent and 43 per cent.

An Atterberg limits test was carried out on one (1) sample of the silty clay deposit and measured a liquid limit of about 43 per cent, a plastic limit of about 20 per cent and a corresponding plasticity index of about 23 per cent. The result of the Atterberg limits test is shown on the plasticity chart on Figure A.S201-03 in Appendix A and indicates that the material is classified as silty clay of intermediate plasticity.

Bedrock / Refusal

Bedrock outcrops are present in the vicinity of the swamp, and along the west toe of the proposed embankment at the location of Borehole S201-07, at about STA 17+735. The bedrock surface at the boreholes and DCPTs is inferred by refusal to further split-spoon advancement and shovel excavation or dynamic cone penetration at depths of between about 0.1 m and 3.4 m below the ice or ground surface, corresponding to between about Elevation 203.5 m and 199.5 m. In general, refusal was encountered at greater depth towards the middle of the swamp between about STA 17+700 and 17+715.

Groundwater Conditions

In general, the samples taken in the boreholes were wet to moist. Water levels observed in the boreholes upon completion of excavating/drilling are at about Elevation 202.8 m and 202.9 m, measured either at the ice or



ground surface, with the exception of the shovel excavations in Boreholes S201-07 and S201-08 which were dry upon completion of excavating/drilling.

4.5 Highway 69 SBL – STA 11+175 to 11+275 (Swamp 202)

The plan and profiles along the centreline and toes of the proposed embankment of the new Highway 69 SBL alignment showing the borehole locations and interpreted stratigraphy between about STA 11+175 and 11+275 in the Township of Henvey are shown on Drawings B1 and B2 in Appendix B. The overall alignment extends across high fill sections from STA 11+175 to 11+195 and STA 11+250 to 11+275, and a swamp crossing area about 55 m long from STA 11+195 to 11+250. The proposed embankment in this area will be up to about 6.5 m above the existing ground surface. A cross-section of the critical section in the vicinity of the proposed swamp crossing/high fill embankment corresponding to the greatest new embankment height and/or the maximum thickness of soft, compressible cohesive soils at approximately STA 11+220 is shown on Drawing B4 in Appendix B.

A total of nine (9) boreholes (Boreholes S202-01 to S202-09, inclusive) and four (4) Dynamic Cone Penetration Tests (DCPTs S202-DC01 to S202-DC04, inclusive) were completed along the overall length of the area to investigate the subsurface conditions within the swamp crossing/high fill areas. One (1) borehole (Borehole S202-13) and two (2) Dynamic Cone Penetration Tests (DCPTs S202-DC05 and S202-DC07) advanced (to the south of the investigation area) on the median with the proposed Highway 69 NBL alignment were also utilized to supplement the investigation for the SBL alignment. In addition, four (4) boreholes (Boreholes C201-01, C201-02, C202-01 and C202-02) advanced along the Culverts 201 and 202 alignments traversing the swamp area and the proposed Highway 69 SBL and NBL alignments were further utilized to define the stratigraphic boundaries between the subsurface soils. The details of the field investigations carried out for the culvert alignments and the Record of Boreholes for C201-01, C201-02, C202-01 and C202-02 are not included in this report, but are presented in Golder Associates' Report "Foundation Investigation and Design Report, Culverts – Contract 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, G.W.P. 5404-05-00" (Report No. 09-1111-6014-2521).

This section of the proposed highway embankment is located within the confines of tree covered valley slopes to the north and south, and consists of wet grassy areas/pasture land and a small creek traversing the valley from east to west near the middle of the area. In general, the ground cover consists of a grassy field with exposed bedrock outcrops and shrub cover and moderately treed areas to the north and south.

The subsurface soils along the SBL alignment in the Swamp 202 swamp crossing/high fill area generally consist of surficial layers of peat and topsoil at the ground surface, underlain by near surface deposits of organic silty sand in places, which in turn is underlain by silty sand to sand. These shallow surficial deposits are underlain by a deposit of clayey silt to clay. The cohesive deposit is underlain in places by cohesionless deposits of sandy silt to sand or silty sand and gravel, in turn underlain by inferred bedrock. At one location, bedrock was cored and samples were retrieved consisting of granite gneiss bedrock. Resistance to dynamic cone penetration, shovel excavation and borehole advancement, was encountered at depths of up to about 25.4 m below ground surface at about STA 11+215. Bedrock outcrops and knobs are present across the site and towards the south east end of the investigated area.



Peat / Topsoil

An approximately 0.1 m to 0.3 m thick layer of peat, topsoil or root mat was encountered at the ground surface at about Elevations 188.0 m and 182.5 m in Boreholes S202-01 and S202-04, respectively on the southern slope of the swamp valley and in Boreholes S202-02, S202-03, S202-05 to S202-09 and S202-13 across the swamp valley and on the northern slope between about Elevation 188.9 m and 182.7 m. In Borehole S202-13, bedrock was inferred at the bottom of topsoil upon refusal to further split-spoon advancement and in Borehole S202-01 and DCPT S202-07, bedrock was exposed by shovel (hand) excavation to confirm refusal at the bottom of this deposit.

The natural water content measured on one (1) specimen of the peat/topsoil layer is about 44 per cent.

Organic Silty Sand

A deposit of dark grey to brown organic silty sand trace clay containing rootlets was encountered locally below the peat in Boreholes S202-04 and S202-05. The top of this deposit is at about Elevation 182.3 and the thickness of the deposit is about 0.4 m and 0.5 m in the respective boreholes.

Two SPT 'N'-values of 1 blow per 0.3 m of penetration were recorded within this deposit, indicating a very loose relative density.

The natural water content measured on two (2) specimens of this deposit is about 39 per cent and 46 per cent.

Silty Sand to Sand

A deposit of brown to grey silty sand to sand, trace clay and containing wood fragments, rootlets and organics was encountered either below the topsoil or the organic silty sand deposit in Boreholes S202-02 to S202-05, S202-07 and S202-09. The top of this deposit ranges from about Elevation 186.0 m to 181.8 m and its thickness ranges from about 0.2 m to 0.6 m. Borehole S202-02 was terminated within this deposit upon refusal to further auger advancement.

The SPT 'N'-values measured within this deposit range from 0 blows (weight of hammer) to 5 blows per 0.3 m of penetration, indicating a very loose to loose relative density.

The natural water content measured on two (2) samples of this deposit is about 20 per cent and 26 per cent.

Clayey Silt to Clay

A deposit of cohesive soil comprised of brown to grey clayey silt, silty clay and clay containing trace to some sand and silt was encountered below the silty sand to sand deposit or topsoil in Boreholes S202-03 to S202-09. The deposit generally contains sand and silty clay layers within the clayey silt portion of the deposit and silt layers at various intervals across the deposit. The near surface portion of this deposit contains organics, rootlets and fibrous peat layers. Along the centreline of the proposed embankment, a layer of silt was encountered within the cohesive deposit in Borehole S202-07 advanced near the northern limit of the investigated area. The top of the cohesive deposit ranges from about Elevation 182.9 m to 181.6 m, and up to about Elevation 185.5 m in Borehole S202-09 advanced on the valley slope. The thickness of the cohesive deposit ranges from about 4.6 m to 18.9 m. The bottom of this deposit is defined by refusal to further split-spoon and casing advancement



and/or dynamic cone penetration in Boreholes S202-03 and S202-07 and by bedrock in Borehole S202-04. DCPT S202-DC01 was terminated within this deposit upon refusal to further dynamic cone penetration.

The SPT 'N'-values recorded within the cohesive deposit range from 0 blows (weight of hammer) to 11 blows per 0.3 m of penetration, with the higher 'N' values being recorded generally within the near surface portion of this deposit underlying the silty sand to sand deposit. In situ field vane tests carried out within this deposit measured undrained shear strengths ranging from about 14 kPa to 96 kPa, but typically less than 45 kPa, and the sensitivity is calculated to range from about 2 to 5. The field vane tests results indicate that the clayey silt to clay deposit has a soft to stiff consistency with shear strength generally increasing with depth.

The natural water content measured on specimens of this deposit ranges from about 27 per cent to 86 per cent, but are typically greater than 50 per cent.

The grain size distributions of fifteen (15) specimens of the clayey silt to clay deposit are shown on Figures B.S202-01A to B.S202-01C in Appendix B.

Atterberg limits tests were carried out on sixteen (16) specimens of the clayey silt to clay deposit and indicate liquid limits ranging from about 24 per cent to 75 per cent, plastic limits ranging from about 15 per cent to 23 per cent and plasticity indices ranging from about 7 per cent to 52 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figures B.S202-02A and B.S202-02B in Appendix B and indicate the material to range from a clayey silt of low plasticity to clay of high plasticity.

A laboratory consolidation test was carried out on one (1) specimen of the clay deposit obtained from a Shelby tube sample in Borehole S202-07. A preconsolidation stress of about 85 kPa was estimated from the void ratio versus logarithmic pressure plot and from the total work versus pressure plot. A bulk unit weight of about 15.3 kN/m³ and a specific gravity of about 2.78 were measured on the consolidation test specimen. Details of the test results are shown on Figure B.S202-03 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 S202-07 Sample 7	7.4 m / 176.1 m	85	85	0	1.0	1.69	0.13	2.16	1.3×10^{-4}

Note: * For stress range of between effective overburden stress and final stress due to 6.5 m high embankment, that is $85 \text{ kPa} \leq \sigma_v' \leq 205 \text{ kPa}$

where: σ_{vo}' is the in situ vertical effective overburden stress in kPa
 σ_p' is the preconsolidation stress in kPa
 σ_v' is the vertical effective stress in kPa
OCR is overconsolidation ratio
 e_o is 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 (Interlayer)

An approximately 1.1 m thick interlayer of grey silt, trace to some sand and trace clay was encountered within the silty clay to clay deposit in Borehole S202-07 at about Elevation 179.4 m.



One SPT 'N'-value measured within this silt interlayer is 14 blows per 0.3 m of penetration, indicating a compact relative density.

The natural water content measured on one (1) specimen of the silt deposit is about 24 per cent.

A grain size distribution of this sample is shown on Figure B.S202-04 in Appendix B.

Sandy Silt to Sand

A deposit of brown to grey sandy silt to sand some silt containing trace gravel and trace clay was encountered underlying the cohesive deposit in Boreholes S202-05, S202-06 and S202-08. The top of this deposit ranges from about Elevation 166.7 m to 162.7 m and the thickness of the deposit ranges from about 1.8 m to 4.8 m. Borehole S202-05 was terminated on refusal to further split-spoon and casing advancement while Boreholes S202-06 and S202-08 were terminated within this deposit as a result of flowing sand into the casing due to groundwater pressure.

The SPT 'N'-values measured within this deposit range from 7 blows to 12 blows per 0.3 m of penetration, indicating a loose to compact relative density.

The natural water content measured on two (2) samples of this deposit is about 21 per cent and 22 per cent.

A grain size distribution of one (1) sample from the sand portion of this deposit is shown on Figure B.S202-05 in Appendix B.

In Borehole S202-09 advanced on the north slope of the valley, the cohesionless layer encountered underlying the silty clay deposit is comprised of silty sand and gravel containing trace clay. The top of this layer is at about Elevation 184.8 m and the thickness of the layer is about 0.3 m. Borehole S202-09 was terminated on refusal to split-spoon and auger advancement. One SPT 'N'-value of 50 blows per 0.05 m of penetration was measured prior to split-spoon refusal, indicating a very dense relative density.

Bedrock / Refusal

Bedrock outcrops and knobs are present to the southern and northern limits of the investigated area. In Boreholes S202-01 and S202-13 located at about STA 11+175 and 11+137.5, bedrock was confirmed by exposure by shovel excavation of the thin layer of topsoil or peat encountered at the ground surface. The bedrock surface at the boreholes and DCPTs is inferred by refusal to further split-spoon and/or auger/casing advancement and shovel excavation or dynamic cone penetration between depths of about 0.1 m and 25.4 m below the ground surface, corresponding to about Elevation 188.9 m and 157.3 m. In general, refusal was encountered at greater depth within the limits of the swamp crossing/high fill area between about STA 11+215 and 11+240.

Bedrock was encountered and core samples were recovered from Borehole S202-04, as shown on the photograph of the recovered core samples presented on Figure B.S202-06. The depth to the surface of the bedrock in this borehole is about 11.3 m corresponding to Elevation 171.2 m. The bedrock consists of granite gneiss and the core samples are described as fresh, foliated, slightly porous, medium crystalline, strong, pink, grey and black with mafic dyke span encountered at varying intervals. The Rock Quality Designation (RQD) measured on the core samples is about 100 per cent and 92 per cent, indicating a rock mass of very good to



excellent quality. The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of the core samples are 100 per cent and 96 per cent, and 100 per cent and 91 per cent, respectively.

Groundwater Conditions

In general, the samples taken in the boreholes were moist to wet. Artesian conditions were observed in Boreholes S202-06 and S202-08 with the groundwater level upon completion of drilling measured at about 0.8 m and 1.4 m above ground surface, about Elevation 183.9 m and 184.1 m, respectively. In the other boreholes, the water levels observed upon completion of drilling range from about Elevation 179.4 m to 185.9 m, typically measured at the ground surface to depths ranging from about 0.2 m to 4.1 m below ground surface, except in Boreholes S202-03 and S202-13 which were observed to be dry upon completion of drilling.

4.6 Highway 69 NBL – STA 11+100 to 11+225 (Swamp 202)

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 11+100 and 11+225 in the Township of Henvey are shown on Drawings B1 to B3 in Appendix B. The overall alignment extends across a high fill section from STA 11+100 to 11+175 and a swamp crossing area about 50 m long from STA 11+175 to 11+225. The proposed embankment in this area will be up to about 6.5 m above the existing ground surface. A cross-section of the critical section in the vicinity of the proposed swamp crossing/high fill embankment corresponding to the greatest new embankment height and/or the maximum thickness of soft, compressible cohesive soils at approximately STA 11+220 is shown on Drawing B4 in Appendix B.

A total of eleven (11) boreholes (Boreholes S202-10 to S202-20, inclusive) and three (3) Dynamic Cone Penetration Tests (DCPTs S202-DC05 to S202-DC07, inclusive) were completed along the overall length of the area to investigate the subsurface conditions within the swamp crossing/high fill areas. Two (2) boreholes (Boreholes S202-02 and S202-06) and two (2) Dynamic Cone Penetration Tests (DCPTs S202-DC02 and S202-DC04) advanced on the median with the proposed Highway 69 SBL alignment were also utilized to supplement the investigation for the NBL alignment. In addition, three (3) boreholes (Boreholes C201-03, C201-04 and C202-03) advanced by Golder along the Culverts 201 and 202 alignments traversing the swamp area and the proposed Highway 69 SBL and NBL alignments were further utilized to define the stratigraphic boundaries between the soil deposits. The details of the field investigations carried out for the culvert alignments and the Record of Borehole C201-03, C201-04 and C202-03 are not included in this report, but are presented in Golder Associates' Report "Foundation Investigation and Design Report, Culverts – Contract 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, G.W.P. 5404-05-00" (Report No. 09-1111-6014-2521).

This section of the proposed highway embankment is located within the confines of tree covered valley slopes to the north and south, and consists of wet grassy areas / pasture land and a small creek traversing the valley from west to east near the middle of the area. In general, the ground cover consists of a grassy field with exposed bedrock outcrops and shrub cover and moderately treed areas to the north and south.

The subsurface soils along the NBL alignment in the Swamp 202 swamp crossing/high fill areas generally consist of surficial layers of peat, topsoil and organics at the ground surface, underlain by a deposit of silty sand to sand, underlain by an extensive deposit of clayey silt to clay. The cohesive deposit is underlain in places by



cohesionless deposits of sandy silt to sand and/or sand and gravel, to refusal depths where the deposit was fully penetrated. At one location, a boulder was encountered within the cohesionless deposit. Resistance to dynamic cone penetration, shovel excavation and borehole advancement, was encountered at depths of up to about 26.5 m below ground surface at about STA 11+195. Bedrock outcrops and knobs are present to the north, south and southeast of the investigated area.

Topsoil

An approximately 0.1 m to 0.4 m thick layer of topsoil was encountered at the ground surface in all the boreholes. The surface of the topsoil layer ranges from about Elevation 184.5 m to 182.9 m at the boreholes advanced within the valley and from about Elevation 191.9 m to 187.3 m at the boreholes advanced along the valley slopes. In Borehole S202-10 and at DCPT S202-DC07, bedrock was exposed by shovel (hand) excavation to confirm refusal at the bottom of the topsoil layer. In Borehole S202-13, bedrock was inferred at the bottom of the topsoil layer upon refusal to further split-spoon advancement and subsequent refusal in two additional boreholes advanced within the proximity of this borehole to verify the refusal condition.

Silty Sand to Sand

A deposit of brown to grey silty sand to sand trace silt containing trace gravel, trace to some clay, sand seams, wood fragments, rootlets and organics was encountered underlying the topsoil in all the boreholes except in Boreholes S202-06, S202-19 and S202-20. The top of this deposit ranges from about Elevation 188.7 m to 182.7 m and the thickness of the deposit ranges from about 0.4 m to 0.7 m. Boreholes S202-02, S202-12 and S202-14 were terminated within this deposit upon refusal to further split-spoon or auger advancement.

The SPT 'N'-values measured within this deposit range from 3 blows to 11 blows per 0.3 m of penetration, and up to 36 blows per 0.3 m of penetration in one borehole, indicating a very loose to dense relative density.

The natural water content measured on samples of this deposit ranges from about 20 per cent to 40 per cent, and up to about 68 per cent. The higher value was recorded within the deposit containing rootlets and organics.

Clayey Silt to Clay

An extensive deposit of cohesive soil comprised of brown to grey clayey silt, silty clay and clay trace to some silt was encountered below the silty sand to sand deposit or topsoil in Boreholes S202-06, S202-11 and S202-15 to S202-20. The deposit contains trace to some sand, silt and sand layers, silty sand and silt seams while the near surface portion of the deposit contains seams of fibrous peat, rootlets and organics. Discontinuous interlayers of silt and sand were encountered and inferred (based on the resistance to dynamic cone penetration) at varying intervals in some of the boreholes advanced towards the southern limit of the investigated area. The top of the clayey silt to clay deposit across the boreholes ranges from about Elevation 183.7 m to 182.0 m, and up to about Elevation 187.7 m in Borehole S202-11 advanced along the valley slope, and the thickness of the deposit ranges from about 0.9 m to 16.1 m. The bottom of this deposit was defined by refusal to further split-spoon and/or casing advancement in Boreholes S202-15 and S202-16, while Borehole S202-18 was extended deeper by driving a dynamic cone to refusal at a depth of about 26.5 m below ground surface (Elevation 156.4 m).



The SPT 'N'-values recorded within the cohesive deposit range from 0 blows (weight of hammer) to 11 blows per 0.3 m of penetration, where the higher 'N' values were recorded within the near surface portion of this deposit underlying the silty sand to sand deposit. In situ field vane tests carried out within this deposit measured undrained shear strengths ranging from about 17 kPa to 96 kPa, but are typically lesser than 40 kPa, and the sensitivity is calculated to range from about 2 to 5. 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 specimens of this deposit ranges from about 27 per cent to 102 per cent, but is typically greater than 41 per cent.

The grain size distributions of nine (9) specimens of the clayey silt to clay deposit are shown on Figures B.S202-07A and B.S202-07B in Appendix B.

Atterberg limits tests were carried out on thirteen (13) specimens of the clayey silt to clay deposit and indicate liquid limits ranging from about 25 per cent to 77 per cent, plastic limits ranging from about 16 per cent to 24 per cent and plasticity indices ranging from about 10 per cent to 54 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figures B.S202-08A and B.S202-08B in Appendix B and indicate the material to range from a clayey silt of low plasticity to clay of high plasticity.

Laboratory consolidation tests were carried out on two (2) specimens of the clay deposit obtained from Shelby tube samples in Boreholes S202-17 and S202-20. Preconsolidation stresses of about 100 kPa were estimated from the void ratio versus logarithmic pressure plot and from the total work versus pressure plot. Bulk unit weights of about 15.3 kN/m³ and 15.9 kN/m³, and specific gravities of about 2.76 and 2.78 were measured on the consolidation test specimens. Details of the test results are shown on Figure B.S202-09 and B.S202-10 in Appendix B, and 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 S202-17 Sample 7	11.0 m / 172.1 m	100	100	0	1.0	1.19	0.14	2.14	4.9×10^{-4}
Borehole S202-20 Sample 11	10.3 m / 173.0 m	75	100	25	1.3	1.20	0.12	1.86	5.5×10^{-5}

Note: * For stress range of between effective overburden stress and final stress due to 6.5 m high embankment, that is $100 \text{ kPa} \leq \sigma_v' \leq 225 \text{ kPa}$ and $75 \text{ kPa} \leq \sigma_v' \leq 200 \text{ kPa}$

where: σ_{vo}' is the in situ vertical effective overburden stress in kPa
 σ_p' is the preconsolidation stress in kPa
 σ_v' is the vertical effective stress in kPa
OCR is overconsolidation ratio
 e_o is 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 and Sand (Interlayers)

Approximately 0.4 m to 1.2 m thick interlayers of grey silt, trace sand and trace clay, and an approximately 0.3 m thick interlayer of sand were encountered within the upper portion of the cohesive deposit in Boreholes S202-18,



and S202-19 and Borehole S202-17, respectively. The top of the silt interlayers is between about Elevation 181.5 m and 179.0 m, and the top of the sand interlayer is at about Elevation 179.4 m.

The SPT 'N'-values measured within the silt and sand interlayers range from 0 blows (weight of hammer) to 20 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

The natural water content measured on a specimen of the silt deposit is about 24 per cent.

A grain size distribution of one (1) sample from the silt interlayer is shown on Figure B.S202-11 in Appendix B. An Atterberg limits test on one (1) sample of the silt deposit indicates this material to be non-plastic.

Sandy Silt to Sand

A cohesionless deposit comprised of brown to grey sandy silt, silty sand and sand trace to some silt, containing trace to some gravel, trace to some clay, sand seams and cobbles was encountered underlying the cohesive deposit in Boreholes S202-06, S202-11 and S202-17 to S202-20. A 1.0 m thick boulder was encountered at about Elevation 165.5 m within the silty sand to sand deposit in Borehole S202-19. The top of the sandy silt to sand deposit ranges from about Elevation 168.7 m to 166.3 m and is at about Elevation 186.8 m in Borehole S202-11 advanced along the valley slope. The thickness of this deposit ranges from about 0.5 m to 4.8 m, and may be up to about 12.3 m as inferred by resistance to a dynamic cone penetration test in Borehole S202-18. Boreholes S202-06 and S202-17 were terminated within this deposit as a result of sand flowing into the casing due to water pressure confined below the overlying cohesive deposit.

The SPT 'N'-values measured within this deposit range from 7 blows to 36 blows per 0.3 m of penetration, with one 'N'-values of 57 blows per 0.3 m of penetration recorded in Borehole S202-19 within the portion of the deposit containing cobbles and boulders, indicating a loose to very dense relative density.

The natural water content measured on samples of this deposit ranges from about 11 per cent to 24 per cent.

The grain size distributions of two (2) samples from the sand layers of this deposit are shown on Figure B.S202-12 in Appendix B.

An Atterberg limits test was carried out on one (1) sample of the silty sand deposit and measured a liquid limit of about 20 per cent, a plastic limit of about 18 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.S202-13 in Appendix B and indicates that the fines material of the silty sand deposit is classified as silt of slight plasticity.

In Boreholes S202-11 and S202-20, the sandy silt to sand deposit grades to a sand and gravel containing trace to some silt, trace clay and contains cobbles. The top of the coarser portion of the deposit is at about Elevation 186.3 m and 167.5 m and the thickness of this portion of the deposit is about 0.1 m and 1.1 m in the respective boreholes. Boreholes S202-11 and S202-18 were terminated within this deposit upon refusal to further split-spoon advancement. One SPT 'N'-value of 64 blows per 0.3 m of penetration was measured in Borehole S202-20 at the bottom of the borehole, indicating a very dense relative density. A grain size distribution test of one (1) sample of the sand and gravel portion of the deposit is shown on Figure B.S202-14 in Appendix B.



Bedrock / Refusal

Bedrock outcrops and knobs are present along the southern and northern limits of the investigated area. In Borehole S202-01 and DCPT S202-DC07 located at about STA 11+187.5 and 11+162.5, bedrock was confirmed by exposure by shovel excavation of the thin layer of topsoil encountered at the ground surface. The bedrock surface at the boreholes and DCPTs is inferred by refusal to further split-spoon and/or auger/casing advancement and shovel excavation or dynamic cone penetration between depths of about 0.1 m and 26.5 m below the ground surface, ranging from about Elevation 191.6 m to 156.4 m. In general, refusal was encountered at greater depth within the limits of the swamp crossing between about STA 11+195 and 11+237.5.

Groundwater Conditions

In general, the samples taken in the boreholes were moist to wet. Artesian conditions were observed in Boreholes S202-06 and S202-20 with the groundwater level upon completion of drilling measured at about 0.8 m and 0.6 m above ground surface, about Elevation 183.9 m at the respective boreholes. In the other boreholes, the water levels observed upon completion of drilling range from about Elevation 179 m to 188 m, typically measured at the ground surface and to depths ranging from about 0.6 m to 4.0 m below ground surface, except in Borehole S202-13 which was observed to be dry upon completion of drilling.

4.7 Highway 69 SBL – STA 11+350 to 11+375 (Swamp 203)

The plan, profile along the centreline and cross-section across the embankment of the new Highway 69 SBL alignment showing the borehole locations and interpreted stratigraphy between about STA 11+350 and 11+375 in the Township of Henvey are shown on Drawing C1 in Appendix C. The proposed alignment within this section of the highway is in a cut, up to about 10 m deep below the existing ground surface. A total of three (3) boreholes (Boreholes S203-01 to S203-03, inclusive) and three (3) DCPTs (DCPTs S203-DC01, S203-DC01A and S203-DC01B) were completed to investigate the subsurface conditions within this swamp area. The topography of this cut section of the proposed highway is comprised of bedrock-dominated high ground, containing a relatively flat swamp area located within the confines of tree covered slopes to the north and south. The ground cover around the perimeter of the swamp is comprised of visible bedrock outcrops and occasional areas of shallow water.

Ponded water was encountered in some areas of the site at the time of the investigation. The subsurface soils along the SBL alignment in Swamp 203 generally consist of a surficial layer of topsoil at the ground surface and a deposit of amorphous peat below the ponded water, underlain by a layer of sand, which in turn is underlain by inferred bedrock. Resistance to dynamic cone penetration, shovel excavation and borehole advancement, was encountered at depths of up to about 1.1 m, being deepest in the vicinity of about STA 11+365. Bedrock outcrops were observed in the vicinity of the proposed alignment and to the north and south limits of the swamp at about STA 11+350 and STA 11+375.

Water

Ponded water was encountered overlying ground surface in Borehole S203-02 to a depth of about 0.2 m.



Peat / Topsoil

A deposit of black to dark brown amorphous peat containing rootlets was encountered under the ponded water in Borehole S203-02. The top of the peat deposit is at about Elevation 196.3 m and the thickness of the deposit is about 0.9 m.

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

The natural water content measured on one (1) sample of the peat is about 405 per cent.

An approximately 0.1 m thick layer of topsoil was encountered in Boreholes S203-01 and S203-03 at the ground surface at about Elevation 197.5 m and 197.2 m, respectively. Bedrock was exposed by shovel (hand) excavation to confirm refusal at the bottom of this layer.

Sand

A layer of brown sand containing rootlets and organics was encountered below the peat deposit in Borehole S203-02. The top of this layer is at about Elevation 195.4 m and the thickness of the layer is about 0.1 m. The bottom of this deposit was defined by refusal to further split-spoon advancement and dynamic cone penetration.

The natural water content measured on a specimen of this layer is about 35 per cent.

Bedrock / Refusal

Bedrock outcrops are present to the north and south limits of the swamp at the location of Boreholes S203-01 and S203-03 at about STA 11+350 and 11+375, respectively. The bedrock surface at the boreholes and DCPTs is inferred by refusal to further split-spoon advancement and shovel excavation or dynamic cone penetration at depths between about 0.1 m and 1.1 m below the ground surface, corresponding to between about Elevation 197.5 m and 195.2 m. Refusal was encountered at a greater depth in the middle of the swamp at about STA 11+365.

Groundwater Conditions

The samples taken in the boreholes were wet at the time of the investigation. Water was ponded at the surface at the location of Borehole S203-02 to about Elevation 196.3 m (about 0.2 m deep).

4.8 Highway 69 NBL – STA 11+375 to 11+400 (Swamp 203)

The plan, profile along the centreline and cross-section across the embankment of the new Highway 69 NBL alignment showing the borehole locations and interpreted stratigraphy between about STA 11+350 and 11+375 in the Township of Henvey are shown on Drawings C1 and C2 in Appendix C. The proposed alignment within this section of the highway is in a cut, up to about 11 m deep below the existing ground surface. A total of three (3) boreholes (Boreholes S203-04 to S203-06, inclusive) and three (3) DCPTs (DCPTs S203-DC02, S203-DC03 and S203-DC03A) were completed to investigate the subsurface conditions within this swamp area.



DCPT S203-DC03 and S203-DC03A are additional DCPTS advanced near the south end of the swamp at about STA 11+365 to further confirm the subsurface conditions and the thickness of the overburden near or at the edge of the swamp. The topography of this cut section of the proposed highway is comprised of bedrock-dominated high ground, undulating within the swamp area and sloping upward to the north and south limits of the swamp. The ground cover in the swamp is characterized by a shallow layer of topsoil and exposed bedrock outcrops.

In general, the subsurface soils consist of a surficial layer of topsoil and a deposit of peat at the ground surface, underlain by a layer of sand, which in turn is underlain by inferred bedrock. Resistance to dynamic cone penetration and shovel excavation, was encountered at depths of up to about 0.9 m, being deepest near the south edge of the swamp at about STA 11+365, while bedrock outcrops are present at the north end of the swamp.

Topsoil

An approximately 0.1 m thick layer of topsoil was encountered in Borehole S203-06 at the ground surface corresponding to about Elevation 197.9 m. At this location, bedrock was exposed by shovel (hand) excavation to confirm refusal at the bottom of this layer.

Bedrock / Refusal

Bedrock outcrops are present at the north end of the swamp at the location of Boreholes S203-04 to S203-06 and DCPT 203-DC02 and the bedrock surface is inferred at depths of 0.7 m and 0.9 m below ground surface at DCPTs S203-DC03 and S203-DC03A, based on refusal to dynamic cone penetration, between about Elevation 197.8 m and 195.8 m. Refusal was encountered at greater depth at or near the south edge of the swamp at about STA 11+365.

Groundwater Conditions

Upon completion of excavation in Borehole S203-06, the excavated topsoil was observed to be moist. Standing / ponded water was observed at ground surface at some locations within this area.

4.9 Highway 69 SBL – STA 11+725 to 11+825 (Swamp 204)

The plan and profiles along the centreline and toes of the proposed embankment of the new Highway 69 SBL alignment showing the borehole locations and interpreted stratigraphy between about STA 11+725 and 11+825 in the Township of Henvey are shown on Drawings D1 and D2 in Appendix D. The alignment extends along a 100 m length of flat to gently sloping ground to the north towards Still River and the proposed highway embankment will be up to about 7.5 m high above the existing ground surface. Two critical cross-sections of the proposed embankment corresponding to the greatest new embankment height and/or the maximum thickness of soft, compressible cohesive soils, at approximately STA 11+760 and 11+810, are shown on Drawing D4 in Appendix D.



A total of nine (9) boreholes (Boreholes S204-01 to S204-09, inclusive) and four (4) Dynamic Cone Penetration Tests (DCPTs S204-DC01 to S204-DC04, inclusive) were completed to investigate the subsurface conditions within this swamp crossing/high fill area. In addition, two (2) boreholes (Boreholes S204-11 and S204-15) and two (2) Dynamic Cone Penetration Tests (DCPTs S204-DC06 and S204-DC08) advanced at the toe of the new Highway 69 NBL alignment were also utilized to supplement this investigation. The topography of this section of the proposed highway is relatively flat and gently sloping down to the north towards Still River, with ground cover consisting of wet grassy areas / pasture land, shrubs and areas of shallow open water. The swamp crossing/high fill area is bounded to the south by a moderately to densely tree covered valley slope and bedrock outcrops, and bounded to the north by Still River flowing in a east-west direction; the south bank is being densely tree covered in places.

In general, the subsurface soils along the SBL alignment in this area consist of localized deposits of sand and gravel/sand/silty sand fill and surficial layers of topsoil, underlain in places by a near surface deposit of sand to silt. The topsoil/fill and/or the sand to silt deposit are underlain by an extensive deposit of alternating layers of cohesive and cohesionless soils comprised of clayey silt to silty clay, sand to sandy silt/silt, clay to clayey silt, sandy silt to silt, silty clay to clay and silt to silty sand, underlain by inferred bedrock. Resistance to dynamic cone penetration, shovel excavation and borehole advancement, was encountered at depths of up to about 45.9 m at about STA 11+825. Bedrock outcrops are present along the southern limit of the investigated area.

Sand and Gravel to Sand/Silty Sand Fill

A cohesionless fill comprised of grey to brown sand and gravel, sand trace to some gravel and silty sand trace gravel, was encountered at the ground surface in Boreholes S204-02 to S204-04. The fill contains rootlets and an approximately 0.1 m thick layer of snow and ice cover was encountered in Borehole S204-04 at the time of the investigation. The top of the fill ranges from about Elevation 181.7 m to 181.4 m and the thickness ranges from about 0.5 m to 0.9 m.

An SPT 'N'-value measured within the fill is 49 blows per 0.3 m of penetration, indicating a dense relative density, possibly due to frozen ground conditions.

The natural water content measured on samples of the fill ranges from about 3 per cent to 38 per cent, with the higher water content value measured in the sample containing rootlets.

Topsoil

An approximately 0.1 m to 0.5 m thick layer of topsoil was encountered at the ground surface in Boreholes S204-01 and S204-05 to S204-09. The surface of topsoil across the boreholes typically ranges from about Elevation 183.9 m to 181 m. At DCPT S204-DC01, where bedrock was exposed by shovel (hand) excavation, the topsoil layer is 0.1 m thick and the surface of the topsoil is at about Elevation 186.4 m.

The natural water content measured on two (2) specimens of topsoil is about 34 per cent and 42 per cent.

Sand to Silt

A deposit of cohesionless soil comprised of brown to grey sand trace to some silt, silty sand, sandy silt and silt trace to some sand, and containing trace to some clay, rootlets and pockets of clayey silt was encountered



underlying either the topsoil or fill in Boreholes S204-01, S204-03, S204-04, S204-11 and S204-15. The top of this deposit ranges from about Elevation 183.6 m to 180.6 m and the thickness of the deposit ranges from about 0.3 m to 1.2 m. The bottom of this deposit was defined by refusal to further split-spoon and auger advancement and dynamic cone penetration in Borehole S204-01.

The SPT 'N'-values measured within this deposit range from 3 blows to 11 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

The natural water content measured on samples of this deposit ranges from about 18 per cent to 33 per cent.

A grain size distribution of one (1) sample from the sandy silt portion of this deposit is shown on Figure D.S204-01 in Appendix D.

An Atterberg limits test was carried out on one sample of the silt portion of this deposit, and measured a liquid limit of about 29 per cent, a plastic limit of about 25 per cent and a corresponding plasticity index of about 5 per cent. The result of the Atterberg limits test is shown on the plasticity chart on Figure D.S204-02 in Appendix D and indicates that the material is classified as silt of slight plasticity.

Clayey Silt to Silty Clay (Near Surface)

A near surface deposit of brown to grey clayey silt to silty clay, trace to some sand and trace gravel, containing rootlets and silty sand seams was encountered underlying the topsoil/fill and/or the sand to silt deposit in all of the boreholes except in Borehole S204-01. In general, the cohesive deposit is comprised of clayey silt to silty clay at the west toe and centre of the proposed embankment to silty clay towards the east toe of the embankment. The top of this deposit ranges from about Elevation 180.9 m to 180 m and the thickness of the deposit ranges from 1.4 m to 2.7 m. Boreholes S204-02 to S204-04 and S204-11 advanced near the south end of the investigated area terminated within this deposit upon refusal to split-spoon and/or auger/casing advancement and/or dynamic cone penetration in DCPTs driven adjacent to some of the boreholes.

The SPT 'N'-values measured within the clayey silt to silty clay deposit range from 0 blow (weight of hammer) to 13 blows per 0.3 m of penetration, but are typically less than 7 blows per 0.3 m of penetration, with a value of 50 blows per 0.02 m of penetration recorded at the depth of auger refusal in Borehole S204-02. In situ field vane tests carried out within this deposit measured undrained shear strengths ranging from about 17 kPa to 58 kPa, but typically less than 27 kPa, and the sensitivity is calculated to range from about 3 to 5. The field vane tests results indicate that the clayey silt to silty clay deposit has a soft to stiff consistency.

The natural water content measured on samples of the clayey silt to silty clay deposit ranges from about 23 per cent to 51 per cent, but is typically greater than 30 per cent.

A grain size distribution of one (1) sample of the silty clay portion of this deposit is shown on Figure D.S204-03 in Appendix D.

Atterberg limits tests were carried out on eight (8) specimens of the clayey silt to silty clay deposit and indicate liquid limits ranging from about 29 per cent to 47 per cent, plastic limits ranging from about 15 per cent to 24 per cent and plasticity indices ranging from about 12 per cent to 25 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure D.S204-04 in Appendix D and indicate the material to range from a clayey silt of low plasticity to silty clay of intermediate plasticity.



Sand to Sandy Silt to Silt (Upper)

A deposit of cohesionless soil comprised of brown to grey sand trace to some silt, silty sand, sand and silt, sandy silt and silt some sand was encountered underlying the near surface deposit of clayey silt to silty clay in Boreholes S204-05 to S204-09 and S204-15. The deposit generally contains trace to some clay, rootlets and organics. The top of this deposit ranges from about Elevation 179.2 m to 178.2 m and the thickness of the deposit ranges from about 4.0 m to 7.3 m.

The SPT 'N'-values measured within this deposit range from 1 blow to 22 blows per 0.3 m of penetration, with the higher N-values being recorded within the sand portion of this deposit, indicating a very loose to compact relative density.

The natural water content measured on samples of this deposit ranges from about 13 per cent to 29 per cent.

The grain size distributions of seven (7) samples of the sand to sandy silt to sand and silt to silty sand portion of this deposit are shown on Figure D.S204-05 in Appendix D.

Clayey Silt to Clay (Upper)

A deposit of cohesive soil comprised of brown to grey clayey silt, silty clay and clay was encountered underlying the upper deposit of sand to sandy silt to silt in Boreholes S204-05 to S204-09 and S204-15. In some boreholes, the deposit contains silt seams and sandy silt interlayers at various depths. The top of this deposit ranges from about Elevation 174.7 m to 171.4 m and the thickness of the deposit ranges from about 2.0 m to 6.6 m.

The SPT 'N'-values recorded within the cohesive deposit range from 0 blows (weight of hammer) to 4 blows per 0.3 m of penetration. In situ field vane tests carried out within this deposit measured undrained shear strengths ranging from about 32 kPa to 96 kPa, and the sensitivity is calculated to range from about 2 to 5. The field vane tests results indicate that the clay to clayey silt deposit has a firm to stiff consistency.

The natural water content measured on specimens of this deposit ranges from about 29 per cent to 118 per cent, but are generally less than 75 per cent.

Atterberg limits tests were carried out on three (3) specimens of the cohesive deposit and indicate liquid limits ranging from about 22 per cent to 51 per cent, plastic limits ranging from about 16 per cent to 20 per cent and plasticity indices ranging from about 6 per cent to 32 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure D.S204-06 in Appendix D and indicate the material to range from a clayey silt of low plasticity to clay of high plasticity.

Sandy Silt to Silt (Lower)

A deposit of grey sandy silt to silt trace to some sand, generally containing trace to some clay, was encountered underlying the clayey silt to clay deposit in Boreholes S204-05 to S204-09 and S204-15. Typically, the deposit ranges from sandy silt encountered at/near the centre and west toe of the proposed embankment to silt encountered along the proposed highway median. Within the silt deposit, silty clay interlayers and silty clay seams were encountered at varying depths. The top of this deposit ranges from about Elevation 172.7 m to 166.4 m and the thickness of the deposit typically ranges from about 1.8 m to 4.8 m, and up to about 6.4 m in Borehole S204-15 advanced near the centre of the investigated area.



The SPT 'N'-values measured within this deposit range from 2 blows to 19 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

The natural water content measured on samples of this deposit ranges from about 23 per cent to 32 per cent.

The grain size distributions of four (4) samples of the sandy silt portion of this deposit are shown on Figure D.S204-07 in Appendix D.

Atterberg limits tests were carried out on two (2) specimens of the silt portion of this deposit containing clayey silt seams and indicate liquid limits of about 22 per cent, plastic limits of about 17 per cent and 19 per cent, and plasticity indices of about 3 per cent and 5 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure D.S204-08 in Appendix D and indicate the material to be silt of slight plasticity.

Silty Clay to Clay (Lower)

A deposit of brown to grey silty clay to clay some silt and trace sand, containing silt and sandy silt interlayers and silt seams at varying depths, was encountered underlying the lower deposit of sandy silt to silt in Boreholes S204-05 to S204-09 and S204-15. The silty clay to clay deposit is intersected by an approximately 2.7 m to 3.0 m thick deposit of sand and silt containing trace to some clay in Boreholes S204-07 to S204-09, as described below. The top of the silty clay to clay deposit ranges from about Elevation 166.3 m to 164.5 m and the overall thickness of the deposit typically ranges from about 14.0 m to 16.4 m, and up to about 23.1 m in Borehole S204-09 advanced near the centre of the investigated area.

The SPT 'N'-values recorded within the silty clay to clay deposit range from 0 blows (weight of hammer) to 11 blows per 0.3 m of penetration. In situ field vane tests carried out within this deposit measured undrained shear strengths ranging from about 53 kPa to greater than 144 kPa, but are typically less than 99 kPa. The sensitivity is calculated to range from about 2 to 5. The field vane tests results indicate that the silty clay to clay deposit has a stiff to very stiff consistency.

The natural water content measured on samples of this deposit ranges from about 34 per cent to 56 per cent.

The grain size distributions of three (3) samples of this deposit are shown on Figure D.S204-09 in Appendix D.

Atterberg limits tests were carried out on nine (9) specimens of the cohesive deposit and indicate liquid limits ranging from about 46 per cent to 63 per cent, plastic limits ranging from about 17 per cent to 22 per cent and plasticity indices ranging from about 26 per cent to 43 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure D.S204-10A and D.S204-10B in Appendix D and indicate the material to range from a silty clay of intermediate plasticity to clay of high plasticity.

Laboratory consolidation tests were carried out on two (2) specimens of the clay deposit obtained from Shelby tube samples in Boreholes S204-05 and S204-07. Preconsolidation stresses of about 285 kPa and 305 kPa were estimated from the void ratio versus logarithmic pressure plot and from the total work versus pressure plot. Bulk unit weights of about 16.6 kN/m³ and 17.6 kN/m³, and specific gravities of about 2.77 were measured on the consolidation test specimens. Details of the test results are shown on Figures D.S204-11 and D.S204-12 in Appendix D, and are summarized below.



FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS - HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

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 S204-05 Sample 17	21.1 m / 160.1 m	190	285	95	1.5	1.0	0.08	1.57	1.1×10^{-3}
Borehole S204-07 Sample 20	4.1 m / 150.9 m	270	305	35	1.1	0.65	0.07	1.25	2.7×10^{-3}

Note: * For stress range between effective overburden stress and final stress due to 7.5 m high embankment, that is $190 \text{ kPa} \leq \sigma_v' \leq 330 \text{ kPa}$ and $270 \text{ kPa} \leq \sigma_v' \leq 410 \text{ kPa}$

where: σ_{vo}' is the in situ vertical effective overburden stress in kPa
 σ_p' is the preconsolidation stress in kPa
 σ_v' is the vertical effective stress in kPa
OCR is overconsolidation ratio
 e_o is 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

Sand and Silt (Interlayer)

A deposit of grey sand and silt, trace to some clay was encountered within the silty clay to clay deposit in Boreholes S204-07 to S204-09 advanced near the northern limit of the investigated area along the centreline and the west toe of the proposed embankment. The top of this interlayer is at about Elevation 161.1 m and the thickness of the layer is between about 2.7 m and 3.0 m.

The SPT 'N'-values measured within this interlayer range from 4 blows to 19 blows per 0.3 m of penetration, indicating a loose to compact relative density.

The natural water content measured on three (3) samples of this deposit ranges between about 21 per cent and 24 per cent.

A grain size distribution of one (1) sample of this deposit is shown on Figure D.S204-13 in Appendix D.

Silt to Silty Sand to Sand and Silt

Underlying the lower deposit of silty clay to clay, Boreholes S204-05, S204-06, S204-08, S204-09 and S204-15 encountered a cohesionless deposit of grey silt trace to some sand, to sandy silt, to sand and silt, to silty sand. The deposit generally contains trace to some clay. The top of this deposit ranges from about Elevation 152.3 m to 138.7 m and the thickness of the deposit ranges from about 3.0 m to 5.1 m in these boreholes. Boreholes S204-05, S204-06, S204-08 and S204-09 were terminated within this deposit; and the bottom of the silt deposit in Borehole S204-15 was defined by refusal to further split-spoon and casing advancement and dynamic cone penetration.

The SPT 'N'-values recorded within this deposit ranges from 11 blows to 42 blows per 0.3 m of penetration, indicating a compact to dense relative density.

The natural water content measured on samples of this deposit ranges from about 21 per cent to 27 per cent.



The grain size distributions of five (5) samples from this deposit are shown on Figures D.S204-14 in Appendix D.

Bedrock / Refusal

Bedrock outcrops and knobs are present along the southern limit of the investigated area. In DCPT S204-DC01 located at about STA 11+740, bedrock was confirmed by exposure by shovel excavation of the thin layer of topsoil encountered at the ground surface. The bedrock surface at the boreholes and DCPTs is inferred by refusal to further split-spoon and/or casing advancement and shovel excavation or dynamic cone penetration at depths between about 0.1 m and 45.9 m below the ground surface, which corresponds to about Elevation 183.0 m to 135.2 m. In general, refusal was encountered at greater depth towards the northern limit of the swamp crossing/high fill area between about STA 11+800 and 11+825.

Groundwater Conditions

In general, the samples taken in the boreholes were moist to wet. Water levels observed in the boreholes upon completion of drilling range from about Elevation 183.4 m to 177.2 m, measured between 0.5 m and 3.8 m below ground surface, with the exception of Borehole S204-03 which was observed to be dry upon completion of drilling; the water level in Borehole S204-02 was not recorded.

4.10 Highway 69 NBL – STA 11+700 to 11+800 (Swamp 204)

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 11+700 and 11+800 in the Township of Henvey are shown on Drawings D1, D2 and D3 in Appendix D. The alignment extends along a 100 m length of flat to gently sloping ground to the north towards the Still River and the proposed highway embankment will be up to about 7.5 m high above existing grade. Two critical cross-sections of the proposed embankment corresponding to the greatest new embankment height and/or the maximum thickness of soft, compressible cohesive soils, at approximately STA 11+760 and 11+810, are shown on Drawing D4 in Appendix D.

A total of nine (9) boreholes (Boreholes S204-10 to S204-18, inclusive) and four (4) Dynamic Cone Penetration Tests (DCPTs S204-DC05 to S204-DC08, inclusive) were completed to investigate the subsurface conditions within this swamp crossing/high fill area. In addition, two (2) boreholes (Boreholes S204-02 and S204-06) and two (2) Dynamic Cone Penetration Tests (DCPTs S204-DC02 and S204-DC04) advanced for the new Highway 69 SBL alignment were also utilized to supplement this investigation. The topography of this section of the proposed highway is relatively flat to gently sloping down to the north towards the Still River, with ground cover consisting of wet grassy areas / pasture land, shrubs and areas of shallow open water. The swamp crossing/high fill area is bounded to the south by a moderately to densely tree covered valley slope and bedrock outcrops, and bounded to the north by the Still River flowing in a east-west direction, the south bank being densely tree covered.

In general, the subsurface soils along the NBL alignment in this area consist of localized deposits of sand and gravel to sand/silty sand fill and/or topsoil, and surficial layers of topsoil underlain by a near surface deposit of silty sand to silt in places. The topsoil/fill and/or the silty sand to silt deposit are underlain by an extensive deposit of alternating layers of cohesive and cohesionless soils comprised of clayey silt to clay, sand to sand



and silt to silt, underlain by inferred bedrock. At one location, bedrock was cored and samples consisting of granite gneiss bedrock were retrieved. Resistance to dynamic cone penetration, shovel excavation and borehole advancement, was encountered at depths up to about 42.8 m below ground surface at about STA 11+800. Bedrock outcrops are present along the southern limit of the investigated area.

Sand and Gravel to Sand/Silty Sand Fill

A cohesionless fill comprised of brown sand and gravel, sand trace gravel, and silty sand, was encountered at the ground surface in Boreholes S204-02 and S204-12, and underlying a layer of topsoil in Borehole S204-13. The fill was interlayered with an approximately 0.1 m thick seam of snow and ice in Borehole S204-12 at the time of the investigation. The top of the fill deposit ranges from about Elevation 181.9 m to 181.4 m and the thickness of the deposit ranges from about 0.4 m to 0.9 m.

One SPT 'N'-value measured within the silty sand fill deposit in Borehole S204-13 is 6 blows per 0.3 m of penetration, indicating a loose relative density.

The natural water content measured on four (4) samples of the fill deposit ranges from about 3 per cent to 40 per cent, with the higher water content value measured in the sample containing rootlets.

Topsoil

An approximately 0.1 m to 0.5 m thick layer of topsoil was encountered at the ground surface in all the boreholes advanced in this area except in Boreholes S204-02 and S204-12, as well as below the sand and gravel fill in Borehole S204-13. The top of this layer at the borehole locations ranges from about Elevation 181.5 m to 181.0 m, but in Boreholes S204-10 and S204-11 which are located on higher ground near the south edge of the investigated area, the top of topsoil is at about Elevation 184.8 m and 183.6 m. In Borehole S204-10, the bedrock was exposed by shovel (hand) excavation.

The natural water content measured on four (4) specimens of topsoil ranges from about 24 per cent to 47 per cent.

Sand to Silt

A deposit of cohesionless soil comprised of brown to dark brown sand trace to some silt, silty sand and silt trace sand and containing trace to some clay, pockets of clayey silt and rootlets was encountered underlying the topsoil in Boreholes S204-11, S204-14, S204-15 and S204-17. The top of this deposit ranges from about Elevation 181.1 m to 180.8 m, and up to about Elevation 183.4 m in Borehole S204-11 located on higher ground near the south edge of the investigated area, and the thickness of the deposit ranges from about 0.2 m to 1.7 m.

The SPT 'N'-values measured within this deposit range from 4 blows to 9 blows per 0.3 m of penetration, indicating a loose relative density.

The natural water content measured on three (3) samples of this deposit ranges from about 21 per cent to 33 per cent.

An Atterberg limits test was carried out on one (1) sample of the silt portion of this deposit, and measured a liquid limit of about 29 per cent, a plastic limit of about 25 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 on Figure D.S204-15 in Appendix D and indicates that the material is classified as silt of slight plasticity.

Clayey Silt to Clay (Near Surface)

A near surface deposit of brown to grey clayey silt to clay, trace to some silt, trace to some sand and trace gravel, containing rootlets, silty sand and silt seams was encountered underlying the topsoil/fill and/or the sand to silt deposit in all of the boreholes advanced for this swamp crossing/high fill area, except in Borehole S204-10. In general, the cohesive deposit is comprised of clayey silt to silty clay along the west and east (median) toes of the proposed embankment to clayey silt to clay towards the centreline of the proposed embankment. The top of this deposit ranges from about Elevation 182.2 m to 180.2 m and the thickness of the deposit ranges from 0.7 m to 2.6 m. Boreholes S204-02 and S204-11 advanced near the south end of the area terminated within this deposit upon refusal to split-spoon/auger advancement and dynamic cone penetration in DCPTs advanced adjacent to some of the boreholes.

The SPT 'N'-values measured within the clayey silt to clay deposit range from 2 blows to 13 blows per 0.3 m of penetration, but are typically less than 7 blows per 0.3 m of penetration; a value of 50 blows per 0.02 m of penetration was recorded at the depth of auger refusal in Borehole S204-02. In situ field vane tests carried out within this deposit measured undrained shear strengths ranging from about 25 kPa to 58 kPa, and the sensitivity is calculated to be about 3 and 4. 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 samples of the clayey silt to clay deposit ranges from about 26 per cent to 48 per cent, but is typically greater than 30 per cent.

Atterberg limits tests were carried out on eight (8) specimens of the clayey silt to clay deposit and indicate liquid limits ranging from about 31 per cent to 51 per cent, plastic limits ranging from about 15 per cent to 24 per cent and plasticity indices ranging from about 12 per cent to 29 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure D.S204-16 in Appendix D and indicate the material to range from a clayey silt of low plasticity to clay of high plasticity.

Sand and Silt to Silt to Silty Sand (Upper)

A deposit of cohesionless soil comprised of brown to grey sand and silt to silt some sand, to sand trace to some silt and silty sand was encountered underlying the near surface deposit of clayey silt to silty clay in Boreholes S204-06 and S204-12 to S204-18. The deposit generally contains trace to some clay and clayey silt pockets. The top of this deposit ranges from about Elevation 179.2 m to 178.3 m and the thickness of the deposit ranges from about 1.0 m to 7.9 m, becoming thinner towards the southern limit of the investigated area.

The SPT 'N'-values measured within this deposit range from 1 blow to 24 blows per 0.3 m of penetration, with the higher N-values being recorded within the sand portion of this deposit, indicating a very loose to compact relative density.

The natural water content measured on samples of this deposit ranges from about 11 per cent to 29 per cent.

The grain size distributions of eight (8) samples of the sand and silt to silt to silty sand portion of this deposit are shown on Figures D.S204-17A and D.S204-17B in Appendix D.



Atterberg limits tests were carried out on two (2) samples of the silt portion of this deposit and indicate liquid limits of about 20 per cent and 21 per cent, plastic limits of about 17 per cent and plasticity indices of about 3 per cent to 4 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure D.S204-18 in Appendix D and indicate the material to be silt of slight plasticity.

Silty Clay (Upper)

A deposit of brown to grey silty clay was encountered underlying the upper cohesionless deposit of silt and sand and silt in Boreholes S204-06 and S204-15 located along the west toe of the proposed embankment. The top of this deposit is at about Elevation 174.4 m and 174.7 m and the thickness of the deposit is about 5.0 m and 2.0 m at the respective boreholes.

The SPT 'N'-values recorded within the upper cohesive deposit range from 0 blows (weight of hammer) to 2 blows per 0.3 m of penetration. In situ field vane tests carried out within this deposit measured undrained shear strengths ranging from about 32 kPa to 60 kPa, and the sensitivity is calculated to be between about 4 and 5. The field vane tests results indicate that the silty clay deposit has a firm to stiff consistency.

The natural water content measured on two (2) specimens of this deposit is about 50 per cent and 75 per cent.

Silt (Lower)

A deposit of grey silt, trace to some sand and trace to some clay, containing silty clay seams and silty clay interlayers, was encountered underlying the upper deposit of silty clay in Boreholes S204-06 and S204-15, advanced along the proposed highway median. The top of this deposit ranges from about Elevation 169.4 m and 172.7 m and the thickness of the deposit is about 4.8 m in Borehole S204-06 and about 6.4 m in Borehole S204-15.

The SPT 'N'-values measured within this deposit range from 2 blows to 12 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

The natural water content measured on samples of this deposit ranges from about 23 per cent to 32 per cent.

Atterberg limits tests were carried out on two (2) specimens of this deposit and indicate liquid limits of about 22 per cent, plastic limits of about 17 per cent and 19 per cent, and plasticity indices of about 3 per cent and 5 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure D.S204-19 in Appendix D and indicate the material to be silt of slight plasticity.

Clayey Silt to Clay (Lower)

A deposit of cohesive soil comprised of brown to grey clayey silt, silty clay and clay was encountered underlying the upper deposit of sand to sand and silt to silt in Boreholes S204-06 and S204-12 to S204-18. In some boreholes, the deposit contains trace sand, silty sand seams and silt interlayers at various depths. In Boreholes S204-06 and S204-15, located along the west toe of the proposed embankment, the cohesive deposit is separated into an upper and a lower deposit by the approximately 4.8 m to 6.4 m thick lower silt deposit, as described above. The top of the cohesive deposit ranges from about Elevation 178.2 m to 170.6 m, while in Boreholes S204-06 and S204-15 the top of the lower portion of the cohesive deposit is at about



Elevation 164.6 m and 166.3 m. The overall thickness of the cohesive deposit ranges from about 2.3 m to 25.1 m. The bottom of this deposit is defined by bedrock in Borehole S204-12 and by refusal to further split-spoon and casing advancement in Borehole S204-13.

The SPT 'N'-values recorded within the cohesive deposit range from 0 blows (weight of hammer) to 14 blows per 0.3 m of penetration. In situ field vane tests carried out within this deposit measured undrained shear strengths ranging from about 23 kPa to greater than 142 kPa, but generally greater than 50 kPa and the sensitivity is calculated to range from about 2 to 5. The field vane tests results indicate that the clayey silt to clay deposit has a soft to very stiff, but generally stiff consistency.

The natural water content measured on specimens of this deposit ranges from about 34 per cent to 76 per cent, but are generally greater than 40 per cent.

The grain size distributions of six (6) specimens of the silty clay to clay portion of this deposit are shown on Figure D.S204-20 in Appendix D.

Atterberg limits tests were carried out on twelve (12) specimens of the silty clay to clay deposit and indicate liquid limits ranging from about 35 per cent to 64 per cent, plastic limits ranging from about 14 per cent to 21 per cent and plasticity indices ranging from about 21 per cent to 45 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figures D.S204-21A and D.S204-21B in Appendix D and indicate the material to range from a silty clay of intermediate plasticity to clay of high plasticity.

A laboratory consolidation test was carried out on one (1) specimen of the clay deposit obtained from a Shelby tube sample in Borehole S204-14. A preconsolidation stress of about 155 kPa was estimated from the void ratio versus logarithmic pressure plot and from the total work versus pressure plot. A bulk unit weight of about 16.7 kN/m³ and a specific gravity of about 2.75 were measured on the consolidation test specimen. Details of the test results are shown on Figure D.S204-22 in Appendix D, and 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 S204-14 Sample 13	13.4 m / 168.1 m	95	155	60	1.6	0.87	0.06	1.46	2.7×10^{-3}

Note: * For stress range between effective overburden stress and final stress due to 7.5 m high embankment, that is $95 \text{ kPa} \leq \sigma_v' \leq 240 \text{ kPa}$

where: σ_{vo}' is the in situ effective overburden stress in kPa
 σ_p' is the preconsolidation stress in kPa
 σ_v' is the vertical effective stress in kPa
OCR is overconsolidation ratio
 e_o is 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

Sand and Silt to Silt (Interlayers)

An approximately 0.4 m thick pocket of grey silt and an approximately 1.8 m thick interlayer of grey sand and silt were encountered within the clay to silty clay deposit in Boreholes S204-17 at about Elevation 169.5 m and



166.3 m, respectively. Similarly, an approximately 3.1 m thick interlayer of grey silt, trace to some sand and trace clay was encountered within the silty clay to clay deposit in Borehole S204-18 at about Elevation 161.3 m.

Two SPT 'N'-values measured within the sand and silt to silt interlayers are 5 blows and 7 blows per 0.3 m of penetration, indicating a loose relative density.

The natural water content measured on a specimen of the silt pocket is about 25 per cent and the natural water content measured on one (1) sample of the silt interlayer is about 27 per cent.

A grain size distribution of one (1) sample of the silt interlayer is shown on Figure D.S204-23 in Appendix D.

An Atterberg limits test carried out on one specimen of the silt pocket 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.S204-24 in Appendix D and classified the material as silt of slight plasticity.

Silt to Sand

Underlying the clayey silt to clay deposit, Boreholes S204-06 and S204-14 to S204-18 encountered a deposit of cohesionless soil grading from grey silt trace to some sand, to sand and silt, to silty sand, to sand trace to some silt. The deposit generally contains trace to some clay and trace to some gravel. Within the sand to silty sand deposit in Borehole S204-14, boulders up to about 0.4 m thick were encountered at about Elevation 155.6 m and 157.9 m. The top of the silt to sand deposit ranges from about Elevation 157.5 m to 143.2 m and the thickness of the deposit ranges from about 2.3 m to 6.4 m. Boreholes S204-06 and S204-16 to S204-18 were terminated within this deposit; where as in Boreholes S204-14 and S204-15, the bottom of this deposit was defined by refusal to further split-spoon and/or casing advancement.

The SPT 'N'-values recorded within this deposit range from 4 blows to 34 blows per 0.3 m of penetration, generally indicating a loose to dense relative density; however, an SPT 'N'-value of 154 blows per 0.3 m of penetration was recorded at the bottom of Borehole S204-14.

The natural water content measured on samples of this deposit ranges from about 11 per cent to 27 per cent.

The grain size distributions of five (5) samples from the silt to sand and silt to silty sand portion of this deposit and a grain size distribution of one (1) sample of the sand portion of the deposit are shown on Figures D.S204-25A and Figure D.S204-25B, respectively in Appendix D.

Bedrock / Refusal

Bedrock outcrops and knobs are present along the southern limit of the investigated area. In Borehole S204-10 located at about STA 11+700, bedrock was confirmed by exposure by shovel excavation of the layer of topsoil encountered at the ground surface. The bedrock surface at the boreholes and DCPTs is inferred by refusal to further split-spoon and/or auger/casing advancement and shovel excavation or dynamic cone penetration between depths of about 0.2 m and 35.4 m below the ground surface, corresponding to between about Elevation 184.6 m and 145.7 m. In general, refusal was encountered at greater depth towards the northern limit of the swamp crossing/high fill area between about STA 11+785 and 11+800.



Bedrock was encountered at a depth of about 6 m, corresponding to Elevation 175.9 m, and core samples were recovered from Borehole S204-12. A photograph of the recovered samples is presented on Figure D.S204-26. The bedrock generally consist of granite gneiss and the core samples are described as fresh, medium crystalline, slightly porous, strong, foliated, pink, grey and black. The Rock Quality Designation (RQD) measured on the core samples is about 94 per cent, indicating a rock mass of excellent quality. The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of the core samples are about 90 per cent and 94 per cent, and about 97 per cent and 100 per cent, respectively.

Groundwater Conditions

In general, the samples taken in the boreholes were moist to wet. Water levels observed in the boreholes upon completion of drilling range from about Elevation 182.8 m to 177.2 m measured at depths between about 0.8 m to 3.8 below ground surface.

4.11 Highway 69 SBL – STA 12+200 to 12+375 (Swamp 205)

The plan and profiles along the centreline and toes of the proposed embankment of the new Highway 69 SBL alignment showing the borehole locations and interpreted stratigraphy between about STA 12+200 and 12+375 in the Township of Henvey are shown on Drawing E1 in Appendix E. The alignment extends across a swamp crossing/high fill area and the proposed highway embankment will be up to about 5 m high above existing grade. A total of fifteen (15) boreholes (Boreholes S205-01 to S205-15, inclusive) and nine (9) Dynamic Cone Penetration Tests (DCPTs S205-DC01 to S205-DC07, S205-DC05A and S205-DC06A) were completed to investigate the subsurface conditions within this swamp crossing/high fill area. The topography of this section of the proposed highway is gently sloping downward to the north, with the ground cover consisting of wet grassy areas, bedrock knobs, shrubs and shallow open water; and upward sloping, moderately tree covered terrain to the north of the swamp crossing/high fill area. Towards the northern limit of the swamp crossing/high fill area between about STA 12+250 and 12+375, the natural terrain of the area is undulating, and the ground surface elevation across this area is highly variable.

Ice and/or water were encountered at the surface in most of the boreholes advanced near the west toe of the proposed embankment. The subsurface soils along the SBL alignment in Swamp 205 generally consist of surficial layers of peat and topsoil at the ground surface or below the ice and water cover, underlain by a deposit of sand to silty sand in places. The peat/topsoil layer and/or the sand to silty sand deposit are underlain by a thick deposit of clayey silt to clay, which in turn is underlain by a deposit of silt to sand. At one location, the silt deposit grades to a gravelly sand and silt prior to refusal to split-spoon and casing advancement. Resistance to dynamic cone penetration, shovel excavation and borehole advancement, was encountered at depths of up to about 11.3 m below ice surface at about STA 12+300. Bedrock outcrops and knobs are present across the site and towards the north, south and west ends of the swamp crossing/high fill area.

Ice / Water

Ice, in places over ponded water, to depths between about 0.1 m and 0.3 m was encountered at the surface in Boreholes S205-07 to S205-09 and S205-12 at the time of the investigation.



Peat / Topsoil

An approximately 0.1 m to 0.3 m thick root mat and an about 0.3 m to 0.4 m thick layer of brown to black fibrous peat containing rootlets and wood fragments was encountered at the ground surface in Boreholes S205-02, S205-04, S205-06 and underlying the ice or water in Boreholes S205-07 to S205-09. An approximately 0.1 m to 0.4 m thick layer of topsoil was encountered at the ground surface in Boreholes S205-01, S205-03, S205-05, S205-10, S205-11 and S205-14, and below the ice cover in Borehole S205-12. The top of the peat or topsoil deposit ranges from about Elevation 189.4 m to 184.9 m. In Boreholes S205-04 and S205-10, bedrock was exposed below the peat and topsoil by shovel (hand) excavation.

The SPT 'N'-values measured within the peat deposit range from 1 blow to 5 blows per 0.3 m of penetration, indicating a very soft to firm consistency.

The natural water content measured on five (5) samples of the peat ranges from about 34 per cent to 688 per cent, whereas, the natural water content measured on a specimen of topsoil is about 93 per cent.

Sand to Silty Sand

A deposit of brown sand trace to some silt to silty sand containing trace gravel, trace to some clay, rootlets, organics and wood fragments was encountered underlying the topsoil in Boreholes S205-01, S205-03, S205-11 and S205-12, and underlying the peat deposit in Borehole S205-02. The top of this deposit ranges from about Elevation 189.3 m to 184.7 m and the thickness of the deposit ranges from about 0.1 m to 0.4 m in Boreholes S205-01 to S205-03 and S205-11, and is about 1.1 m in Borehole S205-12 where the deposit was fully penetrated. Borehole S205-01 was terminated within this deposit upon refusal to further split-spoon advancement.

The SPT 'N'-values measured within this deposit typically range from 2 blows to 9 blows per 0.3 m of penetration, with one 'N'-value of 26 blows per 0.13 m of penetration recorded prior to split-spoon refusal in Borehole S205-01, generally indicating a very loose to loose relative density.

The natural water content measured on samples of this deposit ranges from about 20 per cent to 26 per cent.

A grain size distribution of one (1) sample from the sand portion of this deposit is shown on Figure E.S205-01 in Appendix E.

Clayey Silt to Clay

A deposit of cohesive soil comprised of brown to grey clayey silt, silty clay and clay was encountered either below the peat/topsoil or below the sand deposit in Boreholes S205-02 to S205-10, S205-11, S205-12 and S205-14. The deposit generally contains trace to some gravel, trace to some sand, silt interlayers, and rootlets and wood fragments within the upper approximately 2.1 m. In Boreholes S205-02, the cohesive deposit is interlayered with an approximately 0.8 m thick deposit of sand. The top of the cohesive deposit ranges from about Elevation 188.1 m to 183.6 m and the thickness of the deposit ranges from about 1.0 m to 8.5 m being thickest in Borehole S205-09 advanced near the middle of the swamp crossing/high fill area. The bottom of this deposit was defined by refusal to further split-spoon advancement in Boreholes S205-03, S205-06, S205-08, S205-11 and S205-12 and dynamic cone penetration in DCPTs advanced adjacent to Boreholes S205-11 and S205-12.



The SPT 'N'-values measured within the clayey silt to clay deposit range from 1 blow to 15 blows per 0.3 m of penetration, but are typically less than 5 blows per 0.3 m of penetration, with a value of 50 blows per 0.13 m of penetration recorded at the bottom of Borehole S205-12. In situ field vane tests carried out within this deposit measured undrained shear strengths ranging from about 20 kPa to greater than 132 kPa, but are typically less than 100 kPa, and the sensitivity is calculated to range from about 2 to 5. The field vane tests results indicate that the clayey silt to clay deposit has a soft to very stiff consistency.

The natural water content measured on samples of this deposit ranges from about 20 per cent to 79 per cent.

Atterberg limits tests were carried out on ten (10) specimens of the cohesive deposit and indicate liquid limits ranging from about 21 per cent to 69 per cent, plastic limits ranging from about 15 per cent to 24 per cent and plasticity indices ranging from about 4 per cent to 45 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figures E.S205-02A and E.S205-02B in Appendix E and indicate the material ranges from clayey silt of low plasticity to clay of high plasticity.

A laboratory consolidation test was carried out on one (1) specimen of the clay deposit obtained from a Shelby tube sample in Borehole S205-07. A preconsolidation stress of about 55 kPa was estimated from the void ratio versus logarithmic pressure plot and from the total work versus pressure plot. A bulk unit weight of about 15.3 kN/m³ and a specific gravity of about 2.74 were measured on the consolidation test specimen. Details of the test results are shown on Figure E.S205-03 in Appendix E, and 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 S205-07 Sample 4	4.1 m / 182.7 m	20	55	35	2.8	1.0	0.12	2.10	5.6×10^{-4}

Note: * For stress range between effective overburden stress and final stress due to 5.0 m high embankment, that is $20 \text{ kPa} \leq \sigma_v' \leq 115 \text{ kPa}$

where: σ_{vo}' is the in situ vertical effective overburden stress in kPa
 σ_p' is the preconsolidation stress in kPa
 σ_v' is the vertical effective stress in kPa
OCR is overconsolidation ratio
 e_o is 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

As noted above, a 0.8 m thick layer of brown sand, trace gravel and trace silt containing pockets of clayey was encountered within the deposit of clayey silt to clay in Borehole S205-02 at about Elevation 186.2 m. A SPT 'N'-value of 3 blows per 0.3 m of penetration was recorded in this layer, indicating a very loose relative density.

Silt to Sand

A deposit of cohesionless soil comprised of brown to grey silt trace to some sand, silty sand and sand was encountered underlying the deposit of clayey silt to clay in Boreholes S205-02, S205-05, S205-07, S205-09 and S205-14. The deposit generally contains trace to some gravel, trace to some clay, rootlets and wood fragments. The top of this deposit ranges from about Elevation 187.1 m to 177.4 m and the thickness of the deposit ranges



from about 0.3 m to 1.8 m. Boreholes S205-02, S205-05, S205-07 and S205-14 were terminated within this deposit upon refusal to further split-spoon advancement.

The SPT 'N'-values measured within this deposit range from 7 blows to 44 blows per 0.3 m of penetration, with SPT 'N'-values of 50 blows per 0.03 m of penetration, 75 blows per 0.1 m of penetration and 100 blows per 0.13 m recorded at the bottom of Boreholes S205-05, S205-07 and S205-14, generally indicating loose to very dense relative density.

The natural water content measured on four (4) samples of this deposit ranges from about 16 per cent to 24 per cent.

A grain size distribution of one (1) sample of the silt portion of this deposit is shown on Figure E.S205-04 in Appendix E.

Gravelly Silty Sand

The silt to sand deposit encountered in Borehole S205-09 is underlain by a deposit of grey gravelly silty sand, trace clay and containing silty sand interlayers. The top of this deposit is at about Elevation 176.3 m, the thickness of the deposit is about 1.1 m, and it extends to the bottom of the borehole on refusal to split-spoon and casing advancement.

A SPT 'N'-value recorded within this deposit is 27 blows per 0.3 m of penetration, indicating a compact relative density.

The natural water content measured on one (1) sample of this deposit is about 13 per cent.

A grain size distribution of one (1) sample of this deposit is shown on Figure E.S205-05 in Appendix E.

Bedrock / Refusal

Bedrock outcrops and knobs are present to the north, south and west edges of this swamp crossing/high fill area. In Boreholes S205-04 and S205-10, bedrock was confirmed by exposure by shovel excavation of the thin layers of peat and topsoil, while Boreholes S205-13 and S205-15 and DCPT S205-DC01 are located on bedrock outcrops. The bedrock surface at the boreholes and DCPTs is inferred by refusal to further split-spoon and/or casing advancement and shovel excavation or dynamic cone penetration to a depth of about 11.2 m below ground surface (11.3 m below ice surface), that is between about Elevation 191.4 m and 175.2 m. In general, refusal was encountered at greater depth towards the middle of the swamp crossing/high fill area between about STA 12+275 and 12+300.

Groundwater Conditions

In general, the samples taken in the boreholes were moist to wet. Water levels observed in the boreholes upon completion of drilling range from about Elevation 187.4 m to 185.0 m, measured either at the ice or ground surface and to a depth of 1.2 m below the ground surface, with the exception of shovel excavation in Boreholes S205-04 and S205-10 where the water level was not noted upon completion of excavation, and Borehole S205-01 which was observed to be dry upon completion of drilling.



4.12 Highway 69 NBL – STA 12+750 to 12+825 (Swamp 206)

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 12+750 and 12+825 in the Township of Henvey are shown on Drawing F1 in Appendix F. The overall alignment extends across a high fill section 25 m long extending northerly from STA 12+750 to 12+775 and a swamp area about 50 m long from STA 12+775 to 12+825. The proposed embankment in this area will be up to about 5 m high above the existing ground surface. A total of seven (7) boreholes (Boreholes S206-01 to S206-07, inclusive) and six (6) Dynamic Cone Penetration Tests (DCPTs S206-DC01 to S206-DC04, S206-DC01A and S206-DC03A) were completed to investigate the subsurface conditions within the swamp crossing/high fill area. The topography of this section of the proposed highway is undulating, consisting of bedrock knobs and a low-lying swampy area towards the north east section of the site limits, and the ground cover is comprised of bare rock, shrubs and moderately treed areas. As a result of the varying nature of the terrain within this section of the proposed highway, the ground surface elevation across the site is highly variable.

The subsurface soils along the NBL alignment in the swamp crossing/high fill area in Swamp 206 generally consist of surficial layers of peat and topsoil at the ground surface or below ice cover, underlain by a deposit of sand to sandy silt, underlain by inferred bedrock. At one location within the swamp limits, the topsoil is underlain by a deposit of clayey silt which extends to refusal to split-spoon advancement. Resistance to dynamic cone penetration, shovel excavation and borehole advancement, was encountered at depths up to about 2.1 m below ground surface, being deepest at about STA 12+800. Bedrock outcrops and knobs are present along the southeast limit of the investigated area.

Ice / Water

Ice and water cover to a depth of 0.3 m was encountered at the surface in Borehole S206-04 at the time of investigation.

Peat / Topsoil

An approximately 0.3 m thick layer of dark grey fibrous peat containing rootlets and an approximately 0.1 m to 0.2 m thick layer of topsoil was encountered at the ground surface or below the ice and water cover in Boreholes S206-01 to S206-06. The top of the peat/topsoil ranges from about Elevation 189.2 m to 186.1 m. In Borehole S206-02, bedrock was exposed by shovel (hand) excavation.

Two SPT 'N'-values of 2 blows per 0.3 m of penetration were measured within the peat layer and at the interface of the topsoil and underlying clayey silt layers, indicating a very soft consistency.

The natural water content measured on a specimen of the topsoil layer is about 153 per cent.

Sand to Sandy Silt

A deposit of cohesionless soil comprised of brown to grey sand trace silt, sand and silt and sandy silt was encountered below the topsoil in Boreholes S206-01, S206-03 and S206-05, and below the peat in Borehole S206-06. The deposit generally contains trace to some gravel, trace to some clay, rootlets, topsoil and organics. The top of this deposit ranges from about Elevation 189.0 m to 185.8 m and the thickness of the



deposit ranges from about 0.3 m to 1.6 m. These boreholes were terminated within this deposit upon refusal to further split-spoon advancement and dynamic cone penetration.

The SPT 'N'-values measured within this deposit range from 2 blows to 29 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

The natural water content measured on samples of this deposit ranges from about 9 per cent to 26 per cent. In general, the near surface portion of this deposit was observed to be slightly organic and laboratory testing on specimens of the sand to sand and silt deposit from Borehole S206-03 measured organic contents of about 2 per cent and 3 per cent.

The grain size distributions of two (2) samples of the sand and silt portion of this deposit are shown on Figure F.S206-01 in Appendix F.

Clayey Silt

A cohesive deposit of grey clayey silt, trace sand and containing rootlets, was encountered underlying the topsoil in Borehole S206-04. The top of this deposit is at about Elevation 186.1 m and the thickness of the deposit is about 0.4 m. The bottom of this deposit was defined by refusal to further split-spoon advancement.

The SPT 'N'-value measured at the interface of the topsoil layer and clayey silt deposit is 2 blows per 0.3 m of penetration and at the bottom of the borehole, SPT 'N'-value of 75 blows per 0.1 m of penetration, generally indicating a very soft to very stiff consistency.

The natural water content measured on one (1) sample of this clayey silt deposit is about 31 per cent.

An Atterberg limits test carried out on one (1) specimen of the clayey silt deposit yielded a liquid limit of about 29 per cent and a plastic limit of about 21 per cent, corresponding to a plasticity index of about 8 per cent. The result of the Atterberg limits test is shown on the plasticity chart on Figure F.S206-2 in Appendix B and indicates the material to be clayey silt of low plasticity.

Bedrock / Refusal

Bedrock outcrops and knobs are present throughout the site and at the location of Boreholes S206-02 and S206-07, at about STA 12+765 and 12+825. The bedrock surface at the boreholes and DCPTs is inferred by refusal to further split-spoon advancement and shovel excavation or dynamic cone penetration at depths between about 0.1 m and 2.1 m below the ice cover or ground surface, corresponding to between about Elevation 188.5 m and 183.9 m. In general, refusal was encountered at greater depth near the northern limit of the swamp area between about STA 12+775 and 12+800.

Groundwater Conditions

In general, the samples taken in the boreholes were moist to wet. Water levels observed in the open boreholes upon completion of drilling range from about Elevation 188.3 m to 186.1 m, measured either at the ice or ground surface, with the exception of shovel excavation in Borehole S206-02 where the water level was not noted upon completion of excavating, and Borehole S206-05 which was observed to be dry upon completion of drilling.



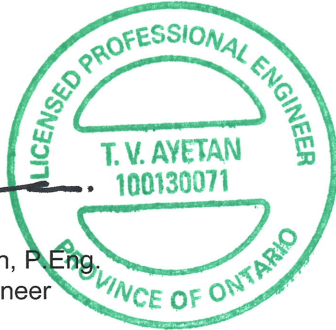
5.0 CLOSURE

The field personnel supervising the drilling program were Messrs. Matt Rhody, Randy Axford and Indulis Dumpis. This report was prepared by Ms. T. Veronica Ayetan, P. Eng., and was 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 Contact for this project and Principal with Golder, conducted an independent quality control review of the report.



Report Signature Page

T. Veronica Ayetan, P. Eng.
Geotechnical Engineer



J. Paul Dittrich, Ph.D., P. Eng.
Senior Geotechnical Engineer, Principal

Jorge M.A. Costa, P. Eng.
Designated MTO Contact, Principal



TV/TZ/CN/JPD/JMAC/sm

[Http://capws/sites/0911116014highway69FourLaning/Contract 2/Reporting/Final/Swamp Crossings and High Fill Areas/09-1111-6014-2520 RPT 12Jul30 Highway 69 Swamp Crossings and High Fill Areas.docx](http://capws/sites/0911116014highway69FourLaning/Contract%20Reporting/Final/Swamp%20Crossings%20and%20High%20Fill%20Areas/09-1111-6014-2520%20RPT%2012Jul30%20Highway%2069%20Swamp%20Crossings%20and%20High%20Fill%20Areas.docx)



PART B

FOUNDATION DESIGN REPORT
SWAMP CROSSINGS AND HIGH FILL AREAS – CONTRACT 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 5404-05-00; WP 5404-05-01



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 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 the swamp crossings and high fill embankments at various locations within Contract 2 along the proposed Highway 69 alignment, associated with the four-laning of Highway 69 in the Townships of Wallbridge, Henvey and Mowat. The proposed Contract 2 swamp crossing/high fill areas are located approximately 1.7 km north of the junction of the existing Highway 529 and Highway 69 and extend northerly for a total distance of about 4.5 km. As part of this work, foundation recommendations are required for areas of proposed swamp crossings and high fill embankments (about 800 m in total length). Table 1 summarizes the locations of the areas investigated within the Contract 2 project limits that require foundation design for the new Highway 69 alignment.

This report presents the results of embankment stability and settlement analyses and provides recommendations for stable embankment geometry and embankment fill materials and implementation of mitigation alternatives that may be required as a means to improve stability (if necessary) and reduce post-construction settlements. The report also addresses potential construction concerns and geotechnical problems associated with embankment construction, sub-excavating soft/organic materials and placement of new fill materials.

6.2 High Fill Embankments and Embankments Over Swamps

Based on the vertical profiles of the proposed Highway 69 alignment provided to Golder by URS on November 28, 2011, the new highway crossings over swamps and high fill sections will require fill embankments ranging in height from about 4 m to about 9 m. In areas where the new alignments pass through existing bedrock outcrops, rock cuts up to about 9 m deep will be required.

Sections 6.2.2 and 6.2.3 of this report summarize the methods used to analyze the stability and settlement for critical sections of swamp crossing/high fill embankment construction for the new four-lane Highway 69. Section 6.4 provides discussions related to recommendations of potential alternatives for mitigating embankment stability and settlement related design and construction issues. The results of the analyses and recommendations for mitigating stability and time-dependent settlements for each individual swamp crossing/high fill areas, where applicable, are presented in Section 6.5. General aspects of subgrade preparation and embankment construction are presented in Section 6.6. Recommendations on the excavation and stability of the deep cuts through rock are provided in Section 6.7.



At all areas, the analyses assume that the peat and near surface organic soils (encountered at the ground surface during drilling operations) will be removed prior to construction of the new embankments (as discussed in Section 6.6.1). For details on the thickness of organic deposits at each swamp crossing/high fill area, refer to Section 4.0. The piezometric conditions required in the analyses are based on the groundwater levels noted during drilling which were generally located at about or below the level of the natural ground surface at most borehole locations (except at three (3) borehole locations in Swamp 202 where the measured groundwater levels were above the ground surface).

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 the availability from rock blasting for road cuts required elsewhere on the project. In this regard, the majority of the stability and settlement analyses discussed in Section 6.5 have been carried out on the basis that the highway embankment will be constructed of rock fill. However, where a stability and/or settlement mitigation option requires the use of lightweight fill (i.e. expanded polystyrene (EPS)) as part of the construction of the embankments, rock fill cannot be used as the levelling pad or protective cover for the EPS due to the size of rock fill particles. As such, for these embankments, granular fill is to be used for levelling pad construction and side slope protective cover.

Rock Fill

The main advantage of constructing embankments using rock fill is the ability to achieve steeper side slopes (1.25H:1V), which is required in areas with limited right-of-way, as well as reducing the overall quantity of fill material required for the project and for placement of material 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 it cannot be used for as a levelling pad or protective cover where EPS is required for the construction of the highway embankment, and 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 berms should be incorporated into the rock fill embankment side slope profile for uninterrupted slopes greater than 10 m high. Given that the proposed new embankments in Contract 2 are less than 10 m high, 2 m wide mid-slope berms are not required.

Granular Fill

The main advantage of using granular fill for embankment construction is the ease of construction and negligible post-construction settlement within the embankment fill itself. However, this option will require a larger volume of fill and potentially 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 be well graded, locally available and/or imported granular material.

For granular fill embankments, 2 m wide berms should be incorporated into the side slope profiles for uninterrupted slopes greater than 8 m high.

6.2.2 Stability

The following sections outline the methodology used to evaluate embankment stability at the various swamp crossing/high fill areas and also present the parameters used in the analyses for each of the critical section(s). The results of the stability analyses are presented in Section 6.5 for each swamp crossing/high fill area where they are discussed together with the results of the settlement analyses and recommendations regarding possible design and construction alternatives to mitigate stability issues and/or post-construction settlement.

6.2.2.1 Methodology

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. Typically, there is one (1) critical section per area; however, in some areas, two (2) critical sections have been identified as a result of non-uniform soil deposits or embankment grades. 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, the stability of the proposed embankment section was considered adequate based on engineering judgement and precedent experience in similar soil conditions. The stability analysis assumes that the organic soils encountered at/below ground surface have been removed and replaced in accordance with OPSD 203.010 prior to construction of the new embankment.

All limit equilibrium slope stability analyses were carried out using the commercially available program Slide (Version 6.0), produced 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.

6.2.2.2 Parameter Selection

The simplified stratigraphy together with the associated strength(s) and unit weight(s) employed for the different native soil types at the critical sections in each swamp crossing/high fill area are summarized in Table 3. Additional details of foundation engineering parameters employed for the cohesive deposits (i.e. clayey silt / silty clay / clay) encountered in Swamps 202, 204 and 205 are provided on Figures B1, D1 and E1 in Appendices B, D and E, respectively. The rock fill modelled in the analyses is assumed to have a unit weight of 19 kN/m^3 and



an effective friction angle of 40°. The stability of the Highway 69 embankments was analyzed for a side slope geometry of 1.25H:1V.

The overburden encountered in the various areas is composed of either granular soils only (silts, sands, sandy silt/silty sand, and/or sand and gravel) or a combination of cohesive deposits (clayey silt, silty clay and/or clay) and granular 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 peat/root mat and granular soils were estimated from empirical correlations 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 analyses assuming 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 pressure (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

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 6.5 for each swamp crossing/high fill area where they are discussed together with the results of the stability analyses and recommendations regarding possible design and construction alternatives to mitigate stability issues and/or post-construction settlement.

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) produced 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 analysis



assumes that the organic soils encountered at/below ground surface have been removed and replaced in accordance with OPSD 203.010 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);
- Secondary time-dependent (creep) consolidation of the cohesive deposits (long-term); and,
- Self-weight compression of the embankment fill materials (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 sections of each swamp crossing/high fill area, the settlements estimated will generally represent the maximum 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 cohesive deposits (i.e. clayey silt / silty clay / clay) encountered in Swamps 202, 204 and 205 are provided on Figures B1, D1 and E1 in Appendices B, D and E, respectively.

The immediate compression of the cohesionless deposits (i.e. silt, sandy silt to silty sand, sand, sand and gravel and gravelly sand and silt) 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 CHBDC (2006) and adjusted, if necessary.

The consolidation settlement of the cohesive deposits was assessed using the results of the laboratory consolidation tests and, where appropriate, in situ field vane tests to estimate the deformation parameters for the cohesive deposits. In addition, the results of the laboratory index testing were also employed to further assess deformation parameters (i.e. recompression and compression indices) using empirical correlations proposed in literature by Koppula (1986), Terzaghi and Peck (1967), Kulhawy and Mayne (1990) and Azzouz et al. (1976). The correlation by Koppula (1986) relating the natural water content and liquid limit to the compression index was found to be the most consistent with the results of laboratory consolidation tests for the clayey soils at this site.

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



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

where:

$$\begin{aligned} S_{u(mob)} &= \mu S_{u(FV)} \\ \sigma'_p &= \text{preconsolidation pressure (kPa)} \\ S_{u(mob)} &= \text{average mobilized undrained shear strength (kPa)} \\ S_{u(FV)} &= \text{undrained shear strength from field vane test (kPa)} \\ \mu &= \text{Bjerrum's correction factor based on Plasticity Index} \end{aligned}$$

The coefficient of consolidation, c_v (cm^2/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 soils.

In addition to primary consolidation within the cohesive deposits (i.e. clays to clayey silts), 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 completion of primary settlement at each location:

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

where :

$$\begin{aligned} S_c &= \text{secondary consolidation (creep) settlement (mm)} \\ C_{\alpha\epsilon} &= \text{modified secondary compression index as estimated from laboratory consolidation tests} \\ H &= \text{initial thickness of compressible clay deposit (mm)} \\ t &= \text{post-construction period of interest (20 years)} \\ t_{EOP} &= \text{time to reach end of primary consolidation (years)} \\ w_n &= \text{natural water content (\%)} \end{aligned}$$

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 Foundations Guideline, 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 Special Provision 206S03. 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 Foundations 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 Foundations 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 of design for high fill embankments and embankments over swamp crossings is in accordance with Section 1.1 of MTO Foundation Guideline, Embankment Settlement Criteria for Design, dated March 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 King's highway.

Where new embankments approach structural elements, more stringent settlement criterion will apply in accordance with Section 1.2 of the MTO Foundation Guideline.

These performance criteria form part of the overall design performance for each swamp crossing/high fill area.

6.4 Stability and Settlement Mitigation Options

At each high fill embankment and embankment over swamp crossing location, stability and settlement have been assessed based on existing subsurface conditions and proposed embankment fill heights. 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. A brief discussion on these alternatives is given below.

Details of the mitigation options for all swamp crossing/high fill areas requiring measures to mitigate stability/settlement issues of the foundation soils are provided in Section 6.5. These include full sub-excavation of unsuitable (organic/soft) soils, preloading with or without surcharging, wick drains, lightweight fill (EPS) and combinations of these measures. Other ground improvement measures such as rammed aggregate piers, deep soil mixing and dynamic compaction are not considered suitable or cost effective due to the composition (i.e. cohesive soils) and/or thickness of the deposit and/or high groundwater conditions, and are not further discussed 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 was carried out for each of the swamp crossing/high fill areas. The results of the settlement analyses are summarized in Table 4.

A summary of the proposed works, recommended embankment fill type and side slope, 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 is provided in Table 5. Depending on the area, one alternative or a combination of alternatives may be more advantageous than others.

In areas where the foundation soils consist of granular soils only, it is not anticipated that there will be embankment stability issues or significant settlement problems, provided all organic layers (i.e. peat) are removed prior to construction and the requirements for mid-height berms are incorporated into the embankment design, 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.

6.4.1 Full Sub-Excavation

Sub-excavation of the weak/soft and compressible (i.e. clayey) 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 embankments in some areas of this site. The removal of the soft,



compressible cohesive soils would result in improved stability and significantly reduce settlements within the areas underlain by relatively thinner cohesive deposits and/or where high embankment fills are proposed. It should be noted that despite the reduction in 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 additional below grade rock fill embankment should be constructed with the same side slope profile as that of the above grade embankment (i.e. 1.25H:1V for rock fill) since the natural slope of the rock fill should not be affected by placement under water. This option has the advantage that construction of the above grade embankment could proceed upon completion of sub-excavation and replacement without concerns of instability. However, full sub-excavation may produce a large volume of spoil material for disposal and may require a large volume of rock fill replacement. 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 and may require 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 swamp crossing/high fill areas varies across the project sites, ranging from about 1.2 m to about 42.4 m below existing ground surface. In general, groundwater was encountered at ground surface at all swamp locations except at few locations where artesian conditions were encountered in Swamp 202. 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, specialized drag-line equipment 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 most suited for areas where there is a limited thickness of organics (peat) 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;
- 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, in addition to sub-excavation, to satisfy the settlement performance criterion;
- May require a larger right-of-way corridor; and,



- Greater quantities of rock fill required.

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

As an alternative to 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 upper portion 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, the upper portions of the weak/soft cohesive deposit would be removed to improve the stability and potentially reduce settlements of the embankment. Stability (toe) berms consist of rock fill buttresses placed against the toe of the proposed embankment fill, producing a stepped embankment cross-section geometry. 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 highway 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 while limiting the potential for instability of the embankment.

It should also be noted that with preloading, it is still required that all existing 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 removal of cohesive soils and their replacement with rock fill is not considered practical (i.e. depth of cohesive deposits is 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;
- Will 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;
- An instrumentation and monitoring program may be required to assess when the settlement performance criterion has been achieved; and,
- Re-grading is required to account for settlement prior to construction of the final pavement structure.

6.4.3 Surcharging (with 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 achieved. 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 reduces the time for of primary consolidation over that achieved by preloading only, resulting in over consolidation of the underlying compressible foundations soils. 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 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 over 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 over 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 are required for stability as compared to preloading alone;
- An instrumentation and monitoring program may be required 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 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 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.

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 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 creep settlement of the cohesive deposit (if not compensated for by surcharging or lightweight fill);
- An instrumentation and monitoring program is required to assess when the settlement performance criterion has been achieved; and,
- Re-grading is required 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 subsurface 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 no available time in the construction schedule for a sufficient preload or surcharge period. In addition, lightweight fill can be used in conjunction with preloading, surcharging and wick drain designs in order to optimize the design.

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 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 requirements on top of the EPS).



6.4.6 Instrumentation and Monitoring

For some areas where the preloading and surcharging options are adopted and in all areas where staged construction and/or wick drains foundation options are adopted, the magnitude and time-rate of settlement as well as dissipation of pore pressures during and after construction of embankments should be assessed with monitoring instrumentation. Such monitoring would consist of installing settlement pins/stakes (Ss), settlement plates (SPs) 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 preloading/surcharging period. In addition, standpipe piezometers (SPPs) may be required and are usually installed to provide background 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. Specifications for the type, number and layout of the instrumentation, together with the supply, installation, protection and monitoring frequency should be included as Non-Standard Special Provisions in the Contract Documents.

6.5 Results of Analysis

The results of the stability and settlement analyses for each swamp crossing/high fill area are provided in the following sections. In addition, the options and recommendations for achieving the target FoS for the required embankment geometry and for minimizing the time-dependent, post-construction settlements 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 Appendices.

In areas where the foundation soils consist of cohesionless deposits only, it is anticipated that there will not be any significant risk of instability of the embankments. Similarly, 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 schedule to maintain stability or to mitigate settlement of the foundation soils.

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). In these areas, the post-construction settlement of rock fill may exceed the settlement performance criterion. As such, the embankment would need to be preloaded to obtain acceptable post-construction settlements associated with long-term performance of the embankment.



6.5.1 Highway 69 SBL – STA 17+750 to 17+775 and Highway 69 NBL – STA 17+700 to 17+750 (Swamp 201)

The swamp area extending from about STA 17+700 to 17+775 along the proposed Highway 69 Southbound lane (SBL) and Northbound lane (NBL) alignments requires new embankments up to about 4 m high to achieve the proposed vertical highway profile. The topography of this section of the proposed highway is a relatively flat to low-lying area between gently sloping bedrock ridges located beyond the north and south limits of the investigated area, and the ground is moderately tree covered encompassing a wet grassy area.

The subsurface conditions in this area generally consist of an about 0.1 m to 0.7 m thick organic deposit (root mat, peat and topsoil) underlain by a deposit of loose sand and silt to sand up to about 0.9 m thick, containing organics. The sand and silt to sand is in turn underlain by an up to 0.6 m thick deposit of compact sand and gravel over inferred bedrock (along the proposed SBL embankment) or an up to 1.9 m thick deposit of soft to stiff silty clay over inferred bedrock (along the proposed NBL embankment).

Bedrock outcrops are present in the area of the proposed alignment and refusal to split-spoon advancement, shovel excavation and dynamic cone penetration is indicative of the potential bedrock surface. In general, refusal was encountered at depths of up to about 3.1 m below ground surface.

Details of the subsurface conditions for this swamp crossing are presented in Section 4.3 and shown on Drawings A1 and A2 in Appendix A.

The simplified stratigraphy and the associated unit weight, 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 ground surface, based on the groundwater levels noted during drilling.

6.5.1.1 Stability

Based on the results of the subsurface investigation and review of the profile drawings, the critical section (i.e. the greatest embankment height and/or maximum thickness of soft, compressible foundation soils) for this swamp crossing is located at approximately STA 17+700 on the NBL embankment. The stability analysis for the up to 4 m high rock fill embankments carried out at the critical section indicates that after the completion of construction (including removal and replacement of the very soft organic deposits), the embankments will have a Factor of Safety (FoS) of 1.3 or greater for deep-seated, global failure surfaces that would impact the operation of the highway.

6.5.1.2 Settlement

To estimate the magnitude of the expected settlements due to new construction, analysis was carried out at the critical section representative of the subsurface conditions within the swamp crossing area, at approximately STA 17+700 on the NBL embankment.

Based on the results of the settlement analysis, with the organic material (up to 0.7 m deep) sub-excavated and replaced with rock fill, the total settlement of the foundation soils at the critical section is estimated to be about 55 mm. The estimated total settlement is comprised of about 5 mm of immediate settlement due to compression



of the cohesionless deposits and about 50 mm of primary consolidation of the up to 1.9 m thick cohesive deposit.

Based on an average coefficient of consolidation (c_v) of about $8.3 \times 10^{-3} \text{ cm}^2/\text{s}$ estimated for the cohesive deposit, the imposed loading conditions for the approximately 4 m high embankment plus about 0.6 m backfill for replacement of the organic deposits, and assuming two-way drainage of the 1.9 m thick cohesive deposit, it is estimated that about 90 per cent of the primary consolidation settlement will be completed in about 15 days.

Given that the final effective stress (resulting from the imposed loading) is less than the preconsolidation pressure of the cohesive deposit in this area, secondary consolidation (creep) settlement for the cohesive deposit is expected to be negligible.

In addition, the total settlement of the rock fill embankment itself at the critical section (based on a 4 m high embankment plus about 0.6 m of additional rock fill required after removal of the organic deposits) is estimated to be about 30 mm, with about 20 mm expected to occur within six (6) months following completion of construction of the embankment, about 5 mm occurring during the next six (6) months and about 5 mm expected to occur over the remaining design life of the embankment.

The estimated total post-construction settlement of the foundation soils and embankment rock fill after completion of embankment construction is estimated to be approximately 80 mm and, therefore, in accordance with the settlement performance criterion in Section 6.3, no foundation mitigation measures are required in this area.

6.5.2 Highway 69 SBL – STA 11+175 to 11+275 and Highway 69 NBL – STA 11+100 to 11+225 (Swamp 202)

The area extending from about STA 11+100 to 11+275 along the proposed Highway 69 Southbound lanes (SBL) and Northbound lanes (NBL) alignment requires new embankments up to about 6.5 m high to achieve the proposed vertical highway profile. The topography of this section of proposed highway is a generally flat to low-lying area located within the confines of tree covered valley slopes to the north and south, consisting of wet grassy areas and a small creek traversing the valley from east to west near the middle of the swamp. In general, the ground cover consists of bedrock outcrops, grass and shrubs and is moderately treed in some areas.

The subsurface conditions in this area generally consist of about 0.1 m to 1.2 m of organic deposits (peat, topsoil and organic silty sand) underlain by a deposit of very loose to dense silty sand to sand up to about 0.7 m thick. Underlying the silty sand to sand is a very soft to stiff clayey silt to clay deposit containing up to about 1.2 m thick silt and sand interlayers. The thickness of the clayey silt to clay deposit ranges from about 0.9 m to 18.9 m, corresponding to a maximum depth of about 19.8 m to the bottom of the clayey silt to clay deposit below existing ground surface. The clayey silt to clay deposit is subsequently underlain by a deposit of sandy silt to sand and/or silty sand and gravel generally up to about 4.8 m thick, but is about 10.2 m thick at one location. The cohesionless deposit is in turn underlain by granite gneiss bedrock or inferred bedrock.

Bedrock outcrops are present at the north and south ends of the investigated area. Refusal to split-spoon, auger and/or casing advancement and shovel excavation or dynamic cone penetration, was encountered between depths of about 0.1 m and 26.5 m. In general, refusal was encountered at greater depth within the central limits of the swamp crossing between about STA 11+195 and 11+237.5.



Details of the subsurface conditions for this swamp crossing/high fill area are presented in Section 4.5 and shown on Drawings B1 to B4 in Appendix B.

The simplified stratigraphy and the associated unit weight, strength, deformation and time-rate consolidation parameters employed for the different soil types encountered in this area are summarized in Table 3. Additional details of foundation engineering parameters employed for the cohesive deposits (i.e. clayey silt / silty clay / clay) encountered in Swamp 202 are provided in Figure B1 in Appendix B. The piezometric condition used in the analyses is the water table at the ground surface.

6.5.2.1 Stability

The critical section (i.e. the greatest embankment height and/or maximum thickness of soft, compressible foundation soils) for this area encompasses the full length of the swamp crossing, between about STA 11+100 and 11+275 where the proposed embankment height is about 6.5 m and the clayey silt, silty clay and clay deposits are up to about 18 m thick. The stability analysis for up to 6.5 m high rock fill embankments carried out at the critical section indicates that after completion of construction (including removal and replacement of the topsoil), the embankment will have a Factor of Safety (FoS) of approximately 0.8 for a deep-seated, global failure surface that would impact the operation of the highway.

To achieve a FoS greater than or equal to 1.3 for the proposed 6.5 m high rock fill embankment, it would be necessary to construct stability berms along the toes of the embankments. Stability analysis indicates that 3 m high by 20 m wide toe berms along the outside embankment toes, as well as a median infill 1.5 m high along the median between the SBL and NBL embankment, would be required at the level of the existing ground surface for the full length of the swamp crossing, as shown on Figure B2.

The size of the toe berm required for embankment stability along the critical section is likely not feasible due to property limits and right-of-way restrictions and considering the requirements for two (2) culverts to be installed through the embankments. As such, other stability mitigations options must be considered.

6.5.2.2 Settlement

To estimate the magnitude of the expected settlements due to new construction, analysis was carried out at the critical section representative of the subsurface conditions within the swamp crossing/high fill area, between approximately STA 11+185 and 11+250.

Based on the results of the settlement analysis with the organic material (up to 1.2 m deep) sub-excavated and replaced with rock fill, the total settlement of the foundation soils is estimated to be about 1,510 mm. The estimated total settlement is comprised of about 65 mm of immediate settlement due to compression of the cohesionless deposits and about 1,445 mm of primary consolidation of the 18 m thick cohesive deposit.

Based on an average coefficient of consolidation (c_v) of about $1.9 \times 10^{-3} \text{ cm}^2/\text{s}$ estimated for the cohesive deposit, the imposed loading conditions for the approximately 6.5 m high embankment plus about 0.6 m backfill for replacement of the organic deposits at the critical section, and assuming two-way drainage of the 18 m thick cohesive deposit, it is estimated that about 90 per cent of the primary consolidation settlement will be completed in about 4,165 days (or about 11.4 years). A longer duration will be required to meet the settlement performance criterion.



The magnitude of secondary consolidation (creep) settlement for the cohesive deposit is expected to be about 270 mm per log-cycle of time for this area corresponding to about 165 mm over a 20-year period following completion of construction.

In addition, the total settlement of the rock fill embankment itself (based on a 6.5 m high embankment plus about 0.6 m of additional rock fill required after removal of the organic deposits at the critical section) is estimated to be about 65 mm, with about 50 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.

6.5.2.3 Mitigation of Stability Issues and/or Time Dependent Settlements

The presence of the up to 18 m thick clayey silt to clay deposit influences both the stability and the settlement for the up to 6.5 m high embankments. In order to construct the embankments to achieve a FoS greater than or equal to 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 summarised in Table B1 in Appendix B. Given the thick cohesive deposits (the bottom of which are up to 19.8 m below ground surface) and the associated magnitude of primary and secondary consolidation settlement (about 1,510 mm) of the foundation soils under a 6.5 m high embankment, a combination of a partial preloading followed by installation of lightweight (EPS) fill is ranked as the preferred mitigation.

Full Sub-Excavation

Taking into consideration the depth to the bottom of the clay deposit (i.e. up to about 20 m below the existing ground surface), full sub-excavation of the cohesive deposit is not feasible for this area.

Preloading with Toe Berms

If preloading is adopted as the foundation mitigation option for the up to 6.5 m high rock fill embankments at this location, 3 m high by 20 m wide toe berms along the outside embankment toes as well as a median infill of 1.5 m high along the inside embankment toe of the SBL and NBL embankment at the level of the existing ground surface would be required for the full length of the swamp crossing in order to maintain a FoS greater than or equal to 1.3 as shown on Figure B2. However, in order to meet the settlement performance criterion of less than 100 mm over a 20-year period following completion of construction, it is estimated that a preload period of 8,500 days (or about 23.3 years) will be required.

Given the long duration of the preload period and the need for large stability berms along the outside embankment toes to maintain stability under preloading, preloading is not considered to be practical for this area.



Surcharging with Toe Berms

Based on stability analysis for an up to 8.5 m high surcharge embankment (consisting of 6.5 m of rock fill and 2 m of granular surcharge), a two-tiered toe berm consisting of a 1.5 m high by 40 m wide lower tier and a 1.5 m high by 25 m wide upper tier, at the level of the existing ground surface along the outside embankment toes as well as a median infill of 2.5 m high along the inside embankment toes of the SBL and NBL embankment would be required for the full length of the swamp crossing in order to maintain a FoS greater than or equal to 1.3 as shown on Figure B3.

In addition, in order to meet the settlement performance criterion of less than 100 mm over a 20-year period following completion of construction, it is estimated that a surcharge period of 2,600 days (or about 7.1 years) will be required. Considering the relatively long duration associated with the surcharge period at this location, the magnitude and time-rate of settlement as well as dissipation of excess pore pressures during and after construction of the surcharge embankment should be assessed by monitoring this area to confirm the end of the surcharge period. Monitoring instrumentation would consist of settlement plates (SPs), vibrating wire piezometers (VWPs) and standpipe piezometers (SPPs).

Given the long duration of the surcharge period and the need for large stability berms to maintain embankment stability under surcharging, surcharging is not considered to be practical for this area and also may not be feasible due to property limits and right-of-way restrictions and considering the requirements for the two (2) culverts to be installed through the embankments.

Wick Drains with Lightweight Fill

Due to the large settlements and long duration to complete primary consolidation associated with the up to 6.5 m rock fill embankments, consideration could be given to the use of wick drains to expedite the consolidation settlement process of the thick cohesive deposits.

If 8.5 m high surcharge embankments (consisting of 6.5 m of rock fills and 2 m of granular surcharges) are to be constructed instantaneously (i.e. without any delays between lift placement) while still maintaining a FoS of 1.3, two-tiered toe berms, consisting of a 1.5 m high by 40 m wide lower tier and a 1.5 m high by 25 m wide upper tier, at the level of the existing ground surface would be required along the outside embankment toes as well as a median infill of 2.5 m high along the inside embankment toes of the SBL and NBL embankment for the full length of the swamp crossing. If wick drains are to be adopted as the settlement mitigation option, detailed wick drain design and additional stability analysis should be carried out to assess whether staged construction and/or smaller toe berms could be utilized to maintain a FoS greater than or equal 1.3.

Preliminary analysis using a wick drain spacing of 1.5 m in a triangular pattern to full depth through to the bottom of the cohesive deposits together with a 2 m high surcharge indicates that 90 per cent of primary consolidation would be completed in about 325 days. However, given the magnitude of secondary consolidation (creep) settlement for the cohesive deposits, it is estimated that a surcharge period of 390 days would be required in order to meet the settlement performance criterion of 100 mm of settlement over a 20-year period following completion of construction.

The total settlement of the foundation soils during construction is estimated to be about 1,145 mm comprised of about 105 mm of immediate settlement due to compression of the cohesionless deposits and about 1,040 mm of primary and secondary consolidation within the cohesive deposits. In addition, about 80 mm of short-term rock fill settlement is expected to occur. As such, approximately 1 m of lightweight fill (i.e. expanded polystyrene



(EPS)) would be required to be incorporated into the final construction of the embankment. The purpose of incorporating the EPS into the construction of the final embankment is to attain the proposed final embankment grade without additional loading on the foundation soils (to satisfy the settlement performance criterion).

Considering the long duration associated with the surcharge period, the magnitude and time rate of settlement as well as dissipation of excess pore pressures during and after construction of the surcharge embankment should be assessed by monitoring this area to confirm the end of the surcharge period. Monitoring instrumentation would consist of settlement plates (SPs), vibrating wire piezometers (VWPs) and standpipe piezometers (SPPs).

Taking into consideration that the use of wick drains will likely require large stability berms which may require the acquisition of additional property and which could also pose additional challenges for the design of the two (2) culverts to be installed through the embankments in this area, as well as risk with respect to the presence of artesian groundwater pressures affecting design, this option is not considered the preferred foundation mitigation for this area. A detailed wick drain investigation and design would be required to further assess the potential benefits of this alternative.

Lightweight Fill with Partial Preloading

Due to the need for toe berms and given the large settlements associated with the up to 6.5 m high rock fill embankments, consideration could be given to constructing the proposed embankments with lightweight fill (i.e. expanded polystyrene (EPS)) to mitigate against stability issues as well as to reduce total settlements affecting the performance of the highway. For the up to 6.5 m high embankments, with 2H:1V side slopes (consisting of 1 m granular base (which includes a 300 mm thick levelling pad), up to 4.5 m of EPS cores and 1 m of granular protective cover/pavement structure), the stability analysis indicates that the embankment will have a FoS of 1.3 or greater for deep-seated, global failure surfaces as shown on Figure B4.

Based on the results of the settlement analysis, the total settlement of the foundation soils for this embankment composition is estimated to be about 490 mm. The estimated total settlement is comprised of between about 25 mm and 35 mm of immediate settlement due to compression of the cohesionless deposits, and between about 170 mm and 200 mm of primary consolidation and between about 15 mm and 60 mm of secondary consolidation for the 18 m thick cohesive deposit.

In order to satisfy the settlement performance criterion of 100 mm of settlement over a 20-year period following completion of construction, it is recommended that a 3.5 m high Granular 'B' Type II preload embankments with temporary toe berms 1.5 m high by 2.5 m wide, at the level of the existing ground surface along the outside embankment toes (for the full length of the swamp crossing in order to maintain a FoS greater than or equal to 1.3) initially be constructed and left in place for a minimum preload period of 130 days.

To facilitate the assessment for the end of the preload period, instrumentation and monitoring during and after construction will be required. Monitoring instrumentation would consist of settlement plates (SPs), vibrating wire piezometers (VWPs) and standpipe piezometers (SPPs).

Upon the completion of the preload period, the granular preload embankments are to be reduced to a height of 0.7 m above ground surface and the final EPS embankment constructed (including a 300 mm thick levelling pad beneath the EPS and a 1 m thick granular protective cover/pavement structure over the EPS cores).



Although a significant quantity of EPS fill will be required for this alternative, it may have the following advantages over the Wick Drain with Lightweight Fill option:

- Detailed wick drain investigation and design is not required;
- Wick drain installation is not required;
- Relatively slow embankment construction in stages is avoided;
- Construction of large toe berms (potentially requiring acquisition of additional property to widen the right-of-way and, in turn, necessitating construction of longer culverts) is avoided;
- Handling of fill for embankment construction, surcharging and then removing for culverts construction and EPS placement is reduced; and,
- Shorter (preload) period required to achieve settlement performance criterion.

Given the above, the lightweight fill with partial preloading is currently considered as the preferred mitigation option for this area.

It should be noted that there are potential cost savings to be realized by adopting the Wick Drains with Lightweight Fill alternative; however, this cannot be confirmed without carrying out a Detailed Wick Drain Investigation and Design.

6.5.3 Highway 69 SBL – STA 11+350 to 11+375 and Highway 69 NBL – STA 11+375 to 11+400 (Swamp 203)

This swamp crossing extends from about STA 11+350 to 11+400 along the proposed Highway 69 Southbound lanes (SBL) and Northbound lanes (NBL) and is located within the confines of a large bedrock outcrop. The new highway alignment is to be in cut through this area and the cut is proposed to be up to about 11 m deep from the existing ground surface to achieve the vertical highway profile. The natural topography of this cut section of the proposed highway is relatively flat, bordered by tree covered valley slopes to the north and south; and the ground cover is generally comprised of visible bedrock outcrops and occasional shallow water.

Where encountered, the overburden soil in this area is generally shallow consisting of an about 0.1 m to 0.9 m thick layers of topsoil and peat, underlain by an up to about 0.3 m thick layer of very loose sand, underlain by inferred bedrock. In addition, the cut in this area may be below a perched groundwater level since ponded water was encountered in some of the investigated areas.

Bedrock outcrops are present in and around the area of the proposed alignment, and refusal to split-spoon advancement, shovel excavation and dynamic cone penetration is indicative of the potential bedrock surface. In general, refusal was encountered at depths of up to about 1.1 m below existing ground surface.

Details of the subsurface conditions for this deep cut section are presented in Section 4.7 and shown on Drawing C1 in Appendix C.

Given the thin overburden encountered in this swamp crossing (i.e. less than 1.1 m deep) and considering the new vertical alignment is proposed to be located up to about 11 m below the existing ground surface in this area, the excavation will be predominately through bedrock. Recommendations on the excavation and stability of the deep cuts through bedrock are provided in Section 6.7.



6.5.4 Highway 69 SBL – STA 11+725 to 11+825 and Highway 69 NBL – STA 11+700 to 11+800 (Swamp 204)

The swamp crossing/high fill embankment area extending from about STA 11+700 to 11+825 along the proposed Highway 69 Southbound lanes (SBL) and Northbound lanes (NBL) alignment requires new embankments up to about 7.5 m high to achieve the proposed vertical highway profile. The natural topography of this swamp crossing/high fill area is relatively flat to low-lying with the ground cover primarily consisting of wet grassy areas and shrubs with some areas of shallow open water. The swamp crossing/high fill area is bounded to the south by a moderately to densely tree covered valley slope and bedrock outcrops, and bounded to the north by the Still River flowing generally in a east-west direction.

The subsurface conditions in this area generally consist of an up to about 0.5 m thick layer of topsoil over an about 0.5 m to 0.9 m thick deposit of sand and gravel to sand/silty sand fill, underlain by near surface deposits of up to about 1.7 m thick sand to silt and up to about 2.7 m thick clayey silt to silty clay, corresponding to a maximum depth of about 3.9 m below existing ground surface. The clayey silt to silty clay deposit is then underlain by an upper deposit of very loose to compact sand to sandy silt to silt up to about 7.9 m thick. The upper sand to sandy silt deposit is in turn underlain by deposits of soft to stiff silty clay to clay, interlayers of silt to silty sand, and stiff and very stiff silty clay to clay. The thickness of the silty clay to clay deposits (including the silt to silty sand interlayers) ranges from about 2.3 m to 28.2 m, corresponding to a maximum depth of about 42.4 m below existing ground surface. In some boreholes, an up to about 5.1 m thick deposit of compact to dense silt to silty sand was encountered beneath the lower silty clay to clay deposit and this deposit extends to refusal at these locations. Below the silty clay to clay deposit is a loose to very dense silt to sand deposit which was penetrated for a thickness between about 3.0 m and 6.4 m, corresponding to a maximum depth of about 39.3 m below existing ground surface. Where encountered, all boreholes were terminated within this lower silt and sand deposit.

Bedrock outcrops are present along the southern limit of the investigated area and to the north of and beyond the adjacent Still River traversing the northern limit of the investigated area. Refusal to split-spoon and/or casing advancement and shovel excavation or dynamic cone penetration, was encountered at depths of between about 0.1 m and 45.9 m. In general, refusal was encountered at greater depth towards the northern limit of the swamp crossing/high fill area, towards Still River.

Details of the subsurface conditions for this swamp crossing/high fill area are presented in Section 4.9 and shown on Drawings D1 to D4 in Appendix D.

The simplified stratigraphy and the associated unit weight, strength, deformation and time-rate consolidation parameters employed for the different soil types encountered in this area are summarized in Table 3. Additional details of foundation engineering parameters employed for the cohesive deposits (i.e. clayey silt / silty clay / clay) encountered in Swamp 204 are provided on Figure D1 in Appendix D. The piezometric condition used in the analyses is the water table at top of the upper sand to silt deposit, based on the groundwater levels noted during drilling.

6.5.4.1 Stability

The critical section (i.e. the greatest embankment height and/or maximum thickness of soft, compressible foundation soils) for this area encompasses the full length of the swamp crossing/high fill area, between about



STA 11+700 and 11+825 where the proposed embankment height is about 7.5 m and the clayey silt, silty clay and clay deposits are up to about 28.2 m thick. The stability analysis for a 7.5 m high rock fill embankment carried out at the critical section indicates that after completion of construction (including removal and replacement of the topsoil), the embankment will have a Factor of Safety (FoS) of approximately 1.2 for a deep-seated, global failure surface that would impact the operation of the highway.

To achieve a FoS greater than or equal to 1.3 for the proposed 7.5 m high rock fill embankment, it would be necessary to construct stability berms along the outside toes of the embankments. Between about STA 11+725 and 11+825 of the SBL and between about STA 11+750 and 11+800 of the NBL, stability analysis indicates that 3 m high by 2.5 m wide toe berms at the level of the existing ground surface would be required along the outside embankment toes, as shown on Figure D2.

As an alternative to the toe berms, 4 m wide localized sub-excavation of the near surface clayey silt to silty clay deposit (up to about 2.6 m deep) replaced with rock fill along the exterior side slope of the embankment can also be considered to maintain a FoS greater than or equal to 1.3. The outer limit of the 4 m wide excavation would be defined by a line drawn at a slope of 1.25H:1V from the proposed embankment toe to the base of the near surface cohesive deposit, as illustrated on Figure D3.

However, regardless of the method adopted, between about STA 11+700 and 11+750 of the NBL, stability analysis indicates that achieve a FoS greater than or equal of 1.3, a 3 m high by 4 m wide toe berm at the level of the existing ground surface would be required along the outside embankment toe as shown on Figure D4, or complete sub-excavation of the near surface clayey silt to silt clay deposit within the footprint of the NBL embankment between STA 11+700 and 11+750 would be required as shown on Figure D5.

6.5.4.2 Settlement

To estimate the magnitude of the expected settlements due to new construction, analysis was carried out at the critical section representative of the subsurface conditions within the swamp crossing/high fill area, between approximately STA 11+700 and 11+825.

Based on the results of the settlement analysis with the organic material (up to 0.2 m deep) sub-excavated and replaced with rock fill, the total settlement of the foundation soils is estimated to be about 1,325 mm. The estimated total settlement is comprised of about 265 mm of immediate settlement due to compression of the cohesionless deposits and about 1,060 mm of primary consolidation of the cohesive deposits.

Based on an average coefficient of consolidation (c_v) of between about $1.8 \times 10^{-3} \text{ cm}^2/\text{s}$ and $3.2 \times 10^{-3} \text{ cm}^2/\text{s}$ estimated for the various cohesive deposits, the imposed loading conditions for the approximately 7.5 m high embankment plus about 0.2 m backfill for replacement of the organic deposits, and assuming two-way drainage for the various cohesive deposits, it is estimated that about 90 per cent of the primary consolidation settlement will be completed in about 3,000 days (or about 8 years). A longer duration will be required to meet the settlement performance criterion.

The magnitude of total secondary consolidation (creep) settlement for the various cohesive deposits is estimated to be about 380 mm per log-cycle of time for this area corresponding to about 245 mm over a 20-year period following completion of construction.

In addition, the total settlement of the rock fill embankment itself (based on a 7.5 m high embankment plus about 0.2 m of additional rock fill required after removal of the organic deposits) 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.

6.5.4.3 Mitigation of Stability Issues and/or Time Dependent Settlements

The presence of multiple deposits of clayey silt to clay, with a combined thickness of up to about 30.3 m, influences both the stability and the settlement for the up to 7.5 m high embankments. In order to construct the embankments to achieve a FoS greater than or equal to 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 D1 in Appendix D. Given the extensive cohesive deposits (the bottom of which are up to 42.4 m below ground surface) and the associated magnitude of primary and secondary consolidation settlement (about 1,305 mm) of the foundation soils under a 7.5 m high embankment, a combination of a partial preloading followed by installation of lightweight (EPS) fill is ranked as the preferred mitigation at this location.

Full Sub-Excavation

Taking into consideration the depth to the bottom of the clay deposits (i.e. up to about 42.4 m below the existing ground surface), full sub-excavation of the cohesive deposit is not feasible for this area.

Preloading with Toe Berms or Localized Shallow Sub-Excavation

If preloading is adopted as the foundation mitigation option for the up to 7.5 m high rock fill embankments at this location, 3 m high by 2.5 m wide toe berms at the level of the existing ground surface along the outside embankment toes would be required between about STA 11+725 and 11+825 of the SBL and between about STA 11+750 and 11+800 of the NBL in order to maintain a FoS greater than or equal to 1.3. Alternatively, in place of stability berms along the outer embankment toes, a 4 m wide localized sub-excavation of the near surface cohesive deposit (up to 2.6 m deep) replaced with rock fill along the embankment exterior side slopes could be considered to maintain a FoS greater than or equal to 1.3. However, to achieve a FoS greater than or equal to 1.3 between about STA 11+700 and 11+750 of the NBL, a 3 m high by 4 m wide toe berm at the level of the existing ground surface along the outside embankment toe would be required or complete sub-excavation of the near surface clayey silt to silt clay deposit within the footprint of the NBL embankment would have to be carried out.

Taking into consideration that the proposed SBL and NBL embankments are contiguous to the proposed Still River bridge structures, the settlement performance criterion in this area is 50 mm over a 20-year period following completion of construction (consistent with Section 1.2 of the MTO Foundation Guideline, Embankment Settlement Criteria for Design). In order to meet the settlement performance criterion, it is estimated that a preload period of 21,000 days (or about 57.5 years) would be required.

Given the extremely long duration of the preload period, preloading is not considered to be practical for this area.



Surcharging with Toe Berms

Based on stability analysis for an up to 9.5 m high surcharge embankment (consisting of 7.5 m of rock fill and 2 m of granular surcharge), a 3 m high by 6 m wide toe berm at the level of the existing ground surface would be required along the outside embankment toe (i.e. on the west side of embankment) as well as a median infill of 2 m high along the inside embankment toe of the SBL and NBL embankment between about STA 11+725 and 11+825 of the SBL and between about STA 11+750 and 11+800 of the NBL, to maintain a FoS greater than or equal to 1.3 as shown on Figure D6. Alternatively, a 5.5 m wide localized sub-excavation of the near surface clayey silt to silty clay deposit (up to about 2.6 m deep) replaced with rock fill along the embankment exterior side slopes can also be considered to maintain a FoS greater than or equal to 1.3. The outer limit of the 5.5 m wide excavation would be defined by a line drawn at a slope of 1.25H:1V from the proposed embankment toe to the base of the near surface cohesive deposit, as illustrated on Figure D7. However, between about STA 11+700 and 11+750 of the NBL, a 3 m high by 15 m wide toe berm at the level of the existing ground surface along the outside embankment toe would be required in order to maintain a FoS greater than or equal to 1.3 as shown on Figure D8. It should be noted that a FoS equal to or greater than 1.3 cannot be achieved by completely sub-excavating the near surface cohesive deposit in this area.

In order to meet the settlement performance criterion, it is estimated that a surcharge period of 4,400 days (or about 12 years) would be required.

Given the extremely long duration of the surcharge period and the requirement for a large toe berm between STA 11+700 and 11+750 on the outside toe of the NBL embankment, surcharging is not considered to be practical for this area.

Wick Drains with Lightweight Fill

Due to the large settlements and long duration to complete primary consolidation associated with the up to 7.5 m rock fill embankment, the use of wick drains could be considered to expedite the consolidation settlement process of the thick cohesive deposits.

If 9.5 m high surcharge embankments (consisting of 7.5 m of rock fill and 2 m of granular surcharge) are constructed instantaneously (i.e. without any delays between lift placement) while still maintaining a FoS of 1.3, 3 m high by 6 m wide stability berms at the level of the existing ground surface along the outside embankment toes as well as a median infill of 2 m along the inside embankment toe of the SBL and NBL embankment would be required between about STA 11+725 and 11+825 of the SBL and between about STA 11+750 and 11+800 of the NBL. However, between about STA 11+700 and 11+750 of the NBL, a 3 m high by 15 m wide toe berm at the level of the existing ground surface along the outside embankment toe would also be required. If wick drains are to be adopted as the settlement mitigation option, detailed wick drain design and additional stability analysis should be carried out to assess whether staged construction and/or smaller toe berms could be utilized to maintain a FoS of greater than or equal 1.3.

Preliminary analysis using a wick drain spacing of 1.5 m in a triangular pattern to full depth through to the bottom of the cohesive deposits indicates that the estimated time to reach 90 per cent of primary consolidation is about 345 days. However, given the large magnitude of secondary consolidation (creep) settlement for the cohesive deposits, it is estimated that a surcharge period of 2,100 days (or about 5.7 years) would be required to achieve the settlement performance criterion of 50 mm of settlement over a 20-year period following completion of construction.



FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS - HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

The total settlement of the foundation soils during construction is estimated to be about 1,955 mm and comprised of about 310 mm of immediate settlement due to compression of the cohesionless deposits, about 1,585 mm of primary and secondary consolidation within the cohesive deposits and about 60 mm of short-term and long-term rock fill settlement. As such, approximately 2.0 m of lightweight fill (i.e. expanded polystyrene (EPS)) would have to be incorporated into the final construction of the embankment to satisfy the settlement performance criterion and to achieve the proposed final embankment grade without additional loading onto the foundation soils.

Considering the relatively long duration associated with the surcharge period, the magnitude and time rate of settlement as well as dissipation of excess pore pressures should be assessed by monitoring this area to confirm completion of the surcharging period. Monitoring instrumentation would consist of settlement plates (SPs), vibrating wire piezometers (VWPs) and standpipe piezometers (SPPs).

To reduce the estimated surcharge period of 2,100 days, consideration could be given to increasing the height of the surcharge embankment and/or incorporating additional EPS into the final configuration of the embankment. The following summarizes the analyses carried out with various combinations of surcharge embankment heights, rock fill thicknesses and EPS thicknesses using a 1.5 m wick drain spacing in a triangular pattern.

Option No.	Initial Height of Surcharge Embankment (m)	Final Rock Fill Thickness ⁽¹⁾ (Granular Cover) (m)	Minimum EPS Thickness ⁽²⁾ (m)	Surcharge Period (days)	Settlement During Surcharge Period ⁽³⁾ (mm)	EPS Top-Up Thickness ⁽⁴⁾ (m)	Total EPS Thickness (m)
1	9.5 ⁽⁵⁾ (7.5+2.0)	3.0 (1.0)	3.5	180	1,175	1.5	5.0
2		4.0 (1.0)	2.5	290	1,380	1.5	4.0
3		5.0 (1.0)	1.5	520	1,585	2.0	3.5
4		6.0 (1.0)	0.5	1,100	1,755	2.0	2.5
5	11.5 ⁽⁶⁾ (7.5+4.0)	3.0 (1.0)	3.5	150	1,210	1.5	5.0
6		4.0 (1.0)	2.5	230	1,405	1.5	4.0
7		5.0 (1.0)	1.5	380	1,610	2.0	3.5
8		6.0 (1.0)	0.5	640	1,800	2.0	2.5

- Notes:
- (1) The rock fill thickness refers to the total thickness of rock fill to be left in place prior to the construction of the final embankment. As a result of settlements of the foundation soils during the surcharge period, portions of the rock fill will be below the original ground surface. 1 m thick granular protective cover/pavement structure are to be placed over the EPS cores.
 - (2) Minimum EPS thickness refers to the thickness of EPS required to achieve the proposed embankment grade without accounting for the settlement of the foundation soils during the surcharge period.
 - (3) Settlement during surcharge period includes immediate settlement of cohesionless soils as well as primary and secondary consolidation settlement of cohesive soils.
 - (4) The EPS top-up thickness refers to the additional amount of EPS required as part of the final embankment construction to achieve the proposed embankment grade to account for the settlement of the foundation soils during the surcharge period. EPS top-up thicknesses are rounded up to the nearest 0.5 m.



- (5) To maintain a FoS greater than or equal to 1.3 for a 9.5 m high surcharge embankment, 3 m high by 6 m wide stability berms at the level of the existing ground surface along the outside embankment toes as well as a median infill of 2 m along the inside embankment toes of the SBL and NBL embankments would be required between about STA 11+725 and 11+825 of the SBL and between about STA 11+750 and 11+800 of the NBL. Between about STA 11+700 and 11+750 of the NBL, a 3 m high by 15 m wide toe berm at the level of the existing ground surface along the outside embankment toe would be required in order to maintain a FoS greater than or equal to 1.3.
- (6) To maintain a FoS greater than or equal to 1.3 for a 11.5 m high surcharge embankment, a 3 m high by 9 m wide stability berm at the level of the existing ground surface along the outside embankment toes as well as a median infill of 3 m along the inside embankment toes of the SBL and NBL embankments would be required.

It is understood that the current construction schedule for Contract 2 is approximately one (1) year and therefore, based on the above preliminary results, Option No. 2 could be considered to meet the settlement performance criterion while minimizing the height of surcharge, the size of toe berms and the amount of EPS.

If Option No. 2 is to be adopted for settlement mitigation in this area, the following summarizes the sequence for which the proposed embankment is to be constructed:

- Place sand blanket and install wick drains at a spacing of 1.5 m in a triangular pattern over the footprint of the proposed embankment and;
- Install monitoring instrumentation;
- Construct 9.5 m high rock fill surcharge embankments with 3 m high by 6 m wide stability berms at the level of the existing ground surface along the outside embankment toes as well as a median infill 2 m high along the inside embankment toes between about STA 11+725 and 11+825 of the SBL and between about STA 11+750 and 11+800 of the NBL, and 3 m high by 15 m wide toe berm at the level of the existing ground surface along the outside NBL embankment toe between about STA 11+700 and 11+750;
- Upon completion of the surcharge period of 290 days, reduce the surcharge embankments to a height of about 2.5 m above ground surface;
- Construct EPS cores (up to 4.0 m thick) for both SBL and NBL embankments; and,
- Construct 1 m thick granular protective cover/pavement structure over the EPS cores.

Given the complexity of the wick drain design and the resulting risks and uncertainties, the requirement for stability berms and median infill and/or staged construction, the requirement for large quantities of EPS despite the use of wick drains, as well as cost associated with the construction operations, this option is not considered the preferred alternative for this area.

Lightweight Fill with Partial Preloading

Due to the need for toe berms and given the large settlements associated with the up to 7.5 m high rock fill embankments, consideration could be given to constructing the proposed embankments with lightweight fill (i.e. expanded polystyrene (EPS)) to mitigate against stability issues as well as to reduce total settlements affecting



the performance of the highway. For the up to 7.5 m high embankments with 2H:1V side slopes (consisting of 1 m granular base (which includes a 300 mm thick levelling pad), up to 5.5 m of EPS cores and 1 m of granular protective cover/pavement structure), the stability analysis indicates that the embankment will have a FoS of 1.3 or greater for deep-seated, global failure surfaces as shown on Figure D9.

Based on the results of the settlement analysis, the total settlement of the foundation soils for this embankment composition is estimated to be about 305 mm. The estimated total settlement is comprised of between about 75 mm and 80 mm of immediate settlement due to compression of the cohesionless deposits, and between about 105 mm and 155 mm of primary consolidation and between about 65 mm and 75 mm of secondary consolidation, for the cohesive deposits.

In order to satisfy the settlement performance criterion of 50 mm of settlement over a 20-year period following completion of construction, it is recommended that 4.5 m high Granular 'B' Type II preload embankments be initially constructed and left in place for a minimum preload period of 95 days.

To facilitate the assessment for the end of the preload period, instrumentation and monitoring during and after construction will be required. Monitoring instrumentation would consist of settlement plates (SPs), vibrating wire piezometers (VWPs) and standpipe piezometers (SPPs).

Upon completion of the preload period, the granular preload embankments are to be reduced to a height of 0.7 m above ground surface and the final EPS embankments constructed (including a 300 mm thick levelling pad beneath the EPS and 1 m granular protective cover/pavement structure over the EPS cores).

Although a significant quantity of EPS fill will be required for this alternative, it has the following advantages over the Wick Drain with Lightweight Fill option:

- Detailed wick drain investigation and design is not required;
- Very deep wick drain installation (i.e. up to 42.4 m below ground surface) through sand and silt interlayers is avoided;
- Relatively slow embankment construction in stages is avoided;
- Construction of toe berms is not required;
- Handling of fill for embankment construction, surcharging and then removing for EPS placement is reduced; and,
- Shorter (preload) period required to achieve the settlement performance criterion;

Given the above, lightweight fill with partial preloading is considered as the preferred mitigation option for this area.

6.5.5 Highway 69 SBL – STA 12+200 to 12+375 (Swamp 205)

The swamp area extending from about STA 12+200 to 12+375 along the proposed Highway 69 Southbound lanes (SBL) alignment requires a new embankment up to about 5 m high to achieve the proposed vertical highway profile. The natural topography of this swamp area is gently sloping downward to the north, with the ground cover consisting of wet grassy areas, bedrock outcrop, shrubs and shallow open water, with upward sloping moderately tree covered terrain to the north of the swamp crossing. Towards the northern limit of the



swamp between about STA 12+250 and 12+375, the natural terrain of the area is undulating and the ground surface elevation across this area is highly variable.

The subsurface conditions in this area generally consist of an about 0.1 m to 0.4 m thick organic deposit (root mat, fibrous peat and topsoil), underlain by a deposit of very loose to compact sand to silty sand up to about 1.1 m thick. The organic deposit and the sand to silty sand deposit are in turn underlain by a soft to very stiff clayey silt to clay deposit. The thickness of the clayey silt to clay deposit ranges from about 1.0 m to 8.5 m, corresponding to a maximum depth of about 8.9 m to the bottom of the cohesive deposit below existing ground surface. Underlying the clayey silt to clay deposit is a loose to very dense silt to sand deposit up to about 1.1 m thick, and a compact gravelly sand and silt deposit at one location.

Bedrock outcrops are present across the site and towards the north, south and west ends of the swamp. Refusal to split-spoon and/or casing advancement and shovel excavation or dynamic cone penetration, was encountered at depths of up to about 11.3 m below ground surface. In general, refusal was encountered at greater depth towards the middle of the swamp between about STA 12+275 and 12+300.

Details of the subsurface conditions for this swamp area are presented in Section 4.11 and shown on Drawing E1 in Appendix E.

The simplified stratigraphy and the associated unit weight, strength, deformation and time-rate consolidation parameters employed for the different soil types encountered in this area are summarized in Table 3. Additional details of foundation engineering parameters employed for the cohesive deposits (i.e. clayey silt / silty clay / clay) encountered in Swamp 205 are provided on Figure E1 in Appendix E. The piezometric condition used in the analyses is the water table at ground surface, based on the groundwater levels noted during drilling.

6.5.5.1 Stability

The critical section (i.e. the greatest embankment height and/or maximum thickness of soft, compressible foundation soils) for this area encompasses the length of the swamp crossing between about STA 12+250 and 12+325. The stability analysis of an up to 5 m high rock fill embankment indicates that after completion of construction (including removal and replacement of the peat and topsoil), the embankment would have a Factor of Safety (FoS) of approximately 1.1 for a deep-seated, global failure surface that would impact the operation of the highway.

To achieve a FoS greater than or equal to 1.3 for the proposed up to 5 m high rock fill embankment, it would be necessary to construct a toe berm along the outside toe of the embankment. Stability analysis indicates that a 2.5 m high by 6.5 m wide toe berm at the level of the existing ground surface would be required along the outside embankment toe (i.e. on the west side of the embankment), as shown on Figure E2.

The size of the toe berm required for embankment stability is reasonable and considered to be practical for construction, however, other stability mitigation options can be considered, including partial sub-excavation and replacement of the weak/soft deposits or the use of lightweight fill to reduce the magnitude of the driving force.

6.5.5.2 Settlement

To estimate the magnitude of the expected settlements due to new construction, analysis was carried out at the critical section representative of the subsurface conditions along the swamp crossing area, from approximately



STA 12+250 to 12+325. Given that the thickness of the clayey silt to clay deposit varies between about 4.7 m and 8.5 m in this area, and considering that the maximum clay thickness of 8.5 m is only present over a relatively small area (i.e. only in one borehole location), for the purpose of the settlement analysis, the cohesive deposit was assigned an average thickness of 7 m.

Based on the results of the settlement analysis with the organic material (up to 0.4 m deep) sub-excavated and replaced with rock fill, the total settlement of the foundation soils is estimated to be about 385 mm. The estimated total settlement is comprised of about 25 mm of immediate settlement due to compression of the cohesionless deposits and about 360 mm of primary consolidation for the 7 m thick cohesive deposit.

Based on an average coefficient of consolidation (c_v) of about $2.1 \times 10^{-3} \text{ cm}^2/\text{s}$ estimated for the cohesive deposit, the imposed loading conditions for the approximately 5 m high embankment plus about 0.3 m backfill for replacement of the organic deposits, and assuming two-way drainage of the 7 m thick cohesive deposit, it is estimated that about 90 per cent of the primary consolidation settlement will be completed in about 575 days. A longer duration will be required to meet the settlement performance criterion.

The magnitude of secondary consolidation (creep) settlement for the cohesive deposit is estimated to be about 75 mm per log-cycle of time for this area corresponding to about 90 mm over a 20-year period following completion of construction.

In addition, the total settlement of the rock fill embankment itself (based on a 5 m high embankment plus about 0.3 m of additional rock fill required after removal of the organic deposits) is estimated to be about 35 mm, with about 25 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.

6.5.5.3 Mitigation of Stability Issues and/or Time Dependent Settlements

The presence of the up to 8.5 m thick clayey silt to clay deposit influences both the stability and the settlement for the up to 5 m high embankment. In order to construct the embankment to achieve a FoS greater than or equal to 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 E1 in Appendix E. Considering the estimated relatively long duration for primary consolidation settlement, the Pavement Engineering mitigation measure for requiring sub-excavation of the cohesive deposits along the adjacent NBL embankment, as well as to minimize excavation spoil volumes and rock fill volumes, the partial sub-excavation with preloading is ranked as the preferred option for this area.

Full Sub-Excavation

Taking into consideration the depth to the bottom of the clay deposit (i.e. up to about 9 m below the existing ground surface), full sub-excavation of the cohesive deposit is feasible, but not practical due to the need for long-stick excavator equipment and the resulting generation of large volumes of excavation spoils requiring disposal/management. As such, full sub-excavation is not the preferred foundation mitigation alternative for this area.



Partial Sub-Excavation with Preloading

The bottom of the cohesive deposit is up to about 9 m below existing ground surface within the proposed embankment footprint at this location. Partial sub-excavation of the cohesive deposit down to about Elevation 181.5 m (corresponding to a maximum depth of approximately 5 m below the existing ground surface) in this area is considered feasible and is considered the preferred mitigation option for this area.

Since the groundwater table is located at or near 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 removal of the cohesive deposits. Excavation ‘in-the-wet’ to partially remove the cohesive deposits in this area should be carried out with side slopes no steeper than 1H:1V to limit the risk of instability. Partial removal of the cohesive deposit 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 deposits below the ground surface (in accordance to OPSD 203.010).

Based on stability analysis, for the proposed up to 5 m high rock fill embankment and an up to about 5 m deep partial sub-excavation for the full length of the swamp crossing, the FoS is estimated to be greater than or equal to 1.3 as shown on Figure E3.

In order to meet the settlement performance criterion, a minimum preload period of 100 days is required for this alternative. However, to eliminate the need for instrumentation and settlement monitoring during and after the construction of the embankment and to meet the settlement performance criterion, it is recommended that a preload period of 200 days be included in the construction schedule.

Preloading with Toe Berms

If preloading is adopted as the foundation mitigation option for the up to 5 m high rock fill embankment at this location, a 2.5 m high by 6.5 m wide toe berm at the level of the existing ground surface along the outside embankment toe (i.e. on the west side of the embankment) would be required for the full length of the swamp crossing in order to maintain a FoS greater than or equal to 1.3. However, in order to meet the settlement performance criterion of less than 100 mm over a 20-year period following completion of construction, it is estimated that a preload period of 750 days will be required.

Given the long duration of the preload period, preloading is not considered to be a practical alternative for this area.

Surcharging with Toe Berms

Based on stability analysis for an up to 7 m high surcharge embankment (consisting of 5 m of rock fill and 2 m of granular surcharge), a two-tiered toe berm consisting of a 1 m high by 15.5 m wide lower-tier and a 1.5 m high by 10 m wide upper-tier, at the level of the existing ground surface along the outside embankment toe (i.e. on the west side of the embankment) would be required for the full length of the swamp crossing in order to maintain a FoS greater than or equal to 1.3 as shown on Figure E4.

In addition, in order to meet the settlement performance criterion of less than 100 mm over a 20-year period following completion of construction, it is estimated that a surcharge period of 245 days will be required.



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

Given the duration of the surcharge period, the need for a large stability berm to maintain embankment stability under surcharging and the requirements for monitoring, surcharging is not considered to be the preferred foundation mitigation option for this area.

Wick Drains with Lightweight Fill

If there is a desire to reduce excavation spoil volumes, consideration could be given to adopting a combination of wick drains with lightweight fill to mitigate the long-term, post-construction settlement.

Preliminary analysis indicates that for wick drains installed to full depth through the cohesive deposit (up to about 9 m) along the full length of the swamp, at a spacing of 1.5 m in a triangular pattern and with a 2 m high surcharge on the embankment, a surcharge period of 165 days would be required in order to meet the settlement performance criterion of less than 100 mm over a 20-year period following completion of construction.

If an up to 7 m high surcharge embankment (consisting of 5 m of rock fill and 2 m of granular surcharge) is to be constructed instantaneously (i.e. without any delays between lift placement) while still maintaining a FoS of 1.3, a two-tiered toe berm consisting of a 1 m high by 15.5 m wide lower-tier and a 1.5 m high by 10 m wide upper-tier, at the level of the existing ground surface along the outside embankment toe (i.e. on the west side of the embankment) would be required for the full length of the swamp crossing. If wick drains are to be adopted as the settlement mitigation option, further detailed wick drain design and stability analysis would be necessary to assess whether staged construction and/or smaller toe berms could be utilized to maintain a FoS of greater than or equal 1.3 during construction.

The total settlement of the foundation soils during surcharging is estimated to be about 430 mm and comprised of about 30 mm of immediate settlement due to compression of the cohesionless deposits, about 385 mm of primary and secondary consolidation within the averaged 7 m thick cohesive deposit, as well as about 15 mm of short-term and long-term rock fill settlement. Given the magnitude of the total settlements, approximately 0.4 m of lightweight fill (i.e. expanded polystyrene (EPS)) would likely have to be incorporated into the final configuration of the embankment. The purpose of incorporating EPS into the construction of the final embankment is to attain the proposed embankment grade without adding additional loads on the foundation soils (to satisfy the settlement performance criterion).

In addition, the magnitude and time-rate of settlement as well as dissipation of excess pore pressures during and after construction of the surcharge embankment should be assessed by monitoring this area to confirm the end of the surcharge period. Monitoring instrumentation would consist of settlement plates (SPs), vibrating wire piezometers (VWPs) and standpipe piezometers (SPPs).

Taking into consideration that wick drains with surcharge and EPS do not offer any time saving over the surcharge with toe berm only option, wick drains are not the preferred mitigation option for this area. In addition, given the proximity of the proposed SBL embankment to the NBL embankment and the Pavement Engineering mitigation measure along the adjacent NBL embankment full sub-excavation of the cohesive deposits and



backfilling with rock fill, portions of the areas requiring wick drain installation along the SBL embankment (i.e. along the inside embankment toe) will coincide with the area sub-excavated along the NBL embankment potentially precluding the installation of wick drains in this area. Further, the cost associated with wick drain and EPS installation and monitoring would likely not make this option cost effective.

Lightweight Fill with Partial Preloading

Consideration could be given to constructing the embankment with lightweight fill (i.e. expanded polystyrene (EPS)) to mitigate against the stability issues. For an up to 5 m high embankment with 2H:1V side slopes (consisting of a 1 m granular base (which includes a 300 mm thick levelling pad), a 3 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 E5.

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 145 mm. The estimated total settlement is comprised of about 10 mm of immediate settlement due to compression of the cohesionless deposits and about 135 mm and 10 mm of primary and secondary consolidation, respectively, for the 7 m thick cohesive deposit.

In order to meet the settlement performance criterion of 100 mm of settlement over a 20-year period following completion of construction, it is recommended that a 2.5 m high granular preload embankment be initially constructed and left in place for a preload period of 30 days for this alternative. To facilitate the assessment for the end of the preload period, instrumentation and monitoring during and after construction should be carried out. Monitoring instrumentation would consist of settlement plates (SPs), vibrating wire piezometers (VWPs) and standpipe piezometers (SPPs). Alternatively, to eliminate the need for instrumentation and monitoring during and after construction, a preload period of 60 days should be included in the construction schedule.

Upon the completion of the preload period, the granular preload embankment would be excavated to a height of 0.7 m above the ground surface and the final EPS embankment constructed (including a 300 mm thick levelling pad beneath the EPS and a 1 m granular protective cover/pavement structure over the EPS core).

Taking into consideration that lightweight fill with preloading does not offer any significant time saving over the partial sub-excavation with preloading option, this option is not the preferred mitigation for this area. In addition, the cost associated with EPS installation would likely not make this option cost effective.

6.5.6 Highway 69 NBL – STA 12+750 to 12+825 (Swamp 206)

The swamp crossing/high fill area extending from about STA 12+750 to 12+825 along the proposed Highway 69 Northbound lanes (NBL) alignment requires a new embankment up to about 5 m high to achieve the proposed vertical highway profile. The natural topography of this area is undulating, consisting of bedrock outcrops and a low-lying swamp area towards the north east section of the swamp limits. The ground cover is comprised of bare rock outcrops, shrubs and moderately treed areas. As a result of the varying nature of the terrain within this section of the proposed highway, the ground surface elevation across the site is highly variable.

The subsurface conditions in this area generally consist of an about 0.1 m to 0.3 m thick organic deposit (peat and topsoil), underlain by a deposit of very loose to compact sand to sandy silt up to about 2.1 m thick. A



localized and discontinuous deposit of very soft to hard clayey silt was encountered underlying the topsoil at some borehole locations. The thickness of the clayey silt deposit is up to about 0.8 m, corresponding to a maximum depth of about 1.1 m below the existing ground surface.

Bedrock outcrops are present across the site and towards the southeast end of the investigated area. Refusal to further split-spoon advancement and shovel excavation or dynamic cone penetration, was encountered at depths up to about 2.1 m below ground surface. In general, refusal was encountered at greater depth between about STA 12+775 and 12+800.

Details of the subsurface conditions for this swamp area are presented in Section 4.12 and shown on Drawing F1 in Appendix F.

The simplified stratigraphy and the associated unit weight, 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 was the water table at ground surface, based on the groundwater levels noted during drilling.

6.5.6.1 Stability

Based on the results of the subsurface investigation and review of the profile drawings, the critical section (i.e. greatest embankment height and/or maximum thickness of soft, compressible foundation soils) for this swamp crossing is located between about STA 12+775 and 12+787.5. The stability analysis of a 5 m high rock fill embankment carried out at the critical section(s) indicates that after the completion of construction (including removal and replacement of the very soft organic deposits), the embankment will have a Factor of Safety (FoS) of 1.3 or greater for deep-seated, global failure surfaces that would impact the operation of the highway.

6.5.6.2 Settlement

To estimate the magnitude of expected settlements due to new construction, analysis was carried out at the critical section(s) representative of the subsurface conditions within the swamp crossing area, between about STA 12+775 and 12+787.5.

Based on the results of the settlement analysis, the total settlement of the foundation soils is estimated to be about 100 mm, comprised of about 35 mm of immediate settlement due to compression of the cohesionless deposits and about 65 mm of primary consolidation of the up to 0.8 m thick 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 5 m high embankment plus about 0.3 m backfill for replacement of the organic deposits, and assuming one-way drainage of the approximately 0.8 m thick cohesive deposit, it is estimated that about 90 per cent of the primary consolidation settlement will be completed in about 10 days.

The magnitude of secondary consolidation (creep) settlement for the cohesive deposit is estimated to be less than about 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 the critical section (based on a 5 m high embankment plus about 0.3 m of additional rock fill required after removal of the organic deposits) is estimated to be about 35 mm, with about 25 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.

The estimated total post-construction settlement of the foundation soils and the embankment rock fill after completion of the embankment construction is approximately 105 mm and, therefore, in accordance with the settlement performance criterion in Section 6.3, no mitigation measures are required.

6.6 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 2 project limits, including: removal of surficial and near surface organic materials; excavation and replacement of soft, cohesive deposits; 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 Ontario Provincial Standard Drawings (OPSD) excavation guideline.

6.6.1 Removal of Organic Materials

Based on the information from the boreholes advanced during the field investigation, the thickness of organic deposits (i.e. topsoil, peat, root mat and/or organic silty sand) in the Contract 2 section of the proposed Highway 69 alignment generally ranges from about 0.1 m to 1.2 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 deposits within the swamp crossing/high fill areas should 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).

6.6.2 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, excavation and replacement, either fully or partially, of soft deposits is recommended. Excavation up to about 5 m below existing ground surface is anticipated in some areas of the



Contract 2 section of the project where sub-excavation and replacement of soft materials is recommended as the preferred mitigation option. In this case, conventional (or long-stick type) equipment is considered suitable for the excavation of these soft deposits. 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 Special Provision 206S03 Earth Excavation, 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.

6.6.3 Groundwater and Surface Water Control

Excavation within the plan limits of the proposed works will be required to remove organic and/or soft deposits prior to embankment fill placement, which 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 in the swamp crossing/high fill areas, however, surface water should be directed away from the excavations at all times.

6.6.4 Backfilling

In general, it is recommended that rock fill be used for replacement of the sub-excavated material. However, in areas where wick drains are required to mitigate stability and/or post-construction settlements, it is recommended that granular fill (i.e. Special Provision 110S13 Granular 'B' Type 1) be used for the replacement of the sub-excavated material. Where sub-excavation of organic materials and soft deposits is being carried out as a foundation mitigation option, it will not likely be possible to place rock fill or granular fill in accordance with Special Provision 206S03 Earth Excavation, Grading, as discussed in Section 6.6.5. For placement below the water table, rock fills and granular fills are anticipated to be end dumped as the excavation advances.

6.6.5 Embankment Fill Placement

Placement of rock fill and granular fill above the water table for construction of new embankments should be carried out in accordance with the requirements as outlined in Special Provision 206S03 Earth Excavation, Grading. 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. Where expanded polystyrene (EPS) levelling pads are required, granular fill should be placed in regular lifts with loose thickness not exceeding 300 mm and compacted to at least 95 per cent of the standard Proctor maximum dry density. Side slopes for granular fill should be no steeper than 2H:1V.



The EPS fill should be installed in accordance with the manufacturer's requirements. It is recommended that a levelling pad comprised of at least 300 mm of Granular 'A' be placed prior to the installation of the EPS. A minimum 125 mm thick reinforced concrete pad should be constructed on top of the EPS followed by the placement of a protective cover/pavement structure over the EPS (from a minimum thickness of 1 m including the concrete pad, compacted granular materials and asphalt). The EPS on the side slopes of the embankment should be covered with a 1 m thick conventional soil cover.

6.7 Rock Excavation

For permanent cuts through the bedrock, the overall slope to the cut face may be formed vertically or near vertically (i.e. about 0.25H:1V). The use of carefully controlled excavation techniques will be required to ensure a neat excavation line and minimize face instabilities and long-term maintenance problems resulting from damage to the rock mass.

6.7.1 Blasting

The use of controlled blasting techniques is recommended for all bedrock excavation for the final rock faces, and the use of explosives should be in accordance with OPSS 120 General Specification for Use of Explosives. It is recommended that a separate Special Provision for the control of all blasting operations be prepared (refer to Special Provision 299F06 Rock Excavation for Controlled Blasting). The Special Provision should include, but not limited to, the following:

- An outline of the requirements, procedure and extent of a pre-blast survey, including all structures within a radius of about 100 m of the blasting operations, as well as notification to all persons working or living within 500 m of the blasting area.
- A blast proposal by the blasting contractor or their blast consultant detailing the blast methodology, including drill hole patterns, hole size and depths, size of blasts, explosive and initiation product details, as well as all blast control procedures. Blast control procedures would include details on controlling flyrock, temporary road closures, blast signalling and site clearing, as well as procedures to deal with debris clean-up. This submission would be required prior to the commencement of any blasting operations.
- The requirement for trial blasts for all proposed production and wall control blast procedures.
- The requirements for ground and air vibration monitoring during the blasting operations. This would include details on instrumentation, number and location of monitoring sites, blast recording and reporting procedures, and procedures to be followed in the event of excessive vibration readings.

It is recommended that ground vibration levels be limited to 50 mm/s for adjacent services and structures. Continuous monitoring of all blasting operations would dictate when changes to the blast procedures become necessary to meet this limit and how close the blasting can be carried out adjacent to any existing services and structures.

It is recommended that the specification for the blasting require a minimum of 80 per cent half barrels (drill hole traces) visible on the cut face after scaling.



6.7.2 Rock Scaling and Bolting

Inspection of all new rock cut faces by a Quality Verification Engineer (QVE) should be carried out soon after blasting in order to assess where scaling/loosened rock removal should be carried out. All loose, unstable rock should be removed from the cut faces in accordance with Special Provision 299F03 Rock Excavation (Machine Scaling) before access to the toe area of the slope is permitted.

After rock blasting, where potentially unstable rock blocks or wedges cannot be removed safely or where the removal of such blocks/wedges could undermine the rock mass above, rock bolting may be required. Where rock bolting is necessary, it should be carried out in accordance with Special Provision 299S07 Rock Bolting.

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 due to space/property issues). It is further understood that the minimum required platform widening on major highways (i.e. including Highway 69) over swamp crossings 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). For non-major highways and roadways (i.e. ramps and side roads) over swamp crossings, the minimum required platform widening is 1 m per side.

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 is summarized in Table 6.

7.0 CLOSURE


This report was prepared by Ms. T. Veronica Ayetan, P.Eng., Messrs. Tomasz Zalucki, P.Eng. and Christopher Ng, 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 Contact for this project and a Principal with Golder, conducted an independent quality control review of the report.



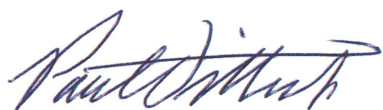
Report Signature Page



Tomasz Zalucki, P.Eng.
Geotechnical Engineer



Christopher Ng, P. Eng.
Senior Geotechnical Engineer



J. Paul Dittrich, Ph.D., P. Eng.
Senior Geotechnical Engineer, Principal



Jorge M.A. Costa, P. Eng.
Designated MTO Contact, Principal

TVA/TZ/CN/JPD/JMAC/sm

[Http://capws/sites/0911116014highway69FourLaning/Contract 2/Reporting/Final/Swamp Crossings and High Fill Areas/09-1111-6014-2520 RPT 12Jul30 Highway 69 Swamp Crossings and High Fill Areas.docx](http://capws/sites/0911116014highway69FourLaning/Contract%20Reporting/Final/Swamp%20Crossings%20and%20High%20Fill%20Areas/09-1111-6014-2520%20RPT%2012Jul30%20Highway%2069%20Swamp%20Crossings%20and%20High%20Fill%20Areas.docx)



REFERENCES

- Azzouz, A.S., Krizek, R.J., and Corotis, R.B. 1976. Regression Analysis of Soil Compressibility. Soils and Foundations, Tokyo, Vol. 16, No. 2, pp. 19-29.
- Bjerrum, L. 1973. Problems of Soil Mechanics and Construction of Soft Clays and Structurally Unstable Soils. State of the Art Report, Session 4. Proceedings, 8th International Conference on Soil Mechanics and Foundation Engineering, Moscow, Vol. 3, pp. 111-159.
- Bowles, J.E. 1984. Physical and Geotechnical Properties of Soils, Second Edition. McGraw Hill Book Company, New York.
- Canadian Geotechnical Society. 2006. Canadian Foundation Engineering Manual, 4th Edition. The Canadian Geotechnical Society c/o BiTech Publisher Ltd, British Columbia.
- Golder Associates Ltd. 2012. Foundation Investigation and Design Report, Culverts – Contract 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, G.W.P. 5404-05-00.
- 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.
- Koppula, S.D. 1986. Discussion: Statistical Estimation of Compression Index, Geotechnical Testing Journal, ASTM, Vol. 4, No. 2, pp. 68-73.
- Kulhawy, F.H. and Mayne, P.W. 1990. Manual on Estimating Soil Properties for Foundation Design. EL 6800, Research Project 1493 6. Prepared for Electric Power Research Institute, Palo Alto, California.
- U.S. Navy. 1986. NAVFAC Design Manual 7.02. Soil Mechanics, Foundation and Earth Structures. Alexandria, Virginia.
- Ontario Geological Society. 1991. Geology of Ontario, Special Volume 4, Part 2. Ministry of Northern Development and Mines, Ontario.
- Terzaghi, K. and Peck, R.B. 1967. Soil Mechanics in Engineering Practice, 2nd Edition, John Wiley and Sons, New York.
- ASTM International
- | | |
|------------|---|
| ASTM D1586 | Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils |
| 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 |
- Commercial Software:
- Settle3D (Version 2.0) by Rocscience Inc.
- Slide (Version 6.0) by Rocscience Inc.
- Contract Design Estimating and Documentation (CDED):



**FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL
AREAS - HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01**

Special Provision 110S13 Amendment to OPSS 1010 – Material Specification for Aggregates.

Special Provision 206S03 Amendment to OPSS 206 – Earth Excavation, Grading.

Special Provision 299F03 Rock Excavation (Machine Scaling)

Special Provision 299F06 Rock Excavation (Controlled Blasting)

Special Provision 299S07 Rock Bolting

Ministry of Transportation Ontario:

Embankment Settlement Criteria for Design. March 2010.

MTO Guideline for Rock Fill Settlement and Rock Fill Quantity Estimates. September 2010.

Northern Region Engineering Directive NRE 98-200. Northern Region Embankment Design Guidelines. October 1998.

Ontario Occupational Health and Safety Act:

Ontario Regulation 213/91 Construction Projects

Ontario Regulation 443/09 Amendment to Ontario Regulation 213

Ontario Provincial Standard Drawings:

OPSD 203.010 Embankments over Swamp – New Construction

Ontario Provincial Standard Specifications:

OPSS 120 General Specification for Use of Explosives

OPSS 209 Construction Specification for Embankments over Swamps and Compressible Soils

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

(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

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

Notes: 1
2

$$\tau = c' + \sigma' \tan \phi'$$

$$\text{shear strength} = (\text{compressive strength})/2$$



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

III. SOIL DESCRIPTION

(a) 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

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.)

(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

Dynamic Cone Penetration Resistance; N_d:

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

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

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

IV. SOIL TESTS

w	water content
w _p	plastic limit
w _l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D _R	relative density (specific gravity, G _s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

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

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 (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 CROSSINGS AND HIGH FILL AREAS - HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

**Table 1: Summary of Swamp Crossings and High Fill Areas
Highway 69 Four-Laning**

Foundation Investigation Area	Foundation Investigation Area Designation	Maximum Proposed Embankment Height ¹	Boreholes/DCPT
Highway 69 SBL STA 17+750 to 17+775	Swamp 201	4.0 m	3 Boreholes (S201-01 to S201-03) 1 DCPT (S201-DC01)
Highway 69 NBL STA 17+700 to 17+750	Swamp 201	4.0 m	8 Boreholes (S201-04 to S201-10 and S201-05A) 4 DCPTs (S201-DC02 to S201-DC04 and S201-DC03A)
Highway 69 SBL STA 11+175 to 11+275	Swamp 202	6.5 m	9 Boreholes (S202-01 to S202-09) 4 DCPTs (S202-DC01 to S202-DC04)
Highway 69 NBL STA 11+100 to 11+225	Swamp 202	6.5 m	11 Boreholes (S202-10 to S202-20) 3 DCPTs (S202-DC05 to S202-DC07)
Highway 69 SBL STA 11+350 to 11+375	Swamp 203	10 m Cut	3 Boreholes (S203-01 to S203-03) 3 DCPTs (S203-DC01, S203-DC01A and S203-DC01B)
Highway 69 NBL STA 11+375 to 11+400	Swamp 203	11 m Cut	3 Boreholes (S203-04 to S203-06) 3 DCPTs (S203-DC02, S203-DC03 and S203-DC03A)
Highway 69 SBL STA 11+725 to 11+825	Swamp 204	7.5 m	9 Boreholes (S204-01 to S204-09) 4 DCPTs (S204-DC01 to S204-DC04)
Highway 69 NBL STA 11+700 to 11+800	Swamp 204	7.5 m	9 Boreholes (S204-10 to S204-18) 4 DCPTs (S204-DC05 to S204-DC08)
Highway 69 SBL STA 12+200 to 12+375	Swamp 205	5.0 m	15 Boreholes (S205-01 to S205-15) 9 DCPTs (S205-DC01 to S205-DC07, S205-DC05A and S205-DC06A)
Highway 69 NBL STA 12+750 to 12+825	Swamp 206	5.0 m	7 Boreholes (S206-01 to S206-07) 6 DCPTs (S206-DC01 to S206-DC04, S206-DC01A and S206-DC03A)

- Note:
1. Based on centreline profile of highway alignment and existing ground surface profiles provided by URS on November 28, 2011. Embankment height is approximate and is relative to top of peat/original ground.
 2. Record of Boreholes sheets for C201-01 to C201-04 and C202-01 to C202-03 are not included in this report. Records of borehole sheets for these boreholes can be found in Golder Associates' Report "Foundation Investigation and Design Report, Culverts – Contract 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, G.W.P. 5404-05-00" (Report No. 09-1111-6014-2521)

Prepared By: TVA

Reviewed By: JPD/JMAC



**FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL
AREAS - HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01**

**Table 2: Summary of Consolidation Test Parameters
Highway 69 Four-Laning**

Foundation Investigation Area	Borehole and Sample No.	Elevation (m)	σ_{vo}' (kPa)	σ_p' (kPa)	$\sigma_{vo}' - \sigma_p'$ (kPa)	OCR	C_c	C_r	e_o	c_v^* (cm ² /s)
Highway 69 SBL Swamp 202	Borehole S202-07 Sample 7	176.1	85	85	0	1.0	1.69	0.13	2.16	1.3×10^{-4}
Highway 69 NBL Swamp 202	Borehole S202-17 Sample 7	172.1	100	100	0	1.0	1.19	0.14	2.14	4.9×10^{-4}
Highway 69 NBL Swamp 202	Borehole S202-20 Sample 11	173.0	75	100	25	1.3	1.20	0.12	1.86	5.5×10^{-5}
Highway 69 SBL Swamp 204	Borehole S204-05 Sample 17	160.1	190	285	95	1.5	1.00	0.08	1.57	1.1×10^{-3}
Highway 69 SBL Swamp 204	Borehole S204-07 Sample 20	150.9	270	305	35	1.1	0.65	0.07	1.25	2.7×10^{-3}
Highway 69 NBL Swamp 204	Borehole S204-14 Sample 13	168.1	95	155	60	1.6	0.87	0.06	1.46	2.7×10^{-3}
Highway 69 SBL Swamp 205	Borehole S205-07 Sample 4	182.7	20	55	35	2.8	1.0	0.12	2.10	5.6×10^{-4}

Note: For stress range between sample in situ effective overburden stress and final stress due to embankment construction for all embankments (4.0 m to 8.5 m high) of $20 \text{ kPa} \leq \sigma_v' \leq 410 \text{ kPa}$

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

Prepared By: TVA

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)
Highway 69 SBL STA 17+750 to 17+775 (Swamp 201)	Peat/Topsoil	202.8 to 203.8	0.1 to 0.3	12 – 15	27	1	-	-	-	-	-	-	-	-
	Sand and Silt	~ 202.6	~ 0.3	18	27	0	-	-	-	-	-	-	10	-
	Sand and Gravel	~ 202.3	~ 0.6	19	28	0	-	-	-	-	-	-	20	-
Highway 69 NBL STA 17+700 to 17+750 (Swamp 201)	Peat/Topsoil	202.6 to 203.4	0.1 to 0.7	12 – 15	27	1	-	-	-	-	-	-	-	-
	Silty Sand to Sand	~ 202.0	0.3 to 0.9	18.5	28	0	-	-	-	-	-	-	10	-
	Silty Clay	201.1 to 201.7	0.9 to 1.9	17	-	-	55	250	1.0	0.6	0.06	-	-	-
Highway 69 SBL STA 11+175 to 11+275 (Swamp 202)	Peat/Topsoil	182.5 to 188.9	0.1 to 0.3	12 – 15	27	1	-	-	-	-	-	-	-	-
	Silty Sand to Sand	181.8 to 186.0	0.2 to 0.6	18.5	28	0	-	-	-	-	-	-	1.5	-
	Clayey Silt to Clay	181.6 to 185.5	4.6 to 18.9	16.5	-	-	16 – 41.5	77.5 – 187	1.8	0.85 – 1.4	0.085 – 0.14	-	-	1.91 x10 ⁻³
	Sandy Silt to Sand	162.7 to 166.7	1.8 to 4.8	18.5 – 19	29	0	-	-	-	-	-	-	7.5	-
Highway 69 NBL STA 11+100 to 11+225 (Swamp 202)	Topsoil	182.9 to 191.9	0.1 to 0.4	15	27	1	-	-	-	-	-	-	-	-
	Silty Sand to Sand	182.7 to 188.7	0.4 to 0.7	18.5	28	0	-	-	-	-	-	-	1.5	-
	Clayey Silt to Clay	182.0 to 187.7	0.9 to 16.1	16.5	-	-	16 – 41.5	77.5 – 187	1.8	0.85 – 1.4	0.085 – 0.14	-	-	1.91 x10 ⁻³
	Silt and Sand Interlayers	179.0 to 181.5	0.4 to 1.2	18	27	0	-	-	-	-	-	-	-	-
	Sandy Silt to Sand	166.3 to 168.7	0.5 to 4.8	19	29	0	-	-	-	-	-	-	7.5	-
	Sand and Gravel	~167.6	~ 1.1	20	34	0	-	-	-	-	-	-	-	-
Highway 69 SBL STA 11+350 to 11+375 (Swamp 203)	Peat/Topsoil	196.3 to 197.5	0.1 to 0.9	12 – 15	27	1	-	-	-	-	-	-	-	-
	Sand	~ 195.4	~ 0.1	18	27	-	-	-	-	-	-	-	-	-
Highway 69 NBL STA 11+375 to 11+400 (Swamp 203)	Peat/Topsoil	196.7 to 197.9	0.1 to 0.6	12 – 15	27	1	-	-	-	-	-	-	-	-
	Sand	~ 195.5	~ 0.3	18	27	0	-	-	-	-	-	-	5	-
Highway 69 SBL STA 11+725 to 11+825 (Swamp 204)	Peat/Topsoil	181 to 186.4	0.1 to 0.5	12 – 15	27	1	-	-	-	-	-	-	-	-
	Sand to Silt	180.6 to 183.6	0.3 to 1.2	18.5	28	0	-	-	-	-	-	-	10	-
	Clayey Silt to Silty Clay (Near Surface)	180 to 180.9	1.4 to 2.7	17.5	-	-	25	110	1.4	0.47	0.047	-	-	3.19 x10 ⁻³
	Sand to Sandy Silt to Silt (Upper)	178.2 to 179.2	4.0 to 7.3	18.5	28	0	-	-	-	-	-	-	5	-
	Clayey Silt to Clay (Upper)	171.4 to 174.7	2.0 to 6.6	17	-	-	35 – 86	170 – 389	1.4	0.57 – 0.8	0.057 – 0.08	-	-	1.81 x10 ⁻³
	Sandy Silt to Silt (Lower)	166.4 to 172.7	1.8 to 6.4	18	29	0	-	-	-	-	-	-	15	-
	Silty Clay to Clay (Lower)	164.5 to 166.3	14.0 to 23.1	17	-	-	35 – 86	170 – 389	1.4	0.57 – 0.8	0.057 – 0.08	-	-	1.81 x10 ⁻³
	Sand and Silt Interlayer	~161.1	2.7 to 3.0	19	29	0	-	-	-	-	-	-	5	-
	Silt to Silty Sand	138.7 to 152.3	3.0 to 5.1	18	29	0	-	-	-	-	-	-	25	-
Highway 69 NBL STA 11+700 to 11+800 (Swamp 204)	Peat/Topsoil	181.0 to 184.8	0.1 to 0.5	12	27	1	-	-	-	-	-	-	-	-
	Sand to Silt	180.8 to 183.4	0.2 to 1.7	18.5	28	0	-	-	-	-	-	-	10	-
	Clayey Silt to Clay (Near Surface)	180.2 to 182.2	0.7 to 2.6	17.5	-	-	25	110	1.4	0.47	0.047	-	-	3.19 x10 ⁻³
	Sand to Sand and Silt to Silt (Upper)	178.3 to 179.2	1.0 to 7.9	18.5	28	0	-	-	-	-	-	-	5	-
	Silt (Lower)	169.4 to 172.7	4.8 to 6.4	18.5	28	0	-	-	-	-	-	-	5	-
	Clayey Silt to Clay (Lower)	164.6 to 178.2	2.0 to 25.1	17	-	-	35 – 86	170 – 389	1.4	0.57 – 0.8	0.057 – 0.08	-	-	1.81 x10 ⁻³



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)	$\sigma_{p'}$ (kPa)	e_o	C_c	C_r	m_v (kPa ⁻¹)	E' (MPa)	C_v (cm ² /s)
	Sand and Silt to Silt Interlayers	166.3 to 169.5	~ 3.1	19	29	0	-	-	-	-	-	-	5	-
	Silt to Sand	143.2 to 157.9	2.3 to 6.4	18	29	0	-	-	-	-	-	-	25	-
Highway 69 SBL STA 12+200 to 12+375 (Swamp 205)	Peat/Topsoil	184.8 to 189.4	0.1 to 0.4	12 – 15	27	1	-	-	-	-	-	-	-	-
	Clayey Silt to Clay	183.6 to 188.1	1.0 to 8.5	16.5	-	-	15 – 65	70 – 240	0.4 – 2.0	0.15 – 1.0	0.015 – 0.01	-	-	2.1 x10 ⁻³
	Silt to Sand	177.4 to 187.1	0.3 to 1.8	18	28	0	-	-	-	-	-	-	10	-
	Gravelly Sand and Silt	~176.3	~ 1.1	19	32	0	-	-	-	-	-	-	25	-
Highway 69 NBL STA 12+750 to 12+825 (Swamp 206)	Peat/Topsoil	186.1 to 189.2	0.1 to 0.3	12 – 15	27	1	-	-	-	-	-	-	-	-
	Sand to Sandy Silt	185.8 to 189.0	0.3 to 2.1	15	-	-	-	-	2	1.0	0.1	-	5	-
	Clayey Silt	~ 186.1	~ 0.4 to 0.8	18	30	-	12	55	0.8	0.4	0.04	-	-	5.68 x10 ⁻³

Note: Additional details of Foundation Engineering Parameters for cohesive deposits (i.e. clayey silt / silty clay / clay) in Swamps 202, 204 and 205 are provided in Figures B1, D1 and E1 in Appendices B, D and E, respectively.

Prepared By: ARM/TVATZ

Reviewed By: JPD/JMAC



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	Partial Sub-Excavation with Preloading ³	Full Sub-Excavation	Wick Drains with Lightweight Fill ³	Lightweight Fill with Partial Preloading ³	
Highway 69 SBL STA 17+750 to 17+775 and Highway 69 NBL STA 17+700 to 17+750 (Swamp 201)	δ_{primary} $\delta_{\text{secondary}}$ $\delta_{\text{rock fill}}$ δ_{total} t_{delay}	50 ~0 30 80 0 days	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	Foundation mitigation is not required
Highway 69 SBL STA 11+175 to 11+275 and Highway 69 NBL STA 11+100 to 11+225 (Swamp 202)	δ_{primary} $\delta_{\text{secondary}}$ $\delta_{\text{rock fill}}$ δ_{total} t_{delay}	1,445 165 65 1,675 0 days	25 75 ~0 100 8,500 days	0 100 ~0 100 2,600 days	- - - - -	- - - - -	0 90 10 100 390 days	40 60 0 100 130 days	Lightweight fill with partial preloading
Highway 69 SBL STA 11+350 to 11+375 and Highway 69 NBL STA 11+375 to 11+400 (Swamp 203)	δ_{primary} $\delta_{\text{secondary}}$ $\delta_{\text{rock fill}}$ δ_{total} t_{delay}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Foundation mitigation is not required (Swamp 203 crossing is comprised of a deep rock cut from STA 11+350 to 11+400 below base of swamp)
Highway 69 SBL STA 11+725 to 11+825 and Highway 69 NBL STA 11+700 to 11+800 (Swamp 204)	δ_{primary} $\delta_{\text{secondary}}$ $\delta_{\text{rock fill}}$ δ_{total} t_{delay}	1,060 245 70 1,375 0 days	0 50 ~0 50 21,000 days	0 50 ~0 50 4,400 days	- - - - -	- - - - -	0 40 10 50 290 days	0 50 0 50 95 days	Lightweight fill with partial preloading
Highway 69 NBL STA 12+200 to 12+375 (Swamp 205)	δ_{primary} $\delta_{\text{secondary}}$ $\delta_{\text{rock fill}}$ δ_{total} t_{delay}	360 90 35 485 0 days	20 80 ~0 100 750 days	5 90 5 100 245 days	~0 55 45 100 200 days	- - - - -	~0 85 15 100 165 days	85 15 0 100 60 days	Partial sub-excavation with preloading
Highway 69 NBL STA 12+750 to 12+825 (Swamp 206)	δ_{primary} $\delta_{\text{secondary}}$ $\delta_{\text{rock fill}}$ δ_{total} t_{delay}	65 ~5 35 ~105 0 days	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	Foundation mitigation is not required

Notes: 1. Delay time refers to the preload or surcharge duration.
2. Refer to Section 6.5 for requirements for stability berms, where applicable.
3. Refer to Section 6.5 and Tables B1, D1 and E1 for the recommended preload and surcharge durations and requirements for stability berms, where applicable.

Prepared By: TZ/CN

Reviewed By: JPD/JMAC



FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS - HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

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

Foundation Investigation Area	Foundation Design Issue (Maximum Height of Fill or Depth of Cut)	Topography and Surface Conditions	Recommended Embankment / Rock Cut 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 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 17+750 to 17+775 and Highway 69 NBL STA 17+700 to 17+750 (Swamp 201)	Swamp Crossing (about 4 m)	Relatively flat to low-lying area between gentle ridge located beyond the north and south limits of the investigated area; the ground is moderately tree covered encompassing a wet grassy area.	1.25H:1V (Rock Fill) 2 m per side	Root mat / peat / topsoil and surficial sand and silt with organics up to about 0.7 m below ground surface.	Sub-excavation of root mat / peat / topsoil and surficial sand and silt with organics (up to about 0.7 m deep) Foundation mitigation not required	$\delta_{\text{Immediate}} = 5 \text{ mm}$ $\delta_{\text{Primary}} = 0 \text{ mm}$ $\delta_{\text{Rock Fill}} = 0 \text{ mm}$	$\delta_{\text{Primary}} = 50 \text{ mm}$ $\delta_{\text{Secondary}} \approx 0 \text{ mm}$ $\delta_{\text{Rock Fill}} = 30 \text{ mm}$	OPSD 203.010
Highway 69 SBL STA 11+175 to 11+275 and Highway 69 NBL STA 11+100 to 11+225 (Swamp 202)	Swamp Crossing/ High Fill (about 6.5 m)	Low-lying swamp/field located within the confines of tree covered valley slopes to the north and south, consisting of wet grassy areas and a small creek traversing the valley from west to east near the middle of the area. In general, the ground cover consists of bedrock outcrops, shrubs and moderately treed areas.	2H:1V (Final EPS embankment) 2H:1V (Partial Granular 'B' Type II preload embankment) 2 m per side	Peat / topsoil and organic silty sand up to about 1.2 m below ground surface.	Sub-excavation of peat / topsoil and organic silty sand (up to about 1.2 m deep) Partial Preloading (3.5 m high for 130 days) with Temporary Toe Berms (1.5 m high by 2.5 m wide) followed by Lightweight Fill Construction (4.5 m of EPS)	$\delta_{\text{Immediate}} = 25 \text{ mm}$ to 35 mm $\delta_{\text{Primary}} = 125 \text{ mm}$ to 140 mm $\delta_{\text{Rock Fill}} = 0 \text{ mm}$	$\delta_{\text{Primary}} = 40 \text{ mm}$ $\delta_{\text{Secondary}} = 60 \text{ mm}$ $\delta_{\text{Rock Fill}} = 0 \text{ mm}$	OPSD 203.010



FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS - HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

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

Foundation Investigation Area	Foundation Design Issue (Maximum Height of Fill or Depth of Cut)	Topography and Surface Conditions	Recommended Embankment / Rock Cut 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 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 11+350 to 11+375 and Highway 69 NBL STA 11+375 to 11+400 (Swamp 203)	Deep Cut (up to about 11 m)	Relatively flat swamp area located within the confines of shallow tree covered valley slopes to the north and south. The ground cover within the swamp comprised of wet grassy areas, occasional bedrock outcrops and occasional shallow ponded water.	0H:1V to 0.25H:1V (Rock Cut)	Peat / topsoil up to about 0.9 m below ground surface.	Recommendations on stability of deep cuts through rock are provided in Section 6.7.	N/A	N/A	N/A
Highway 69 SBL STA 11+725 to 11+825 and Highway 69 NBL STA 11+700 to 11+800 (Swamp 204)	Swamp Crossing/ High Fill (about 7.5 m)	Flat to low-lying with the ground cover consisting of wet grassy areas, shrubs and areas of shallow open water. The high fill area is bounded to the south by moderately to densely tree covered valley slopes and bedrock outcrops, and bounded to the north by the Still River flowing generally in a east-west direction.	2H:1V (Final EPS embankment) 2H:1V (Partial Granular 'B' Type II preload embankment) 2 m per side	Topsoil up to about 0.6 m below ground surface and sand and gravel to sand/silty sand fill up to about 0.9 m below ground surface.	Sub-excavation of peat / topsoil and sand and gravel to sand/silty sand fill (up to about 0.9 m deep) Partial preloading (4.5 m high for 95 days) followed by lightweight fill construction (5.5 m of EPS)	$\delta_{\text{Immediate}} = 125 \text{ mm to } 140 \text{ mm}$ $\delta_{\text{Primary}} = 155 \text{ mm to } 175 \text{ mm}$ $\delta_{\text{Rock Fill}} = 0 \text{ mm}$	$\delta_{\text{Primary}} = 0 \text{ mm}$ $\delta_{\text{Secondary}} = 50 \text{ mm}$ $\delta_{\text{Rock Fill}} = 0 \text{ mm}$	OPSD 203.010



FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS - HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

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

Foundation Investigation Area	Foundation Design Issue (Maximum Height of Fill or Depth of Cut)	Topography and Surface Conditions	Recommended Embankment / Rock Cut 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 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 12+200 to 12+375 (Swamp 205)	Swamp Crossing/ High Fill (about 5.0 m)	Topography sloping downward to the north, with the ground cover consisting of wet grassy areas, bedrock outcrops, shrubs and shallow open water, with moderately tree covered terrain to the north of the swamp crossing. Towards the northern limit of the swamp between about STA 12+250 and 12+375, the ground surface elevation across this area is highly variable.	1.25H:1V (Rock fill) 2 m per side	Peat / topsoil up to about 0.4 m below ground surface.	Sub-excavation of peat / topsoil (up to about 0.4 m deep) Partial sub-excavation (up to 5 m deep) with preloading (200 days)	$\delta_{\text{Immediate}} = 25 \text{ mm}$ $\delta_{\text{Primary}} = 55 \text{ mm}$ $\delta_{\text{Rock Fill}} = 40 \text{ mm}$	$\delta_{\text{Primary}} = 0 \text{ mm}$ $\delta_{\text{Secondary}} = 55 \text{ mm}$ $\delta_{\text{Rock Fill}} = 45 \text{ mm}$	OPSD 203.010
Highway 69 NBL STA 12+750 to 12+825 (Swamp 206)	Swamp Crossing/ High Fill (about 5.0 m)	Undulating topography consisting of bedrock outcrops and a low-lying swamp area towards the northeast section of the swamp limits, and the ground cover comprised of bare rock, shrubs and moderately treed areas. As a result of the varying nature of the terrain within this section of the proposed highway, the ground surface elevation across the site is highly variable.	1.25H:1V (Rock fill) 2 m per side	Peat/topsoil up to about 0.3 m below ground surface.	Sub-excavation of peat / topsoil (up to about 0.3 m deep) Foundation mitigation not required	$\delta_{\text{Immediate}} = 35 \text{ mm}$ $\delta_{\text{Primary}} = 0 \text{ mm}$ $\delta_{\text{Rock Fill}} = 0 \text{ mm}$	$\delta_{\text{Primary}} = 65 \text{ mm}$ $\delta_{\text{Secondary}} \approx 5 \text{ mm}$ $\delta_{\text{Rock Fill}} = 35 \text{ mm}$	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.

Prepared By: TZ/CN

Reviewed By: JPD/JMAC



**FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL
AREAS - HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01**

**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 Period ¹ (mm)	Assumed Side Slope of Pavement Structure	Minimum Embankment Platform Widening Per Side (m)
Highway 69 SBL and NBL Swamp 201	Foundation mitigation not required	N/A	0 + 80	4H:1V	2.0
Highway 69 SBL and NBL Swamp 202	Lightweight fill with partial preloading	130	145 + 100	4H:1V	2.0
Highway 69 SBL and NBL Swamp 203	No foundation mitigation is required (Swamp 203 crossing is comprised of a deep rock cut from STA 11+350 to 11+400 below base of swamp)	N/A	N/A	4H:1V	N/A
Highway 69 SBL and NBL Swamp 204	Lightweight fill with partial preloading	75	175 + 50	4H:1V	2.0
Highway 69 SBL Swamp 205	Partial sub-excavation with preloading	200	95 + 100	4H:1V	2.0
Highway 69 NBL Swamp 206	Foundation mitigation not required	N/A	0 + ~105	4H:1V	2.0

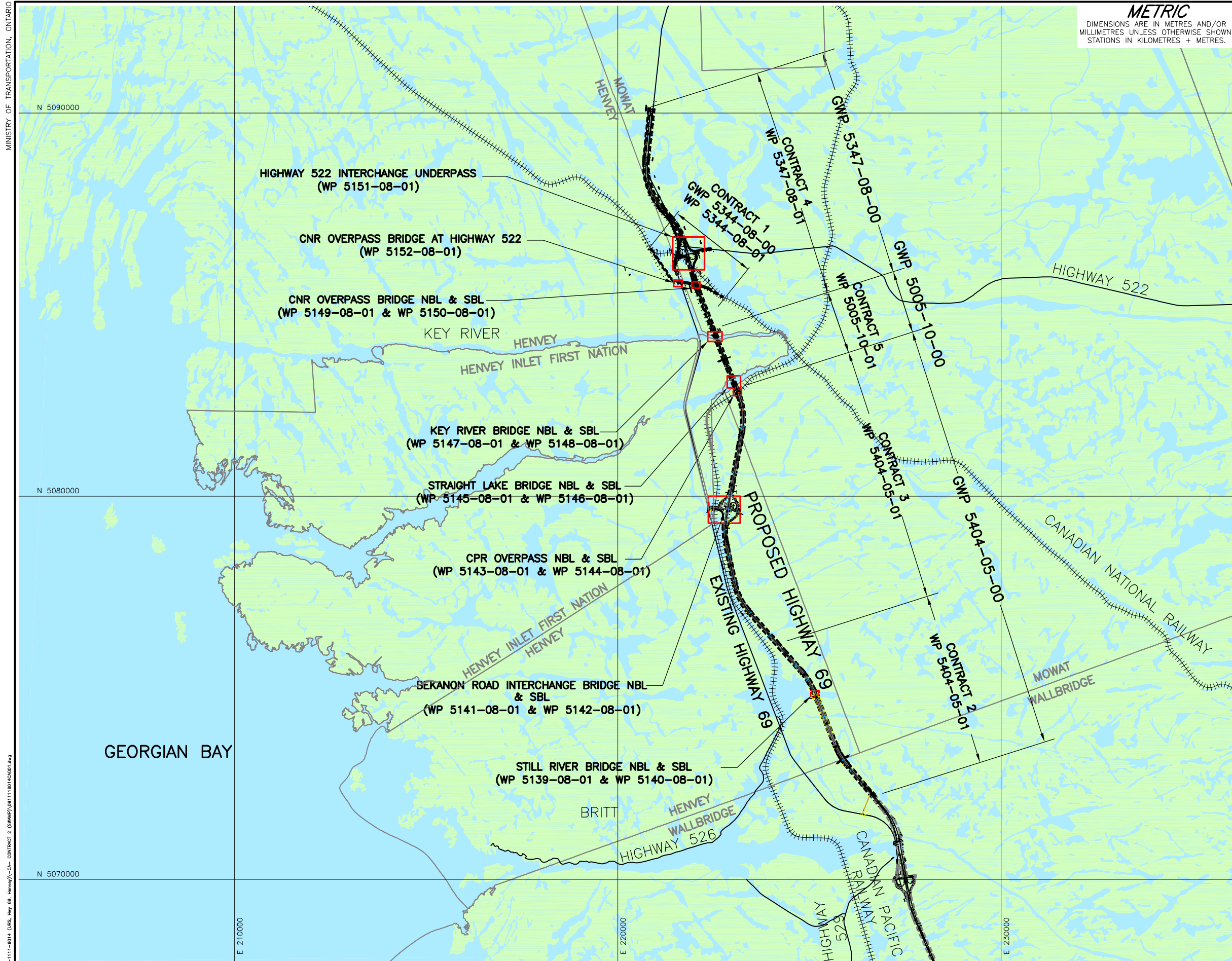
Note: 1. Estimated settlement is comprised of settlement during construction plus (+) post-construction settlement and includes primary and secondary (creep) consolidation of the cohesive deposits as well as rock fill settlement. The settlements do not include the immediate settlement of the granular fills and foundation soils, where applicable.

Prepared By: TZ/CN

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

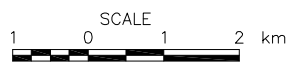
HIGHWAY 69
SITE LOCATION PLAN

SHEET

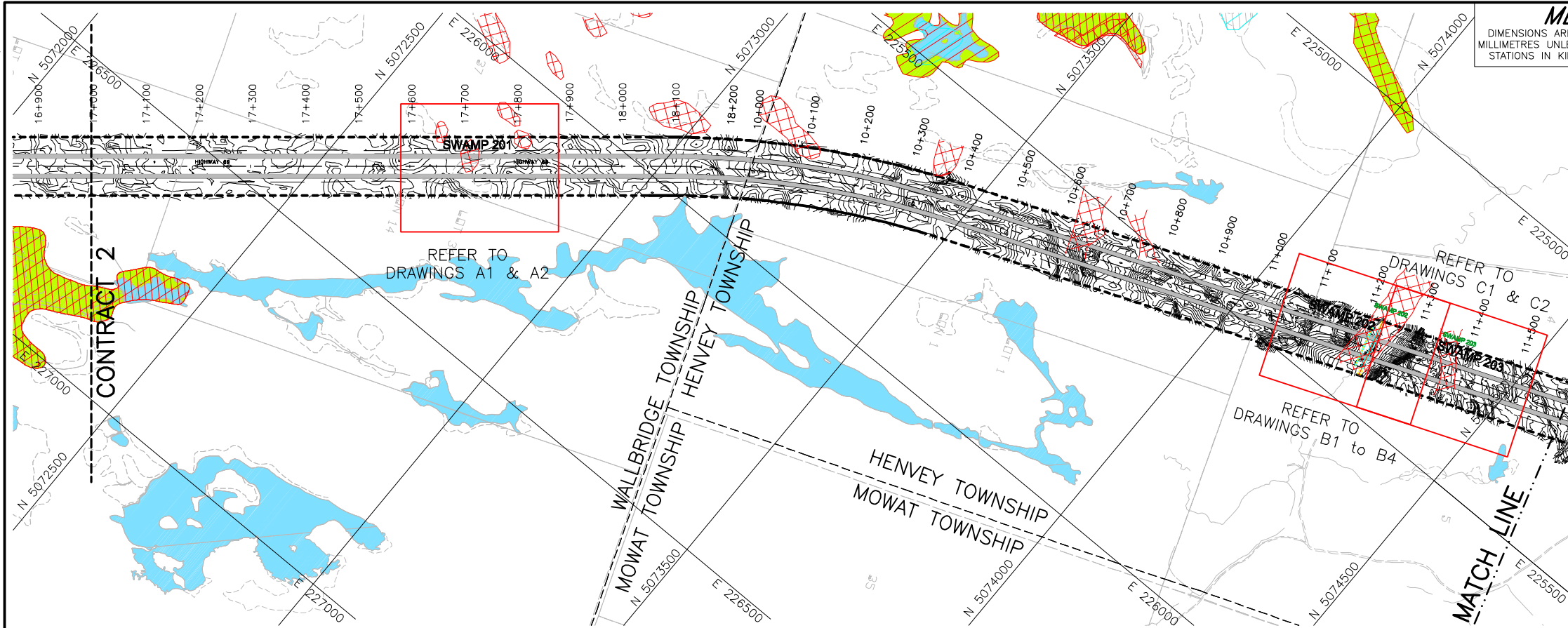
Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

KEY PLAN
NOT TO SCALE

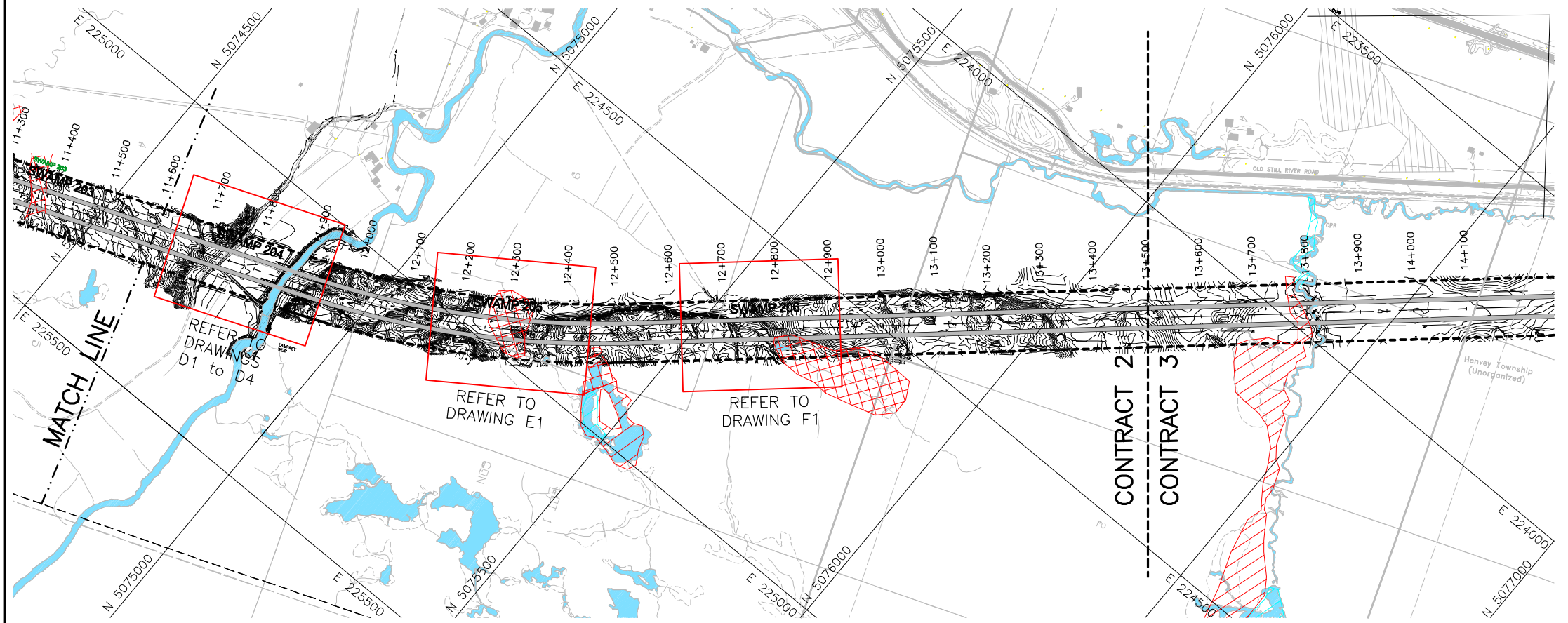
PLAN



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			
Geocres No. 41H-115			
NO.	DATE	BY	REVISION
HWY. 69			PROJECT NO. 09-1111-6014 DIST.
SUBM'D. TVA	CHKD. TVA	DATE: July 2012	SITE:
DRAWN: JFC	CHKD. CN	APPD. JPD/JMAC	DWG. 1



PLAN



PLAN

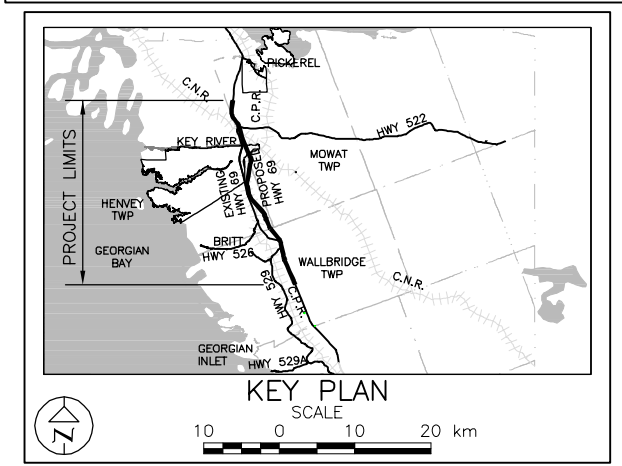


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 5404-05-01

HIGHWAY 69
SWAMP CROSSINGS AND HIGH FILL AREAS
INDEX PLAN

**Golder Associates Ltd.**
MISSISSAUGA, ONTARIO, CANADA

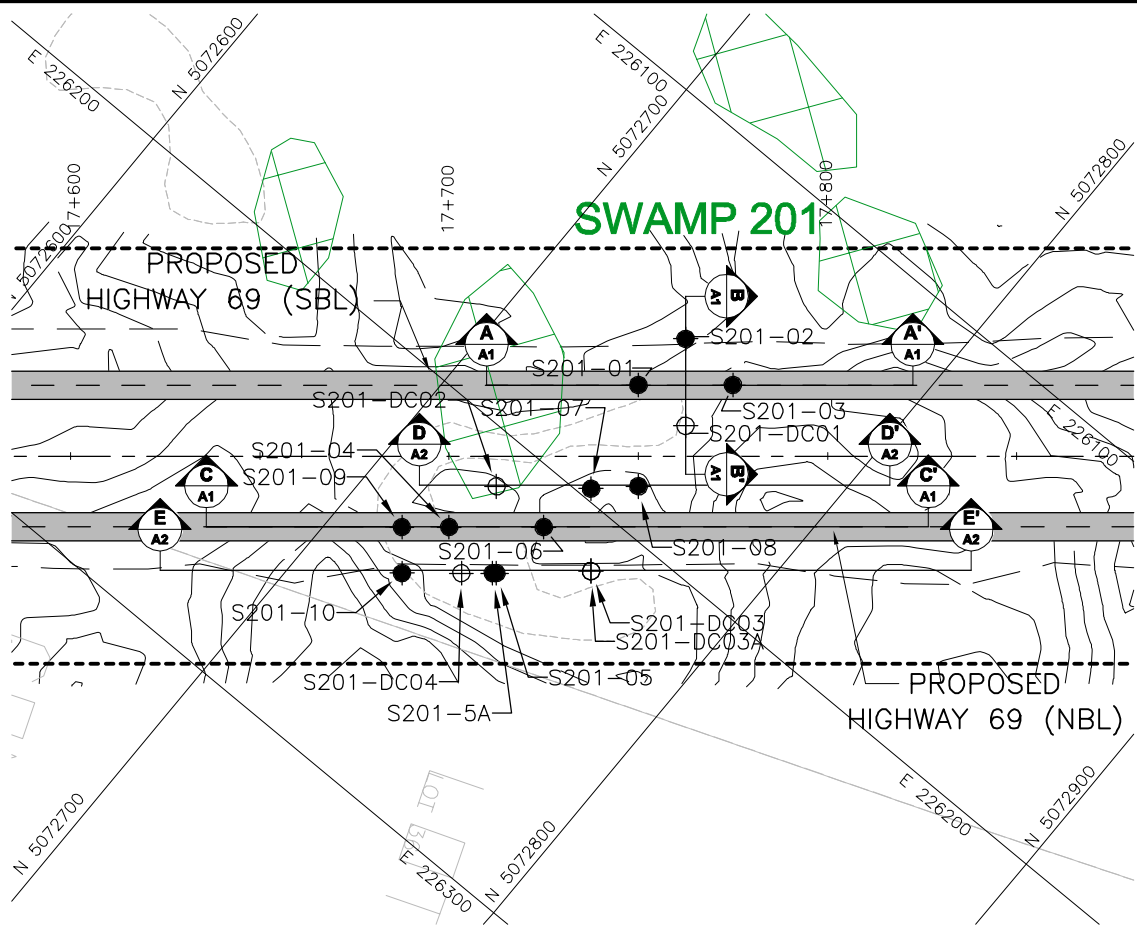


REFERENCE			
Base plans provided in digital format by URS, drawing files Hwy69_base.dwg, Hwy69_plan.dwg, received December 16, 2009, Contour drawing file HWY69_Contours-Plan_C2-C3.dwg, received July 14, 2011			
NO.	DATE	BY	REVISION
Geocres No. 41H-115			
HWY. 69	PROJECT NO. 09-1111-6014		DIST.
SUBM'D. TVA	CHKD. TVA	DATE: July 2012	SITE:
DRAWN: JFC	CHKD. CN	APPD. JPD/JMAC	DWG. 2

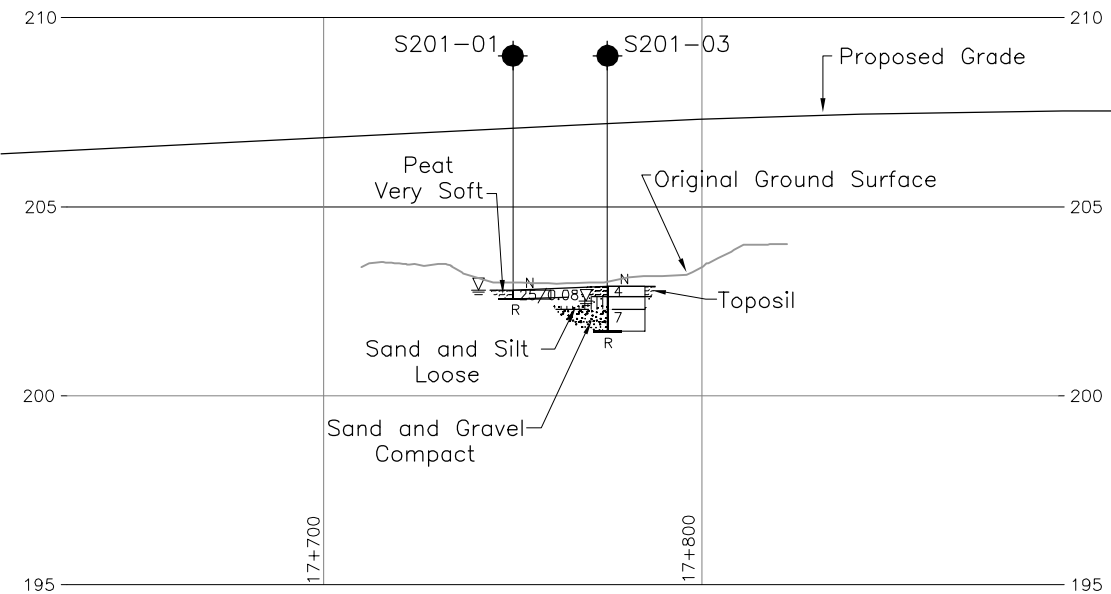


APPENDIX A

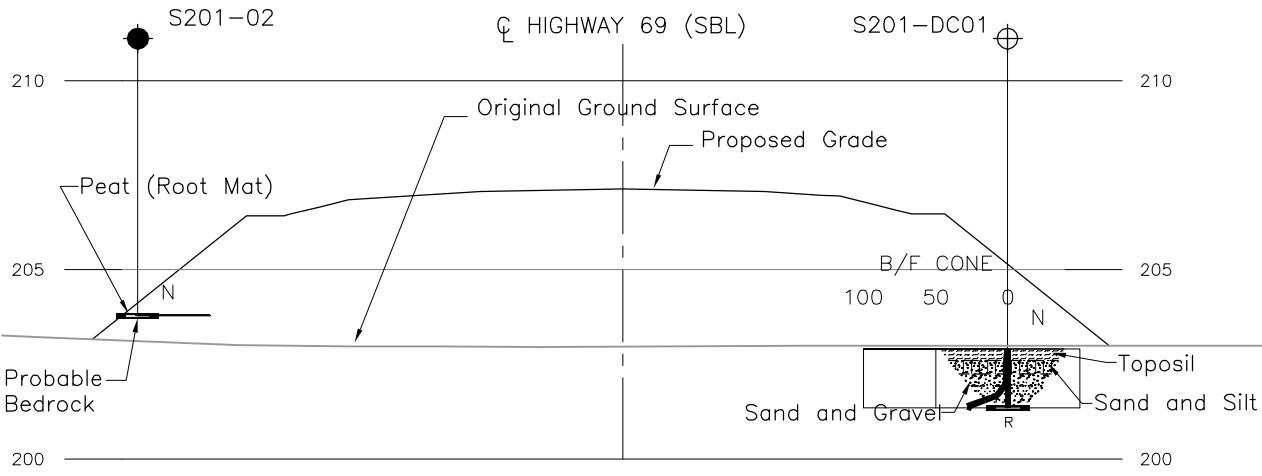
Highway 69 SBL – STA 17+750 to 17+775 and
Highway 69 NBL – STA 17+700 to 17+750 (Swamp 201)



PLAN
SCALE
0 20 40 m

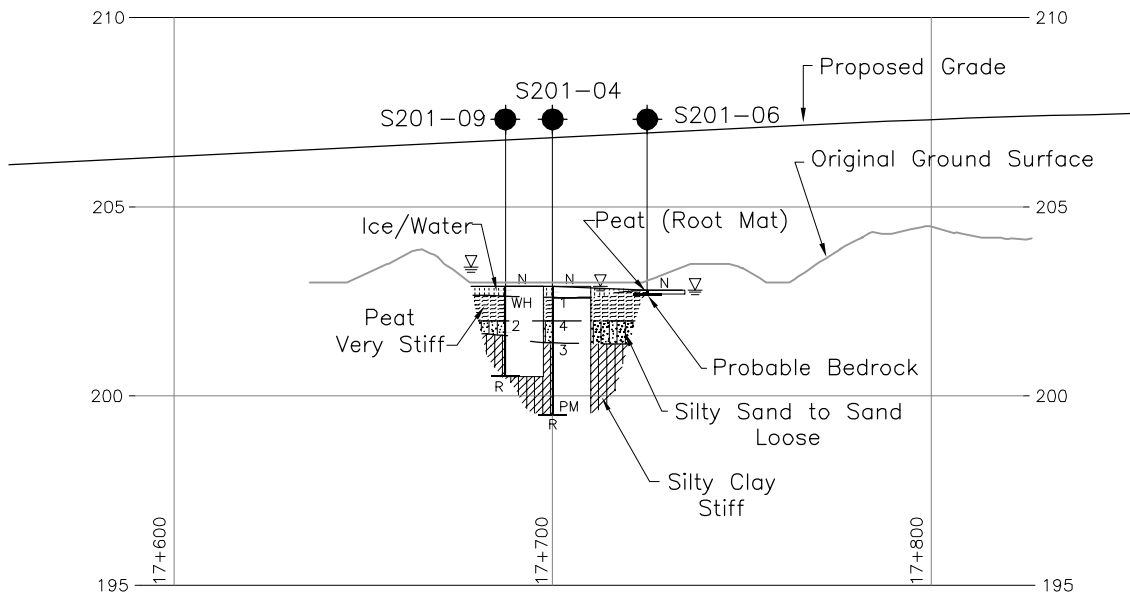


A-A' A1
CENTRELINE PROFILE
HIGHWAY 69 (SBL)
HORIZONTAL SCALE
0 20 40 m
VERTICAL SCALE
2 0 2 4 m



B-B' A1
CROSS-SECTION STA. 17+762.5
HIGHWAY 69 (SBL)
SCALE
2 0 2 4 m

Note: The Proposed Grade was provided in a digital format by URS, drawing file Hwy69_Contract2_xsections.dwg, received September 9, 2010.



C-C' A1
CENTRELINE PROFILE
HIGHWAY 69 (NBL)
HORIZONTAL SCALE
0 20 40 m
VERTICAL SCALE
2 0 2 4 m

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.

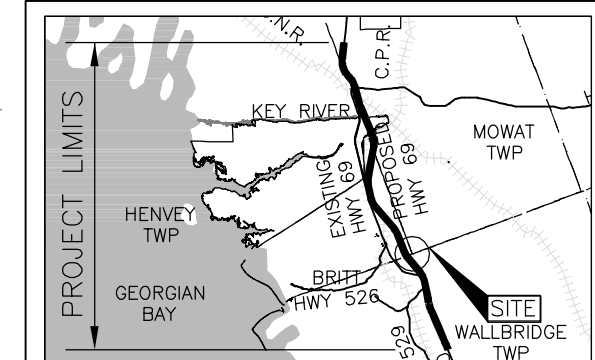
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 5404-05-01

HIGHWAY 69
STA 17+750 TO 17+775 (SBL)
STA. 17+700 TO 17+750 (NBL)
BOREHOLE LOCATIONS AND SOIL STRATA



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN
SCALE
0 6 12 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
S201-01	202.8	5072740.2	226168.1
S201-02	203.8	5072742.0	226150.8
S201-03	202.9	5072759.4	226152.1
S201-04	202.9	5072725.8	226229.0
S201-05	202.9	5072743.2	226230.4
S201-5A	202.9	5072742.4	226231.0
S201-06	202.8	5072745.0	226213.0
S201-07	203.5	5072748.1	226197.2
S201-08	203.3	5072757.3	226188.7
S201-09	202.9	5072716.2	226237.0
S201-10	203.4	5072724.0	226246.3
S201-DC01	202.9	5072756.7	226168.4
S201-DC02	203.1	5072728.5	226212.7
S201-DC03	203.0	5072762.0	226214.0
S201-DC03A	203.0	5072762.0	226214.0
S201-DC04	202.9	5072736.1	226236.3

REFERENCE

Base plans provided in digital format by URS, drawing files Hwy69_base.dwg, Hwy69_plan.dwg, received December 16, 2009. Original Ground Surface cut from contour drawing file HWY69_Contour-Plan_C2_C3.dwg, received July 14, 2011 and the Proposed Grade obtained from drawing file Hwy69_profile-nov-18-2011, received December 5, 2011.

NO.	DATE	BY	REVISION
Geocres No. 41H-115			
HWY. 69		PROJECT NO. 09-1111-6014	DIST.
SUBM'D. TVA	CHKD. TVA	DATE: July 2012	SITE:
DRAWN: JFC/CD	CHKD. CN	APPD. JPD/JMAC	DWG. A1



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

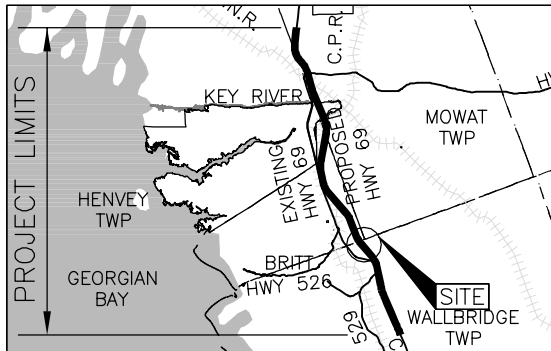
CONT No.
WP No. 5404-05-01

HIGHWAY 69
STA 17+690 TO 17+740 (NBL)
SOIL STRATA

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



SCALE
6 0 6 12 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
S201-05	202.9	5072743.2	226230.4
S201-05A	202.9	5072742.4	226231.0
S201-07	203.5	5072748.1	226197.2
S201-08	203.3	5072757.3	226188.7
S201-10	203.4	5072724.0	226246.3
S201-DC02	203.1	5072728.5	226212.7
S201-DC03	203.0	5072762.0	226214.0
S201-DC04	202.9	5072736.1	226236.3

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.

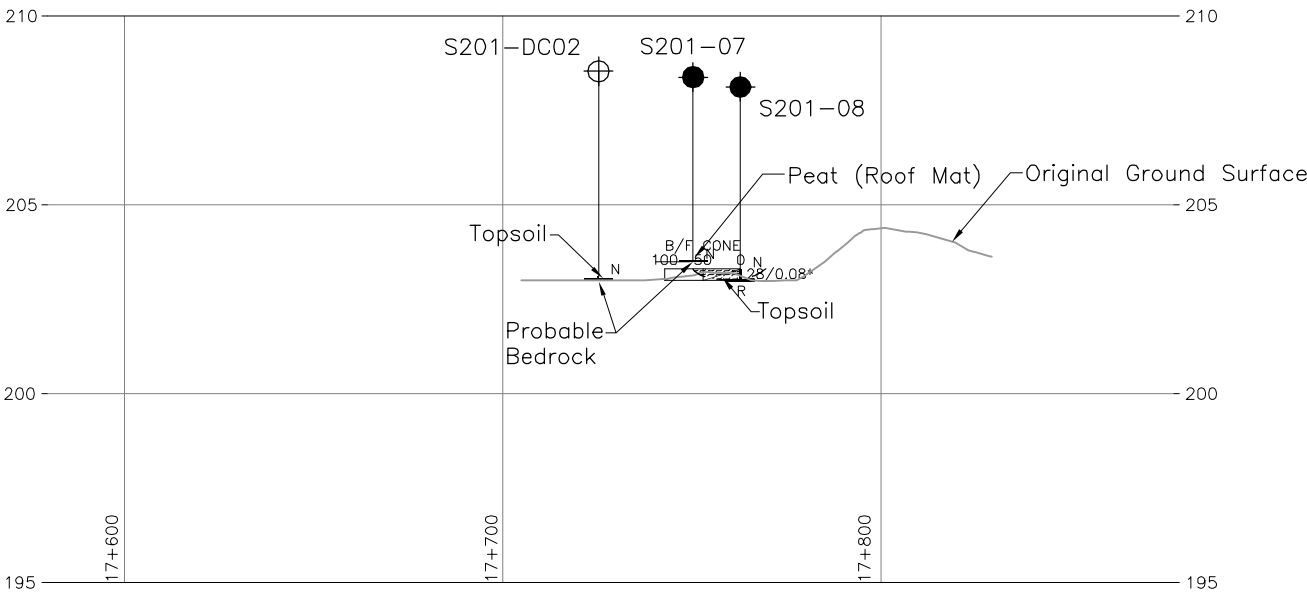
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

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.

NO.	DATE	BY	REVISION
Geocres No. 41H-115			
HWY. 69		PROJECT NO. 09-1111-6014	DIST.
SUBM'D. TVA	CHKD. TVA	DATE: July 2012	SITE:
DRAWN: JFC	CHKD. CN	APPD. JPD/JMAC	DWG. A2

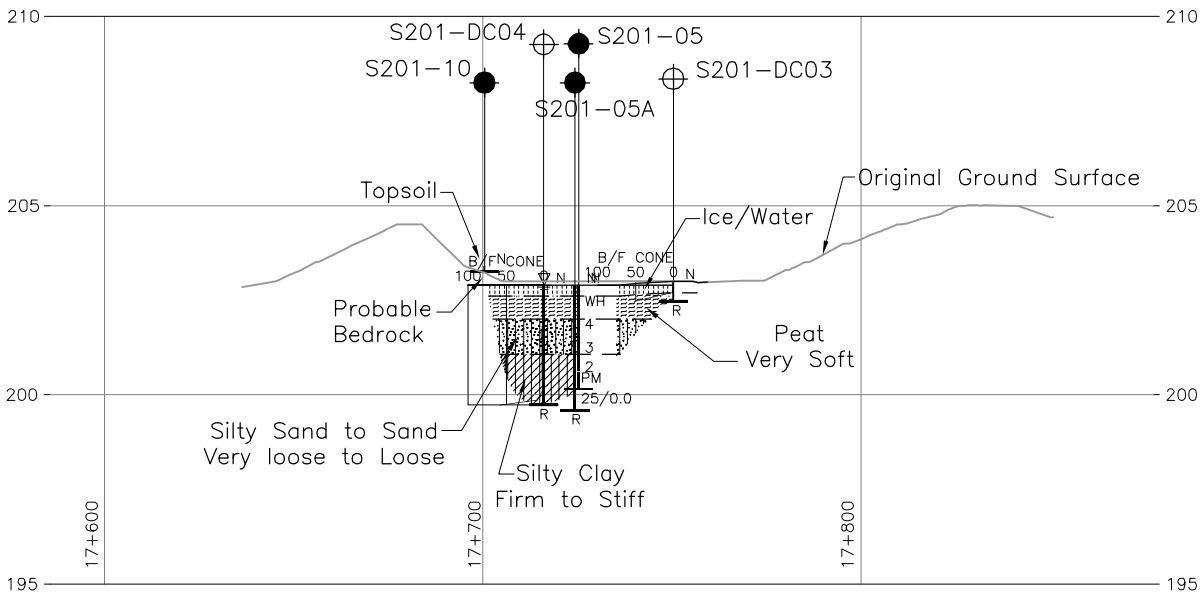
REFERENCE

Original Ground Surface cut from contour drawing file
HWY69_Contours-Plan_C2-C3.dwg, received April 5, 2011



D-D'
A2
EMBANKMENT TOE PROFILE
HIGHWAY 69 (NBL)

HORIZONTAL SCALE
20 0 20 40 m
VERTICAL SCALE
2 0 2 4 m



E-E'
A2
EMBANKMENT TOE PROFILE
HIGHWAY 69 (NBL)

HORIZONTAL SCALE
20 0 20 40 m
VERTICAL SCALE
2 0 2 4 m



PROJECT		RECORD OF BOREHOLE		No S201-01		SHEET 1 OF 1		METRIC						
W.P. 5404-05-01		LOCATION		N 5072740.2 ; E 226168.1		ORIGINATED BY		MR						
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment		COMPILED BY		OK				
DATUM		Geodetic		DATE		January 26, 2010		CHECKED BY		TVA				
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						
202.8	GROUND SURFACE							20 40 60 80 100						
0.0	PEAT, containing rootlets (Amorphous) Very soft Black Wet		1	SS	25/0.08			20 40 60 80 100						
0.4	END OF BOREHOLE SPOON REFUSAL END OF DCPT Refusal to Further Penetration (Hammer Bouncing)													
NOTES: 1. Water level in open borehole at ground surface (Elev. 202.8 m) upon completion of drilling. 2. A Dynamic Cone Penetration Test was advanced 1.0 m east of Borehole S201-01 to confirm depth to refusal; refusal encountered at a depth of 0.4 m below ground surface (Elev. 202.4 m). 3. Borehole and DCPT advanced using portable drilling equipment with a half-weight hammer. SPT 'N' value shown has been adjusted to reflect value that would be obtained with a standard weight hammer.														



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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD


PROJECT		RECORD OF BOREHOLE		No S201-03		SHEET 1 OF 1		METRIC					
W.P.		LOCATION		ORIGINATED BY		MR							
DIST		BOREHOLE TYPE		COMPILED BY		OK							
DATUM		DATE		CHECKED BY		TVA							
09-1111-6014		N 5072759.4 ; E 226152.1											
5404-05-01		Portable Equipment											
Geodetic		January 26, 2010											
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
202.9	GROUND SURFACE												
202.8	TOPSOIL		1A	SS	4								1 45 51 3
202.3	SAND and SILT, trace gravel, trace clay, containing wood fragments, organics and rootlets		1B	SS	4								
0.6	Loose Brown Wet		2	SS	7		202						
201.7	SAND and GRAVEL, trace to some silt, containing rootlets												
1.2	Loose Grey Wet												
	END OF BOREHOLE SPOON REFUSAL												
NOTES: 1. Water level in open borehole at a depth of 0.4 m below ground surface (Elev. 202.5 m) upon completion of drilling. 2. Borehole and DCPT advanced using portable drilling equipment with a half-weight hammer. SPT 'N' values shown have been adjusted to reflect values that would be obtained with a standard weight hammer.													

PROJECT		RECORD OF BOREHOLE		No S201-04		SHEET 1 OF 1		METRIC	
W.P.		LOCATION		ORIGINATED BY		DIST		BOREHOLE TYPE	
DATE		COMPILED BY		CHECKED BY		DATUM		DATE	
09-1111-6014		N 5072725.8 ; E 226229.0		MR		HWY 69		Portable Equipment, Wash Boring, BW Casing	
Geodetic		January 26, 2010		TVA		OK			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
202.9	ICE SURFACE													
0.0	ICE													
0.3	WATER													
202.0	PEAT, trace sand, containing rootlets (Amorphous) Very soft Dark Brown Wet		1	SS	1									
0.9			2	SS	4									
201.4	SAND, trace silt, containing rootlets Loose Grey Wet		3	SS	3									
1.5	SILTY CLAY Stiff Brown to grey Moist													
199.5	END OF BOREHOLE SPOON REFUSAL		4	TO	PM*									
3.4	NOTES: * Unable to recover a Shelby tube sample between depths of 3.0 m and 3.4 m. 1. Water level in open borehole at ice surface (Elev. 202.9 m) upon completion of drilling. 2. Upper 1.5 m of borehole advanced using portable drilling equipment with a half-weight hammer. SPT 'N' values shown have been adjusted to reflect values that would be obtained with a standard weight hammer. 3. An additional borehole was drilled 1.0 m south of Borehole S201-04 to obtain a shelly tube sample between depths of 1.5 m and 2.0 m below ice surface (Elev 201.4 m and Elev 200.9 m).		5	SS	50/0.0									

PROJECT		RECORD OF BOREHOLE		No S201-05		SHEET 1 OF 1		METRIC										
W.P.		LOCATION		ORIGINATED BY														
DIST		BOREHOLE TYPE		COMPILED BY														
DATUM		DATE		CHECKED BY														
09-1111-6014		N 5072743.2 ; E 226230.4		MR														
5404-05-01		Portable Equipment		OK														
Geodetic		January 26, 2010		TVA														
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
								20 40 60 80 100	20 40 60 80 100	W _p	W	W _L	20 40 60	kN/m ³				
202.9	0.0	ICE SURFACE																
		ICE																
	0.3	WATER																
		PEAT, containing wood fragments and rootlets (Amorphous)		1	SS	WH												
202.0	0.9	Very soft Dark brown Wet		2	SS	4												
201.4		Silty SAND, trace gravel, trace clay, containing rootlets		3A	SS	3												
201.1	1.8	Loose Grey Wet		3B	SS													
		SAND, trace to some gravel, trace to some silt, some clay		4	SS	2												
200.2	2.7	Very loose Grey Wet																
		SILTY CLAY, trace sand																
		Soft to firm Grey Moist																
		END OF BOREHOLE																
NOTES: 1. Water level in open borehole at ice surface (Elev. 202.9 m) upon completion of drilling. 2. An additional borehole was drilled 1.0 m south of Borehole S201-05 to obtain a Shelby tube sample and to carry out in situ vane test; see Record of Borehole No. S201-05A for details. 3. Borehole advanced using portable drilling equipment with a half-weight hammer. SPT 'N' values shown have been adjusted to reflect values that would be obtained with a standard weight hammer.																		

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No S201-05A		SHEET 1 OF 1		METRIC	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5072742.4 ; E 226231.0</u>		ORIGINATED BY <u>MR</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Portable Equipment, Wash Boring, BW Casing</u>		COMPILED BY <u>OK</u>			
DATUM <u>Geodetic</u>		DATE <u>January 26, 2010</u>		CHECKED BY <u>TVA</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × REMOULDED											
202.9	ICE SURFACE																			
0.0	See Record of Borehole S201-05 for subsurface conditions within these elevations.																			
200.6																				
2.3	SILTY CLAY Firm Grey Moist		5	TO	PM															
199.6																				
3.3	END OF BOREHOLE SPOON REFUSAL NOTE: 1. Unable to push in situ vane past a depth of 3.3 m below ice surface (Elev. 199.6 m). 3. Borehole advanced using portable drilling equipment with a half-weight hammer. SPT 'N' values shown have been adjusted to reflect values that would be obtained with a standard weight hammer.		6	SS	25/0.0															



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

GT-A-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S201-07				SHEET 1 OF 1		METRIC								
W.P. 5404-05-01		LOCATION N 5072748.1 ; E 226197.2				ORIGINATED BY MR										
DIST _____ HWY 69		BOREHOLE TYPE Hand Excavation				COMPILED BY OK										
DATUM Geodetic		DATE January 26, 2010				CHECKED BY TVA										
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 (%)			
203.5	GROUND SURFACE						20	40	60	80	100	W _p	W	W _L		
0.0	PEAT (Root Mat) END OF EXCAVATION PROBABLE BEDROCK NOTES: 1. Hand digging carried out at proposed borehole location to expose bedrock. 2. Excavation dry upon completion. 3. Bedrock outcrop noted within the vicinity of Borehole S201-07.															

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT		RECORD OF BOREHOLE		No S201-08		SHEET 1 OF 1		METRIC					
W.P.		LOCATION		ORIGINATED BY									
DIST		BOREHOLE TYPE		COMPILED BY									
DATUM		DATE		CHECKED BY									
09-1111-6014		N 5072757.3 ; E 226188.7		MR									
5404-05-01		Portable Equipment, Uncased		OK									
Geodetic		January 26, 2010		TVA									
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
203.3	GROUND SURFACE												
0.0	TOPSOIL		1	SS	28/0.08		203						
0.3	END OF BOREHOLE SPOON REFUSAL END OF DCPT Refusal to Further Penetration (Hammer Bouncing) NOTES: 1. Open borehole dry upon completion of drilling. 2. A Dynamic Cone Penetration Test was advanced 1.0 m west of Borehole S201-08, refusal encountered at a depth of 0.3 m below ground surface (Elev. 203.0 m). 3. Borehole and DCPT advanced using portable drilling equipment with a half-weight hammer. SPT 'N' value shown has been adjusted to reflect value that would be obtained with a standard weight hammer.												

PROJECT		RECORD OF BOREHOLE		No S201-09		SHEET 1 OF 1		METRIC								
W.P.		LOCATION		ORIGINATED BY												
DIST		BOREHOLE TYPE		COMPILED BY												
DATUM		DATE		CHECKED BY												
09-1111-6014		N 5072716.2 ; E 226237.0		MR												
5404-05-01		Portable Equipment, BW Casing, Wash Boring		OK												
Geodetic		January 27, 2010		TVA												
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 (%)
202.9	ICE SURFACE															
0.0	ICE															
0.2	WATER															
202.0	PEAT, containing rootlets (Amorphous) Very soft Dark brown Wet		1	SS	WH											
201.7			2A	SS	2											
1.2	Silty SAND, trace to some gravel, containing rootlets Very loose Grey Wet		2B													
200.5	SILTY CLAY, trace to some sand, containing rootlets Stiff Grey Moist		3	SS	50/0.0											
2.4	END OF BOREHOLE SPOON REFUSAL															
NOTE: 1. Water level in open borehole at ice surface (Elev. 202.9 m) upon completion of drilling.																

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S201-10		SHEET 1 OF 1		METRIC											
W.P. 5404-05-01		LOCATION N 5072724.0 ; E 226246.3		ORIGINATED BY MR													
DIST HWY 69		BOREHOLE TYPE Hand Excavation		COMPILED BY OK													
DATUM Geodetic		DATE January 27, 2010		CHECKED BY TVA													
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 (%)				
203.4	GROUND SURFACE																
0.0	TOPSOIL																
0.2	END OF EXCAVATION PROBABLE BEDROCK																
	NOTE: 1. Hand digging carried out at proposed borehole location to expose bedrock. 2. Excavation dry upon completion.																

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

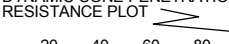
PROJECT 09-1111-6014		RECORD OF DCPT No S201-DC01		SHEET 1 OF 1		METRIC											
W.P. 5404-05-01		LOCATION N 5072756.7 ; E 226168.4		ORIGINATED BY MR													
DIST _____ HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test		COMPILED BY OK													
DATUM Geodetic		DATE January 26, 2010		CHECKED BY TVA													
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 (%)				
202.9 0.0	GROUND SURFACE Dynamic Cone Penetration Test (DCPT)						202	20	40	60	80	100	20	40	60		
201.4 1.6	END OF DCPT Refusal to Further Penetration (Hammer Bouncing) NOTE: 1. DCPT advanced using portable drilling equipment with a half-weight hammer. Blows shown have been adjusted to reflect values that would be obtained with a standard weight hammer.																

PROJECT 09-1111-6014		RECORD OF DCPT No S201-DC02		SHEET 1 OF 1		METRIC											
W.P. 5404-05-01		LOCATION N 5072728.5 ; E 226212.7		ORIGINATED BY MR													
DIST HWY 69		BOREHOLE TYPE Hand Excavation		COMPILED BY OK													
DATUM Geodetic		DATE January 26, 2010		CHECKED BY TVA													
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 (%)				
203.1	GROUND SURFACE																
0.0	TOPSOIL																
	END OF EXCAVATION PROBABLE BEDROCK																
	NOTE:																
	1. Bedrock outcrop observed in the vicinity of the DCPT; bedrock confirmed by hand excavation at the DCPT location.																
	2. Excavation dry upon completion.																

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT 09-1111-6014		RECORD OF DCPT No S201-DC03		SHEET 1 OF 1		METRIC											
W.P. 5404-05-01		LOCATION N 5072762.0 ; E 226214.0		ORIGINATED BY MR													
DIST HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test		COMPILED BY OK													
DATUM Geodetic		DATE January 26, 2010		CHECKED BY TVA													
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 (%)				
203.0	GROUND SURFACE																
0.0	Dynamic Cone Penetration Test (DCPT)																
202.5	END OF DCPT Refusal to Further Penetration (Hammer Bouncing)																
0.5	NOTES: 1. DCPT advanced using portable drilling equipment with a half-weight hammer. Blows shown have been adjusted to reflect values that would be obtained with a standard weight hammer. 2. An additional Dynamic Cone Penetration Test was driven adjacent to DCPT S201-DC03; See Record of DCPT S201-DC03A for details.																

PROJECT <u>09-1111-6014</u>		RECORD OF DCPT No S201-DC03A		SHEET 1 OF 1		METRIC														
W.P. <u>5404-05-01</u>		LOCATION <u>N 5072762.0 ; E 226214.0</u>		ORIGINATED BY <u>MR</u>																
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Portable Equipment, Dynamic Cone Penetration Test</u>		COMPILED BY <u>OK</u>																
DATUM <u>Geodetic</u>		DATE <u>January 26, 2010</u>		CHECKED BY <u>TVA</u>																
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W _p W W _L				WATER CONTENT (%)			
203.0	GROUND SURFACE							20	40	60	80	100								
0.0	Dynamic Cone Penetration Test (DCPT)																			
202.4	END OF DCPT																			
0.6	Refusal to Further Penetration (Hammer Bouncing)																			
	NOTE: 1. DCPT advanced using portable drilling equipment with a half-weight hammer. Blows shown have been adjusted to reflect values that would be obtained with a standard weight hammer.																			

PROJECT 09-1111-6014		RECORD OF DCPT No S201-DC04		SHEET 1 OF 1		METRIC				
W.P. 5404-05-01		LOCATION N 5072736.1 ; E 226236.3		ORIGINATED BY MR						
DIST _____ HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test		COMPILED BY OK						
DATUM Geodetic		DATE January 27, 2010		CHECKED BY TVA						
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						
202.9 0.0	GROUND SURFACE Dynamic Cone Penetration Test (DCPT)									
199.7 3.2	END OF DCPT Refusal to Further Penetration (Hammer Bouncing)									

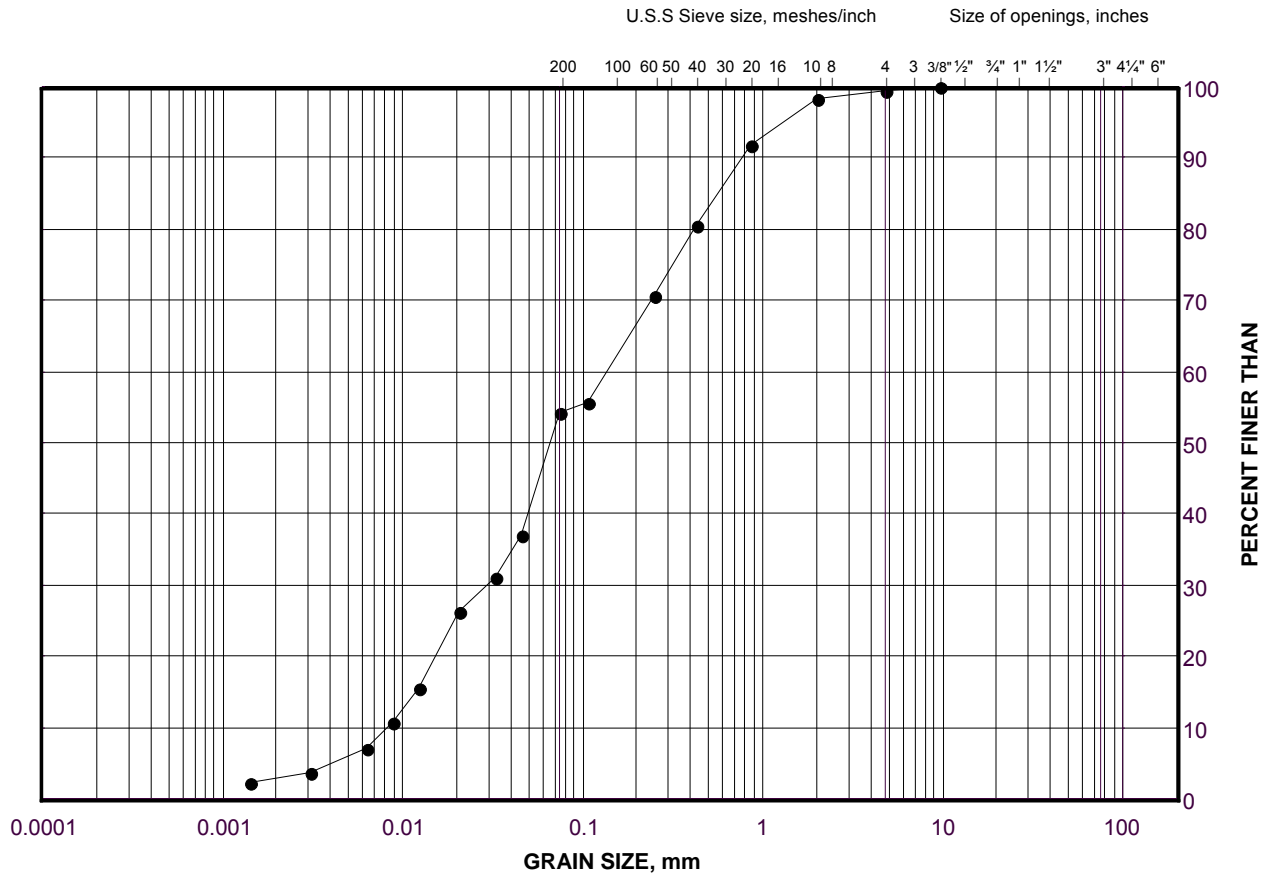
GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

GRAIN SIZE DISTRIBUTION

Sand and Silt

Highway 69 (SBL) STA 17+750 to 17+775 (Swamp 201)

FIGURE A.S201-01



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

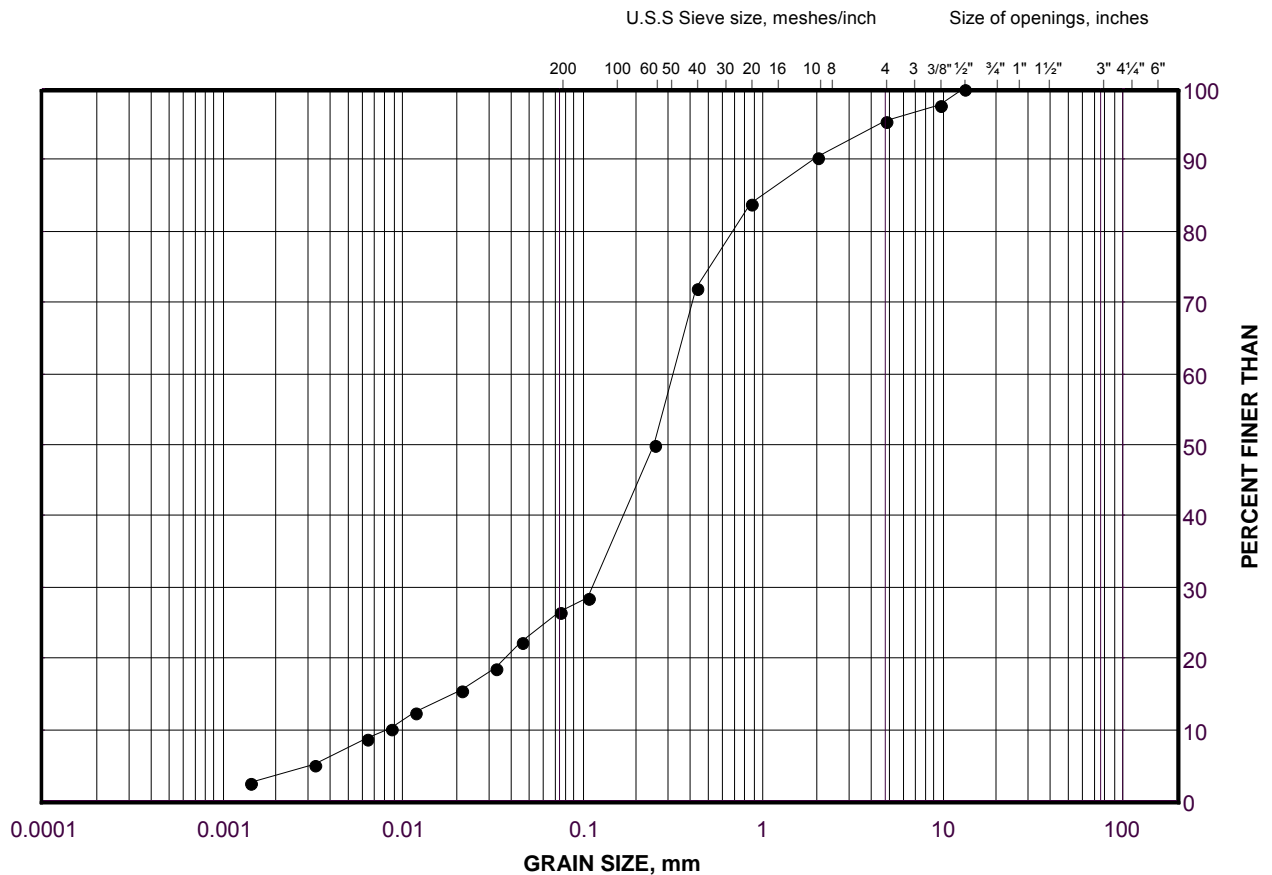
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S201-03	1B	202.5

GRAIN SIZE DISTRIBUTION

Silty Sand

Highway 69 (NBL) STA 17+700 to 17+750 (Swamp 201)

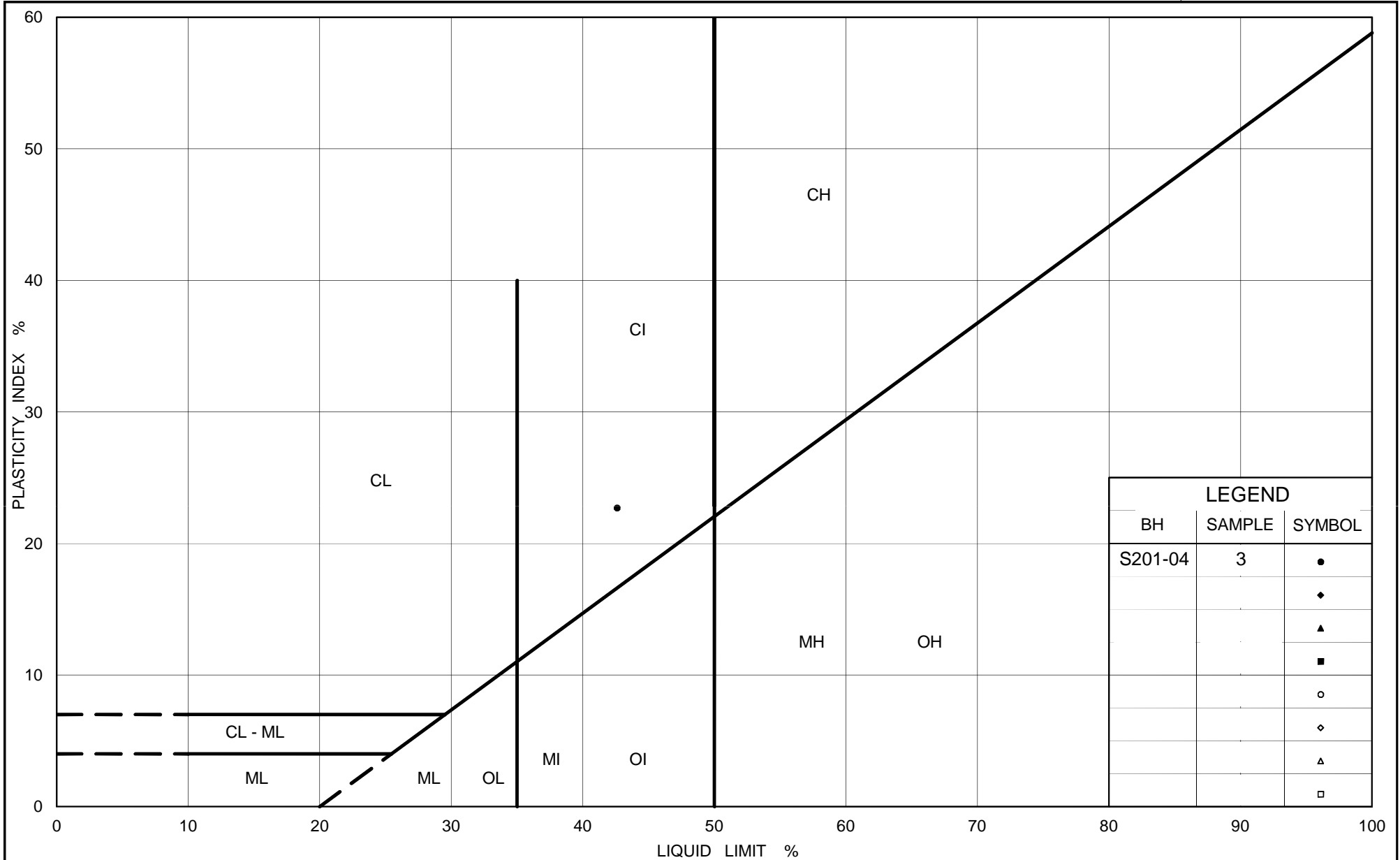
FIGURE A.S201-02



SILT AND CLAY SIZES				FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED				SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S201-05	2	201.7



Ministry of Transportation

Ontario

PLASTICITY CHART

Silty Clay

Highway 69 (SBL) STA 17+700 to 17+750 (Swamp 201)

Figure No. A.S201-03

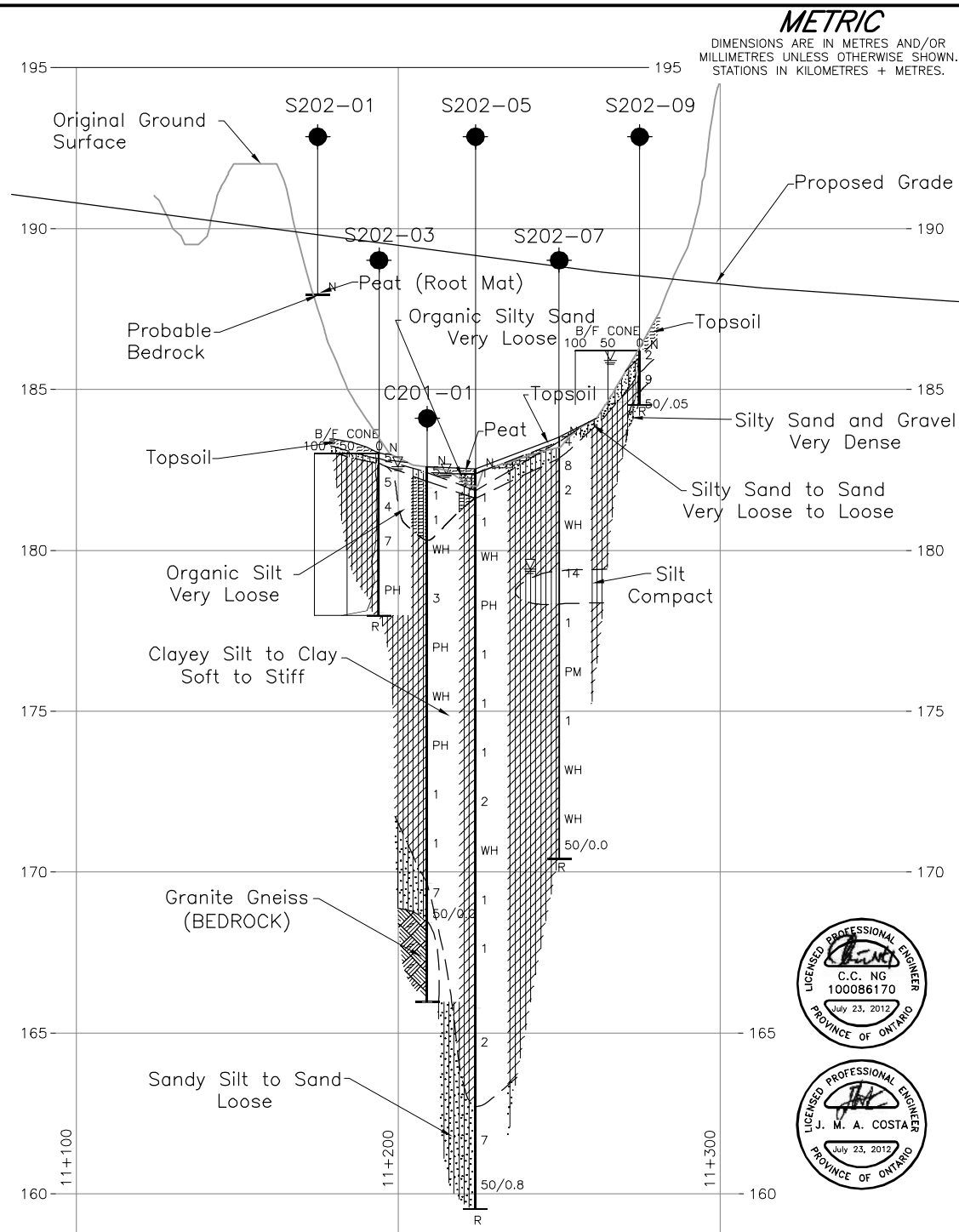
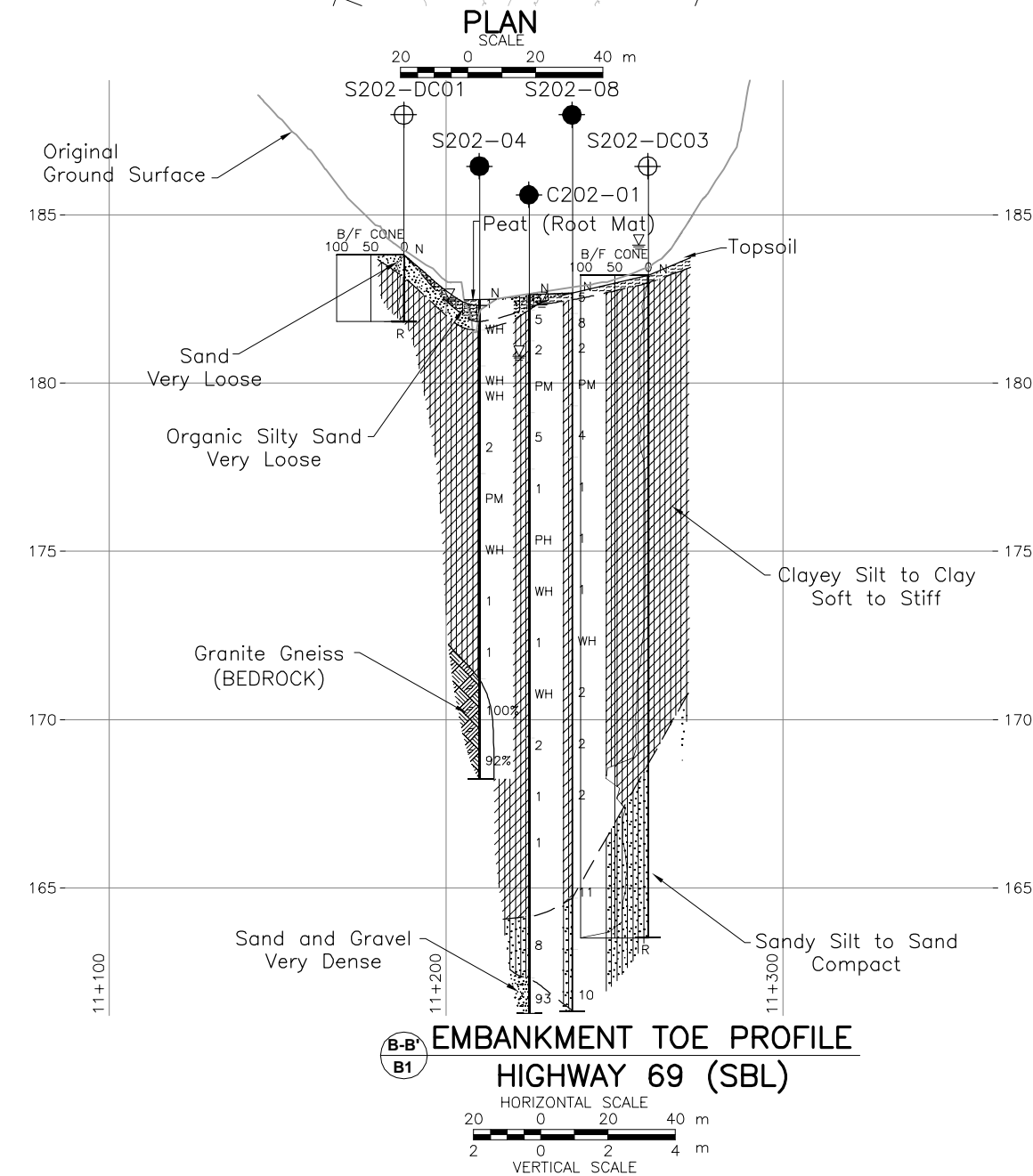
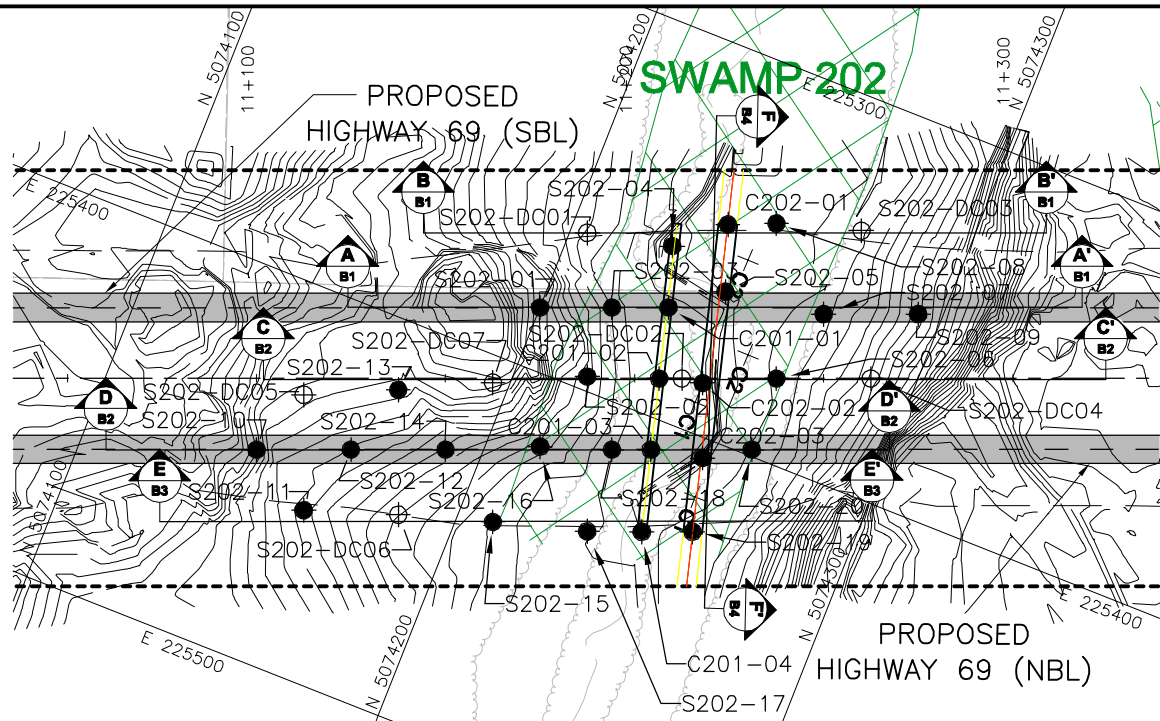
Project No. 09-1111-6014

Checked By: TVA



APPENDIX B

**Highway 69 SBL – STA 11+175 to 11+275 and
Highway 69 NBL – STA 11+100 to 11+225 (Swamp 202)**



CENTRELINE PROFILE HIGHWAY 69 (SBL)

HORIZONTAL SCALE
20 0 20 40 m
VERTICAL SCALE
2 0 2 4 m

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 files Hwy69_base.dwg, Hwy69_plan.dwg, received December 16, 2009. Original Ground Surface cut from contour drawing file HWY69_Contour-Plan_C2_C3.dwg, received July 14, 2011 and the Proposed Grade obtained from drawing file Hwy69_profile-nov-18-2011.dwg, received December 5, 2011.

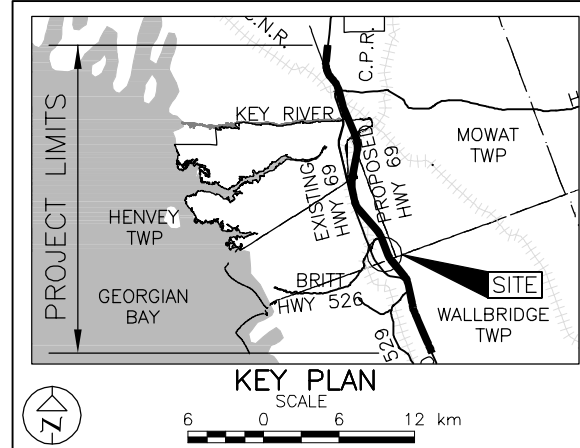
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 5404-05-01

HIGHWAY 69
STA 11+175 TO 11+275 (SBL)
STA 11+100 TO 11+225 (NBL)
BOREHOLE LOCATIONS AND SOIL STRATA



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)
- 100% Rock Quality Designation (RQD)
- ≡ WL upon completion of drilling
- R Refusal

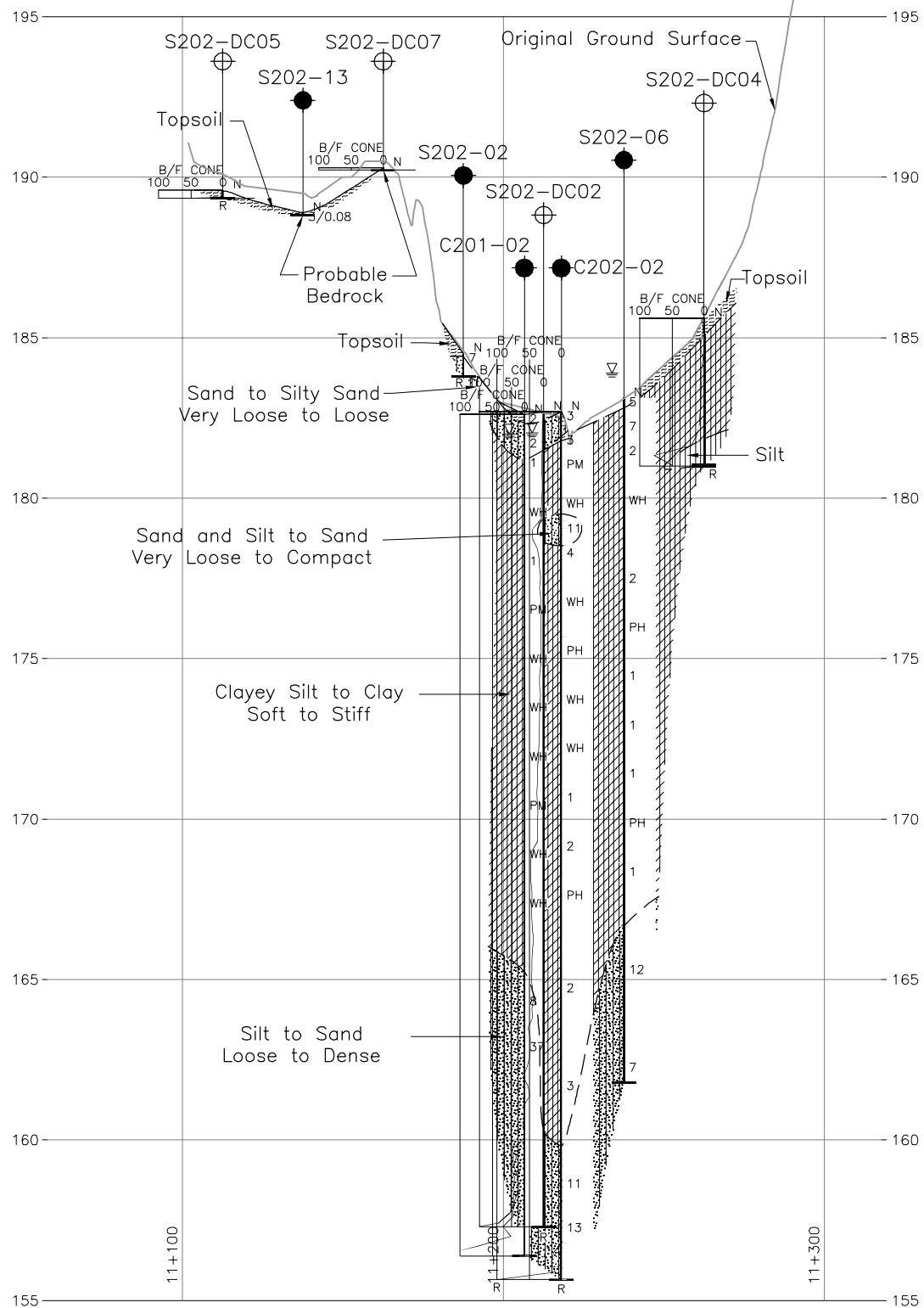
BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
S202-01	188.0	5074200.1	225383.9
S202-02	184.5	5074218.4	225396.3
S202-03	183.0	5074217.8	225377.0
S202-04	182.5	5074226.7	225356.0
S202-05	182.5	5074244.1	225362.1
S202-06	183.1	5074265.1	225378.4
S202-07	183.5	5074270.5	225358.0
S202-08	182.7	5074250.0	225340.3
S202-09	186.2	5074293.7	225348.8
S202-10	191.9	5074144.2	225446.5
S202-11	188.3	5074161.7	225456.7
S202-12	188.8	5074167.4	225437.3
S202-13	188.9	5074173.2	225418.0
S202-14	187.3	5074190.7	225428.1
S202-15	184.1	5074209.3	225441.2
S202-16	184.5	5074213.6	225418.1
S202-17	183.1	5074233.5	225434.4
S202-18	182.9	5074231.6	225411.9
S202-19	183.0	5074259.4	225424.2
S202-20	183.3	5074266.0	225398.3

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
C201-01	182.6	5074231.7	225371.4
C201-02	182.6	5074236.3	225389.8
C201-03	182.9	5074241.2	225408.1
C201-04	182.7	5074246.9	225429.2
C202-01	182.6	5074238.2	225345.3
C202-02	182.6	5074247.4	225386.7
C202-03	182.8	5074254.7	225405.1

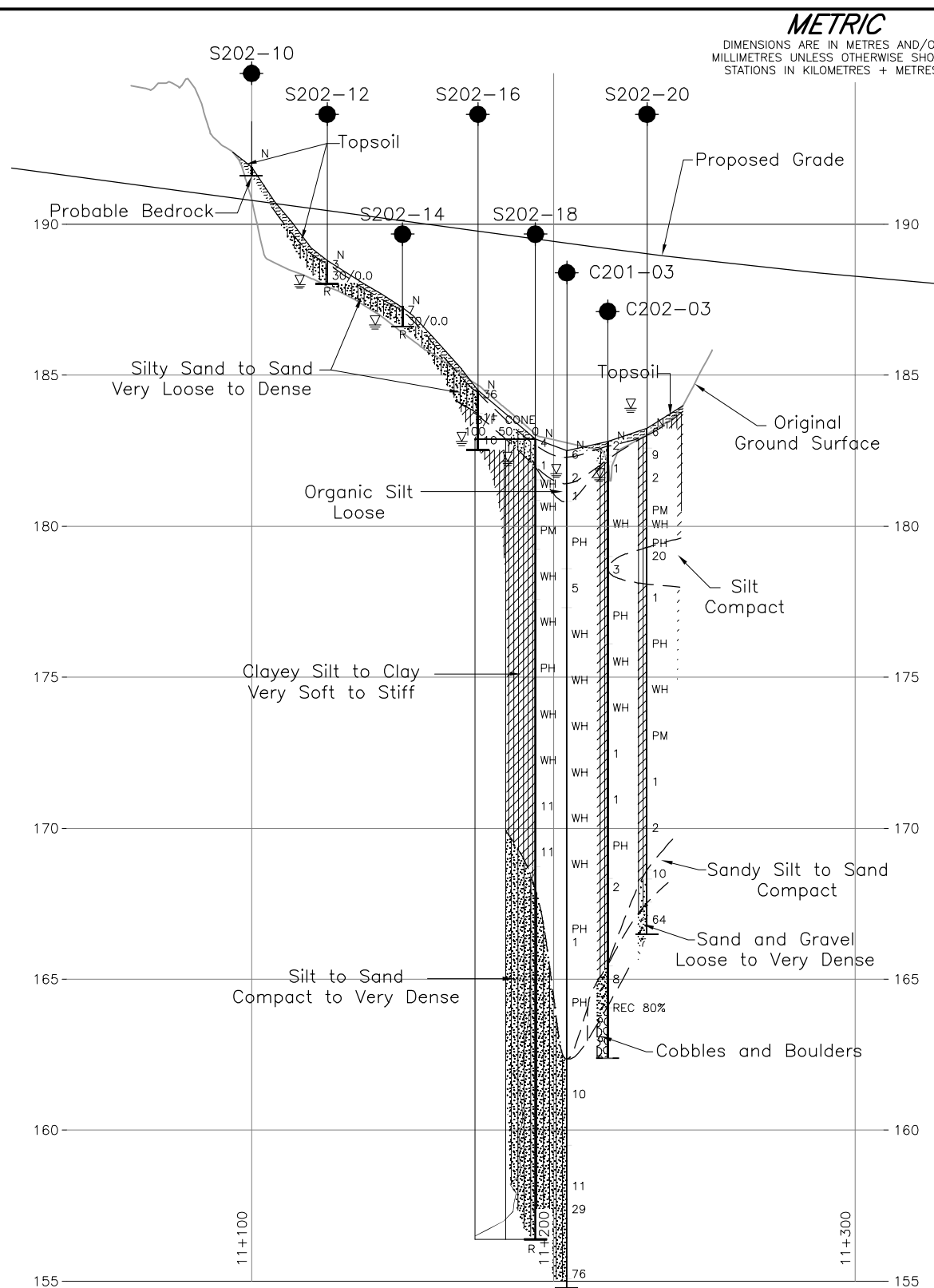
BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
S202-DC01	183.8	5074204.5	225361.0
S202-DC02	182.7	5074241.9	225387.6
S202-DC03	183.2	5074271.7	225333.8
S202-DC04	185.6	5074288.4	225369.2
S202-DC05	189.6	5074150.5	225428.4
S202-DC06	185.7	5074185.4	225448.7
S202-DC07	190.3	5074195.8	225407.0

NO.	DATE	BY	REVISION
Geocres No. 41H-115			
HWY. 69		PROJECT NO. 09-1111-6014	
SUBM'D. TVA	CHKD. TVA	DATE: July 2012	SITE:
DRAWN: JFC	CHKD. CN	APPD. JPD/JMAC	DWG. B1



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

HORIZONTAL SCALE
20 0 20 40 m
VERTICAL SCALE
2 0 2 4 m



**CENTRELINE PROFILE
HIGHWAY 69 (NBL)**

HORIZONTAL SCALE
20 0 20 40 m
VERTICAL SCALE
2 0 2 4 m

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.



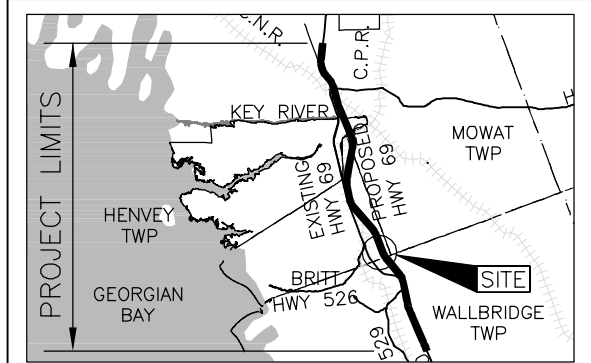
CONT No.
WP No. 5404-05-01

HIGHWAY 69
STA 11+175 TO 11+275 (SBL)
STA 11+100 TO 11+225 (NBL)
SOIL STRATA

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN

SCALE
6 0 6 12 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)
- 100% Rock Quality Designation (RQD)
- WL upon completion of drilling
- REC Recovery (%)
- R Refusal

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
C201-02	182.6	5074236.3	225389.8
C201-03	182.9	5074241.2	225408.1
C202-02	182.6	5074247.4	225386.7
C202-03	182.8	5074254.7	225405.1
S202-02	184.5	5074218.4	225396.3
S202-06	183.1	5074265.1	225378.4
S202-10	191.9	5074144.2	225446.5
S202-12	188.8	5074167.4	225437.3
S202-13	188.9	5074173.2	225418.0
S202-14	187.3	5074190.7	225428.1
S202-16	184.5	5074213.6	225418.1
S202-18	182.9	5074231.6	225411.9
S202-20	183.3	5074266.0	225398.3
S202-DC02	182.7	5074241.9	225387.6
S202-DC04	185.6	5074288.4	225369.2
S202-DC05	189.6	5074150.5	225428.4
S202-DC07	190.3	5074195.8	225407.0

REFERENCE

Original Ground Surface cut from contour drawing file HWY69_Contour-Plan_C2_C3.dwg, received July 14, 2011 and the Proposed Grade obtained from drawing file Hwy69_profile-nov-18-2011.dwg, received December 5, 2011.

NO.	DATE	BY	REVISION
NO.	DATE	BY	REVISION
HWY. 69			PROJECT NO. 09-1111-6014
SUBM'D. TVA	CHKD. TVA	DATE: July 2012	SITE:
DRAWN: JFC	CHKD. CN	APPD. JPD/JMAC	DWG. B2

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

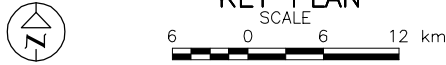
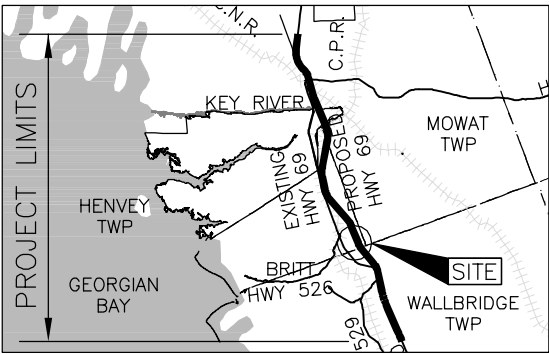
CONT No.
WP No. 5404-05-01

HIGHWAY 69
STA 11+175 TO 11+275 (SBL)
STA 11+100 TO 11+225 (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
- REC Recovery (%)
- R Refusal

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
C201-04	183.0	5074246.9	225429.2
S202-11	188.3	5074161.7	225456.7
S202-15	184.1	5074209.3	225441.2
S202-17	183.1	5074233.5	225434.4
S202-19	183.0	5074259.4	225424.2
S202-DC06	185.7	5074185.4	225448.7

NOTES

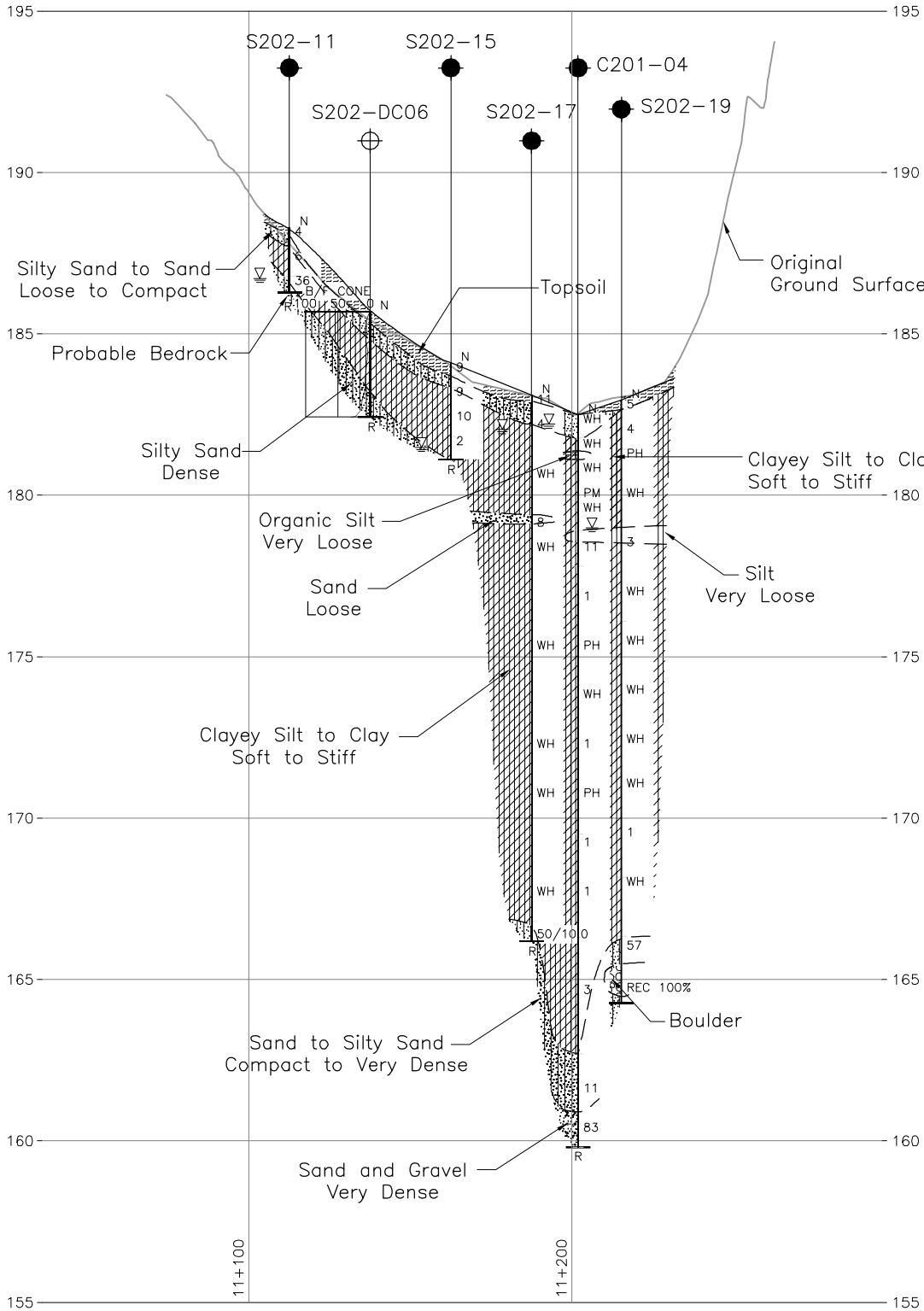
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

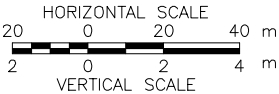
The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS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

REFERENCE

Original Ground Surface cut from contour drawing file
HWY69_Contour-Plan_C2_C3.dwg, received July 14, 2011



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



NO.	DATE	BY	REVISION
Geocres No. 41H-115			
HWY. 69			PROJECT NO. 09-1111-6014 DIST.
SUBM'D. TVA	CHKD. TVA	DATE: July 2012	SITE:
DRAWN: JFC	CHKD. CN	APPD. JPD/JMAC	DWG. B3

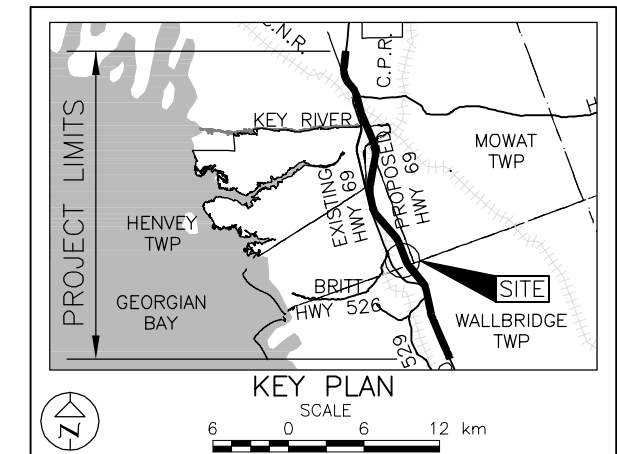
CONT No.
WP No. 5404-05-01

HIGHWAY 69
CROSS-SECTION STA. 11+220 (SBL AND NBL)
SOIL STRATA






**Golder
Associates**

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 |
| REC | Recovery (%) |
| R | Refusal |

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
S202-05	182.5	5074244.1	225362.1
S202-06	183.1	5074265.1	225378.4
S202-08	182.7	5074250.0	225340.3
S202-19	183.0	5074259.4	225424.2
S202-20	183.3	5074266.0	225398.3

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.

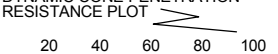
The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS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

REFERENCE

Cross-Section provided in a digital format by URS, drawing file culv_11+220.dwg, received December 23, 2011.

NO.	DATE	BY	REVISION		
Geocres No. 41H-115					
HWY. 69			PROJECT NO. 09-1111-6014		DIST.
SUBM'D. TVA		CHKD. TVA		DATE: July 2012	SITE:
DRAWN: JFC		CHKD. CN		APPD. JPD/JMAC	DWG. B4



PROJECT 09-1111-6014		RECORD OF BOREHOLE No S202-01		SHEET 1 OF 1		METRIC				
W.P. 5404-05-01		LOCATION N 5074200.1 ; E 225383.9		ORIGINATED BY ID						
DIST HWY 69		BOREHOLE TYPE Hand Excavation		COMPILED BY NK						
DATUM Geodetic		DATE March 2, 2010		CHECKED BY TVA						
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT  SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p — W — 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						
188.0	GROUND SURFACE									
0.9	PEAT (Root Mat), containing topsoil Moist END OF EXCAVATION PROBABLE BEDROCK NOTES: 1. Hand digging carried out at proposed borehole location to expose bedrock. 2. Excavation dry upon completion.									

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT		RECORD OF BOREHOLE		No S202-02		SHEET 1 OF 1		METRIC					
W.P.		LOCATION		ORIGINATED BY		ID							
DIST		BOREHOLE TYPE		COMPILED BY		NK							
DATUM		DATE		CHECKED BY		TVA							
PROJECT 09-1111-6014		N 5074218.4 ; E 225396.3											
5404-05-01		Portable Equipment											
HWY 69		March 2, 2010											
Geodetic													
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
184.5	GROUND SURFACE												
0.0	TOPSOIL												
183.8	Silty SAND Loose Dark brown Moist		1	SS	7		184						
0.7	END OF BOREHOLE AUGER REFUSAL												
NOTES: 1. Open borehole dry upon completion of drilling. 2. Two additional boreholes were drilled 1.0 m east and 0.5 m south of Borehole S202-02 to confirm depth to refusal; refusal encountered at a depth of 0.7 m below ground surface (Elev. 183.8 m) in both boreholes.													

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

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S202-04		SHEET 1 OF 2		METRIC											
W.P. 5404-05-01		LOCATION N 5074226.7 ;E 225356.0		ORIGINATED BY MR													
DIST HWY 69		BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY ARM													
DATUM Geodetic		DATE March 12, 2011		CHECKED BY TVA													
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	Wp	w	wL	γ	GR	SA	SI	CL	
182.5	GROUND SURFACE							20 40 60 80 100									
0.0	Peat (Root Mat)		1A	SS	1		182	○ UNCONFINED + FIELD VANE									
0.2	Organic Silty SAND, containing rootlets		1B	SS				● QUICK TRIAXIAL × REMOULDED									
181.8	Very loose Grey Wet		2A	SS	WH												
0.9	SAND, containing wood fragments		2B	SS													
180.5	Very loose Grey Wet						181										
2.0	SILTY CLAY, containing organics and fibrous peat layers		3	SS	WH												
	Soft Grey Wet		4	SS	WH		180										
	SILTY CLAY, trace sand																
	Soft to stiff Grey Wet						179										
	Containing silt layers between depths of 3.7 m and 5.2 m		5	SS	2												
177.3	CLAY, trace to some silt, trace sand						178										
5.2	Soft to firm Brown to grey Wet		6	TO	PM												
							177										
							176										
			7	SS	WH		175										
							174										
			8	SS	1												
							173										
			9	SS	1		172										
171.2	Granite Gneiss (BEDROCK)						171										
11.3	Bedrock cored from depths of 11.3 m to 14.3 m		1	NQ RC	REC 100%		170										
	For bedrock coring details refer to Record of Drillhole S202-04																
			2	NQ RC	REC 96%		169										
168.2	END OF BOREHOLE																
14.3																	

Continued Next Page

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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD



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

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: S202-04

SHEET 1 OF 1

LOCATION: N 5074226.7 ; E 225356.0

DRILLING DATE: March 12, 2011

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D25 Bomb

DRILLING CONTRACTOR: Walker Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	JN - Joint FLT - Fault SHR- 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 MB- Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.														FEATURES	NOTES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
						RECOVERY		R.Q.D. %	FRACT. INDEX PER Meter	DIP w.r.t. CORE AXIS	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec	WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
						TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr		Ja	W1	W2	W3	W4	W5			W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
						100 00000	100 00000																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
	NW Casing March 12, 2011	Continued from Record of Borehole C201-1		171.21																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					

DEPTH SCALE

1 : 50



LOGGED: MR

CHECKED: TVA

GTA-RCK 030 09-1111-6014.GPJ GAL-MISS.GDT 7/24/12 SAC/DD

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S202-05		SHEET 1 OF 2		METRIC	
W.P. 5404-05-01		LOCATION N 5074244.1 ;E 225362.1		ORIGINATED BY		MR	
DIST HWY 69		BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY		MAS	
DATUM Geodetic		DATE March 13, 2011		CHECKED BY		TVA	



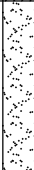
[illegible]

Continued Next Page

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

GT-A-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT		RECORD OF BOREHOLE		No S202-05		SHEET 2 OF 2		METRIC			
W.P.		LOCATION		ORIGINATED BY		DIST		BOREHOLE TYPE		COMPILED BY	
DATUM		DATE		CHECKED BY		MASS		TVA			
09-1111-6014		N 5074244.1 ; E 225362.1		MR		HWY 69		127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		MAS	
Geodetic		March 13, 2011		TVA							


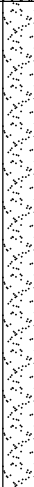
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W _p	W	W _L		
165.7	SILTY CLAY, trace to some sand Soft to stiff Grey Wet		12	SS	1		167							0 0 37 63
166							166							
165							165							
164	CLAY, some silt, containing grey silt layers Stiff Brown Wet		13	SS	2		164							
163							163							
162							162							
161						161								
160						160								
159.5	SAND, some silt Loose Grey Wet		14	SS	7		162							
162							162							
161							161							
160						160								
159.5						159.5								
23.0	END OF BOREHOLE SPOON AND CASING REFUSAL		15	SS	50/0.0		23.0							
NOTES: 1. Water flowing from top of casing when advanced to a depth of 20.7 m below ground surface (Elev. 161.8 m). Water level in open borehole at a depth of 0.2 m below ground surface (Elev. 182.3 m) upon completion of drilling.														

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S202-06		SHEET 1 OF 2		METRIC	
W.P. 5404-05-01		LOCATION N 5074265.1 ; E 225378.4		ORIGINATED BY MR			
DIST HWY 69		BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY AM			
DATUM Geodetic		DATE February 1 and March 9, 2011		CHECKED BY TVA			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)	
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × REMOULDED							
183.1	GROUND SURFACE															
0.0	TOPSOIL															
182.8			1	SS	5											
182.4	CLAYEY SILT, containing sand layers															
0.7	Firm		2	SS	7											
	Brownish grey															
	Moist															
	SILTY CLAY, trace sand															
	Soft to stiff		3	SS	2											
	Brown and grey															
	Moist															
	Silt layers encountered between depths of 4.3 m and 6.6 m		4	SS	WH									0 1 61 38		
			5	SS	2											
			6	TO	PH											
			7	SS	1											
			8	SS	1									0 1 50 49		
			9	SS	1											
			10	TO	PH											
			11	SS	1											

Continued Next Page

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

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S202-06		SHEET 2 OF 2		METRIC															
W.P. 5404-05-01		LOCATION N 5074265.1 ; E 225378.4		ORIGINATED BY MR																	
DIST _____ HWY 69		BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY AM																	
DATUM Geodetic		DATE February 1 and March 9, 2011		CHECKED BY TVA																	
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					
166.6	SILTY CLAY, trace sand Soft to stiff Brown and grey Moist						168														
							167														
16.5	SAND, some silt, trace gravel and clay Loose to compact Grey Wet		12	SS	12		166														
							165														
							164														
							163														
161.8			13	SS	7		162														
21.3	END OF BOREHOLE NOTES: * Water flowing from top of casing when advanced to a depth of 17.7 m below ground surface (Elev. 165.4 m); height of casing at about 0.8 m above ground surface. 1. Water level (not-stabilized) in casing at 0.8 m above ground surface (Elev. 183.9 m) during drilling - Artesian Condition. 2. Open borehole filled with drilling mud in order to continue borehole advancement; Water level measured in open casing prior to grouting at a depth of 2.8 m below ground surface (Elev. 180.3 m)																				

PROJECT		RECORD OF BOREHOLE		No S202-07		SHEET 1 OF 1		METRIC																
W.P. 5404-05-01		LOCATION		N 5074270.5 ; E 225358.0		ORIGINATED BY		MR																
DIST		HWY 69		BOREHOLE TYPE		127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY																
AM		DATE		March 14, 2011		CHECKED BY		TVA																
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																		
183.5	0.0	GROUND SURFACE		1A																				
183.3	0.2	TOPSOIL		1B	SS	4																		
182.8	0.7	Silty SAND, trace clay Loose Brownish grey Wet		2	SS	8																		
		SILT, trace clay, trace sand Soft Brown and grey Moist to wet		3	SS	2																		
		Becoming grey below a depth of 2.4 m		4	SS	WH																		
179.4	4.1	SILT, trace clay, trace to some sand Compact Grey Wet		5	SS	14																		
178.3	5.2	CLAY, some silt, trace sand Firm Brown to grey Moist		6	SS	1																		
				7	TO	PM																		
175.0	8.5	SILTY CLAY, trace sand Firm Brown to grey Moist		8	SS	1																		
				9	SS	WH																		
				10	SS	WH																		
170.4	13.1	END OF BOREHOLE SPOON AND CASING REFUSAL		11	SS	50/0.0																		
NOTE: 1. Water level in open borehole at a depth of 4.1 m below ground surface (Elev. 179.4 m) upon completion of drilling.																								

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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD




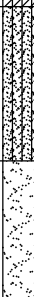

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No S202-08		SHEET 1 OF 2		METRIC	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074250.0 ;E 225340.3</u>		ORIGINATED BY <u>MR</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring</u>		COMPILED BY <u>MAS</u>			
DATUM <u>Geodetic</u>		DATE <u>March 11, 2011</u>		CHECKED BY <u>TVA</u>			

[illegible]


Continued Next Page

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

GT-A-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT		RECORD OF BOREHOLE		No S202-08		SHEET 2 OF 2		METRIC				
W.P.		LOCATION		ORIGINATED BY		DIST		BOREHOLE TYPE				
DATE		COMPILED BY		CHECKED BY		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT				
ELEVATION SCALE		SHEAR STRENGTH kPa		WATER CONTENT (%)		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	Wp W WL	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
--- CONTINUED FROM PREVIOUS PAGE ---												
164.7	SILTY CLAY, trace sand, containing silt layers up to a depth of 6.7 m Firm Grey Moist		12	SS	2		167					
18.0	Sandy SILT, trace clay Compact Grey Wet		13A 13B	SS	11		166					
163.2	SAND, some silt Compact Grey Wet						165					
19.5							164					
161.4			14	SS	10		163					
21.3	END OF BOREHOLE						162					
NOTES: * Water flowing from top of casing when advanced to a depth of 19.2 m below ground surface (Elev. 163.5 m). 1. Water level (not-stabilized) in casing at a depth of 0.3 m below ground surface (Elev. 182.0 m) measured at about 6:30 pm on March 11, 2011. 2. Water level (stabilized) in casing at a depth of 1.4 m above ground surface (Elev. 184.1 m) measured at about 7:00 am on March 12, 2011 - Artesian Condition.												

PROJECT		RECORD OF BOREHOLE		No S202-09		SHEET 1 OF 1		METRIC					
W.P. 5404-05-01		LOCATION		N 5074293.7 ; E 225348.8		ORIGINATED BY		MR					
DIST		HWY 69		BOREHOLE TYPE		127 mm O.D. Continuous Flight Solid Stem Augers		COMPILED BY					
DATUM		Geodetic		DATE		March 14, 2011		CHECKED BY					
								TVA					
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 (%)			
186.2	GROUND SURFACE												
0.0	TOPSOIL		1A	SS	2								
0.2	Silty SAND, containing rootlets		1B										
185.5	Very loose												
0.7	Brown												
	Wet												
184.8	SILTY CLAY, trace sand		2	SS	9								
	Stiff												
	Brown and grey												
	Moist		3	SS	50/05								
1.7	Silty SAND and GRAVEL, trace clay												
	Very dense												
	Brown												
	Moist to wet												
	END OF BOREHOLE SPOON AND AUGER REFUSAL												
	END OF DCPT Refusal to Further Penetration (Hammer Bouncing)												
NOTES: 1. Water level in open borehole at a depth of 0.3 m below ground surface (Elev. 185.9 m) upon completion of drilling. 2. Auger grinding at a depth of 1.6 m below ground surface (Elev. 184.6 m). 3. A Dynamic Cone Penetration Test was advanced 1.0 m north of Borehole S202-09 to confirm depth to refusal; refusal encountered at a depth of 1.7 m below ground surface (Elev. 184.5 m).													

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S202-10		SHEET 1 OF 1		METRIC											
W.P. 5404-05-01		LOCATION N 5074144.2 ; E 225446.5		ORIGINATED BY ID													
DIST _____ HWY 69		BOREHOLE TYPE Hand Excavation		COMPILED BY NK													
DATUM Geodetic		DATE March 1, 2010		CHECKED BY TVA													
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
								20 40 60 80 100	20 40 60 80 100	W _p	W	W _L	20 40 60	kN/m ³			
191.9	SNOW SURFACE																
0.0	TOPSOIL																
191.6	END OF EXCAVATION PROBABLE BEDROCK																
0.3	NOTES: 1. Hand digging carried out at proposed borehole location to expose bedrock. 2. Excavation dry upon completion.																

GTA-MTO 001 09-1111-6014.GPJ GAL-MASS.GDT 7/25/12 SAC/DD

PROJECT		RECORD OF BOREHOLE		No S202-11		SHEET 1 OF 1		METRIC						
W.P. 09-1111-6014		LOCATION		N 5074161.7 ; E 225456.7		ORIGINATED BY		ID						
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, BW Casing		COMPILED BY						
DATUM		Geodetic		DATE		March 1, 2010		CHECKED BY						
								TVA						
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													
0.2	Silty SAND, trace gravel, containing organics		1	SS	4									
187.7	Loose Brown Moist													
0.6	SILTY CLAY, containing organics		2	SS	6									
186.8	Firm													
1.5	Brown to grey Wet													
186.3	Silty SAND, trace gravel, trace to some clay, containing sand seams		3	SS	36									
2.0	Dense Brown Wet		4	SS	30/0.0									
	GRAVEL													
	END OF BOREHOLE SPOON REFUSAL													
NOTES: 1. Water level in open borehole at a depth of 1.6 m below ground surface (Elev. 186.7 m) upon completion of drilling. 2. Borehole caved to a depth of 2.0 m below ground surface (Elev. 186.0 m) upon removal of casing.														

PROJECT		RECORD OF BOREHOLE		No S202-12		SHEET 1 OF 1		METRIC														
W.P.		LOCATION		ORIGINATED BY		ID																
DIST		BOREHOLE TYPE		COMPILED BY		NK																
DATUM		DATE		CHECKED BY		TVA																
PROJECT 09-1111-6014		N 5074167.4 ; E 225437.3																				
5404-05-01		Portable Equipment																				
HWY 69		March 2, 2010																				
Geodetic																						
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		
188.8	0.0	GROUND SURFACE							20 40 60 80 100	20 40 60												
188.0	0.8	TOPSOIL Silty SAND, trace to some clay, containing sand seams Very loose Brown to grey Wet END OF BOREHOLE SPOON REFUSAL		1	SS	3			20 40 60 80 100	20 40 60												
				2	SS	30/0.0																
NOTES: 1. Water level in open borehole at a depth of 0.8 m below ground surface (Elev. 188.0 m) upon completion of drilling. 2. Borehole caved to a depth of 0.7 m below ground surface (Elev. 188.1 m) upon removal of casing. 3. Two additional boreholes were drilled 0.5 m west and 1.0 m south of Borehole S202-12 to confirm depth to refusal; refusal encountered at a depth of 0.8 m below ground surface (Elev. 188.0 m) in both boreholes.																						

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S202-13		SHEET 1 OF 1		METRIC										
W.P. 5404-05-01		LOCATION N 5074173.2 ; E 225418.0		ORIGINATED BY ID												
DIST _____ HWY 69		BOREHOLE TYPE Portable Equipment		COMPILED BY NK												
DATUM Geodetic		DATE March 2, 2010		CHECKED BY TVA												
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								
188.9	GROUND SURFACE															
0.1	TOPSOIL		1	SS	3/0.08											
	END OF BOREHOLE SPOON REFUSAL PROBABLE BEDROCK															
	NOTES:															
	1. Borehole dry upon completion of drilling.															
	2. Two additional boreholes were drilled 0.5 m south and 1.0 m west of Borehole S202-13 to confirm depth to refusal; refusal encountered at a depth of 0.1 m below ground surface (Elev. 188.8 m) in both boreholes.															

GTA-MTO 001 09-1111-6014.GPJ GAL-MASS.GDT 7/25/12 SAC/DD

PROJECT		RECORD OF BOREHOLE		No S202-14		SHEET 1 OF 1		METRIC					
W.P.		LOCATION		ORIGINATED BY		ID							
DIST		BOREHOLE TYPE		COMPILED BY		NK							
DATUM		DATE		CHECKED BY		TVA							
PROJECT 09-1111-6014		N 5074190.7 ; E 225428.1											
5404-05-01		Portable Equipment											
HWY 69		March 2, 2010											
Geodetic													
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												
0.9	TOPSOIL		1	SS	7		187						
186.6	Silty SAND, trace to some clay, trace gravel, containing sand seams		2	SS	30/0.0								
0.7	Loose Brown Moist END OF BOREHOLE SPOON REFUSAL												
NOTES: 1. Water level in open borehole at a depth of 0.6 m below ground surface (Elev. 186.7 m) upon completion of drilling. 2. An additional borehole was drilled 0.6 m south of Borehole S202-14 to confirm depth to refusal; refusal encountered at a depth of 0.7 m below ground surface (Elev. 186.6 m).													

PROJECT		09-1111-6014		RECORD OF BOREHOLE No S202-15		SHEET 1 OF 1		METRIC						
W.P.		5404-05-01		LOCATION		N 5074209.3 ; E 225441.2		ORIGINATED BY ID						
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, BW Casing		COMPILED BY NK						
DATUM		Geodetic		DATE		March 2, 2010		CHECKED BY TVA						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
184.1	GROUND SURFACE							20 40 60 80 100						
0.0	TOPSOIL		1	SS	9									
183.7														
183.3	SAND Loose Brown Moist		2	SS	9									
0.8	SILTY CLAY, containing silt seams, organics and rootlets Stiff Grey Wet		3	SS	10									
181.8														
2.3	CLAY, some silt Soft Grey Wet		4	SS	2									
181.1														
3.0	END OF BOREHOLE CASING REFUSAL PROBABLE BEDROCK													
NOTES: 1. Water level in open borehole at a depth of 2.6 m below ground surface (Elev. 181.5 m) upon completion of drilling. 2. An additional borehole was drilled 1.0 m north of Borehole S202-15 to carry out in situ vane test between depths of 2.4 m and 2.7 m below ground surface (Elev. 181.7 m and Elev. 181.4 m).														

PROJECT		RECORD OF BOREHOLE		No S202-16		SHEET 1 OF 1		METRIC									
W.P. 09-1111-6014		LOCATION		N 5074213.6 ; E 225418.1		ORIGINATED BY		ID									
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, BW Casing		COMPILED BY									
DATUM		Geodetic		DATE		March 2, 2010		CHECKED BY									
								TVA									
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									
184.5	GROUND SURFACE							20	40	60	80	100					
0.0	TOPSOIL		1	SS	36		184										
183.7	Silty SAND Dense Dark brown Moist to wet		2	SS	11		183										
0.8	SILTY CLAY, containing silty sand seams and organics Stiff Grey Wet		3	SS	10												
182.5	END OF BOREHOLE SPOON AND CASING REFUSAL																
2.0	NOTES: 1. Water level in open borehole at a depth of 1.7 m below ground surface (Elev. 182.8 m) upon completion of drilling. 2. Borehole caved to a depth of 1.9 m below ground surface (Elev. 182.6 m) upon removal of casing.																



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

GT-A-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT		RECORD OF BOREHOLE		No S202-17		SHEET 2 OF 2		METRIC								
W.P.		LOCATION		ORIGINATED BY		ID										
DIST		BOREHOLE TYPE		COMPILED BY		NK										
DATUM		DATE		CHECKED BY		TVA										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
	--- CONTINUED FROM PREVIOUS PAGE ---						20	40	60	80	100	W _p	W	W _L		
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED									
							20	40	60	80	100	20	40	60		
166.8	CLAY, trace silt Firm Grey Wet		9	TO	WH											
166.3	SAND, some silt, trace clay Compact Grey Wet		10	SS	58/0.15							o				0 83 13 4
166.2	END OF BOREHOLE SPOON AND CASING REFUSAL															
16.9	NOTES: 1. Water level in open borehole at a depth of 1.1 m below ground surface (Elev. 182.0 m) upon completion of drilling. 2. Borehole caved to a depth of 16.1 m below ground surface (Elev. 167.0 m) upon removal of casing.															



PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No S202-18		SHEET 1 OF 3		METRIC	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074231.6 ;E 225411.9</u>		ORIGINATED BY <u>MR</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>NW Casing Tricone, Wash Boring</u>		COMPILED BY <u>AM</u>			
DATUM <u>Geodetic</u>		DATE <u>February 25, 2011</u>		CHECKED BY <u>TVA</u>			

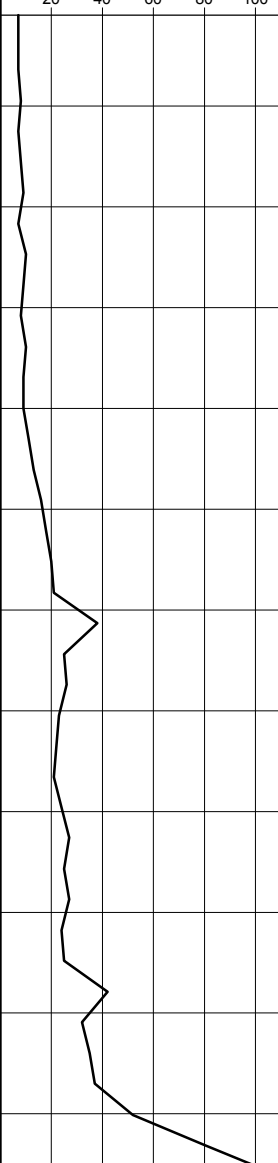
[illegible]

GT-A-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

Continued Next Page

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

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No S202-18		SHEET 2 OF 3		METRIC	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074231.6 ; E 225411.9</u>		ORIGINATED BY <u>MR</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>NW Casing Tricone, Wash Boring</u>		COMPILED BY <u>AM</u>			
DATUM <u>Geodetic</u>		DATE <u>February 25, 2011</u>		CHECKED BY <u>TVA</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W _P	W	W _L						
								○ UNCONFINED + FIELD VANE	WATER CONTENT (%)									
							● QUICK TRIAXIAL × REMOULDED											
	--- CONTINUED FROM PREVIOUS PAGE ---							20 40 60 80 100		20 40 60								
	END OF BOREHOLE CASING AND TRICONE REFUSAL Dynamic Cone Penetration Test (DCPT)																	
156.4																		
26.5																		

Continued Next Page

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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S202-18				SHEET 3 OF 3		METRIC										
W.P. 5404-05-01		LOCATION N 5074231.6 ;E 225411.9				ORIGINATED BY MR												
DIST HWY 69		BOREHOLE TYPE NW Casing Tricone, Wash Boring				COMPILED BY AM												
DATUM Geodetic		DATE February 25, 2011				CHECKED BY TVA												
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 (%)					
	--- 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>					<div style="display: flex; justify-content: space-between;"> W_p W W_L </div>						
	END OF DCPT Refusal to Further Penetration (110 Blows / 0.30 m) NOTES: * Unable to push insitu vane test past a depth of 14.6 m below ground surface (Elev. 168.3 m). 1. Water level in open borehole at a depth of 0.8 m below ground surface (Elev. 182.1 m) upon completion of drilling. 2. Casing refusal at a depth of 14.2 m; then lowered tricone to confirm depth of refusal but was grinding at a depth of 13.7 m; likely that casing is broken; pull out rods and tricone and advanced DCPT to refusal.																	

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD







PROJECT 09-1111-6014		RECORD OF BOREHOLE No S202-19		SHEET 1 OF 2		METRIC	
W.P. 5404-05-01		LOCATION N 5074259.4 ;E 225424.2		ORIGINATED BY		MR	
DIST HWY 69		BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY		MAS	
DATUM Geodetic		DATE March 3, 2011		CHECKED BY		TVA	

[illegible]

Continued Next Page

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

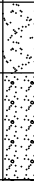
GT-A-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT		RECORD OF BOREHOLE		No S202-19		SHEET 2 OF 2		METRIC							
W.P. 09-1111-6014		LOCATION		N 5074259.4 ; E 225424.2		ORIGINATED BY		MR							
DIST		HWY 69		BOREHOLE TYPE		127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY							
DATUM		Geodetic		DATE		March 3, 2011		CHECKED BY							
								TVA							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)				
	--- CONTINUED FROM PREVIOUS PAGE ---														
166.4	SILTY CLAY, trace sand, containing grey silt interlayers Stiff Brown Moist		12	SS	WH										
166	Silty SAND, some gravel, containing cobbles Very dense Grey Wet		13	SS	57										
165.5	Boulder Dark grey with reddish pink bands		14	SC	REC 100%										
164.5	SAND COBBLE Dark grey END OF BOREHOLE		15	SC	REC 100%										
18.7	NOTES: 1. Water flowing from top of casing when advanced to a depth of 17.1 m below ground surface (Elev. 165.9 m), height of casing at about 0.7 m above ground surface. Water level in open borehole at a depth of 4.0 m below ground surface (Elev. 179.0 m) upon completion of drilling.														

Continued Next Page

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

GT A-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S202-20		SHEET 2 OF 2		METRIC												
W.P. 5404-05-01		LOCATION N 5074266.0 ; E 225398.3		ORIGINATED BY MR														
DIST _____ HWY 69		BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY MAS														
DATUM Geodetic		DATE March 9, 2011		CHECKED BY TVA														
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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%)			γ kN/m³	GR SA SI CL	
							20 40 60 80 100	20 40 60 80 100	W _p W W _L	20 40 60								
14.9	--- CONTINUED FROM PREVIOUS PAGE --- Sandy SILT, trace clay Compact Grey Wet SAND, trace silt, trace gravel Compact Grey Wet SAND and GRAVEL, trace to some silt, trace clay. Cobbles at 16.2 m depth Very dense Grey Wet END OF BOREHOLE NOTES: * Water flowing from top and around casing at ground surface (Elev. 183.3 m) upon completion of drilling. 1. Water level (not-stabilized) in casing at 0.6 m above ground surface (Elev. 183.9 m) measured at about 6:30 pm on March 9, 2011 - Artesian Condition.						168											
167.6																		
15.7									167									
166.5			15	SS	64										o			40 52 7 1
16.8																		

PROJECT <u>09-1111-6014</u>		RECORD OF DCPT No S202-DC01		SHEET 1 OF 1		METRIC	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074204.5 ; E 225361.0</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>NK</u>			
DATUM <u>Geodetic</u>		DATE <u>March 4, 2010</u>		CHECKED BY <u>TVA</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20	40	60	80	100	W _p	W	W _L		
183.8	GROUND SURFACE																
0.0	Dynamic Cone Penetration Test (DCPT)																
181.8																	
2.0	END OF DCPT Refusal to Further Penetration (Hammer Bouncing) NOTE: 1. Bedrock outcrop observed east of DCPT S202-DC01.																

GTA-MTO 001 09-1111-6014.GPJ GAL-MASS.GDT 7/25/12 SAC/DD

Continued Next Page

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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

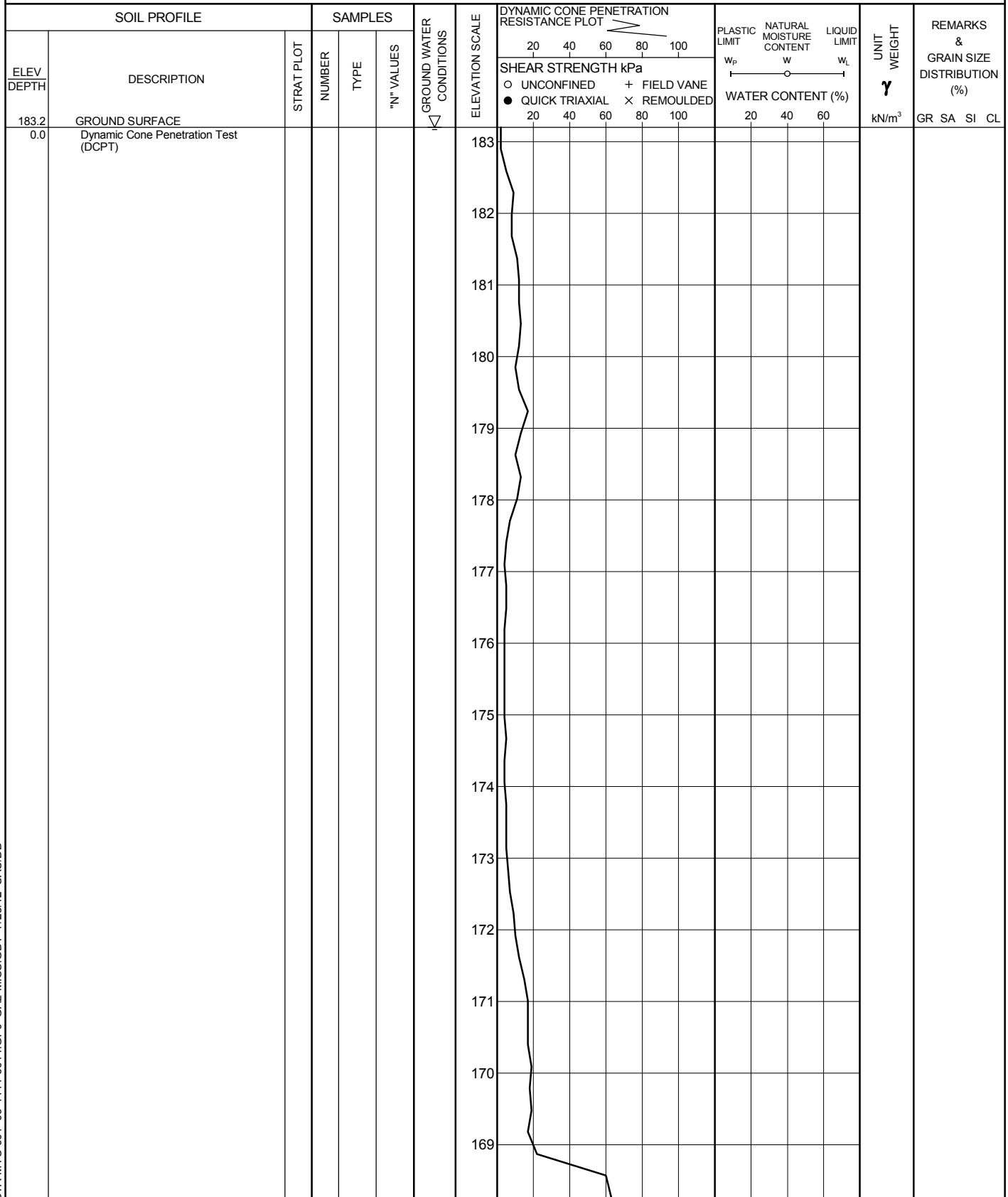
PROJECT <u>09-1111-6014</u>		RECORD OF DCPT No S202-DC02		SHEET 2 OF 2		METRIC	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074241.9 ; E 225387.6</u>		ORIGINATED BY <u>ID</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Portable Equipment, Dynamic Cone Penetration Test</u>		COMPILED BY <u>NK</u>			
DATUM <u>Geodetic</u>		DATE <u>March 4, 2010</u>		CHECKED BY <u>TVA</u>			

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 (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa			WATER CONTENT (%)			GR SA SI CL								
	--- CONTINUED FROM PREVIOUS PAGE ---					<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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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></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><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>														

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

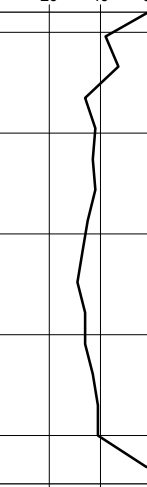
GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

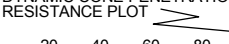
PROJECT <u>09-1111-6014</u>		RECORD OF DCPT No S202-DC03		SHEET 1 OF 2		METRIC	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074271.7 ; E 225333.8</u>		ORIGINATED BY <u>MR</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Dynamic Cone Penetration Test</u>		COMPILED BY <u>MAS</u>			
DATUM <u>Geodetic</u>		DATE <u>March 10, 2011</u>		CHECKED BY <u>TVA</u>			



Continued Next Page

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

PROJECT 09-1111-6014		RECORD OF DCPT No S202-DC03		SHEET 2 OF 2		METRIC							
W.P. 5404-05-01		LOCATION N 5074271.7 ; E 225333.8		ORIGINATED BY MR									
DIST _____ HWY 69		BOREHOLE TYPE Dynamic Cone Penetration Test		COMPILED BY MAS									
DATUM Geodetic		DATE March 10, 2011		CHECKED BY TVA									
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		W _p	W		
	--- 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>					
163.5	Dynamic Cone Penetration Test (DCPT)					168							
						167							
						166							
						165							
						164							
19.7	END OF DCPT Refusal to Further Penetration (100 Blows / 0.18 m) NOTE: 1. Water flowing out of the DCPT hole at ground surface upon completion of penetration test.												

PROJECT		RECORD OF DCPT No S202-DC04		SHEET 1 OF 1		METRIC				
W.P. 09-1111-6014		LOCATION N 5074288.4 ; E 225369.2		ORIGINATED BY MR						
DIST _____ HWY 69		BOREHOLE TYPE Dynamic Cone Penetration Test		COMPILED BY MAS						
DATUM Geodetic		DATE March 14, 2011		CHECKED BY TVA						
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT  SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p — W — 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						
185.6 0.0	GROUND SURFACE Dynamic Cone Penetration Test (DCPT)									
181.0 4.6	END OF DCPT Refusal to Further Penetration (Hammer Bouncing) NOTE: 1. Bedrock outcrop observed in the vicinity of the DCPT.									

PROJECT 09-1111-6014		RECORD OF DCPT No S202-DC05		SHEET 1 OF 1		METRIC											
W.P. 5404-05-01		LOCATION N 5074150.5 ; E 225428.4		ORIGINATED BY ID													
DIST HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test		COMPILED BY NK													
DATUM Geodetic		DATE March 1, 2010		CHECKED BY TVA													
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 (%)				
189.6	GROUND SURFACE																
0.0	Dynamic Cone Penetration Test (DCPT)																
0.3	END OF DCPT Refusal to Further Penetration (Hammer Bouncing) NOTE: 1. Additional Dynamic Cone Penetration Tests were advanced within 1.5 m radius of DCPT S202-DC05; refusal encountered at a depth of 0.3 m below ground surface (Elev. 189.3 m) in all the DCPTs.																

GTA-MTO 001 09-1111-6014.GPJ GAL-MASS.GDT 7/25/12 SAC/DD



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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT <u>09-1111-6014</u>		RECORD OF DCPT No S202-DC07		SHEET 1 OF 1		METRIC											
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074195.8 ; E 225407.0</u>		ORIGINATED BY <u>ID</u>													
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Hand Excavation</u>		COMPILED BY <u>NK</u>													
DATUM <u>Geodetic</u>		DATE <u>March 2, 2010</u>		CHECKED BY <u>TVA</u>													
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 (%)				
190.3	GROUND SURFACE																
8.9	TOPSOIL																
	END OF EXCAVATION PROBABLE BEDROCK																
	NOTES:																
	1. Bedrock outcrop observed in the vicinity of the DCPT; bedrock confirmed by hand excavation at the DCPT location.																
	2. Excavation dry upon completion.																

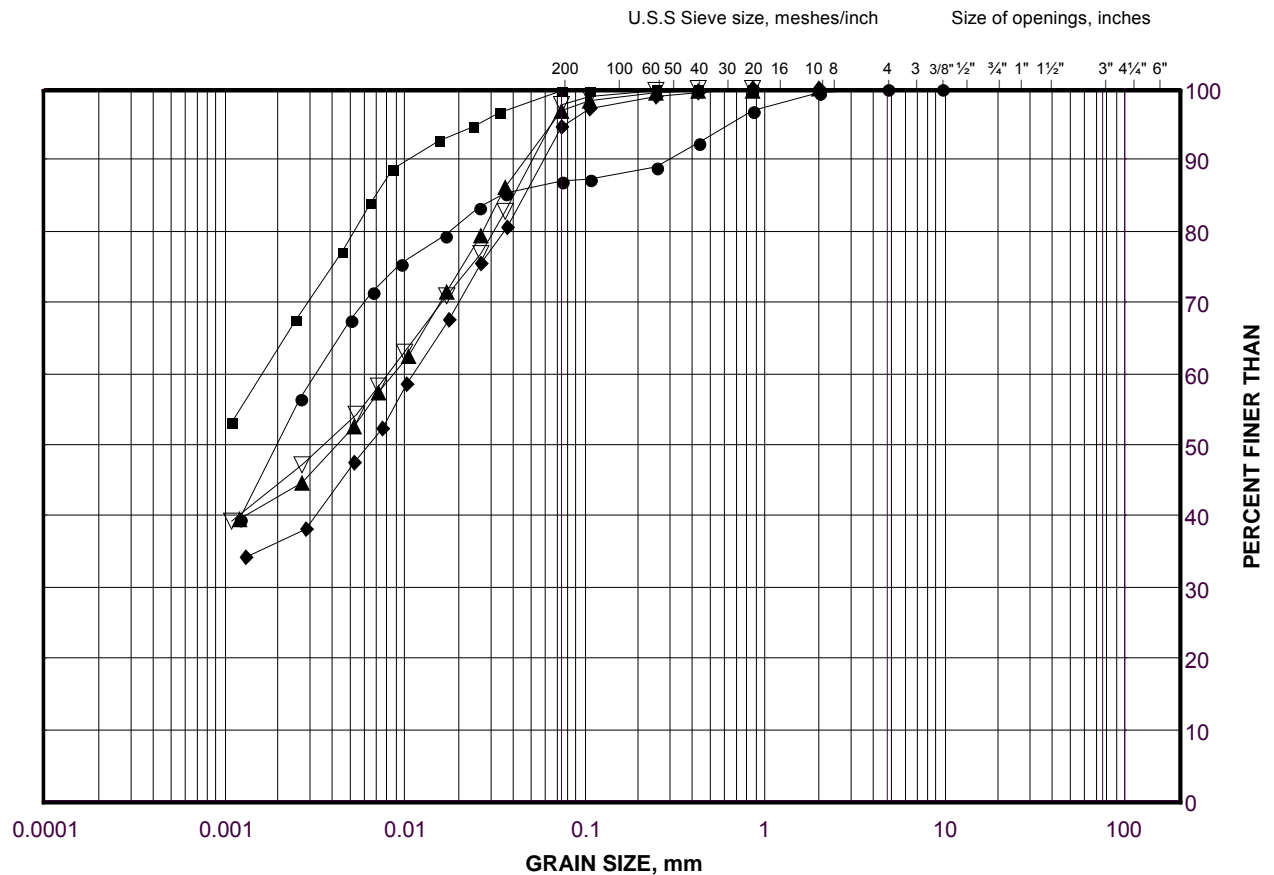
GTA-MTO 001 09-1111-6014.GPJ GAL-MASS.GDT 7/25/12 SAC/DD

GRAIN SIZE DISTRIBUTION

Clayey Silt to Clay

Highway 69 (SBL) STA 11+175 to 11+275 (Swamp 202)

FIGURE B.S202-01A



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

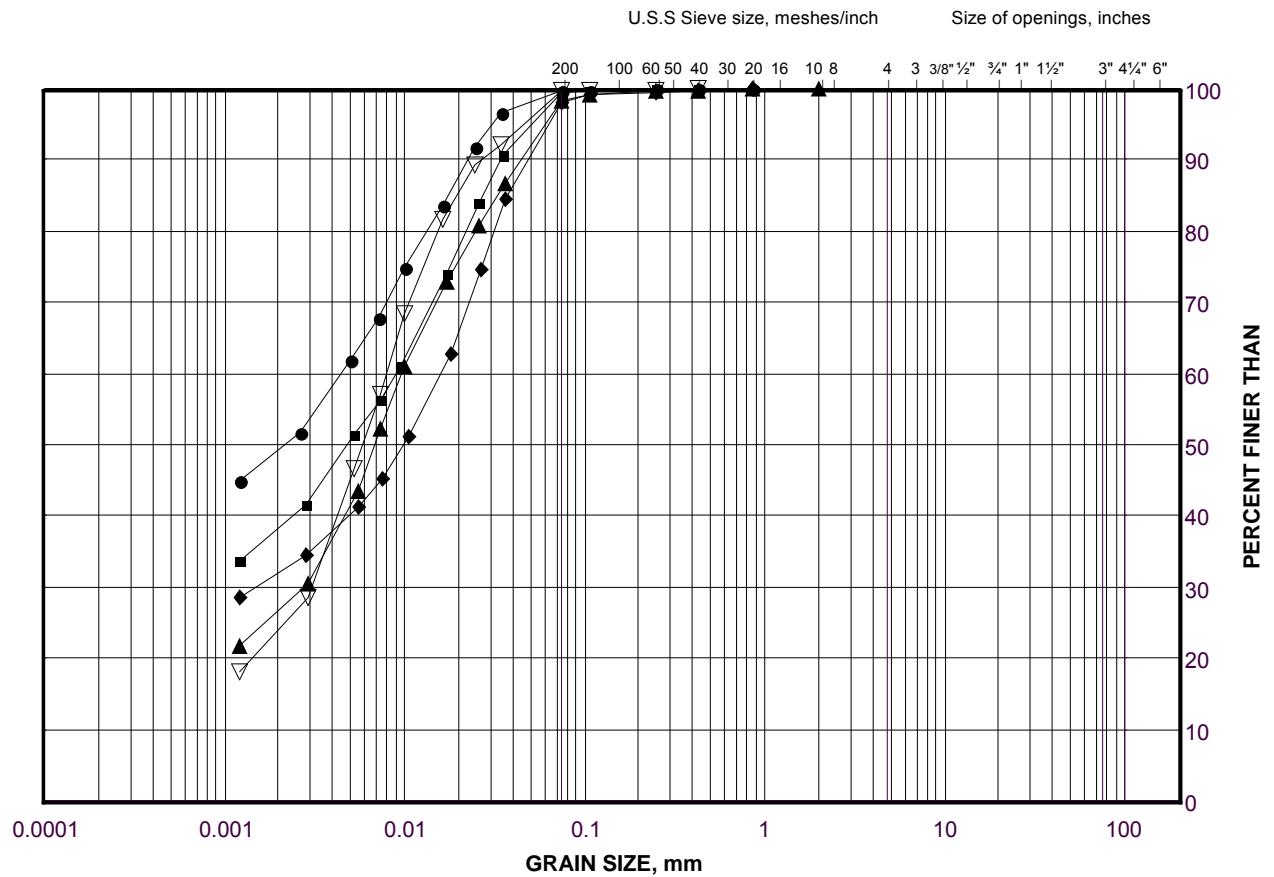
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S202-05	11	169.9
■	S202-05	13	164.5
◆	S202-03	2	181.9
▲	S202-09	2	185.1
▽	S202-08	3	180.9

GRAIN SIZE DISTRIBUTION

Clayey Silt to Clay

Highway 69 (SBL) STA 11+175 to 11+275 (Swamp 202)

FIGURE B.S202-01B



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

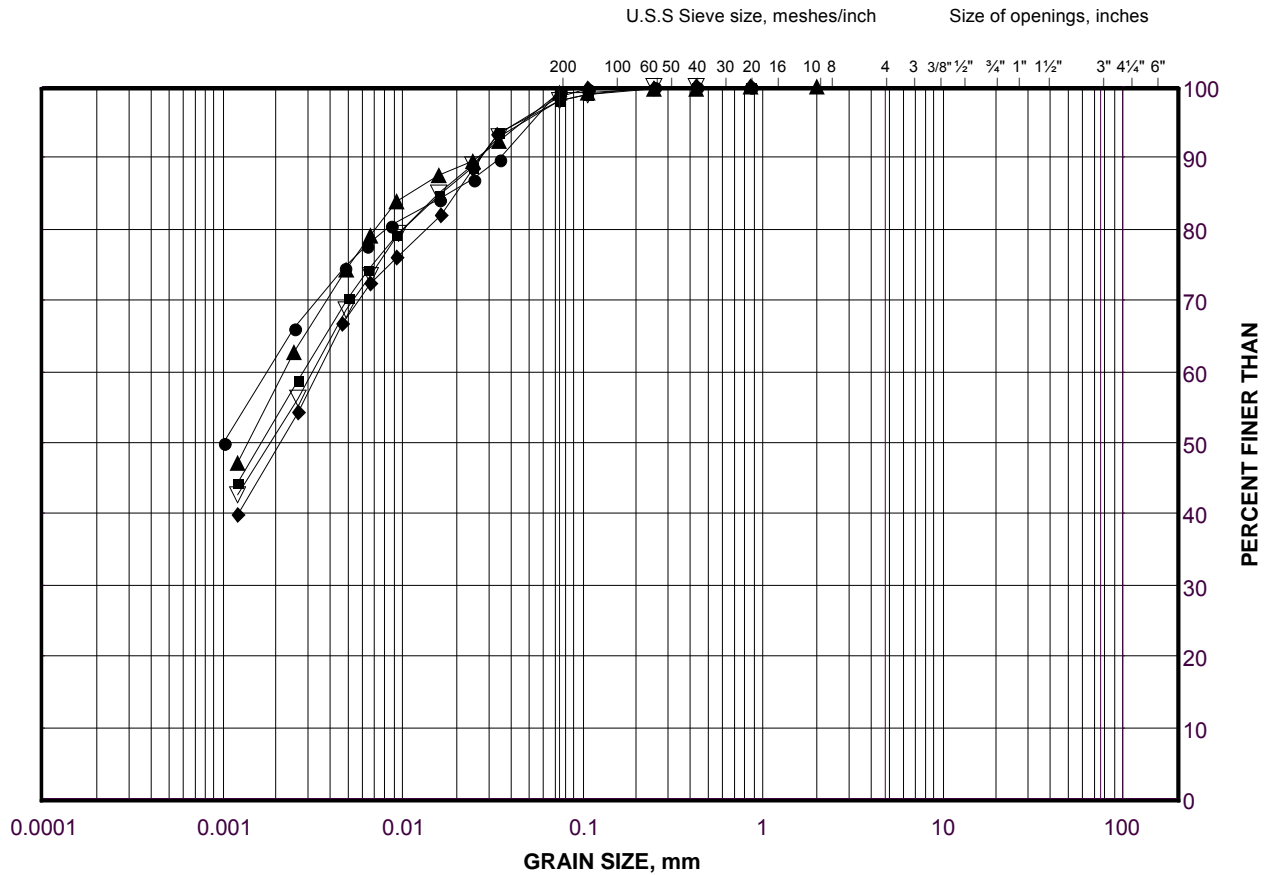
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S202-04	4	179.5
■	S202-06	4	179.7
◆	S202-05	4	179.6
▲	S202-03	4	180.1
▽	S202-08	5	178.3

GRAIN SIZE DISTRIBUTION

Clayey Silt to Clay

Highway 69 (SBL) STA 11+175 to 11+275 (Swamp 202)

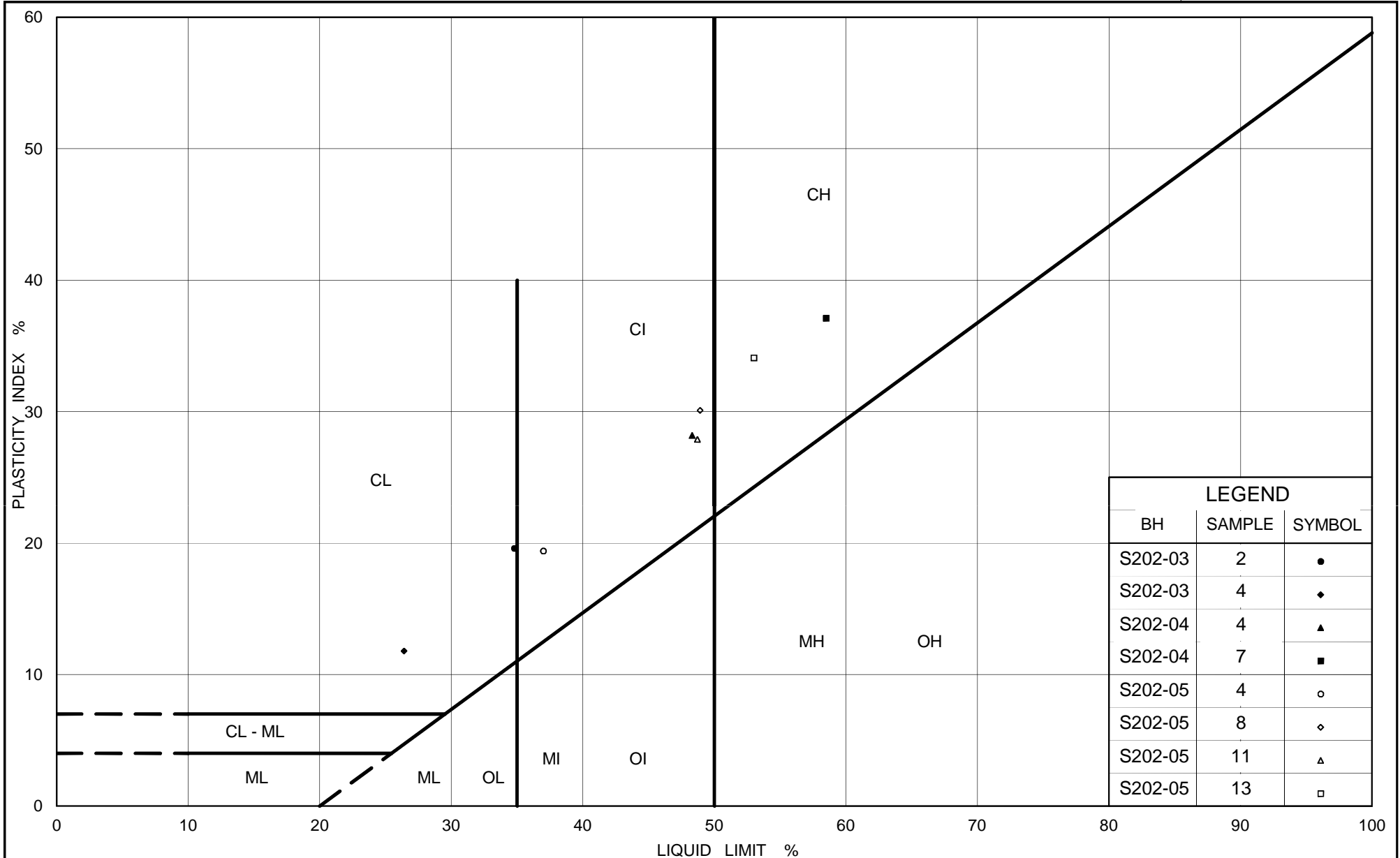
FIGURE B.S202-01C



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S202-04	7	174.9
■	S202-07	8	174.5
◆	S202-06	8	172.7
▲	S202-05	8	173.5
▽	S202-08	9	172.2



Ministry of Transportation

Ontario

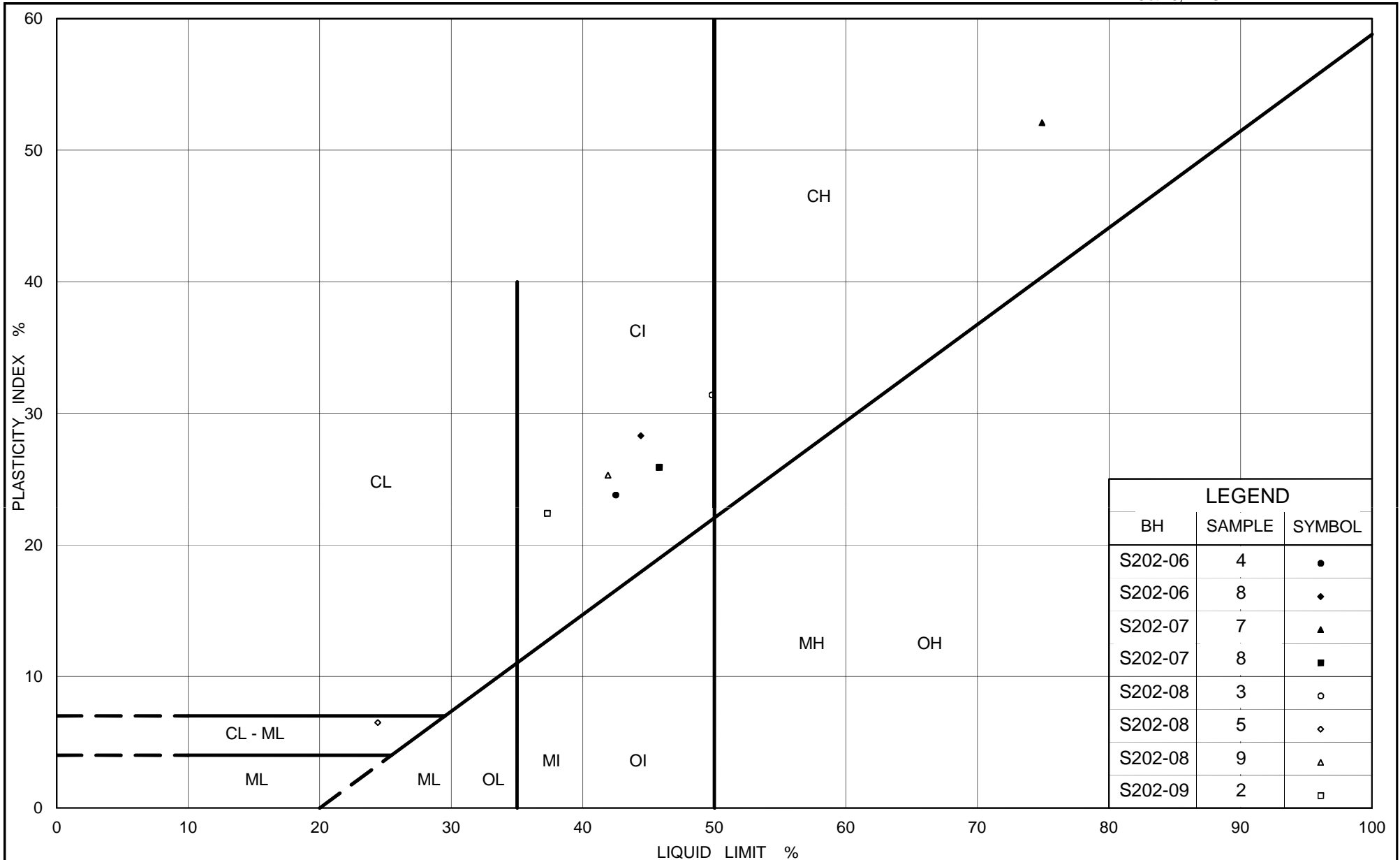
PLASTICITY CHART Clayey Silt to Clay

Highway 69 (SBL) STA 11+175 to 11+275 (Swamp 202)

Figure No. B.S202-02A

Project No. 09-1111-6014

Checked By: TVA



Ministry of Transportation

Ontario

PLASTICITY CHART

Clayey Silt to Clay

Highway 69 (SBL) STA 11+175 to 11+275 (Swamp 202)

Figure No. B.S202-02B

Project No. 09-1111-6014

Checked By: TVA

CONSOLIDATION TEST SUMMARY Highway 69 (NBL) STA 11+100 to 11+225 (Swamp 202)					FIGURE B.S202-03 Sheet 1 of 4		
SAMPLE IDENTIFICATION							
Project Number	09-1111-6014	Sample Number	7				
Borehole Number	S202-07	Sample Depth, m	7.2-7.6				
TEST CONDITIONS							
Test Type	Standard	Load Duration, hr	24				
Oedometer Number	7						
Date Started	5/24/2011						
Date Completed	6/19/2011						
SAMPLE DIMENSIONS AND PROPERTIES - INITIAL							
Sample Height, cm	1.89	Unit Weight, kN/m ³	15.33				
Sample Diameter, cm	6.33	Dry Unit Weight, kN/m ³	8.62				
Area, cm ²	31.48	Specific Gravity, measured	2.78				
Volume, cm ³	59.62	Solids Height, cm	0.599				
Water Content, %	77.82	Volume of Solids, cm ³	18.85				
Wet Mass, g	93.18	Volume of Voids, cm ³	40.77				
Dry Mass, g	52.4	Degree of Saturation, %	100.0				
TEST COMPUTATIONS							
Pressure kPa	Corr. Height cm	Void Ratio	Average Height cm	t ₉₀ sec	c _v cm ² /s	m _v m ² /kN	k cm/s
0.00	1.894	2.163	1.894				
5.00	1.892	2.160	1.893	7	1.09E-01	2.01E-04	2.13E-06
10.00	1.890	2.157	1.891	58	1.31E-02	2.01E-04	2.57E-07
19.99	1.883	2.145	1.887	154	4.90E-03	3.81E-04	1.83E-07
40.00	1.871	2.125	1.877	240	3.11E-03	3.09E-04	9.42E-08
59.96	1.858	2.104	1.865	1874	3.93E-04	3.41E-04	1.32E-08
79.99	1.832	2.059	1.845	6000	1.20E-04	7.09E-04	8.36E-09
99.91	1.738	1.902	1.785	22685	2.98E-05	2.49E-03	7.26E-09
119.93	1.648	1.752	1.693	20093	3.02E-05	2.37E-03	7.03E-09
159.90	1.531	1.556	1.589	5289	1.01E-04	1.54E-03	1.53E-08
319.80	1.343	1.242	1.437	1284	3.41E-04	6.21E-04	2.07E-08
630.22	1.199	1.002	1.271	228	1.50E-03	2.45E-04	3.61E-08
1254.09	1.091	0.822	1.145	441	6.30E-04	9.12E-05	5.63E-09
2503.19	0.998	0.667	1.045	454	5.10E-04	3.91E-05	1.95E-09
1254.09	1.016	0.697	1.007				
318.71	1.048	0.750	1.032				
119.93	1.084	0.810	1.066				
79.99	1.096	0.831	1.090				
39.95	1.121	0.872	1.108				
10.00	1.152	0.924	1.136				
5.00	1.170	0.955	1.161				
Note: k calculated using cv based on t ₉₀ values.							
SAMPLE DIMENSIONS AND PROPERTIES - FINAL							
Sample Height, cm	1.05	Unit Weight, kN/m ³	21.35				
Sample Diameter, cm	6.33	Dry Unit Weight, kN/m ³	15.57				
Area, cm ²	31.48	Specific Gravity, measured	2.78				
Volume, cm ³	32.99	Solids Height, cm	0.599				
Water Content, %	37.10	Volume of Solids, cm ³	18.85				
Wet Mass, g	71.84	Volume of Voids, cm ³	14.15				
Dry Mass, g	52.4						
<div style="display: flex; justify-content: space-between;"> Prepared By: LH Golder Associates Checked By: TVA </div>							

CONSOLIDATION TEST SUMMARY

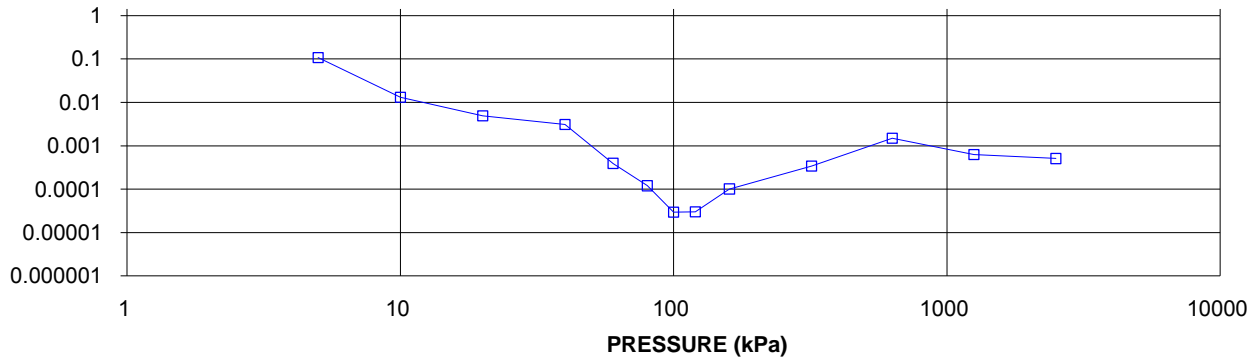
Highway 69 (NBL) STA 11+100 to 11+225 (Swamp 202)

FIGURE B.S202-03

Sheet 2 of 4

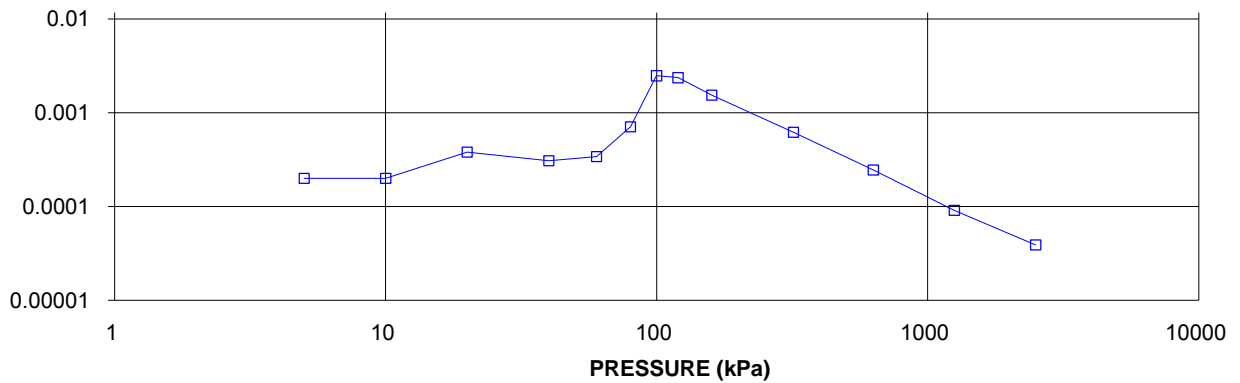
COEFFICIENT OF CONSOLIDATION,
cm²/s

CONSOLIDATION TEST
C_v cm²/s VS PRESSURE (kPa)
BH S202-07 SA 7



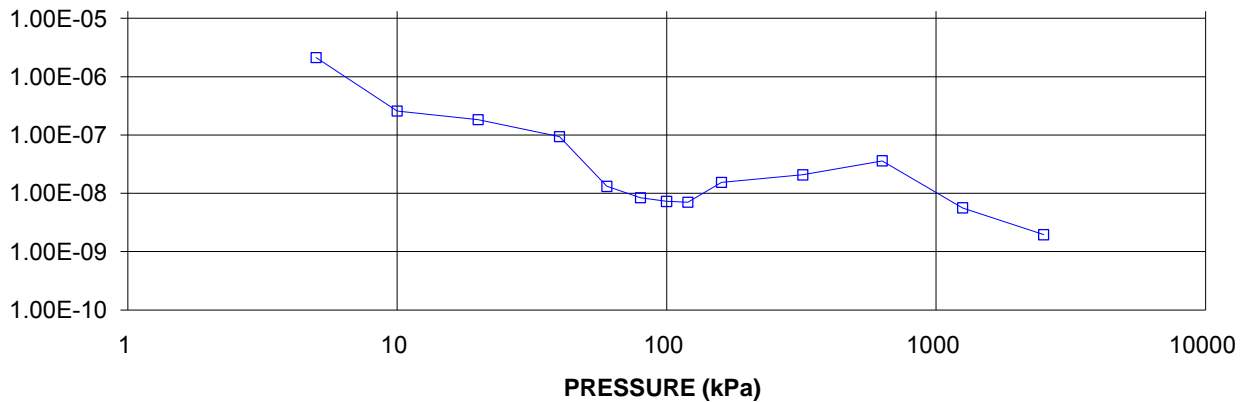
VOLUME COMPRESSIBILITY, m²/kN

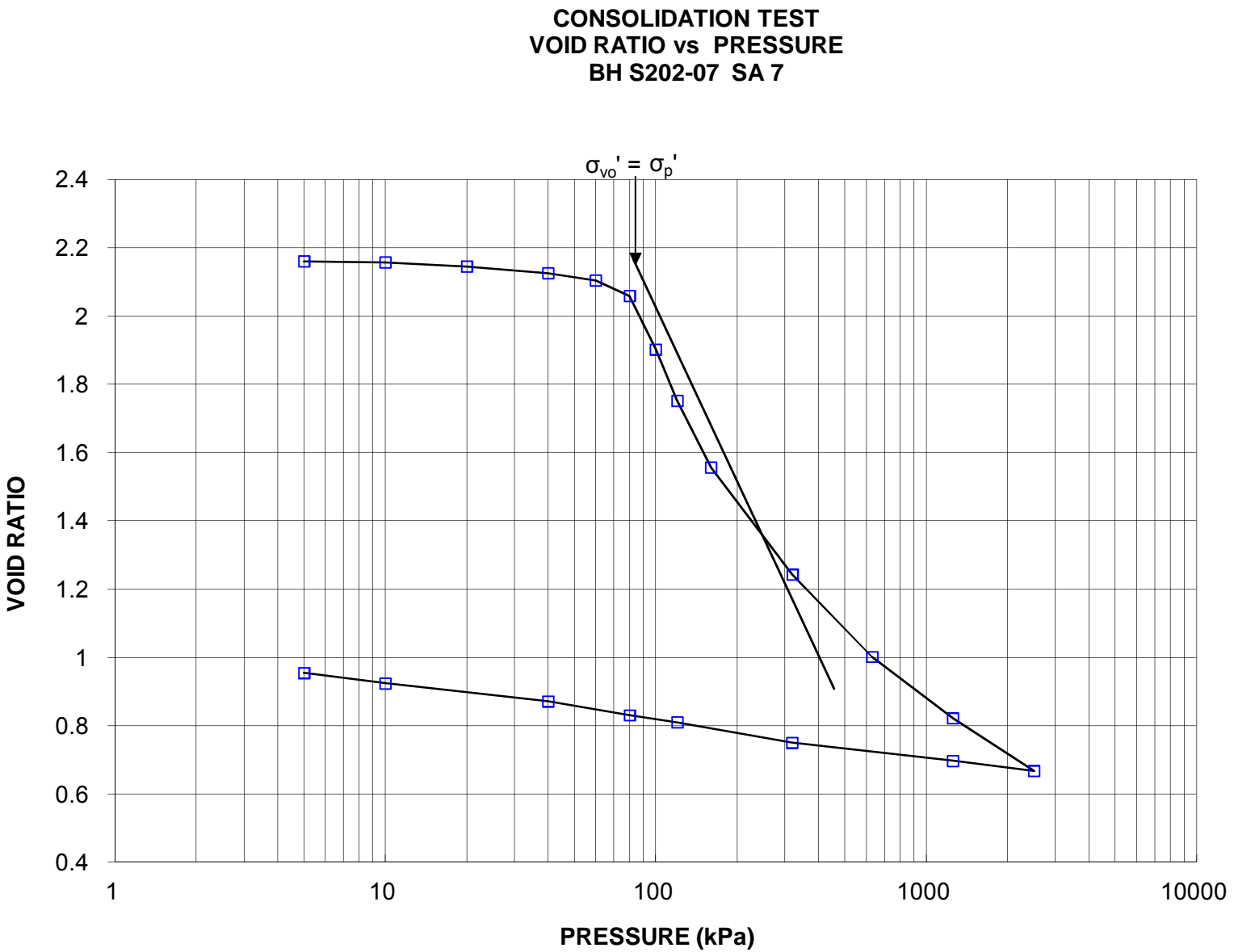
CONSOLIDATION TEST
M_v m²/kN vs PRESSURE (kPa)
BH S202-07 SA 7

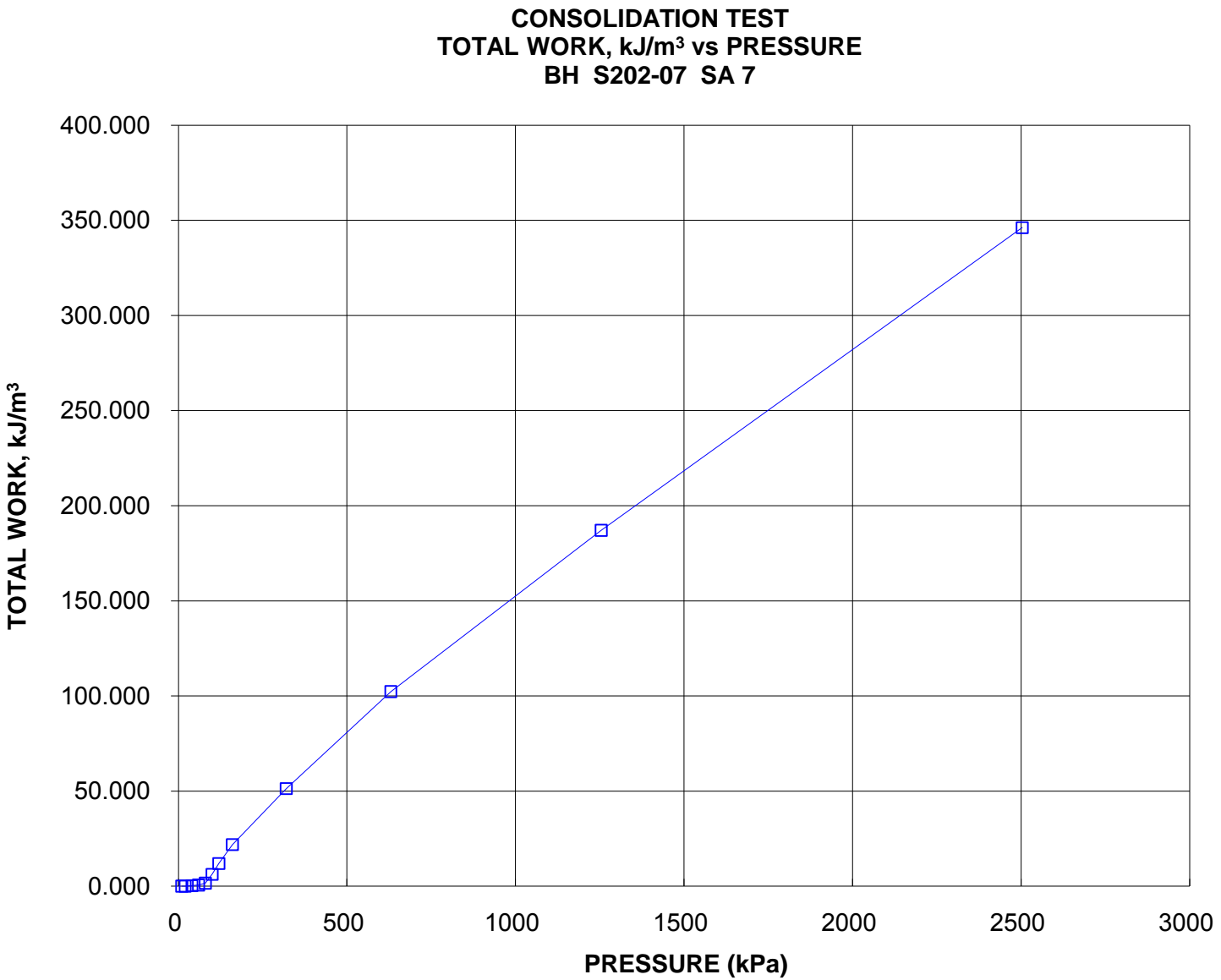


HYDRAULIC CONDUCTIVITY, cm/s

CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs PRESSURE
BH S202-07 SA 7







Project No. 09-1111-6014
Prepared By: LH

Golder Associates

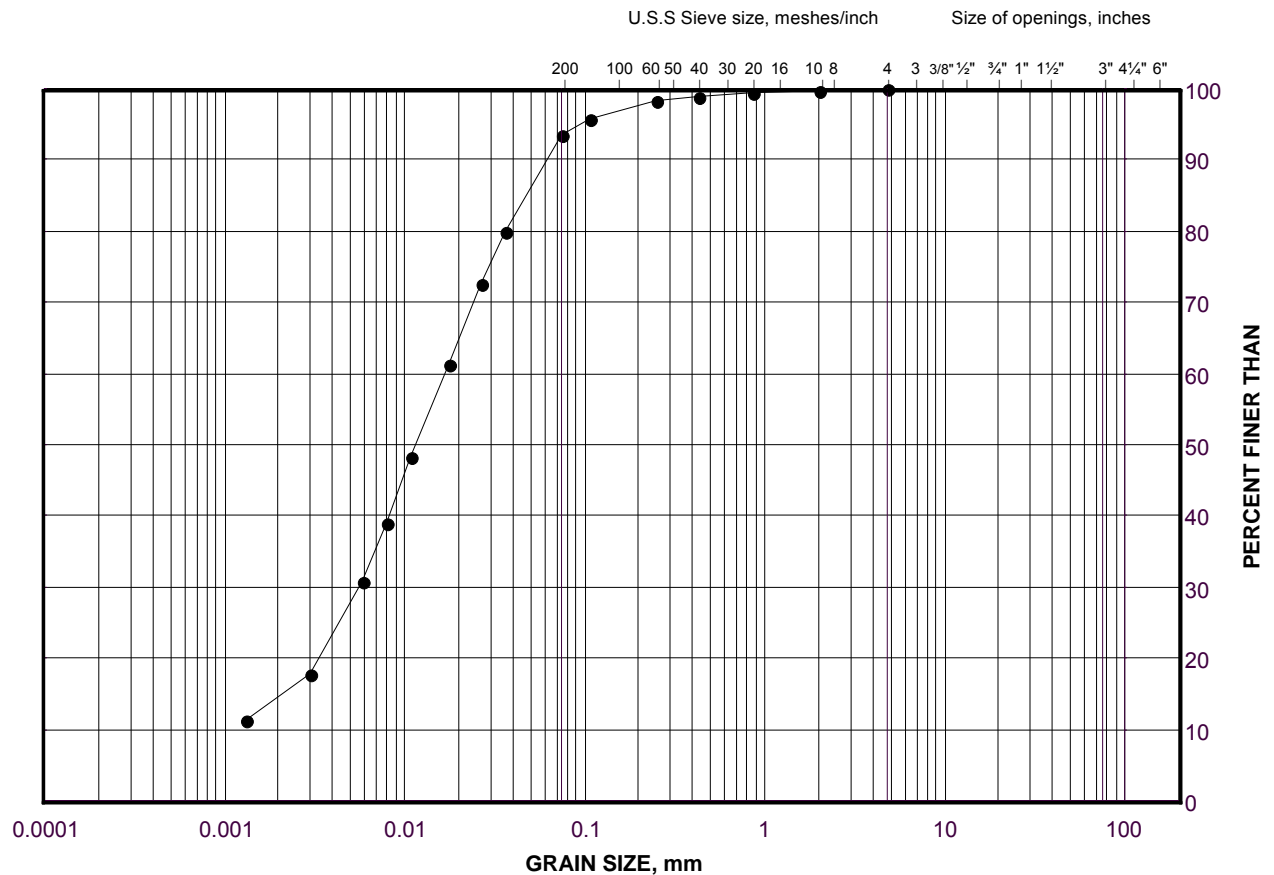
Checked By: TVA

GRAIN SIZE DISTRIBUTION

Silt (Interlayer)

Highway 69 (SBL) STA 11+175 to 11+275 (Swamp 202)

FIGURE B.S202-04



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

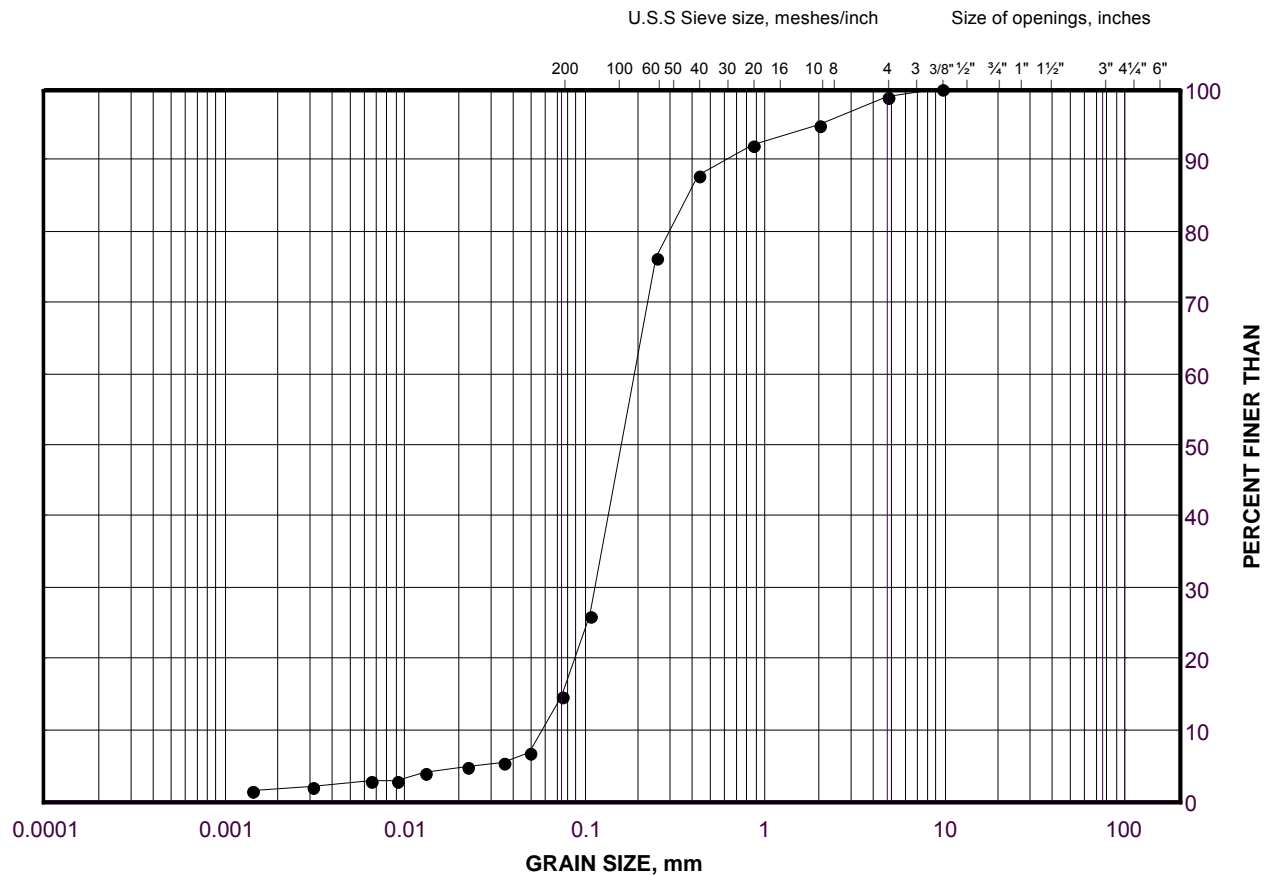
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S202-07	5	179.1

GRAIN SIZE DISTRIBUTION

Sand

Highway 69 (SBL) STA 11+175 to 11+275 (Swamp 202)

FIGURE B.S202-05



SILT AND CLAY SIZES			FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED			SAND SIZE			GRAVEL SIZE		SIZE

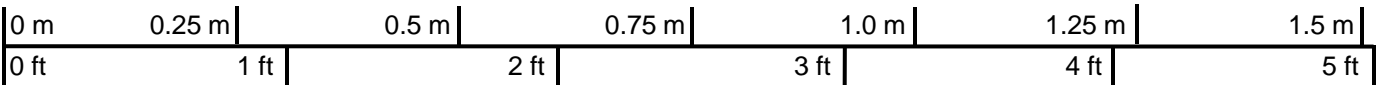
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S202-06	12	165.1


Borehole S202-04



Box 1: 11.27 m – 14.26 m



Scale

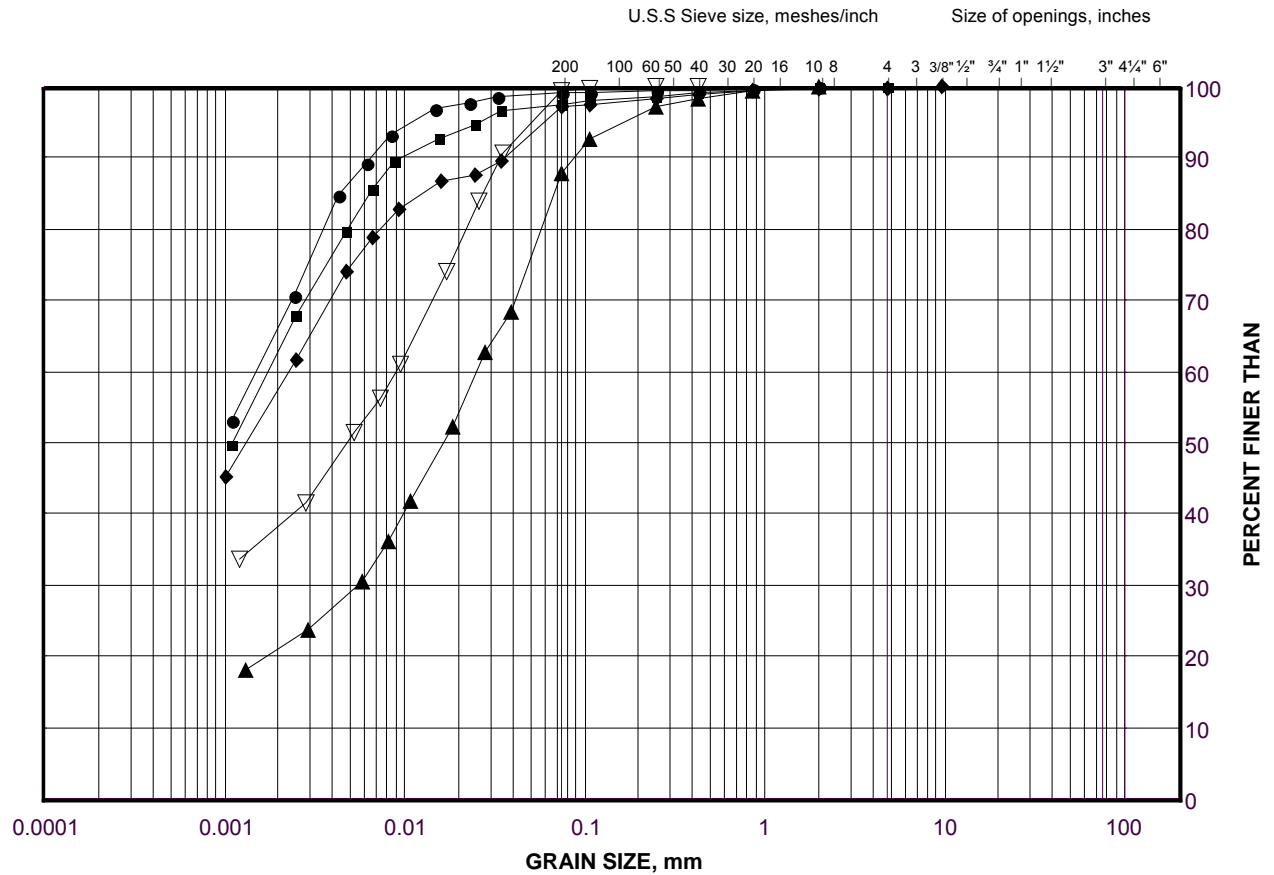
PROJECT		Swamp Crossings and High Fill Areas Highway 69 Four-Laning GWP 5404-05-00; WP 5404-05-01		
TITLE		Core Photo – Swamp 202 Highway 69 (SBL) STA 11+175 to 11+275		
		PROJECT No. 09-1111-6014		FILE No. ----
		DESIGN	AT	SCALE NTS
		CADD	--	REV.
		CHECK	AT	
		REVIEW	TVA	
FIGURE B.S202-06				

GRAIN SIZE DISTRIBUTION

Clayey Silt to Clay

Highway 69 (NBL) STA 11+100 to 11+225 (Swamp 202)

FIGURE B.S202-07A



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

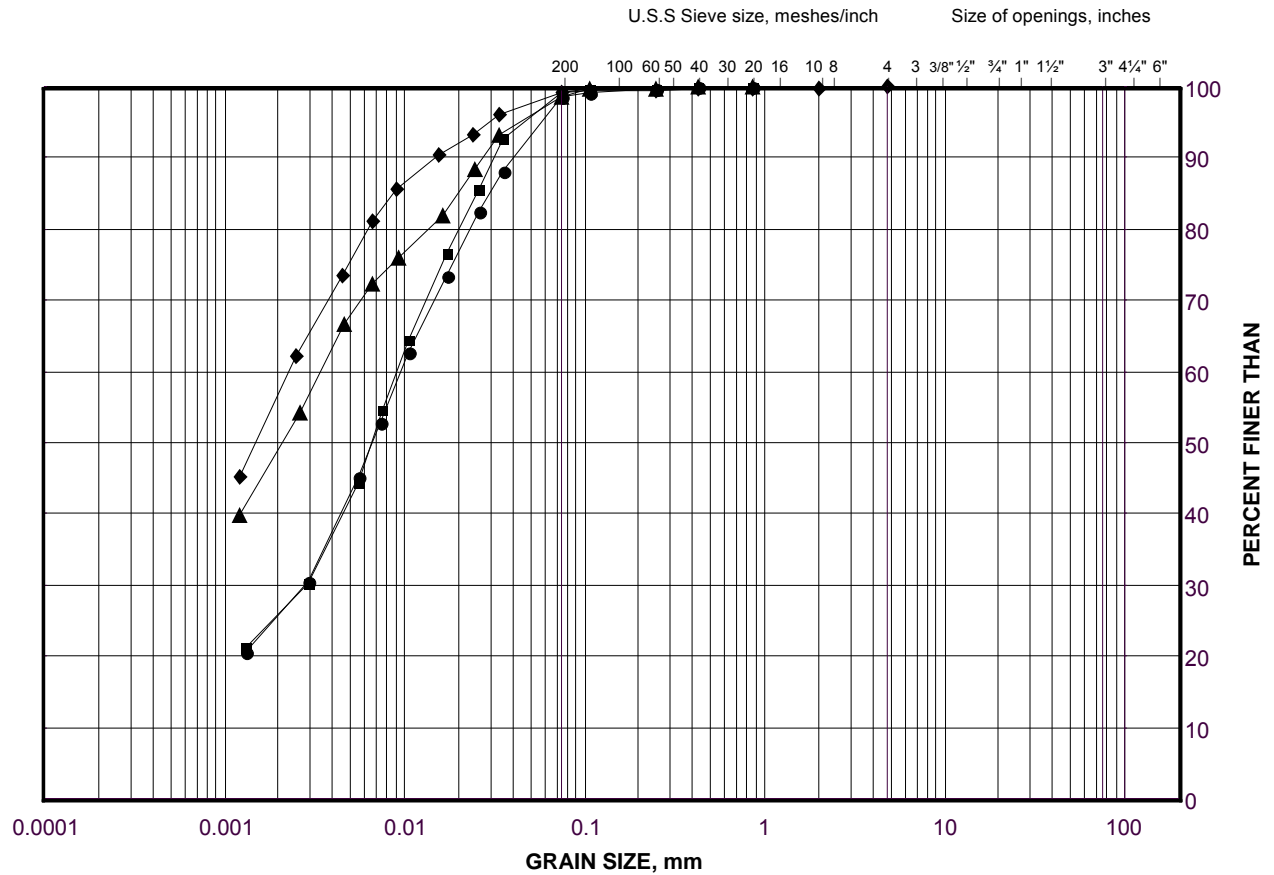
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S202-18	10	172.1
■	S202-19	11	169.4
◆	S202-20	12	171.4
▲	S202-18	2B	181.8
▽	S202-06	4	179.7

GRAIN SIZE DISTRIBUTION

Clayey Silt to Clay

Highway 69 (NBL) STA 11+100 to 11+225 (Swamp 202)

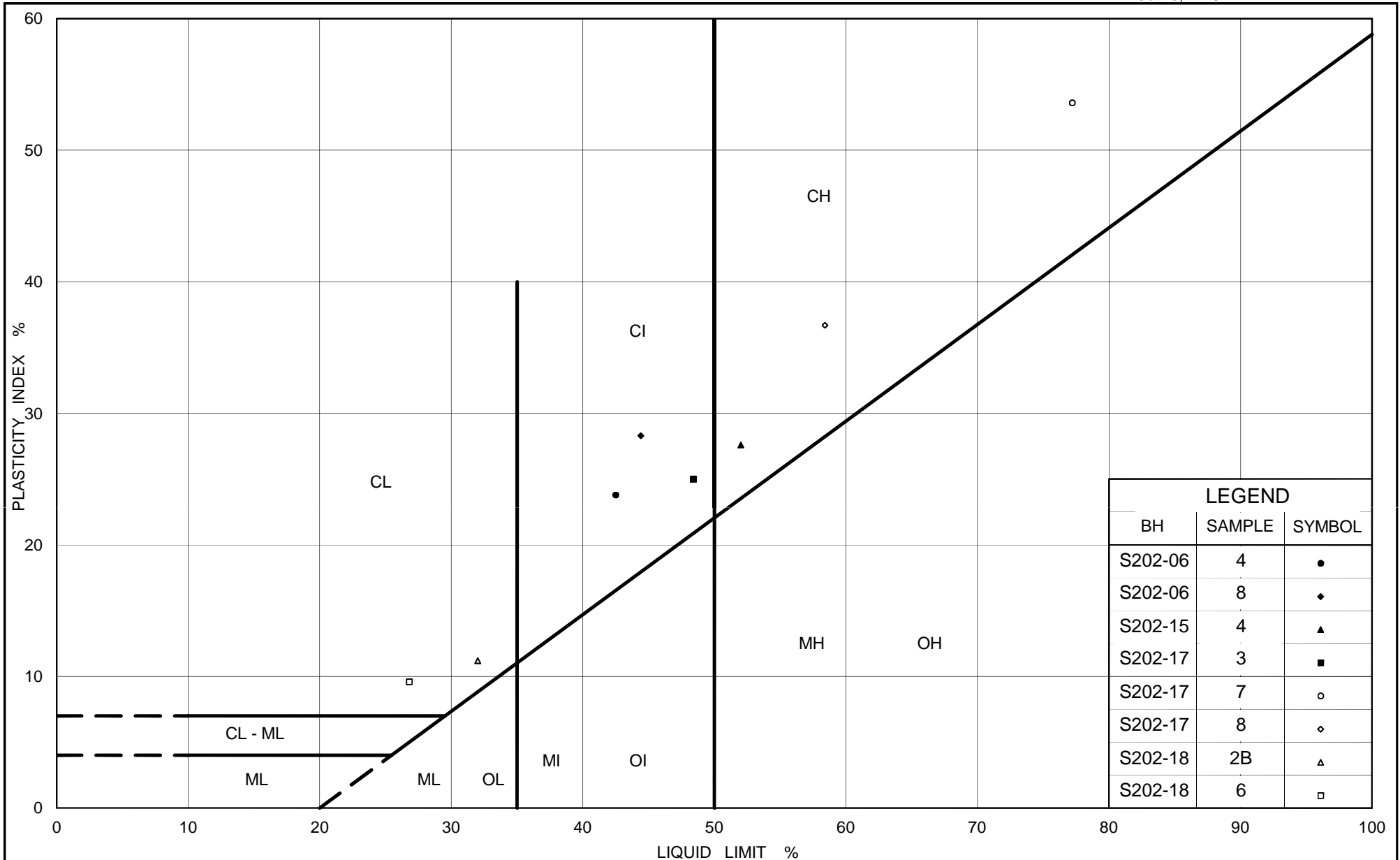
FIGURE B.S202-07B



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S202-19	5B	178.3
■	S202-18	6	178.2
◆	S202-19	8	173.9
▲	S202-06	8	172.7



Ministry of Transportation

Ontario

PLASTICITY CHART

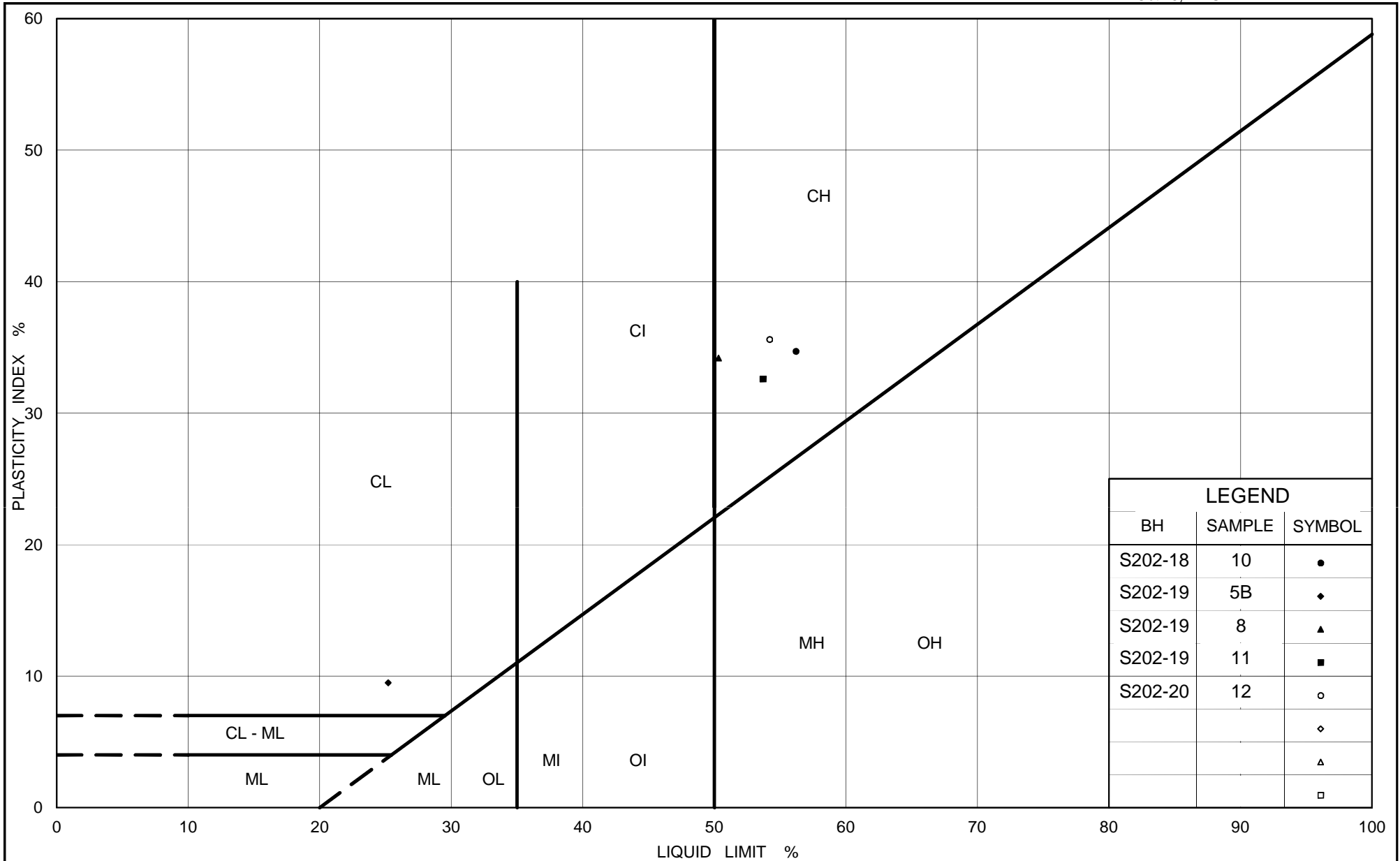
Clayey Silt to Clay

Highway 69 (NBL) STA 11+100 to 11+225 (Swamp 202)

Figure No. B.S202-08A

Project No. 09-1111-6014

Checked By: TVA



Ministry of Transportation

Ontario

PLASTICITY CHART Clayey Silt and Clay

Highway 69 (NBL) STA 11+100 to 11+225 (Swamp 202)

Figure No. B.S202-08B

Project No. 09-1111-6014

Checked By: TVA

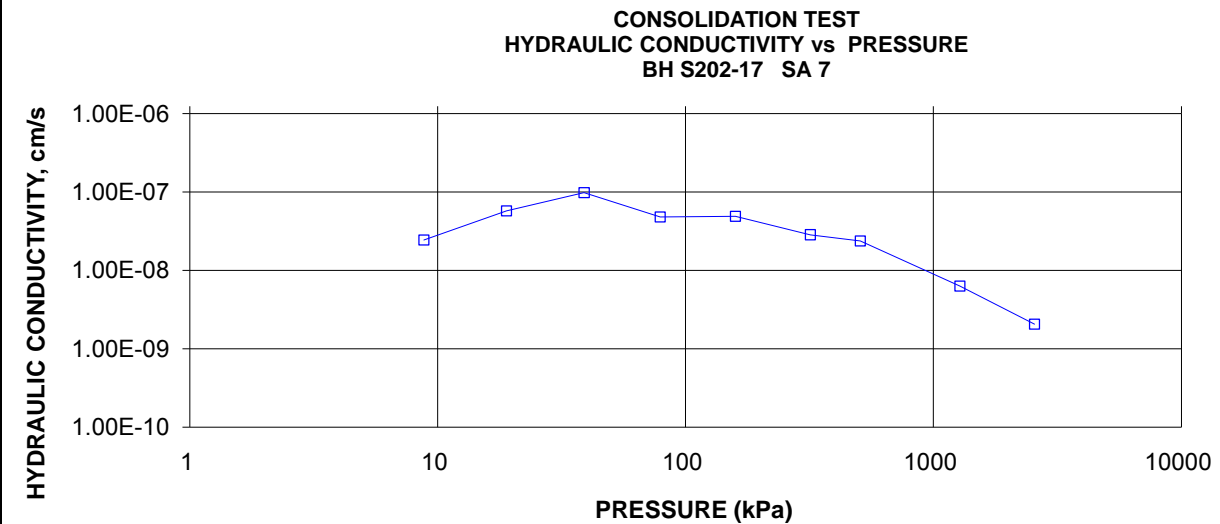
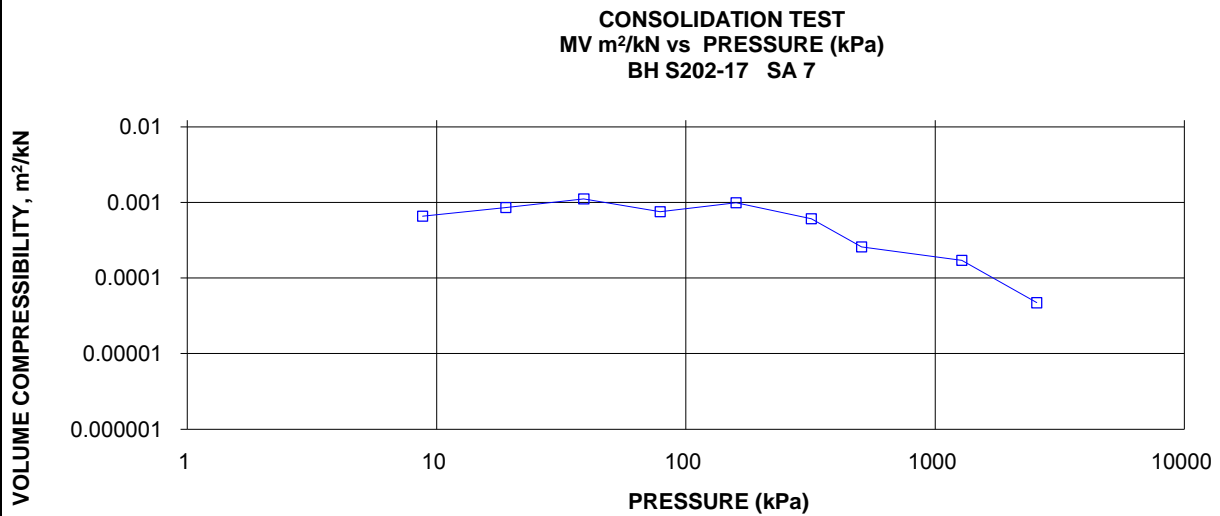
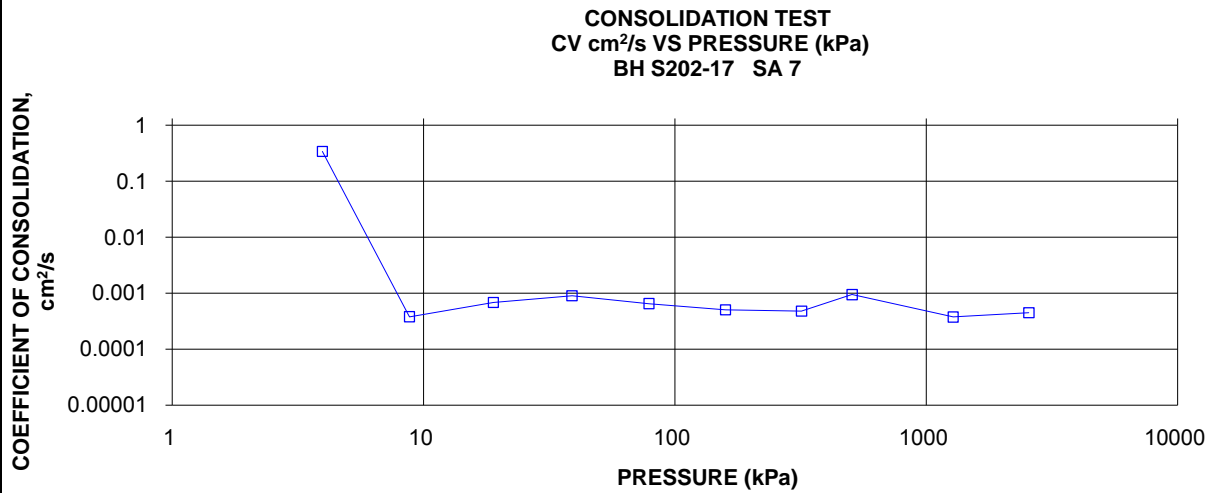
CONSOLIDATION TEST SUMMARY					FIGURE B.S202-09		
Highway 69 (NBL) STA 11+100 to 11+225 (Swamp 202)					Sheet 1 of 4		
SAMPLE IDENTIFICATION							
Project Number	09-1111-6014			Sample Number	7		
Borehole Number	S202-17			Sample Depth, m	11.0		
TEST CONDITIONS							
Test Type	Standard			Load Duration, hr	24		
Oedometer Number	5						
Date Started	4/19/2011						
Date Completed	4/30/2011						
SAMPLE DIMENSIONS AND PROPERTIES - INITIAL							
Sample Height, cm	1.26			Unit Weight, kN/m ³	15.29		
Sample Diameter, cm	4.96			Dry Unit Weight, kN/m ³	8.62		
Area, cm ²	19.34			Specific Gravity, measured	2.76		
Volume, cm ³	24.42			Solids Height, cm	0.402		
Water Content, %	77.32			Volume of Solids, cm ³	7.78		
Wet Mass, g	38.07			Volume of Voids, cm ³	16.64		
Dry Mass, g	21.47			Degree of Saturation, %	99.7		
TEST COMPUTATIONS							
	Corr.		Average				
Pressure	Height	Void	Height	t ₉₀	cv.	mv	k
kPa	cm	Ratio	cm	sec	cm ² /s	m ² /kN	cm/s
0.00	1.263	2.140	1.263				
3.96	1.263	2.140	1.263	1	3.38E-01	0.00E+00	0.00E+00
8.79	1.259	2.130	1.261	889	3.79E-04	6.56E-04	2.44E-08
18.96	1.248	2.102	1.254	487	6.84E-04	8.56E-04	5.74E-08
38.97	1.220	2.033	1.234	359	8.99E-04	1.11E-03	9.76E-08
78.94	1.182	1.938	1.201	470	6.51E-04	7.53E-04	4.80E-08
158.97	1.082	1.690	1.132	540	5.03E-04	9.89E-04	4.88E-08
318.97	0.959	1.384	1.021	463	4.77E-04	6.09E-04	2.84E-08
507.07	0.898	1.232	0.928	194	9.42E-04	2.57E-04	2.37E-08
1278.98	0.731	0.817	0.814	375	3.75E-04	1.71E-04	6.29E-09
2559.01	0.655	0.628	0.693	228	4.47E-04	4.70E-05	2.06E-09
1278.98	0.663	0.648	0.659				
319.14	0.684	0.700	0.674				
78.94	0.717	0.782	0.701				
18.96	0.750	0.864	0.734				
3.96	0.774	0.924	0.762				
Note: k calculated using cv based on t ₉₀ values.							
SAMPLE DIMENSIONS AND PROPERTIES - FINAL							
Sample Height, cm	0.77			Unit Weight, kN/m ³	19.15		
Sample Diameter, cm	4.96			Dry Unit Weight, kN/m ³	14.07		
Area, cm ²	19.34			Specific Gravity, measured	2.76		
Volume, cm ³	14.97			Solids Height, cm	0.402		
Water Content, %	36.14			Volume of Solids, cm ³	7.78		
Wet Mass, g	29.23			Volume of Voids, cm ³	7.19		
Dry Mass, g	21.47						
Prepared By: LFG					Golder Associates		Checked By: TVA

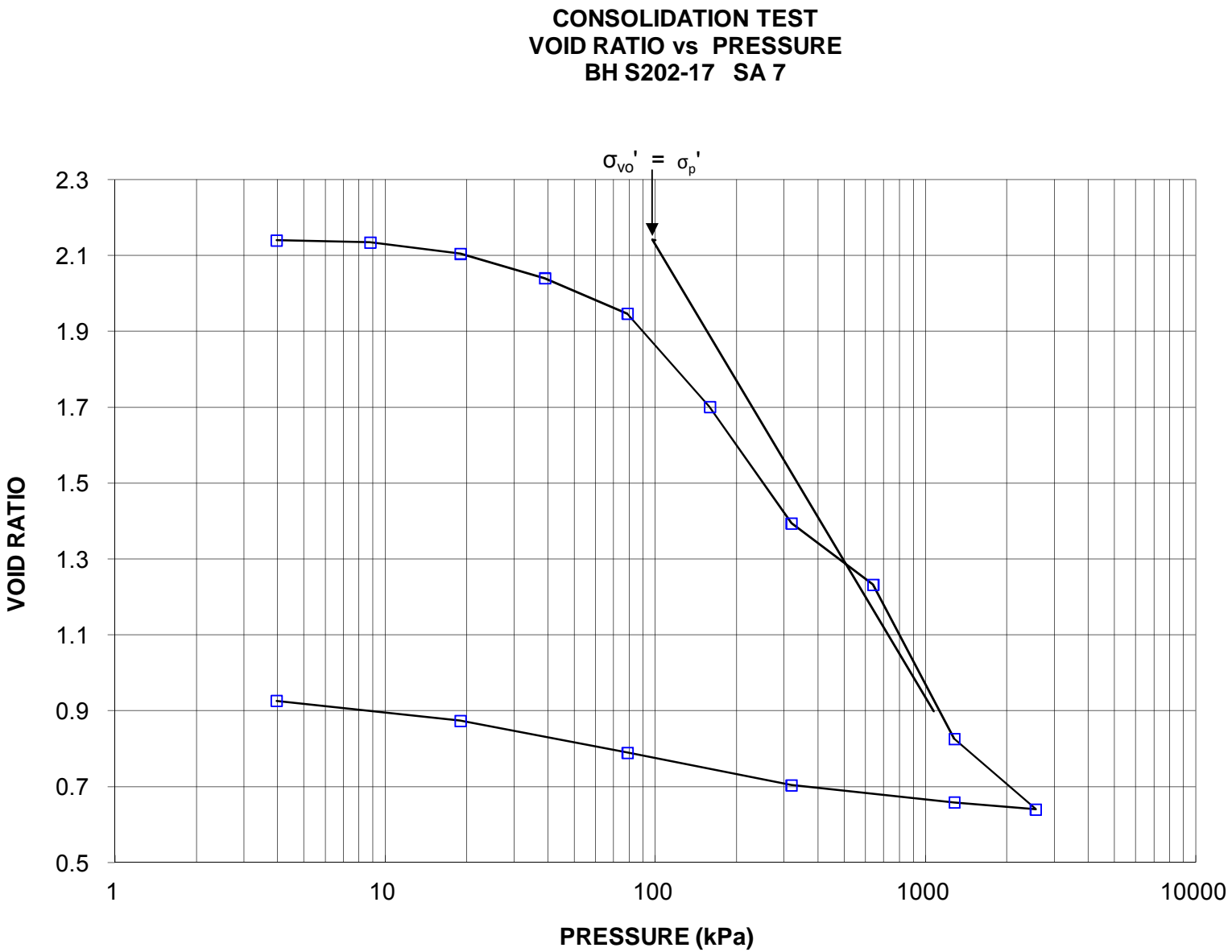
CONSOLIDATION TEST SUMMARY

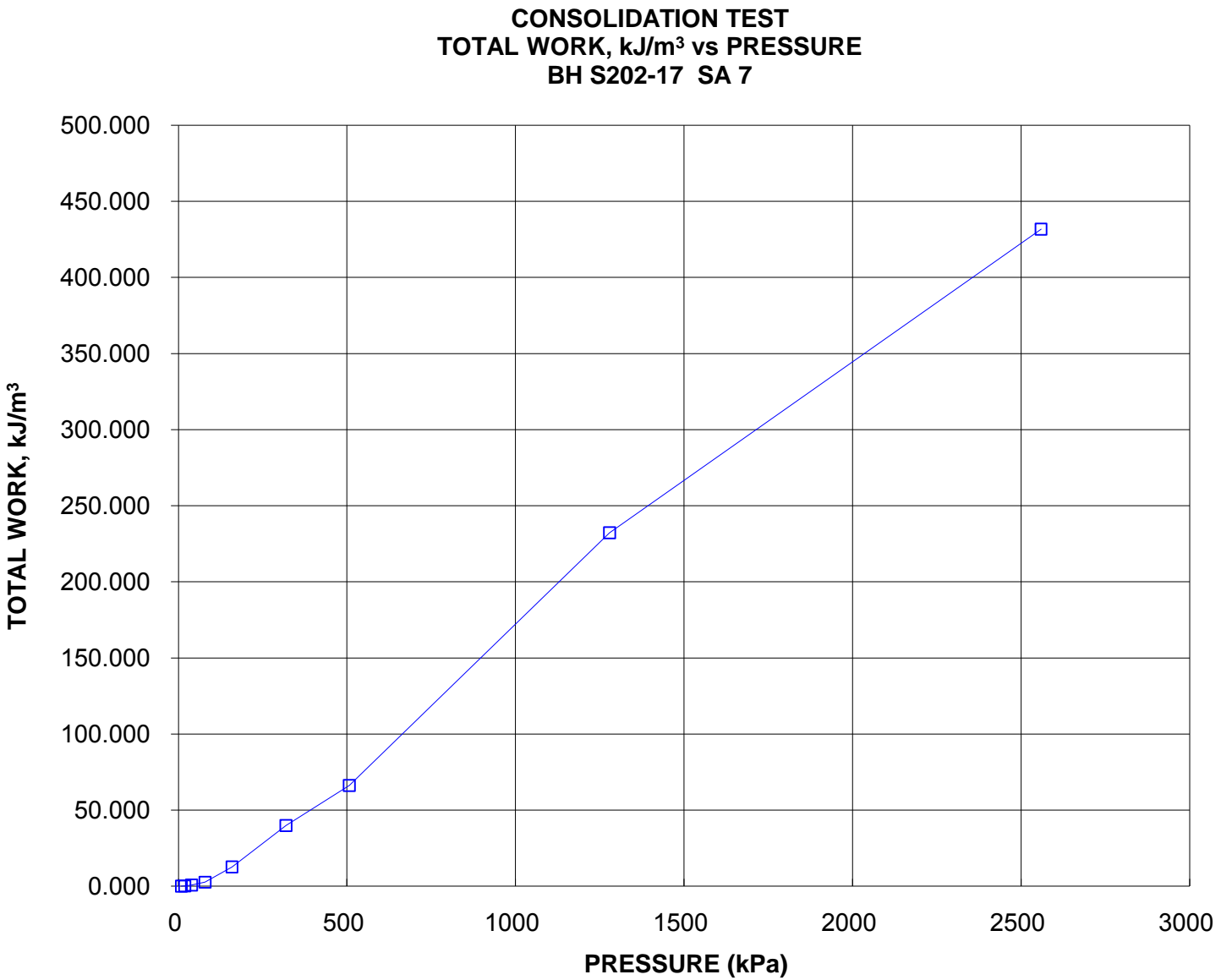
Highway 69 (NBL) STA 11+100 to 11+225 (Swamp 202)

FIGURE B.S202-09

Sheet 2 of 4







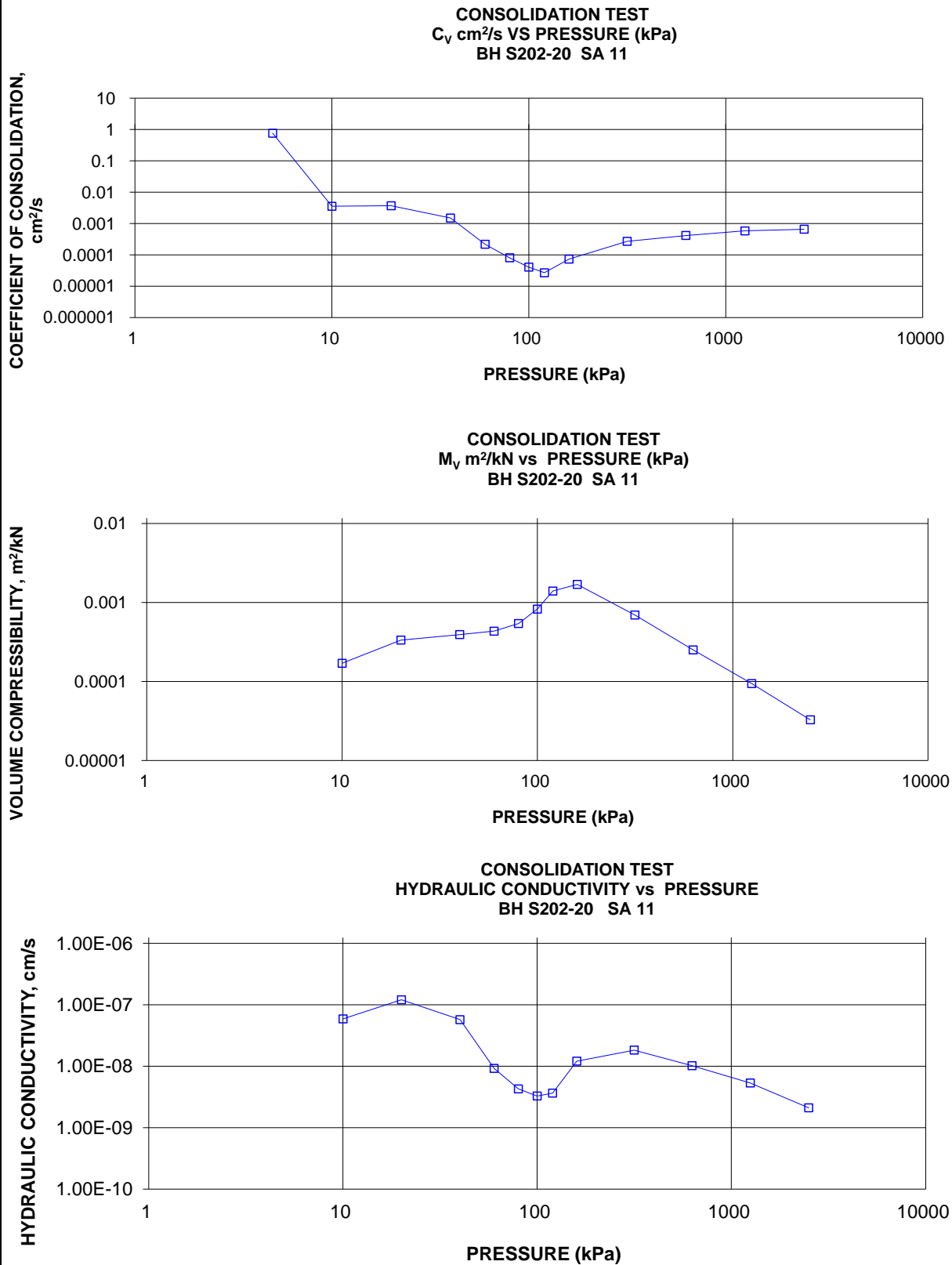
CONSOLIDATION TEST SUMMARY					FIGURE B.S202-10		
Highway 69 (NBL) STA 11+100 to 11+225 (Swamp 202)					Sheet 1 of 4		
SAMPLE IDENTIFICATION							
Project Number	09-1111-6014			Sample Number	11		
Borehole Number	S202-20			Sample Depth, m	10.1-10.5		
TEST CONDITIONS							
Test Type	Standard			Load Duration, hr	24		
Oedometer Number	6						
Date Started	5/27/2011						
Date Completed	6/20/2011						
SAMPLE DIMENSIONS AND PROPERTIES - INITIAL							
Sample Height, cm	1.89			Unit Weight, kN/m ³	15.89		
Sample Diameter, cm	6.33			Dry Unit Weight, kN/m ³	9.52		
Area, cm ²	31.46			Specific Gravity, measured	2.78		
Volume, cm ³	59.46			Solids Height, cm	0.660		
Water Content, %	66.99			Volume of Solids, cm ³	20.76		
Wet Mass, g	96.37			Volume of Voids, cm ³	38.70		
Dry Mass, g	57.71			Degree of Saturation, %	99.9		
TEST COMPUTATIONS							
	Corr.		Average				
Pressure	Height	Void	Height	t ₉₀	c _v	m _v	k
kPa	cm	Ratio	cm	sec	cm ² /s	m ² /kN	cm/s
0.00	1.890	1.864	1.890				
5.01	1.892	1.867	1.891	1	7.58E-01	-	-
10.01	1.890	1.865	1.891	214	3.54E-03	1.69E-04	5.88E-08
20.01	1.884	1.855	1.887	205	3.68E-03	3.33E-04	1.20E-07
40.03	1.869	1.833	1.877	501	1.49E-03	3.91E-04	5.71E-08
60.01	1.853	1.808	1.861	3375	2.18E-04	4.32E-04	9.20E-09
80.01	1.833	1.777	1.843	8930	8.06E-05	5.40E-04	4.26E-09
100.01	1.802	1.730	1.817	17238	4.06E-05	8.22E-04	3.27E-09
120.01	1.749	1.651	1.775	24970	2.68E-05	1.39E-03	3.64E-09
160.01	1.621	1.457	1.685	8247	7.30E-05	1.69E-03	1.21E-08
315.82	1.418	1.149	1.520	1815	2.70E-04	6.92E-04	1.83E-08
627.15	1.271	0.925	1.344	922	4.15E-04	2.50E-04	1.02E-08
1251.42	1.160	0.758	1.215	540	5.80E-04	9.37E-05	5.33E-09
2500.20	1.083	0.641	1.121	406	6.57E-04	3.26E-05	2.10E-09
1251.42	1.098	0.664	1.090				
315.82	1.130	0.712	1.114				
120.01	1.165	0.765	1.147				
80.01	1.176	0.783	1.171				
40.03	1.198	0.815	1.187				
10.01	1.246	0.889	1.222				
5.01	1.258	0.906	1.252				
Note:							
k calculated using cv based on t ₉₀ values.							
Specimen swelled under 5kPa							
SAMPLE DIMENSIONS AND PROPERTIES - FINAL							
Sample Height, cm	1.13			Unit Weight, kN/m ³	21.36		
Sample Diameter, cm	6.33			Dry Unit Weight, kN/m ³	15.93		
Area, cm ²	31.46			Specific Gravity, measured	2.78		
Volume, cm ³	35.54			Solids Height, cm	0.660		
Water Content, %	34.12			Volume of Solids, cm ³	20.76		
Wet Mass, g	77.40			Volume of Voids, cm ³	14.78		
Dry Mass, g	57.71						
Prepared By: LH				Golder Associates		Checked By: MM	

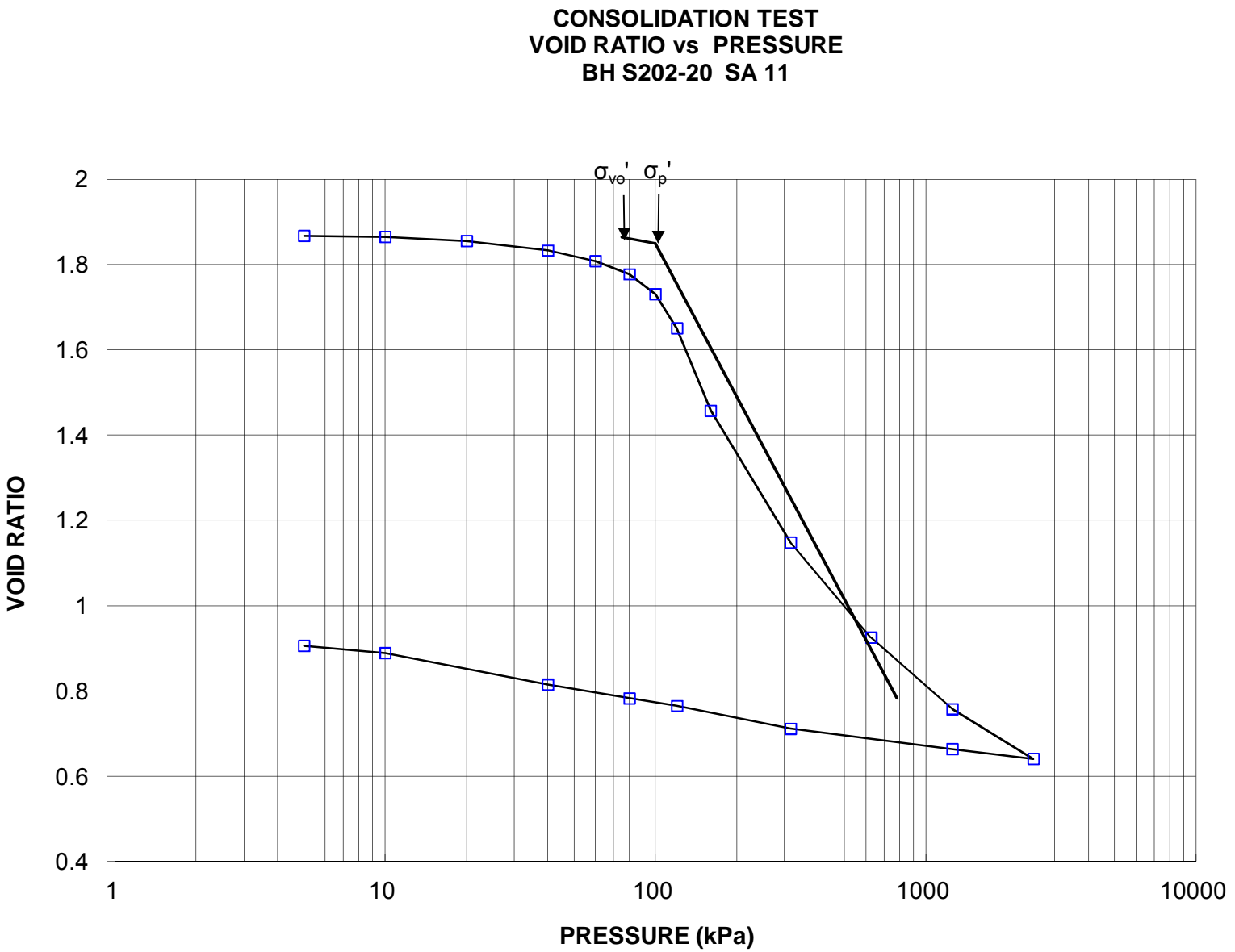
CONSOLIDATION TEST SUMMARY

Highway 69 (NBL) STA 11+100 to 11+225 (Swamp 202)

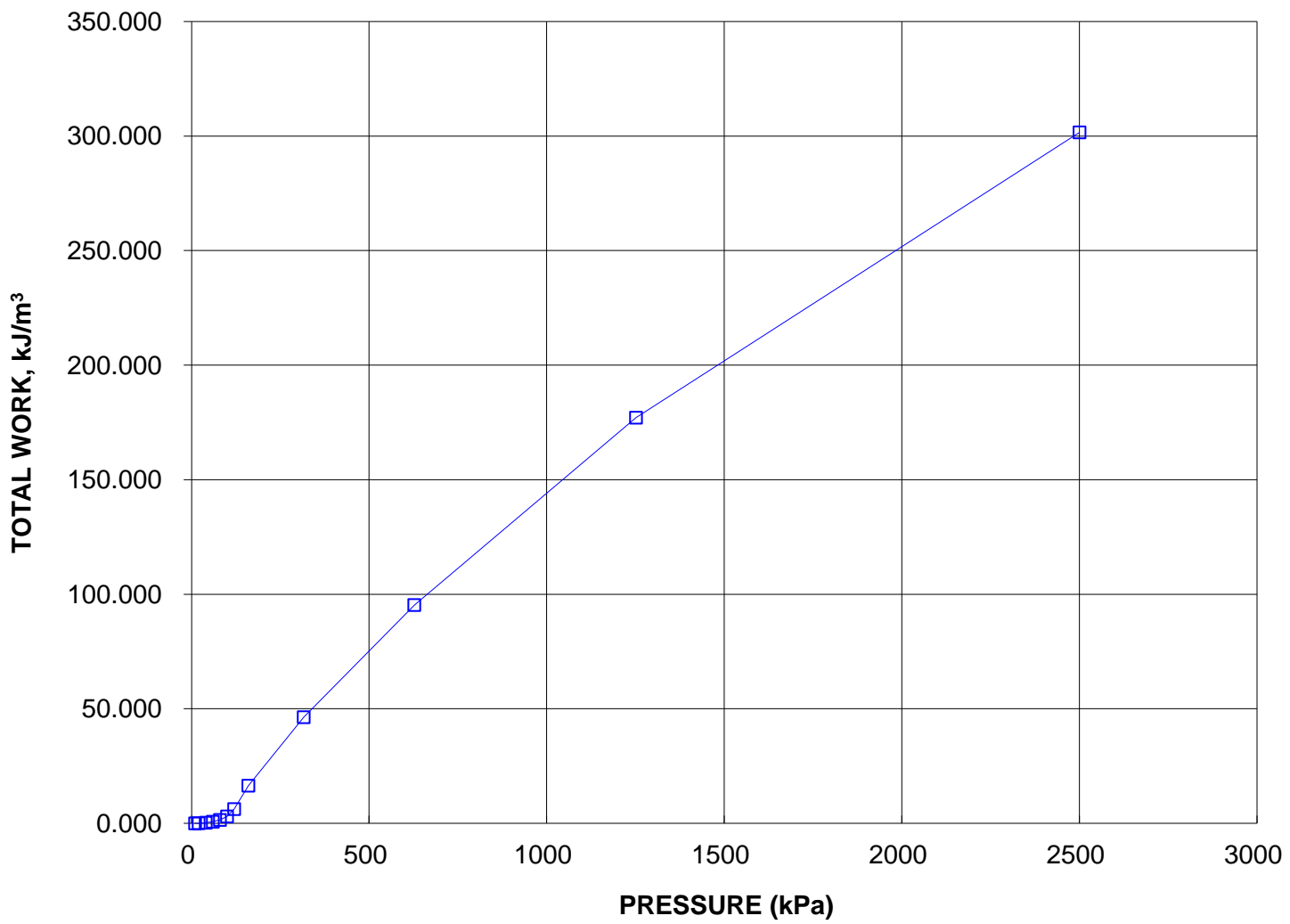
FIGURE B.S202-10

Sheet 2 of 4





CONSOLIDATION TEST
TOTAL WORK, kJ/m³ vs PRESSURE
BH S202-20 SA 11

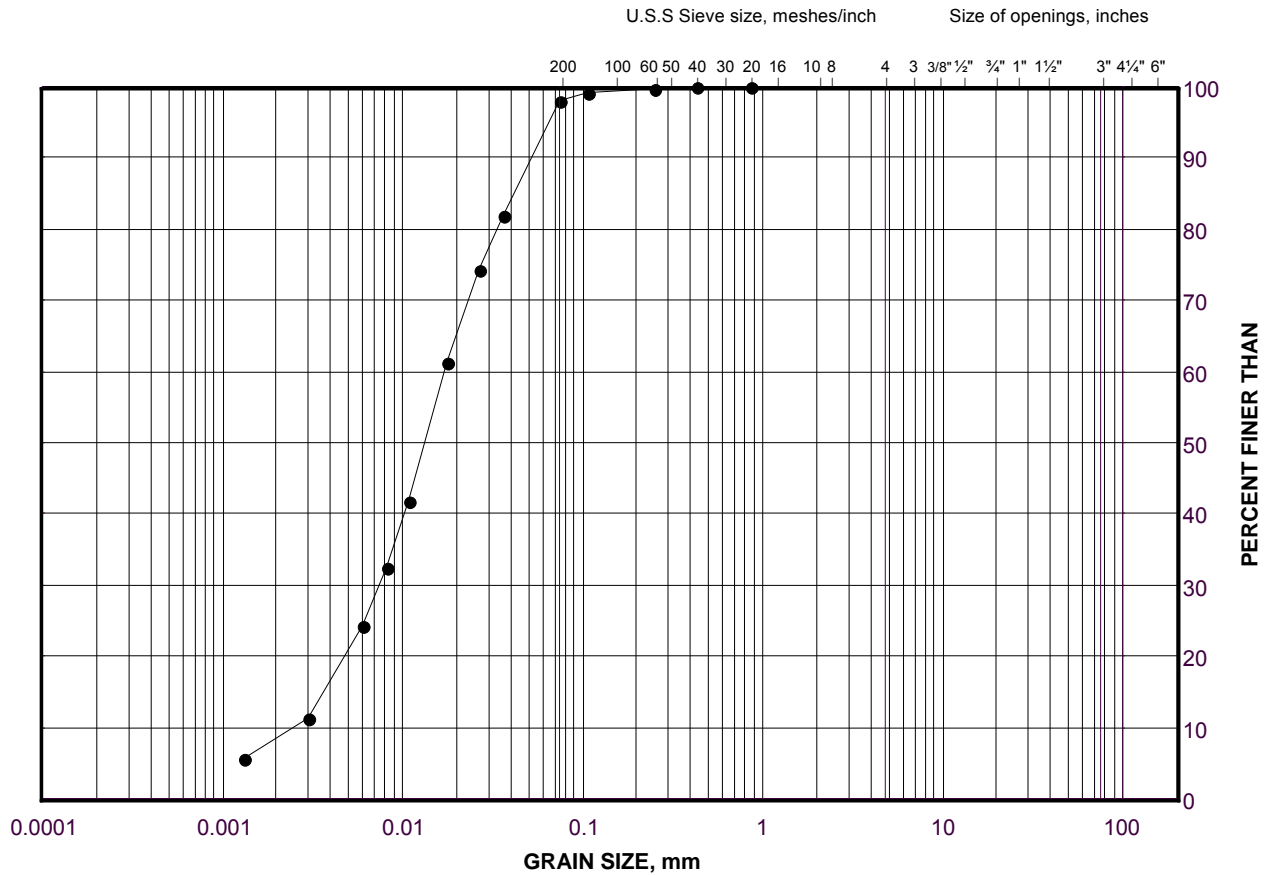


GRAIN SIZE DISTRIBUTION

Silt (Interlayer)

Highway 69 (NBL) STA 11+100 to 11+225 (Swamp 202)

FIGURE B.S202-11



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

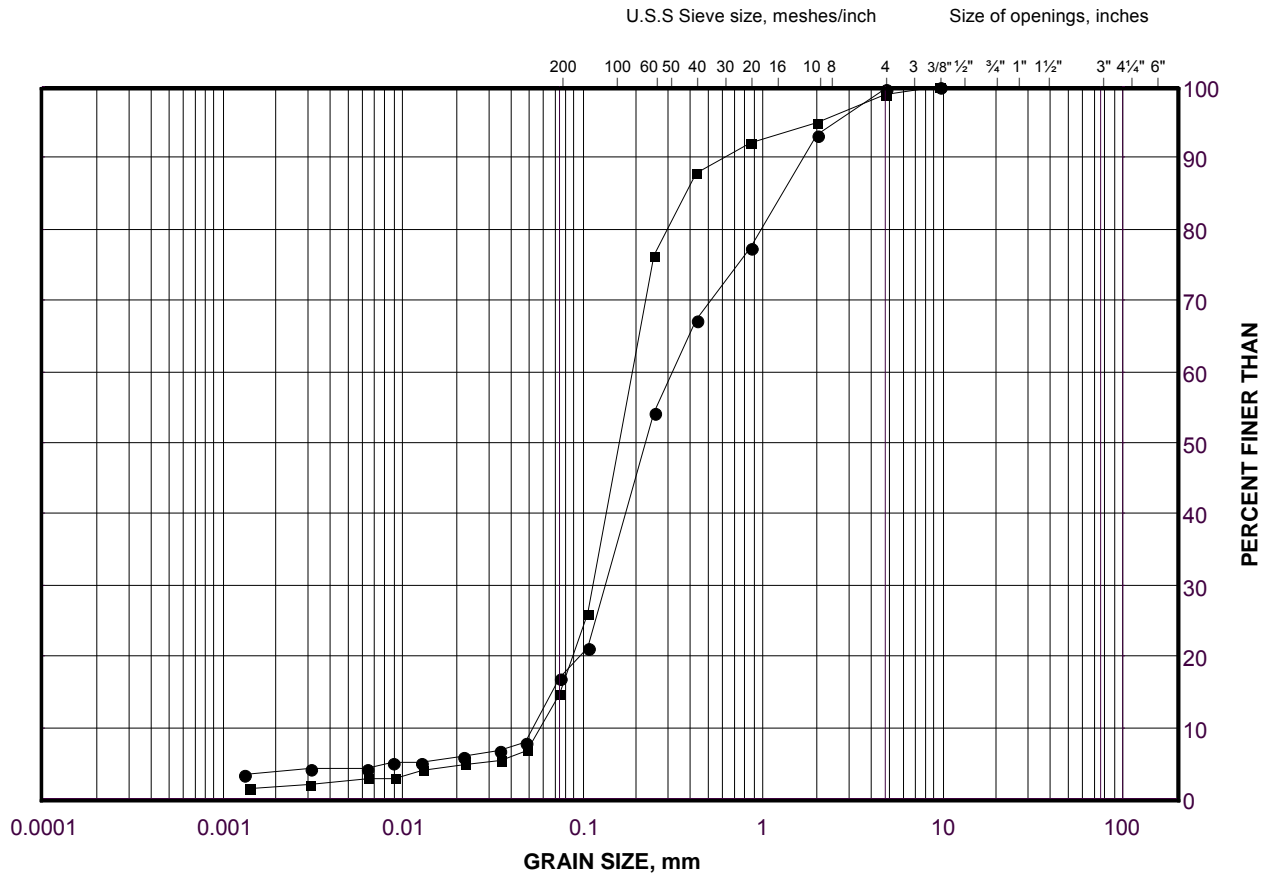
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S202-20	7	178.9

GRAIN SIZE DISTRIBUTION

Sand

Highway 69 (NBL) STA 11+100 to 11+225 (Swamp 202)

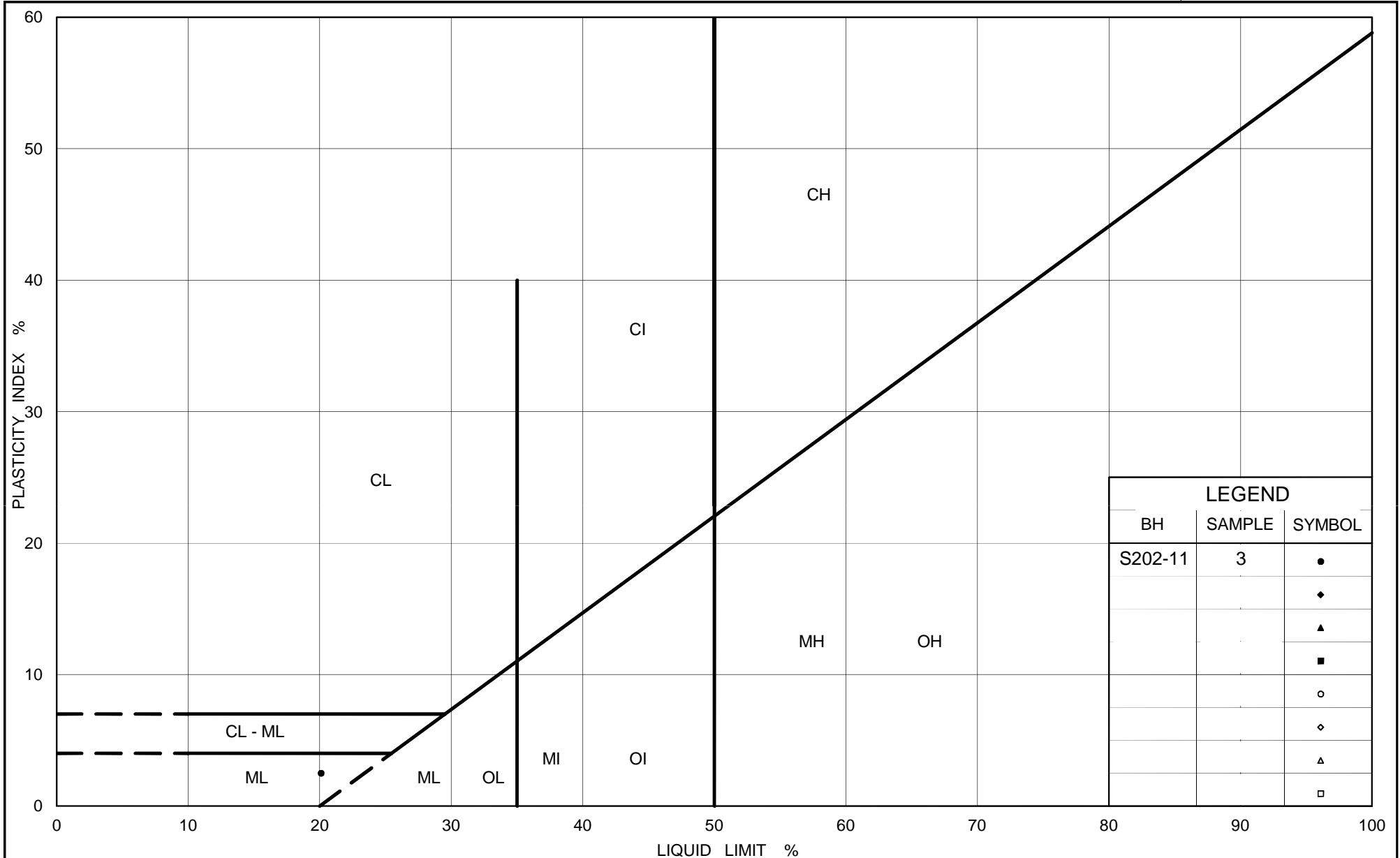
FIGURE B.S202-12



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S202-17	10	166.3
■	S202-06	12	165.1



Ministry of Transportation

Ontario

PLASTICITY CHART
 Silty Sand (Slight Plasticity)
 Highway 69 (NBL) STA 11+100 to 11+225 (Swamp 202)

Figure No. B.S202-13

Project No. 09-1111-6014

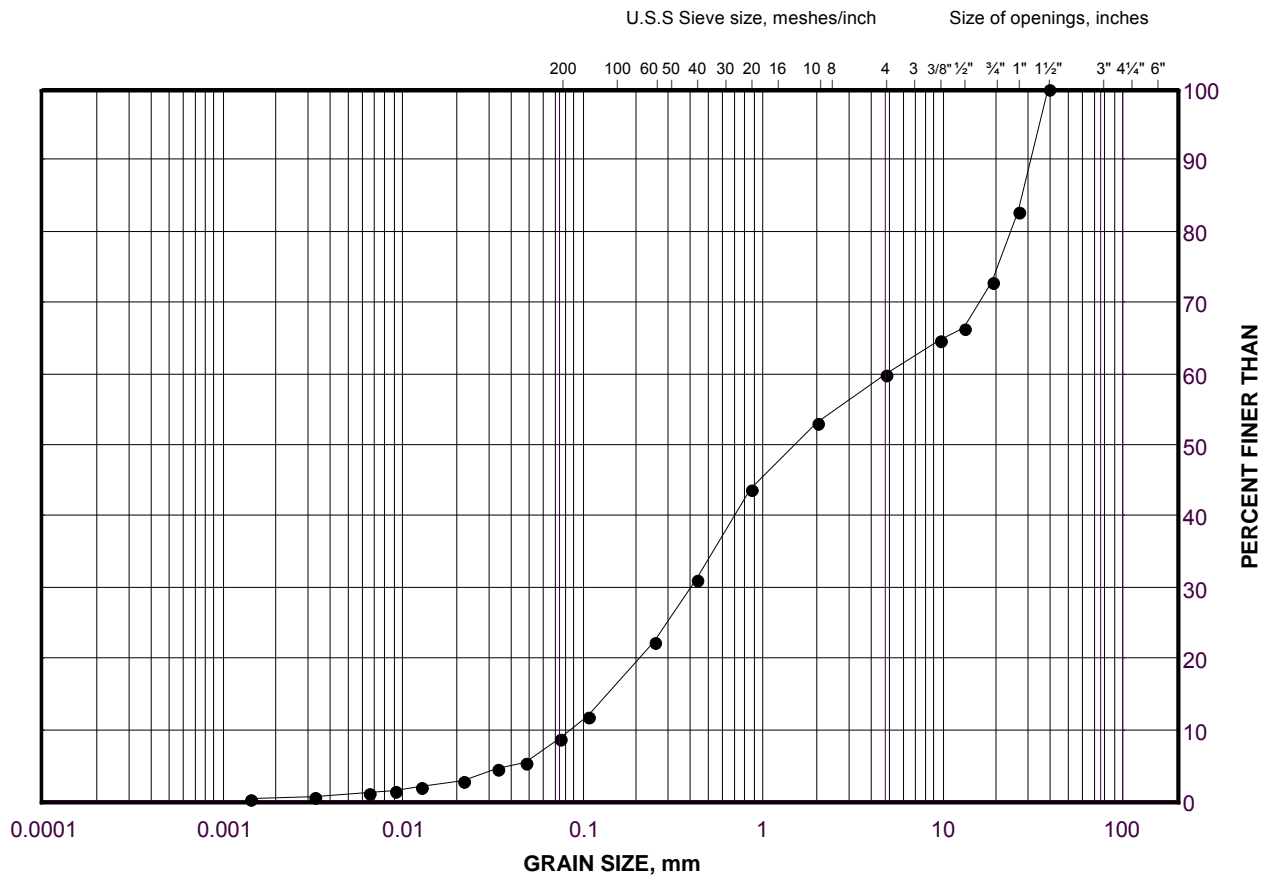
Checked By: TVA

GRAIN SIZE DISTRIBUTION

Sand and Gravel

Highway 69 (NBL) STA 11+100 to 11+225 (Swamp 202)

FIGURE B.S202-14



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

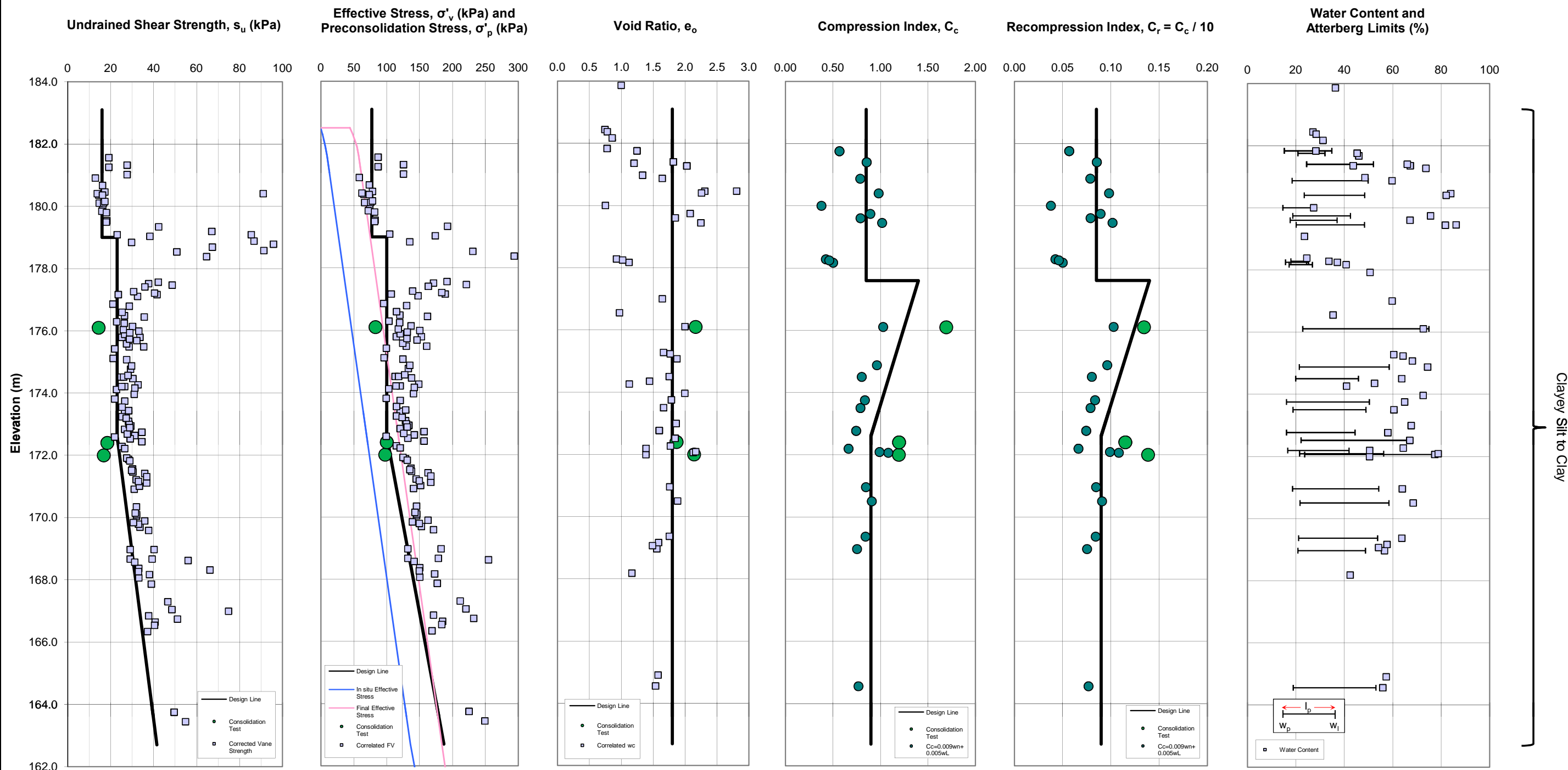
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S202-20	15	166.8

\\capws\dav\WWW\Root\sites\0911116014\highway69\FourLaning\Contract 2\Reporting\Final\Swamp Crossings and High Fill Areas\Tables and Figures\09-1111-6014-Contract 2 Swamp202-Parameters and Design Lines-PRIORITY A-REV_FIN

SUMMARY PLOT OF ENGINEERING PARAMETERS FOR
COHESIVE DEPOSITS
Highway 69 SBL - STA 11+175 to 11+275 (Swamp 202)
Highway 69 NBL - STA 11+100 to 11+225 (Swamp 202)

FIGURE B1



Golder Associates

Date: July 2012
Project No: 09-1111-6014-2520

Prepared By: ARM/TZ
Checked By: JPD/JMAC



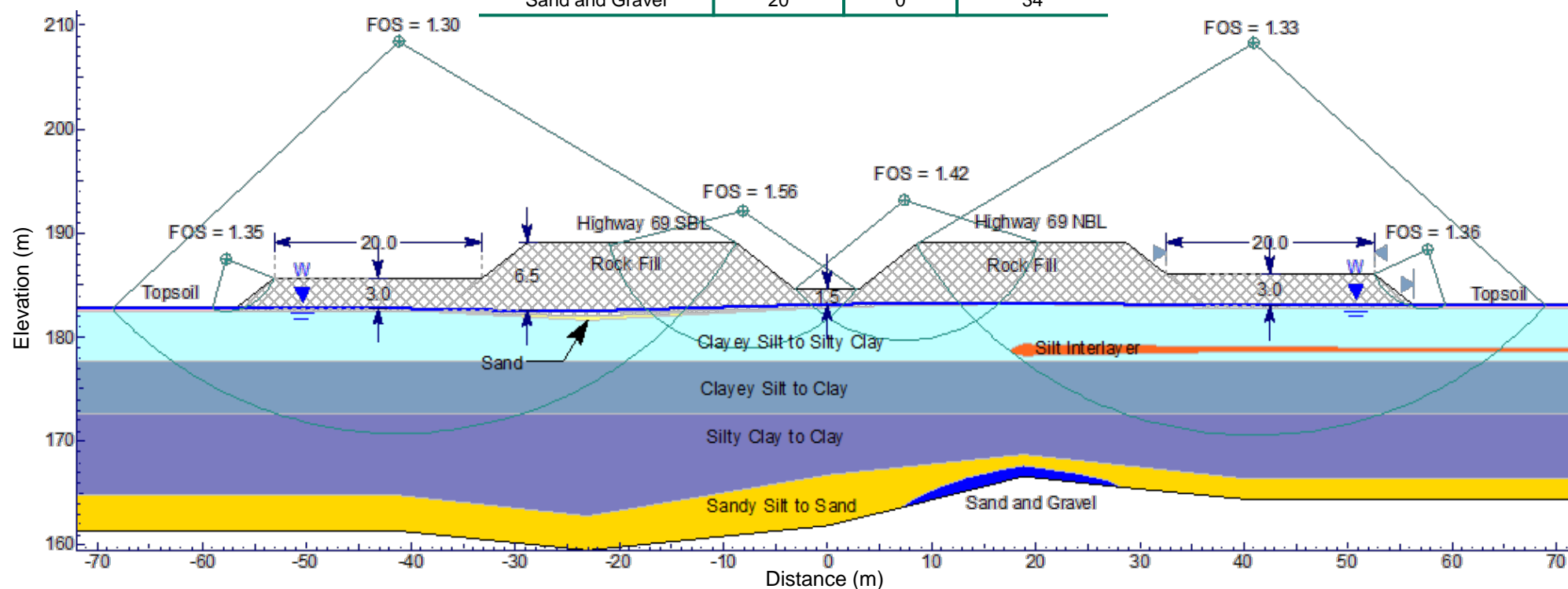


Highway 69 SBL – STA 11+175 to 11+275 (Swamp 202) Highway 69 NBL – STA 11+100 to 11+225 (Swamp 202) Slope Stability (Outside Toe Berms)

Figure B2

All dimensions are in metres

Material Name	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (degrees)
Rock Fill	19	0	40
Topsoil	15	0	12
Sand	18.5	0	27
Clayey Silt to Silty Clay	16.5	16	-
Silt Interlayer	18	0	27
Clayey Silt to Clay	16.5	23	-
Silty Clay to Clay	16.5	23 - 41.5	-
Sandy Silt to Sand	19	0	29
Sand and Gravel	20	0	34



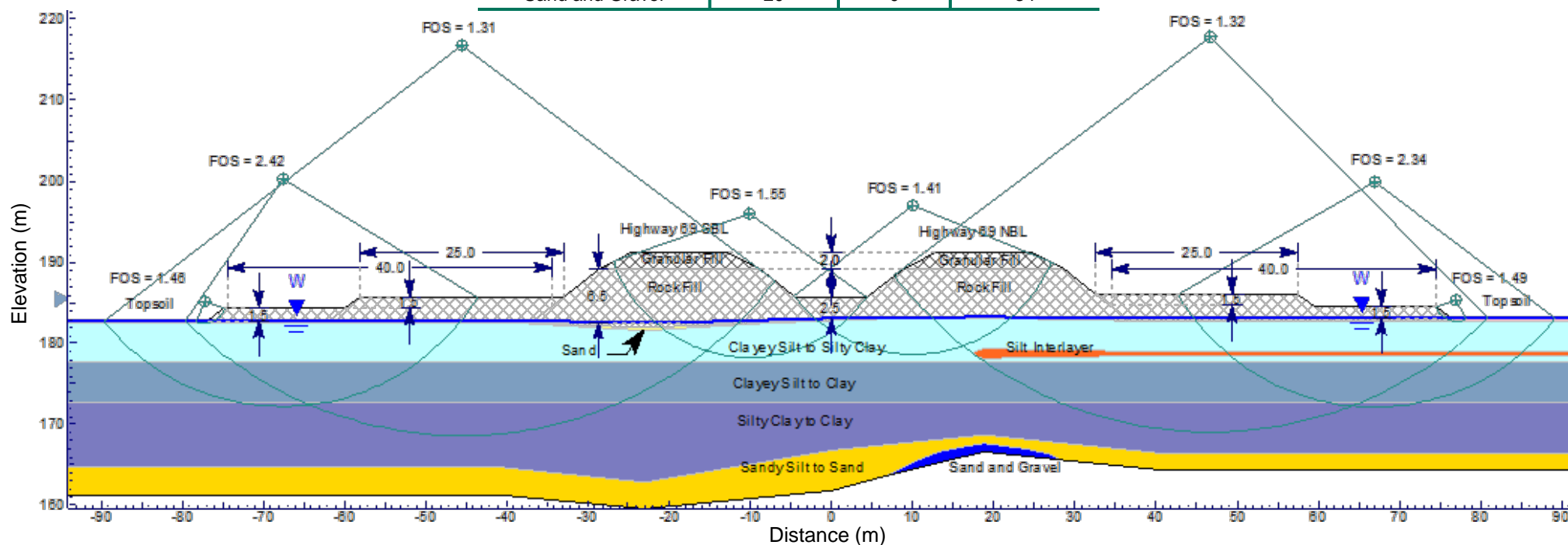


Highway 69 SBL – STA 11+175 to 11+275 (Swamp 202) Highway 69 NBL – STA 11+100 to 11+225 (Swamp 202) Slope Stability (2 m Surcharge and Outside Toe Berms/Median Infill)

Figure B3

All dimensions are in metres

Material Name	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (degrees)
Surcharge Fill	20	0	34
Rock Fill	19	0	40
Topsoil	15	0	12
Sand	18.5	0	27
Clayey Silt to Silty Clay	16.5	16	-
Silt Interlayer	18	0	27
Clayey Silt to Clay	16.5	23	-
Silty Clay to Clay	16.5	23 - 41.5	-
Sandy Silt to Sand	19	0	29
Sand and Gravel	20	0	34



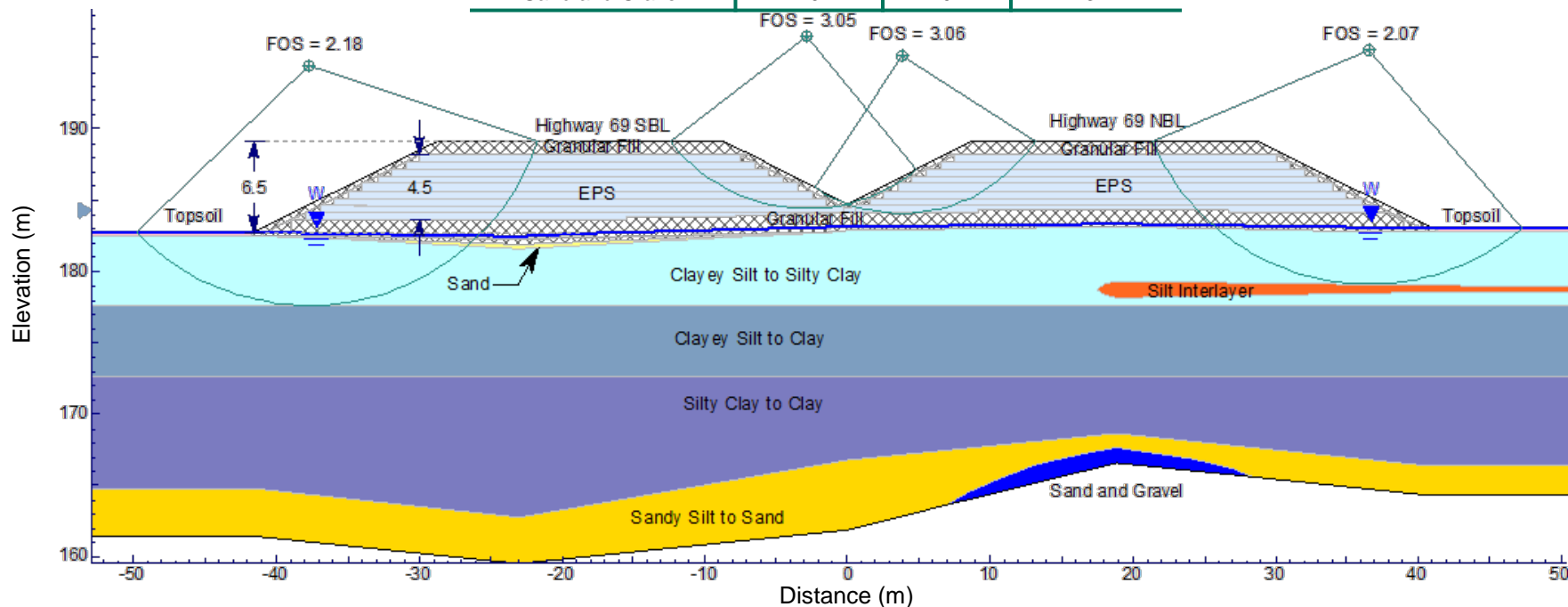


Highway 69 SBL – STA 11+175 to 11+275 (Swamp 202) Highway 69 NBL – STA 11+100 to 11+225 (Swamp 202) Slope Stability (4.5 m of EPS Fill)

Figure B4

All dimensions are in metres

Material Name	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (degrees)
Granular Fill	21	0	34
EPS	0.5	15	-
Rock Fill	19	0	40
Topsoil	15	0	12
Sand	18.5	0	27
Clayey Silt to Silty Clay	16.5	16	-
Silt Interlayer	18	0	27
Clayey Silt to Clay	16.5	23	-
Silty Clay to Clay	16.5	23 - 41.5	-
Sandy Silt to Sand	19	0	29
Sand and Gravel	20	0	34





FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS

HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

Table B1
Evaluation of Stability/Settlement Mitigation Options
Highway 69 SBL – STA 11+175 to 11+275 and Highway 69 NBL – STA 11+100 to 11+225 (Swamp 202)

Stability/Settlement Mitigation Option	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
Full Sub-Excavation (up to 20 m deep)	Not practical	<ul style="list-style-type: none"> ■ Reduced total settlement. ■ Toe berms are not required. 	<ul style="list-style-type: none"> ■ Generation of large volume of excess excavation spoil. ■ Significant quantity of rock fill will be required for backfilling. Delay in construction associated with up to 20 m deep sub-excavation and replacement with rock fill operation. ■ Specialized equipment and additional effort required for deep sub-excavation and replacement. ■ Additional post-construction settlement of rock fill itself. ■ May require additional right-of-way to accommodate deep sub-excavation. 	<ul style="list-style-type: none"> ■ Additional costs associated with sub-excavation (specialized drag-line equipment required), disposal and replacement of weak/soft, compressible deposits. ■ Possible additional cost for acquiring additional right-of-way for deep sub-excavation. 	<ul style="list-style-type: none"> ■ Preloading would be required to reduce large post-construction settlement of rock fill. ■ Higher risk with maintaining stability of excavation slopes. ■ Very low risk with respect to maintaining stability of proposed embankments.
Preloading (8,500 days or about 23.3 years) with Large Toe Berms	Not practical	<ul style="list-style-type: none"> ■ Standard construction operation. ■ Avoids generation of large volume of excess 	<ul style="list-style-type: none"> ■ Excessive delay in construction to reach post-construction settlement criteria or regular maintenance of 	<ul style="list-style-type: none"> ■ Schedule impacts will increase overall project costs or additional costs for regular maintenance of 	<ul style="list-style-type: none"> ■ Some risk with maintaining stability of preload embankments on weak/soft foundation soils.



FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS

HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

Table B1
Evaluation of Stability/Settlement Mitigation Options
Highway 69 SBL – STA 11+175 to 11+275 and Highway 69 NBL – STA 11+100 to 11+225 (Swamp 202)

Stability/Settlement Mitigation Option	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
<p>(3 m high by 20 m wide)</p> <p>About 1,505 mm of primary and secondary consolidation settlement and about 65 mm of immediate settlement.</p>		<p>excavation spoil.</p>	<p>roadway required throughout preload period.</p> <ul style="list-style-type: none"> Large toe berms are required to maintain stability of embankment. Re-grading is required prior to final pavement structure construction to account for large settlement associated with preloading (about 2 m of EPS top-up required). Additional right-of-way will be required to accommodate very large toe berms. Instrumentation and monitoring program required to assess end of preload period. Size of toe berms will affect the design of culverts through the proposed embankments. 	<p>roadway throughout preload period.</p> <ul style="list-style-type: none"> Additional cost for acquiring additional right-of-way to accommodate very large berms. Additional cost for longer culverts. Additional cost for EPS top-up and re-grading. Additional cost for instrumentation and associated monitoring program. 	<ul style="list-style-type: none"> Size of toe berms will significantly increase length of culverts through the proposed embankments. Additional right-of-way required for very large toe berms. Subject to the monitoring data collected during the preload period, the preload embankment may need to be left in place for an extended period of time.



FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS

HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

Table B1
Evaluation of Stability/Settlement Mitigation Options
Highway 69 SBL – STA 11+175 to 11+275 and Highway 69 NBL – STA 11+100 to 11+225 (Swamp 202)

Stability/Settlement Mitigation Option	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
<p>Surcharging (2 m high for 2,600 days or about 7.1 years) with Very Large Toe Berms (1.5 m high by 40 m wide lower tier and 1.5 m high by 25 m wide upper tier)</p> <p>About 1425 mm of primary and secondary consolidation settlement and about 80 mm of immediate settlement.</p>	Not practical	<ul style="list-style-type: none"> Standard construction operation. Reduced time to reach post-construction settlement criteria as compared with preloading alternative. Avoid generation of large volume of excess excavation spoil. 	<ul style="list-style-type: none"> Excessive delay in construction to reach post-construction settlement criteria or, regular maintenance of roadway required throughout surcharge period. Increased handling of surcharge fills (Granular 'B') upon completion of surcharge period. Very large toe berms are required to maintain stability of surcharge embankment. Re-grading is required prior to final pavement structure construction to account for large settlement associated with preloading (about 2 m of EPS top-up). Additional right-of-way will be required to accommodate very large toe berms. Instrumentation and 	<ul style="list-style-type: none"> Schedule impacts will increase overall project costs or, additional costs for regular maintenance of roadway throughout surcharge period. Additional cost associated with construction for 2 m high surcharge and very large toe berms. Additional cost for acquiring additional right-of-way to accommodate very large berms. Additional cost for longer culverts. Additional cost for EPS top-up and re-grading. Additional cost for instrumentation and associated monitoring program. 	<ul style="list-style-type: none"> Higher risk with respect to maintaining stability of embankment with surcharge on weak/soft foundation soils. Size of toe berms will significantly increase length of culverts through the proposed embankments. Additional right-of-way required for very large toe berms. Subject to the monitoring data collected during the surcharge period, the surcharge embankment may need to be left in place for an extended period of time.



FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS

HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

Table B1
Evaluation of Stability/Settlement Mitigation Options
Highway 69 SBL – STA 11+175 to 11+275 and Highway 69 NBL – STA 11+100 to 11+225 (Swamp 202)

Stability/Settlement Mitigation Option	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
			<p>monitoring program required to assess end of surcharge period.</p> <ul style="list-style-type: none"> Size of toe berms will affect the design of culverts through the proposed embankments. 		
<p>Wick Drains with Surcharging (390 days) and Very Large Toe Berms (Up to 1.5 m high by 40 m wide lower tier and up to 1.5 m high by 25 m wide upper tier) followed by Lightweight Fill (1 m of EPS)</p> <p>About 1,815 mm of primary and secondary consolidation settlement and about 80 mm of immediate settlement.</p>	2	<ul style="list-style-type: none"> Reduced time for primary consolidation settlement to complete. Size of toe berms may be reduced by staged construction. Requires confirmation during detail wick drain design. 	<ul style="list-style-type: none"> Very large toe berms may be required if preload embankment plus surcharge is constructed continuously in one stage. Additional right-of-way will be required to accommodate large toe berms. Detail wick drain investigation and design will be required. Additional time required for installation of wick drains. Increased magnitude of secondary consolidation (creep) settlement as a result of 	<ul style="list-style-type: none"> Schedule impacts may increase overall project costs. Additional costs associated with detail wick drain investigation and design. Additional cost for the installation of wick drains, instrumentation and associated monitoring program. Additional costs associated with construction and materials for 2 m high surcharge and partial deconstruction of surcharge embankment upon completion of surcharge period. 	<ul style="list-style-type: none"> Some risk with respect to stability of surcharge embankment on weak/soft foundation soils if staged construction is employed. Some risk with respect to presence of artesian of groundwater pressures affecting design. Size of toe berms may significantly increase length of culverts through the proposed embankments if staged construction is not employed. Higher risk associated with the complexity of a



FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS

HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

Table B1
Evaluation of Stability/Settlement Mitigation Options
Highway 69 SBL – STA 11+175 to 11+275 and Highway 69 NBL – STA 11+100 to 11+225 (Swamp 202)

Stability/Settlement Mitigation Option	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
			<p>the accelerated completion of primary consolidation settlement.</p> <ul style="list-style-type: none"> ■ Presence of artesian pressures will have to be carefully considered in design. ■ Delay in construction schedule to allow for sufficient settlement to occur to meet post-construction settlement criteria. ■ Total magnitude of secondary (creep) consolidation settlement will be significantly greater than other alternatives. ■ Instrumentation and monitoring program required to monitor staged construction and to assess end of surcharge period. ■ Increased handling of surcharge fill (Granular 'B') to 	<ul style="list-style-type: none"> ■ Additional costs associated with 1.5 m of EPS top-up and the construction of final embankment. ■ Potential additional cost for acquiring additional right-of-way to accommodate very large berms. ■ Potential additional cost for longer culverts. ■ Estimated cost is about \$ 370,000 for wick drains, \$ 2,100,000 for EPS top-up plus cost for handling of surcharge construction. 	<p>wick drain/lightweight fill design.</p> <ul style="list-style-type: none"> ■ Additional right-of-way may be required for very large toe berms. ■ Subject to the monitoring data collected during the surcharge period, the surcharge embankment may need to be left in place for an extended period of time.



FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

Table B1
Evaluation of Stability/Settlement Mitigation Options
Highway 69 SBL – STA 11+175 to 11+275 and Highway 69 NBL – STA 11+100 to 11+225 (Swamp 202)

Stability/Settlement Mitigation Option	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
			remove surcharge.		
Partial Preloading (3.5 m high for 130 days) with Temporary Toe Berms (1.5 m high by 2.5 m wide) followed by Lightweight Fill Construction (4.5 m of EPS)	1	<ul style="list-style-type: none"> ■ Improved stability. ■ Reduced total settlement of foundation soils. ■ May shorten construction schedule. 	<ul style="list-style-type: none"> ■ Relatively small temporary toe berms will be required when partial preload is applied. ■ Very high cost of EPS construction materials. ■ Some additional effort required to remove the partial preload embankments in order to construct the EPS embankment. ■ Instrumentation and monitoring program required to assess end of preload period. 	<ul style="list-style-type: none"> ■ Relative cost of EPS fill is about an order of magnitude higher than fill required for the other options. ■ Estimated cost for EPS is about \$ 6,700,000 minus cost of rock fill to construct embankments in base case. 	<ul style="list-style-type: none"> ■ Very low risk with respect to stability of partial preload embankments and final EPS embankments on weak/soft foundation soils. ■ Low risk with respect to unexpected post-construction settlements.

[http://capws/sites/0911116014highway69fourlaning/contract 2/reporting/final/swamp crossings and high fill areas/tables and figures/09-1111-6014-1 tbl b1 evaluation of mitigation options-swamp 202 sbl and nbl.docx](http://capws/sites/0911116014highway69fourlaning/contract%20reporting/final/swamp%20crossings%20and%20high%20fill%20areas/tables%20and%20figures/09-1111-6014-1%20tbl%20b1%20evaluation%20of%20mitigation%20options-swamp%20202%20sbl%20and%20nbl.docx)

Prepared By: TZ/CN

Reviewed By: JPD/JMAC

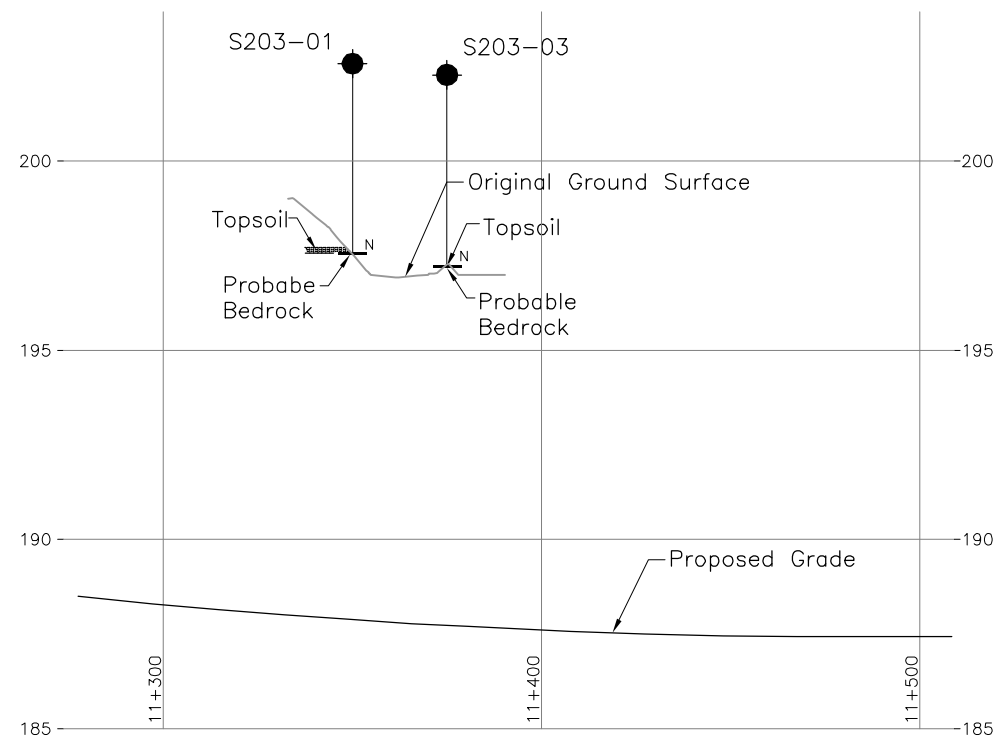
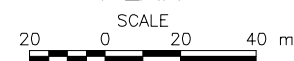


APPENDIX C

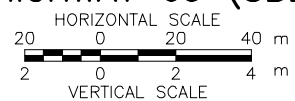
**Highway 69 SBL – STA 11+350 to 11+375 and
Highway 69 NBL – STA 11+375 to 11+400 (Swamp 203)**



PLAN

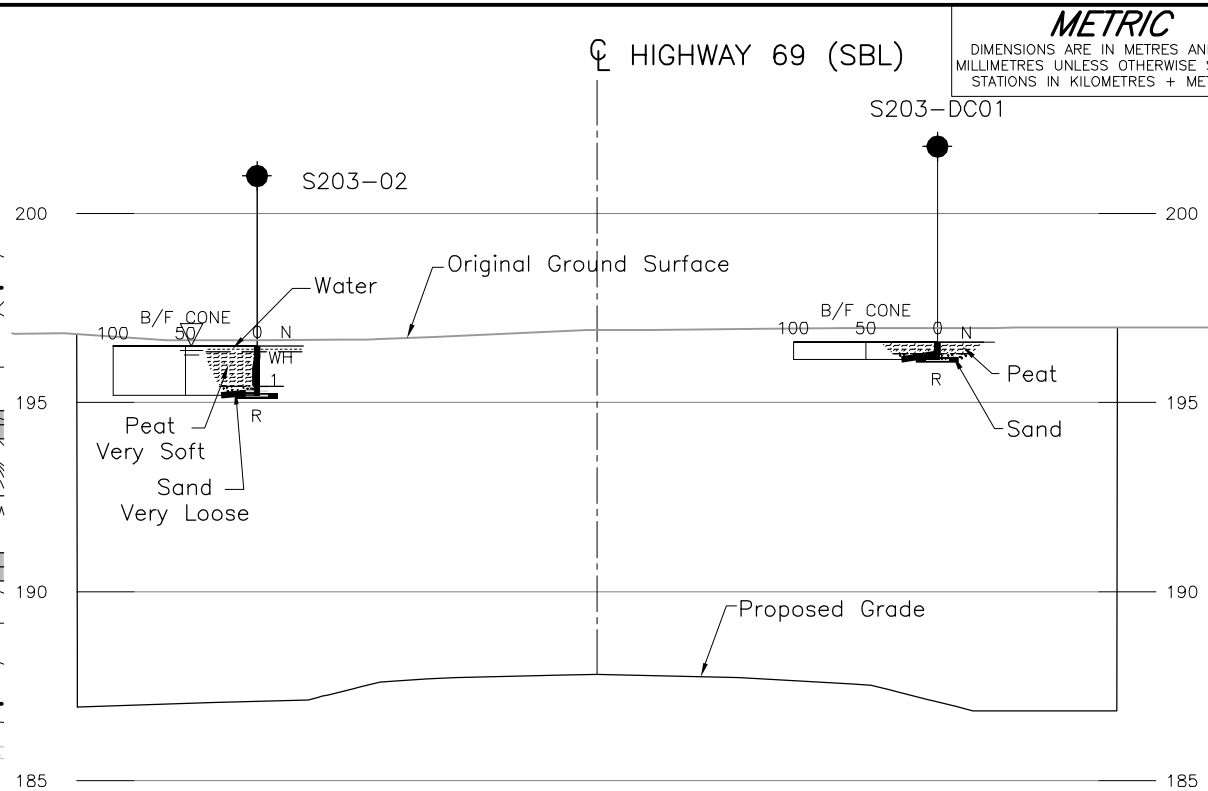


CENTRELINE PROFILE
HIGHWAY 69 (SBL)



REFERENCE

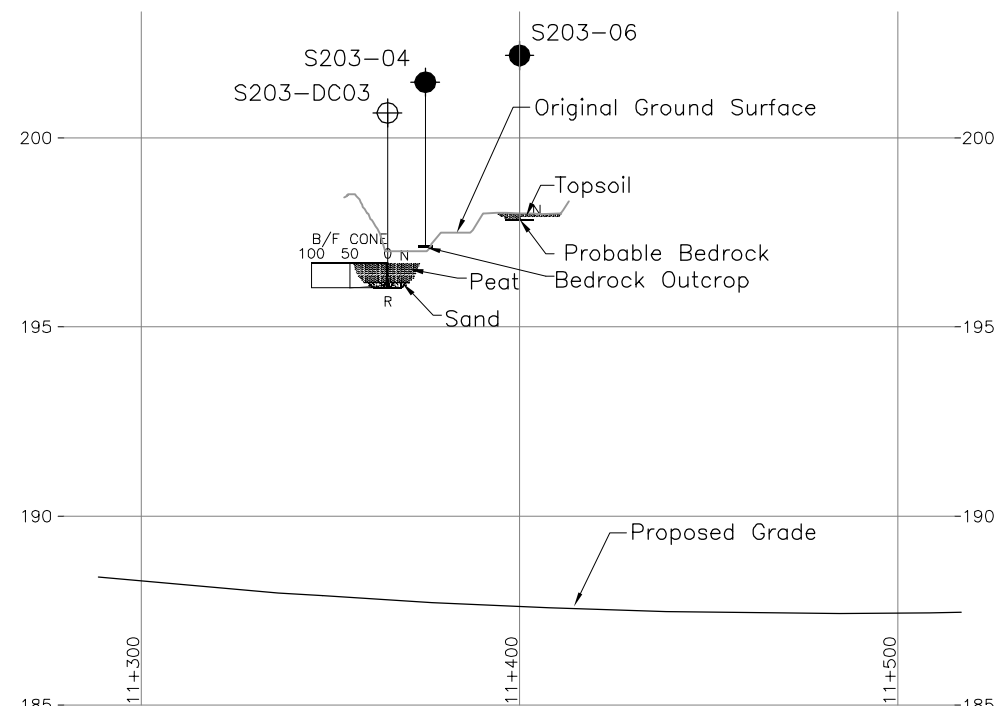
Base plans provided in digital format by URS, drawing files Hwy69_base.dwg, Hwy69_plan.dwg, received December 16, 2009. Original Ground Surface cut from contour drawing file HWY69_Contour-Plan_C2_C3.dwg, received July 14, 2011 and the Proposed Grade obtained from drawing files Hwy69_profile-nov-18-2011 received November 18, 2011.



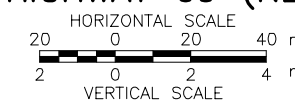
CROSS-SECTION STA 11+362.5
HIGHWAY 69 (SBL)



Note: The Proposed Grade at STA. 11+362.5 was provided in a digital format by URS, drawing file_revised_XS_to_golder-dec-07-2011.dwg, received December 7, 2011.



C-C' CENTRELINE PROFILE
C1 HIGHWAY 69 (NBL)



CONT No.
WP No. 5404-05-01

HIGHWAY 69

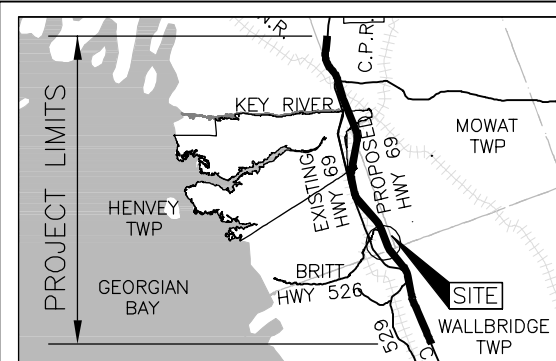
SHEET

STA 11+350 TO 11+375 (SBL)
STA 11+375 TO 11+400 (NBL)

BOREHOLE LOCATIONS AND SOIL STRATA



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA






KEY PLAN

SCALE 6 12 km

SCALE
6 0 6 12 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
S203-01	197.6	5074362.8	225319.6
S203-02	196.5	5074370.9	225305.9
S203-03	197.3	5074386.1	225310.4
S203-04	197.2	5074399.9	225345.3
S203-05	197.0	5074415.1	225349.7
S203-06	197.9	5074423.1	225336.1
S203-DC01	196.6	5074377.5	225322.7
S203-DC01A	196.6	5074376.9	225321.3
S203-DC01B	196.6	5074378.0	225324.1
S203-DC02	198.0	5074408.5	225333.0
S203-DC03	196.7	5074390.7	225349.2
S203-DC03A	196.7	5074390.0	225347.6

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.

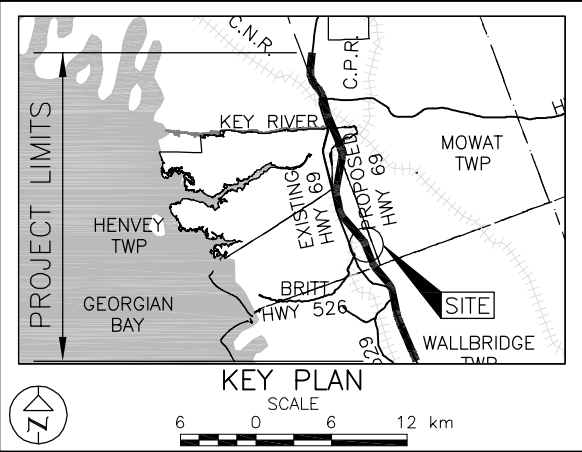
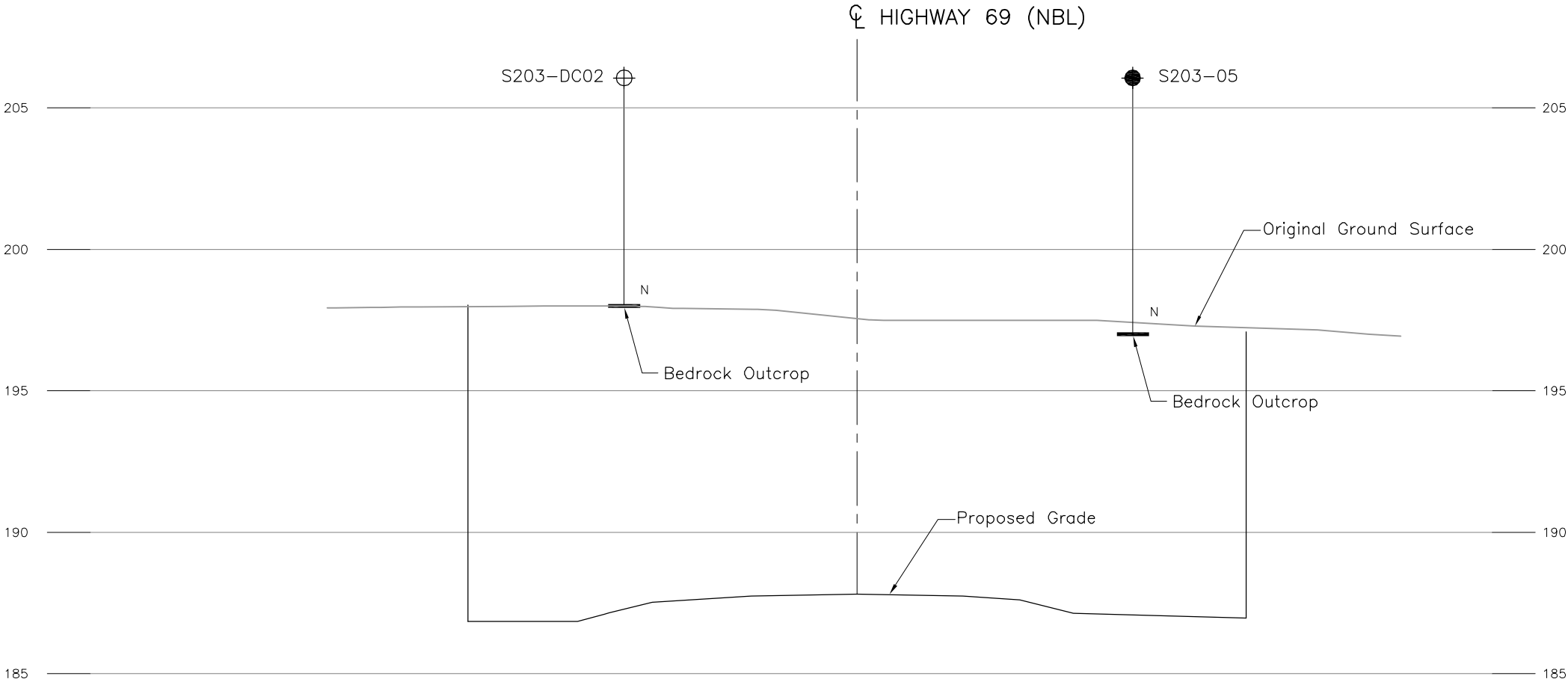
NO.	DATE	BY	REVISION		
Geocres No. 41H-115					
HWY. 69		PROJECT NO. 09-1111-6014		DIST.	
SUBM'D. TVA	CHKD. TVA		DATE: July 2012		SITE:
DRAWN: JFC	CHKD. CN		APPD. JPD/JMAC		DWG. C1




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

CONT No.
WP No. 5404-05-01

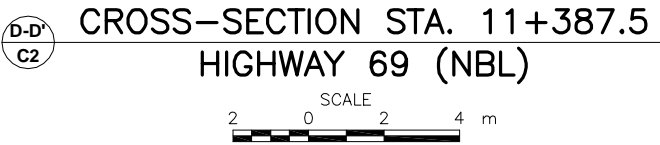
HIGHWAY 69
STA 11+375 TO 11+400 (NBL)
SOIL STRATA

**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
S203-05	197.0	5074415.1	225349.7
S203-DC02	198.0	5074408.5	225333.0



Note: The Proposed Grade at STA. 11+387.5 was provided in a digital format by URS, drawing file_revised_XS_to_golder-dec-07-2011.dwg, received December 5, 2011.

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

Original Ground Surface cut from contour drawing file HWY69_Contour-Plan_C2_C3.dwg, received July 14, 2011



NO.	DATE	BY	REVISION
Geocres No. 41H-115			
HWY. 69		PROJECT NO. 09-1111-6014	
SUBM'D. TVA	CHKD. TVA	DATE: July 2012	SITE:
DRAWN: JFC	CHKD. CN	APPD. JPD/JMAC	DWG. C2



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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT		RECORD OF BOREHOLE		No S203-02		SHEET 1 OF 1		METRIC									
W.P. 09-1111-6014		LOCATION		N 5074370.9 ; E 225305.9		ORIGINATED BY		MR									
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, Uncased		COMPILED BY									
DATUM		Geodetic		DATE		January 25, 2010		CHECKED BY									
								TVA									
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									
196.5	WATER SURFACE																
0.0	WATER																
0.2	PEAT, containing rootlets (Amorphous) Very soft Black to dark brown Wet		1	SS	WH		196										
195.4			2A	SS	1												
	SAND, containing rootlets and organics Very loose Brown Wet		2B														
1.3	END OF BOREHOLE SPOON REFUSAL END OF DCPT Refusal to Further Penetration (Hammer Bouncing)																
NOTES: 1. A Dynamic Cone Penetration Test was advanced 1.5 m east of Borehole S203-02 to confirm depth to refusal, refusal encountered at a depth of 1.3 m below water surface (Elev. 195.2 m). 2. Borehole and DCPT advanced using portable drilling equipment with a half-weight hammer. SPT 'N' values shown have been adjusted to reflect values that would be obtained with a standard weight hammer.																	



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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD



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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD



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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S203-06		SHEET 1 OF 1		METRIC										
W.P. 5404-05-01		LOCATION N 5074423.1 ; E 225336.1		ORIGINATED BY MR												
DIST HWY 69		BOREHOLE TYPE Hand Excavation		COMPILED BY OK												
DATUM Geodetic		DATE January 25, 2010		CHECKED BY TVA												
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 (%)			
197.9	GROUND SURFACE						20	40	60	80	100	20	40	60		
8.9	TOPSOIL															
	END OF EXCAVATION PROBABLE BEDROCK															
	NOTES:															
	1. Hand digging carried out at proposed borehole location to expose bedrock.															
	2. Excavation dry upon completion.															

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT <u>09-1111-6014</u>		RECORD OF DCPT No S203-DC01		SHEET 1 OF 1		METRIC										
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074377.5 ; E 225322.7</u>		ORIGINATED BY <u>MR</u>												
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Portable Equipment, Dynamic Cone Penetration Test</u>		COMPILED BY <u>OK</u>												
DATUM <u>Geodetic</u>		DATE <u>January 25, 2010</u>		CHECKED BY <u>TVA</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			
196.6	GROUND SURFACE															
0.0	Dynamic Cone Penetration Test (DCPT)															
196.1	END OF DCPT Refusal to Further Penetration (Hammer Bouncing)															
0.5	NOTE: 1. Two additional DCPTs were drilled 1.5 m west and 1.5 m east of DCPT S203-DC01 to confirm depth to refusal; see Records of DCPT S203-DC01A and DCPT S203-DC01B for details.															



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



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

GT-A-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD



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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT 09-1111-6014		RECORD OF DCPT No S203-DC03		SHEET 1 OF 1		METRIC										
W.P. 5404-05-01		LOCATION N 5074390.7 ; E 225349.2		ORIGINATED BY MR												
DIST HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test		COMPILED BY OK												
DATUM Geodetic		DATE January 25, 2010		CHECKED BY TVA												
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								
196.7	GROUND SURFACE															
0.0	Dynamic Cone Penetration Test (DCPT)															
196.0	END OF DCPT Refusal to Further Penetration (Hammer Bouncing)															
0.7	NOTES: 1. DCPT advanced using portable drilling equipment with a half-weight hammer. Blows shown have been adjusted to reflect values that would be obtained with a standard weight hammer. 2. An additional DCPT was drilled 1.5 m west of DCPT S203-DC03 to confirm depth to refusal; see Record of DCPT S203-DC03A for details.															

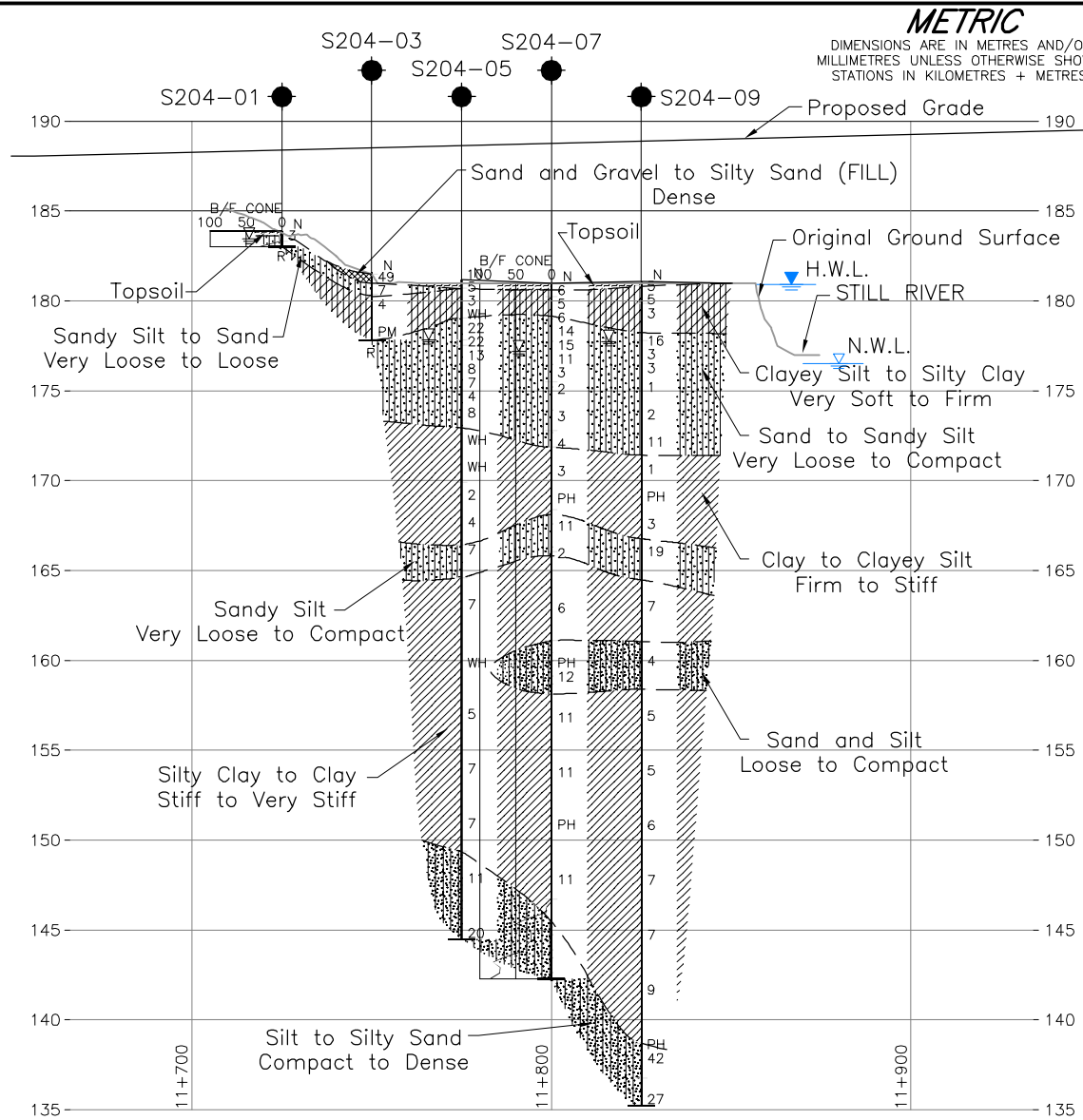
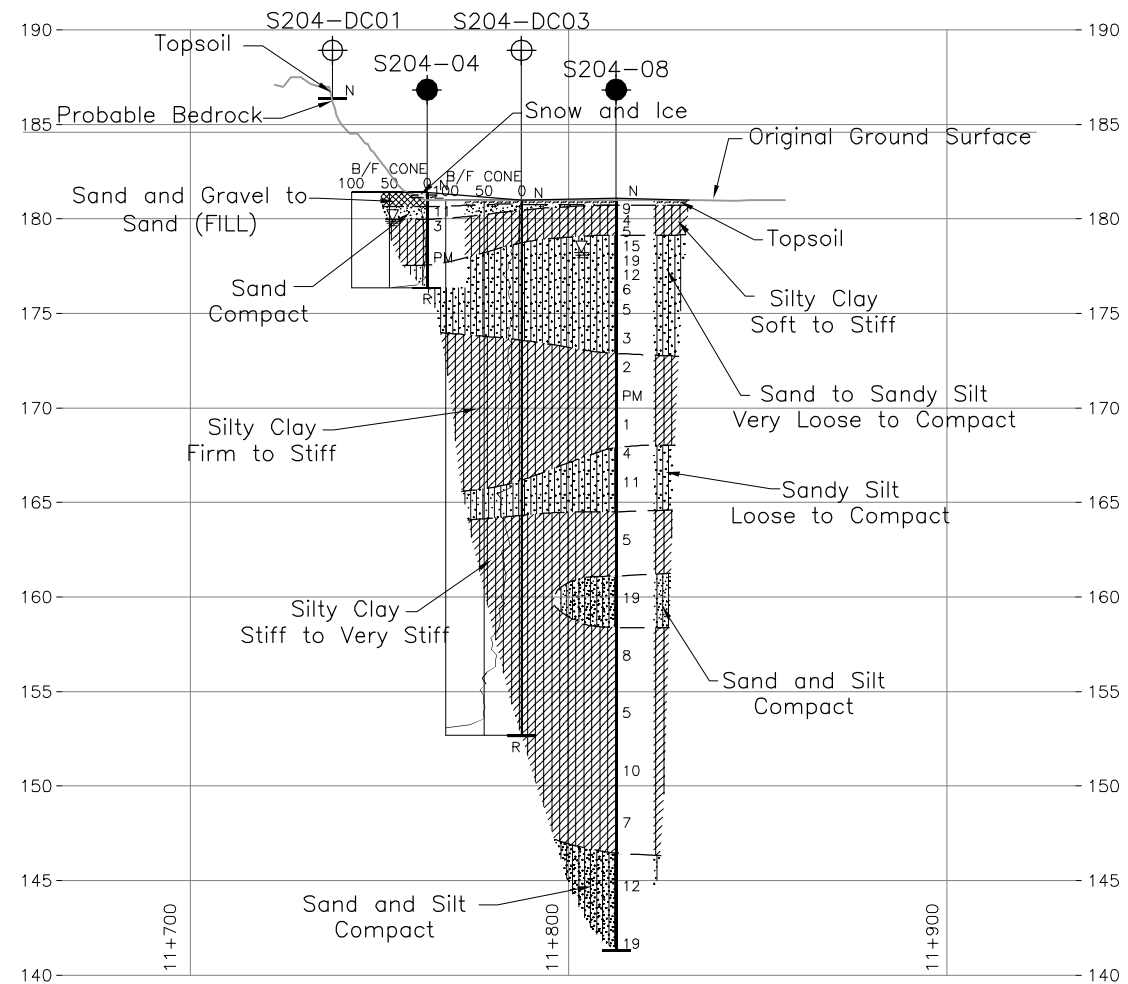
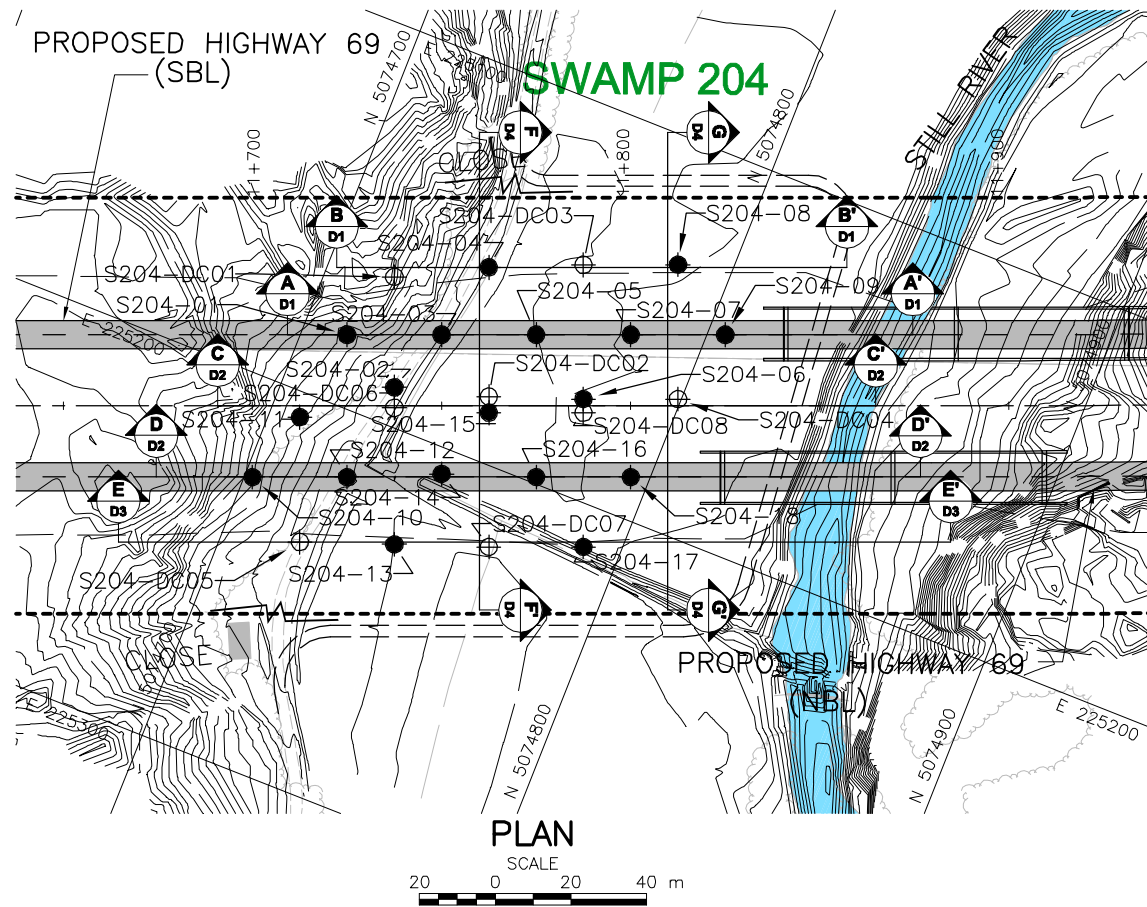
PROJECT 09-1111-6014		RECORD OF DCPT No S203-DC03A				SHEET 1 OF 1		METRIC									
W.P. 5404-05-01		LOCATION N 5074390.0 ; E 225347.6				ORIGINATED BY MR											
DIST _____ HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test				COMPILED BY OK											
DATUM Geodetic		DATE January 25, 2010				CHECKED BY TVA											
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 (%)
196.7	GROUND SURFACE						20	40	60	80	100						
0.0	Dynamic Cone Penetration Test (DCPT)						20	40	60	80	100						
195.8	END OF DCPT Refusal to Further Penetration (Hammer Bouncing)						20	40	60	80	100						
0.9	NOTE: 1. DCPT advanced using portable drilling equipment with a half-weight hammer. Blows shown have been adjusted to reflect values that would be obtained with a standard weight hammer.																

GTA-MTO 001 09-1111-6014.GPJ GAL-MASS.GDT 7/25/12 SAC/DD

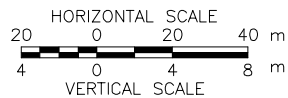


APPENDIX D

Highway 69 SBL – STA 11+725 to 11+825 and
Highway 69 NBL – STA 11+700 to 11+800 (Swamp 204)



EMBANKMENT TOE PROFILE
HIGHWAY 69 (SBL)



BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
S204-DC01	186.4	5074717.5	225162.8
S204-DC02	181.4	5074752.4	225183.1
S204-DC03	181.0	5074762.9	225141.5
S204-DC04	181.1	5074799.2	225165.3
S204-DC05	182.1	5074720.1	225237.2
S204-DC06	181.6	5074730.3	225195.0
S204-DC07	181.4	5074767.0	225220.0
S204-DC08	181.0	5074777.2	225177.8

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.

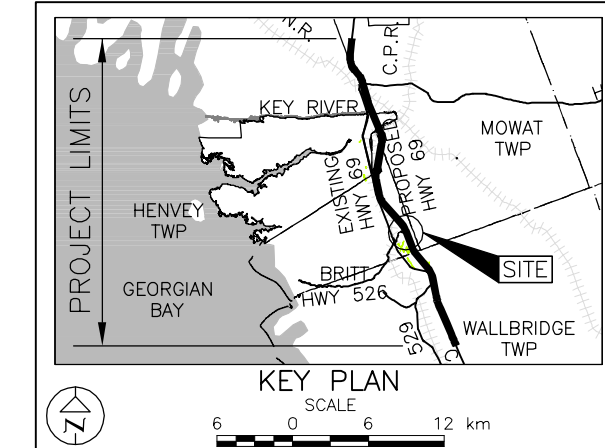
The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS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

CONT No.
WP No. 5404-05-01

HIGHWAY 69
STA 11+725 TO 11+825 (SBL)
STA. 11+700 TO 11+800 (NBL)
BOREHOLE LOCATIONS AND SOIL STRATA



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
S204-01	183.9	5074711.5	225181.6
S204-02	181.7	5074728.3	225190.0
S204-03	181.6	5074734.8	225172.4
S204-04	181.4	5074739.9	225151.3
S204-05	181.2	5074758.0	225163.3
S204-06	181.1	5074775.9	225174.5
S204-07	181.0	5074781.3	225154.1
S204-08	181.1	5074786.1	225132.3
S204-09	181.1	5074804.5	225144.9
S204-10	184.8	5074702.1	225225.8
S204-11	183.6	5074707.9	225206.5
S204-12	181.9	5074725.4	225216.6
S204-13	181.5	5074743.5	225228.6
S204-14	181.4	5074748.3	225206.7
S204-15	181.4	5074754.0	225187.0
S204-16	181.0	5074771.9	225198.2
S204-17	181.1	5074790.3	225210.8
S204-18	181.1	5074795.1	225189.0

REFERENCE

Base plans provided in digital format by URS, drawing files Hwy69_base.dwg, Hwy69_plan.dwg, received December 16, 2009. Original Ground Surface cut from contour drawing file HWY69_Contour-Plan_C2_C3.dwg, received July 14, 2011 and the Proposed Grade obtained from drawing file Hwy69_profile-nov-18-2011.dwg, received December 5, 2011.

NO.	DATE	BY	REVISION
Geocres No. 41H-115			
HWY. 69		PROJECT NO. 09-1111-6014	
SUBM'D. TVA		CHKD. TVA	DATE: July 2012
DRAWN: JFC		CHKD. CN	APPD. JPD/JMAC
		DIST. SITE:	
		DWG. D1	

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

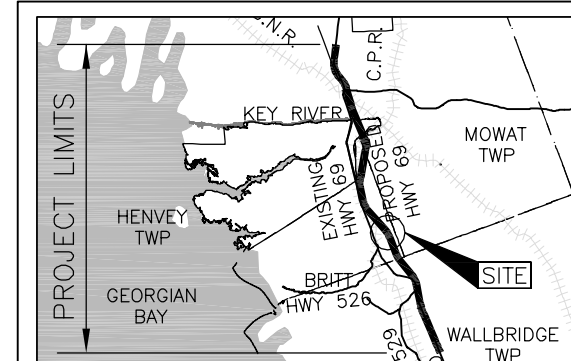
CONT No.
WP No. 5404-05-01

HIGHWAY 69
STA. 11+725 TO 11+825 (SBL)
STA. 11+700 TO 11+800 (NBL)
SOIL STRATA

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



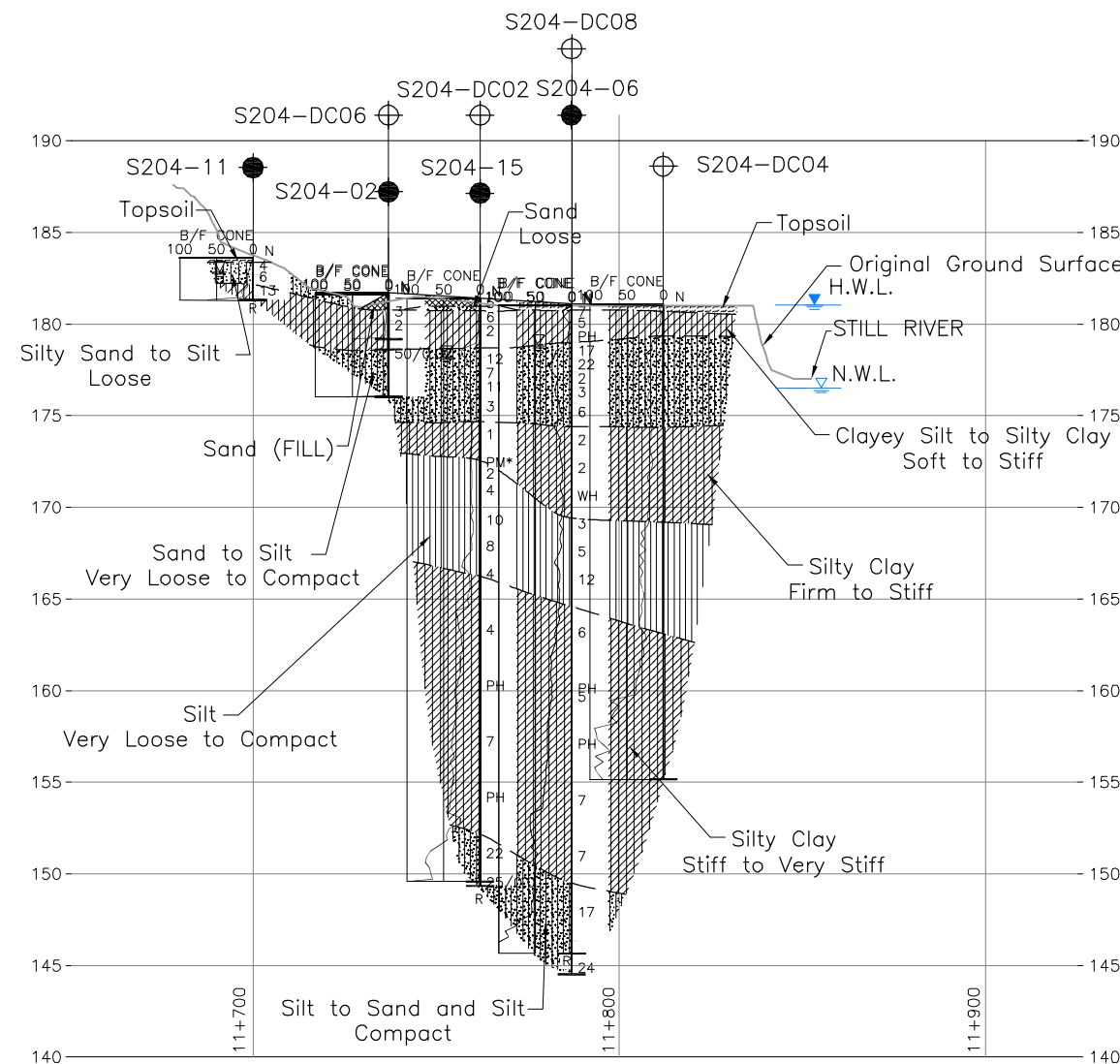
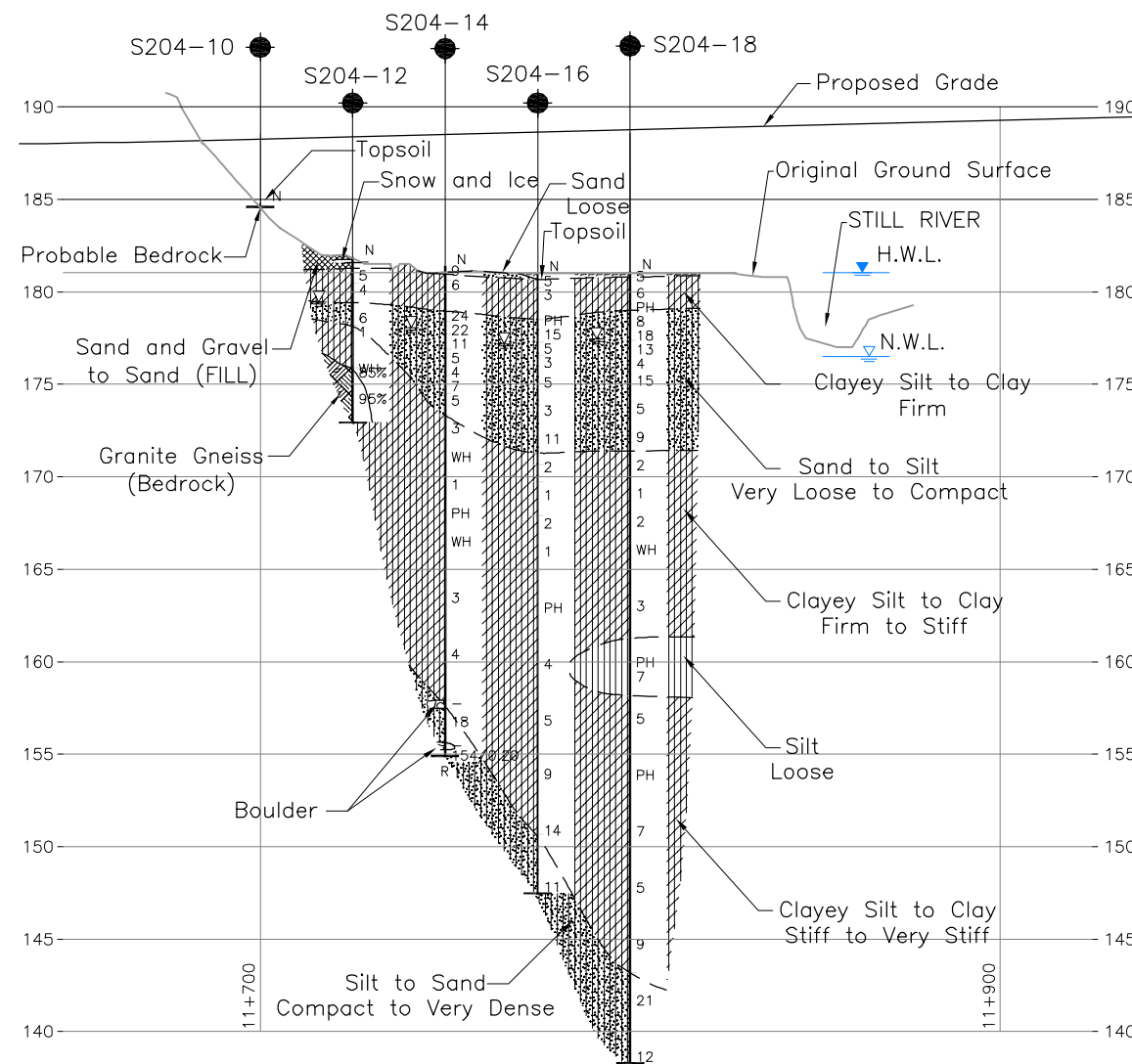
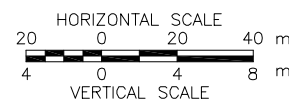
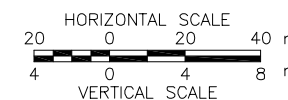
KEY PLAN

SCALE

0 6 12 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)
- 100% Rock Quality Designation (RQD)
- WL upon completion of drilling
- R Refusal

C-C'
D1EMBANKMENT TOE PROFILE
HIGHWAY 69 (MEDIAN)D-D'
D1CENTRELINE PROFILE
HIGHWAY 69 (NBL)

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.

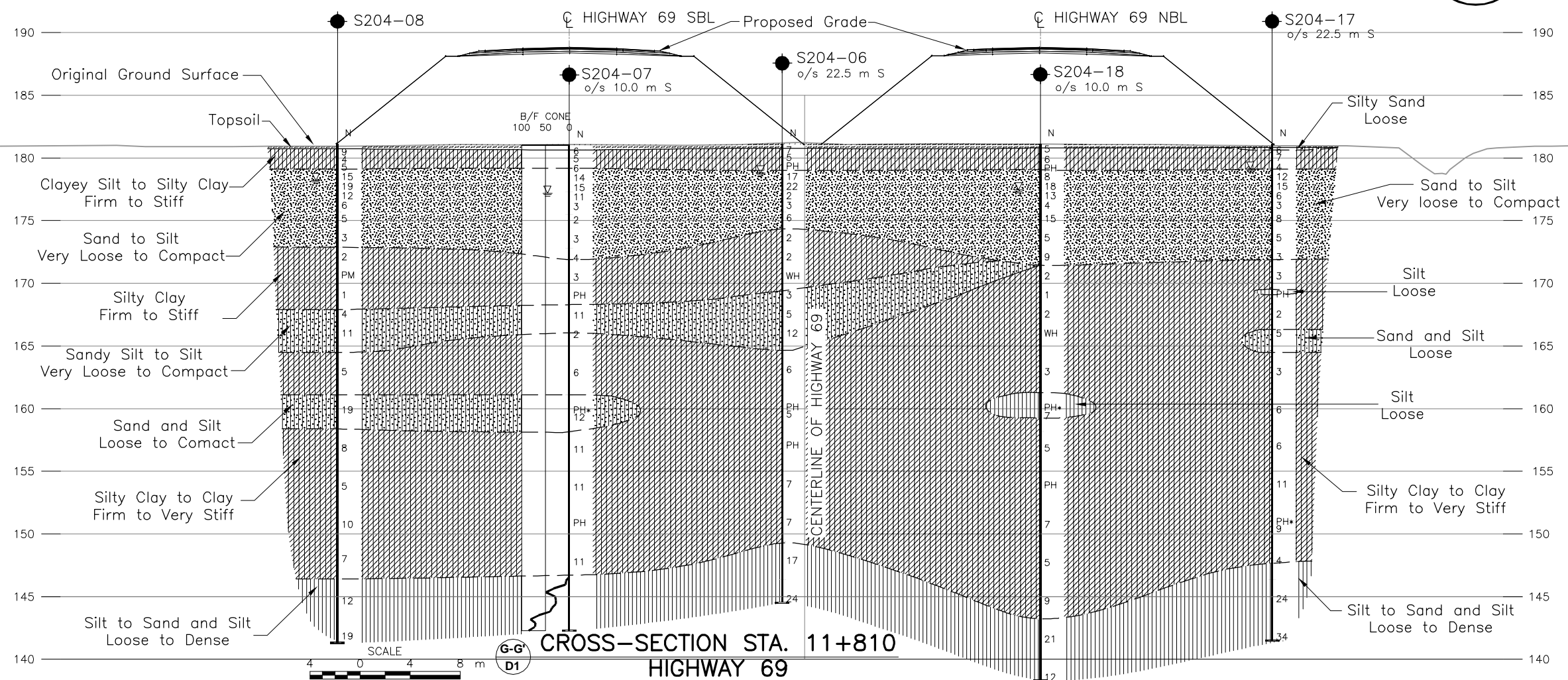
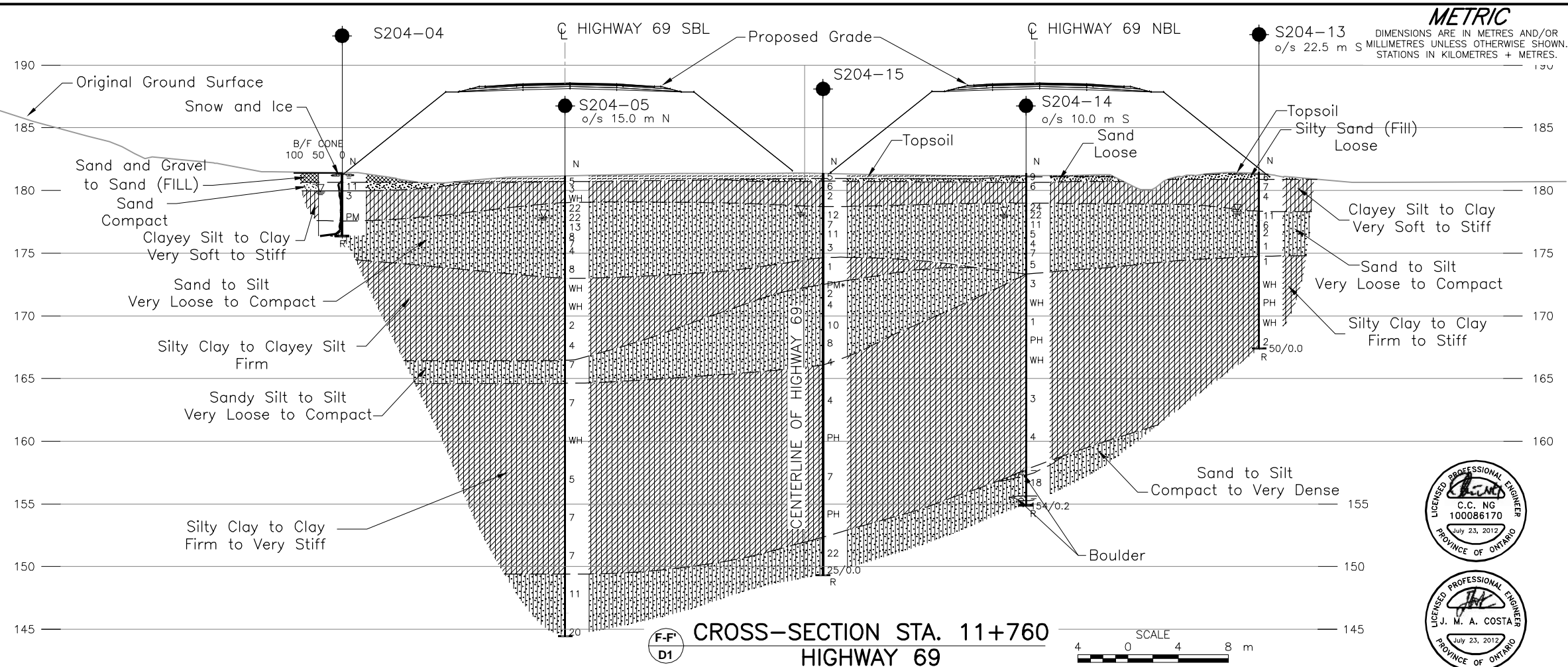
The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS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

REFERENCE

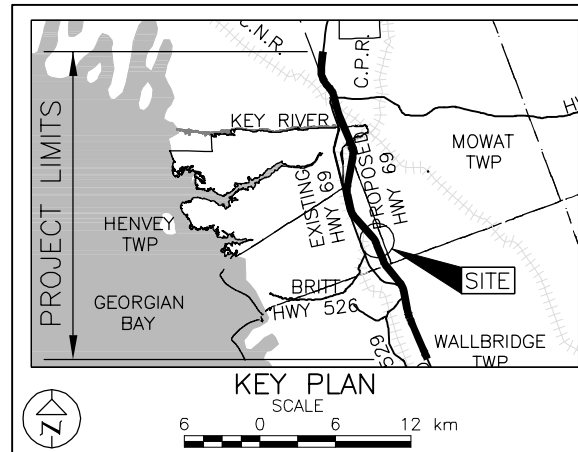
Original Ground Surface cut from contour drawing file HWY69_Contour-Plan_C2_C3.dwg, received July 14, 2011 and the Proposed Grade obtained from drawing file Hwy69_profile-nov-18-2011.dwg, received December 5, 2011.

NO.	DATE	BY	REVISION
Geocres No. 41H-115			
HWY. 69	PROJECT NO. 09-1111-6014		DIST.
SUBM'D. TVA	CHKD. TVA	DATE: July 2012	SITE:
DRAWN: JFC	CHKD. CN	APPD. JPD/JMAC	DWG. D2



CONT No.
WP No. 5404-05-01HIGHWAY 69
CROSS-SECTIONS
STA. 11+760 AND 11+810 (SBL AND NBL)
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
S204-04	181.4	5074739.9	225151.3
S204-05	181.2	5074758.0	225163.3
S204-06	181.1	5074775.9	225174.5
S204-07	181.0	5074781.3	225154.1
S204-08	181.1	5074786.1	225132.3
S204-13	181.5	5074743.5	225228.6
S204-14	181.4	5074748.3	225206.7
S204-15	181.4	5074754.0	225187.0
S204-17	181.1	5074790.3	225210.8
S204-18	181.1	5074795.1	225189.0

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-Sections provided in a digital format by URS, drawing files Hwy69_Xs.dwg, received June 06, 2011

NO.	DATE	BY	REVISION
Geocres. No. 41H-115			
HWY. 69			PROJECT NO. 09-1111-6014
SUBM'D. TVA	CHKD. TVA	DATE: July 2012	SITE:
DRAWN: JFC/CD	CHKD. CN	APPD. JPD/JMAC	DWG. D4

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S204-01		SHEET 1 OF 1		METRIC										
W.P. 5404-05-01		LOCATION N 5074711.5 ; E 225181.6		ORIGINATED BY MR												
DIST HWY 69		BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers		COMPILED BY OK												
DATUM Geodetic		DATE February 16, 2010		CHECKED BY TVA												
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 (%)			
183.9	GROUND SURFACE															
183.6	TOPSOIL		1A	SS	3	▽										
183.3	Sandy SILT, some clay, trace gravel, containing rootlets Very loose		1B											o		2 29 57 12
183.0	Brown Moist to wet															
0.9	END OF BOREHOLE SPOON AND AUGER REFUSAL END OF DCPT Refusal to Further Penetration (Hammer Bouncing)															
NOTES: 1. Water level in open borehole at a depth of 0.5 m below ground surface (Elev. 183.4 m) upon completion of drilling. 2. A Dynamic Cone Penetration Test was advanced 1.5 m east of Borehole S204-01 to confirm depth to refusal; refusal encountered at a depth of 0.9 m below ground surface (Elev. 183.0 m).																

PROJECT		RECORD OF BOREHOLE		No S204-02		SHEET 1 OF 1		METRIC	
W.P.		LOCATION		ORIGINATED BY		DIST		BOREHOLE TYPE	
DATE		DATE		COMPILED BY		CHECKED BY			
09-1111-6014		N 5074728.3 ; E 225190.0		MR		HWY 69		127 mm O.D. Continuous Flight Solid Stem Augers	
Geodetic		February 16, 2010		OK		TVA			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
181.7	GROUND SURFACE													
0.0	Sand and gravel (FILL)		1A	AS	-									
	Sand, trace gravel, trace silt (FILL)		1B											
180.8	CLAYEY SILT, trace sand		2A	SS	3									
0.9	Soft Brown and grey Moist		2B											
180.2	SILTY CLAY		3	SS	2									
1.5	Firm to stiff Grey Moist													
178.6	END OF BOREHOLE SPOON AND AUGER REFUSAL		4	SS	50/0.02									
3.1	NOTES: 1. Water level in open borehole not noted. 2. A Dynamic Cone Penetration Test was advanced 1.5 m west of Borehole S204-02 to confirm depth to refusal; refusal encountered at a depth of 2.5 m below ground surface (Elev. 179.2 m).													

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S204-03		SHEET 1 OF 1		METRIC	
W.P. 5404-05-01		LOCATION N 5074734.8 ; E 225172.4		ORIGINATED BY MR			
DIST HWY 69		BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers		COMPILED BY OK			
DATUM Geodetic		DATE February 16, 2010		CHECKED BY TVA			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100			W _p
181.6	GROUND SURFACE														
0.0	Sand and gravel (FILL)		1A	SS	49										
181.0	Silty sand, trace gravel, trace clay, containing rootlets (FILL)		1B												
0.6	Dense Brown Moist		2A	SS	7										
180.4	SAND, trace to some gravel, trace to some silt, trace clay, containing rootlets		2B												
1.4	Loose Brown Moist		3A	SS	4										
	CLAYEY SILT, trace sand, containing rootlets		3B												
	Firm Grey Moist														
	SILTY CLAY, trace to some sand containing rootlets to a depth of 2.1 m		4	TO	PM										
177.8	Firm Grey Moist														
3.8	END OF BOREHOLE AUGER REFUSAL														
NOTE: 1. Open borehole dry upon completion of drilling.															

PROJECT		RECORD OF BOREHOLE		No S204-04		SHEET 1 OF 1		METRIC	
W.P.		LOCATION		ORIGINATED BY		DIST		BOREHOLE TYPE	
DATE		COMPILED BY		CHECKED BY		DATUM		DATE	
09-1111-6014		N 5074739.9 ; E 225151.3		MR		HWY 69		127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring	
Geodetic		February 17, 2010		TVA					

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
181.4	GROUND SURFACE													
0.0	Sand and gravel (FILL) Grey Moist		1A	AS	-									
0.2			1B											
180.6	SNOW and ICE													
0.8	Sand, some gravel (FILL) Brown Moist		2	SS	11									
180.0														
1.4	SAND, trace silt, trace clay Compact Brown Moist		3	SS	3									
	SILTY CLAY, trace to some sand Soft Grey Moist													
			4	TO	PM									
177.5	END OF BOREHOLE CASING AND AUGER REFUSAL													
3.9														
176.4	END OF DCPT Refusal to Further Penetration (Hammer Bouncing)													
5.0	END OF DCPT Refusal to Further Penetration (Hammer Bouncing)													
NOTES: 1. Water level in open borehole at a depth of 1.5 m below ground surface (Elev. 179.9 m) upon completion of drilling. 2. A Dynamic Cone Penetration Test was advanced 1.5 m west of Borehole S204-04 to confirm depth to refusal; refusal encountered at a depth of 5.0 m below ground surface (Elev. 176.4 m).														

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S204-05		SHEET 1 OF 3		METRIC	
W.P. 5404-05-01		LOCATION N 5074758.0 ; E 225163.3		ORIGINATED BY RA			
DIST _____ HWY 69		BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY OK			
DATUM Geodetic		DATE February 8 and 9, 2010		CHECKED BY TVA			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							W _p W W _L					
															○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%)
181.2	GROUND SURFACE							20	40	60	80	100								
0.0	TOPSOIL		1A	SS	5		181													
180.7			1B																	
0.5	SILTY CLAY, trace sand, containing rootlets Very soft to firm Brown to grey Moist		2	SS	3		180													
			3	SS	WH															
179.1																				
2.1	SAND, trace to some silt, trace clay Compact Brown Moist		4	SS	22		179													
177.9			5A				178													
3.4	SAND and SILT, trace clay Loose to compact Grey Moist to wet		5B	SS	22															
			6	SS	13		177													
			7	SS	8															
			8	SS	7		176													
			9	SS	4															
							175													
			10	SS	8		174													
							173													
173.0																				
8.2	SILTY CLAY Firm Grey Moist		11	SS	WH		172													
			12	TO	WH		171													
							170													
169.7																				
11.5	CLAYEY SILT containing silt seams Stiff Grey Moist		13	SS	2		169													
							168													
			14	SS	4															
							167													
166.4																				
14.8																				

Continued Next Page

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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

Continued Next Page

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

○ 3% STRAIN AT FAILURE

○ 3% STRAIN AT FAILURE

PROJECT		RECORD OF BOREHOLE		No S204-05		SHEET 3 OF 3		METRIC	
W.P.		LOCATION		ORIGINATED BY		DIST		BOREHOLE TYPE	
DATE		COMPILED BY		CHECKED BY		DATUM		DATE	
09-1111-6014		N 5074758.0 ; E 225163.3		RA		HWY 69		127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring	
Geodetic		February 8 and 9, 2010		TVA					

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W _p	W	W _L		
	--- CONTINUED FROM PREVIOUS PAGE ---																
149.4	CLAY, some silt, containing silt seams to a depth of 19.7 m Stiff Grey Moist		20	SS	7												
150																	
149	Sandy SILT, trace clay Compact Grey Wet																
148																	
146.3	Silty SAND Compact Grey Wet		21	SS	11												
147																	
144.5	END OF BOREHOLE		22	SS	20												
145																	
144.5	NOTE: 1. Water level in open borehole at a depth of 3.4 m below ground surface (Elev. 177.8 m) upon completion of drilling.																

PROJECT		RECORD OF BOREHOLE		No S204-06		SHEET 1 OF 3		METRIC					
W.P.		LOCATION		ORIGINATED BY		MR							
DIST		BOREHOLE TYPE		COMPILED BY		OK							
DATUM		DATE		CHECKED BY		TVA							
09-1111-6014		N 5074775.9 ; E 225174.5											
5404-05-01		127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring											
Geodetic		February 21 to 23, 2010											
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
181.1	GROUND SURFACE						181						
0.0	TOPSOIL		1A										
180.8			1B	SS	7								
0.3	SILTY CLAY, trace sand, containing rootlets Firm Brown to grey Moist		2	SS	5		180						
			3	TO	PH								
179.0							179						
2.1	SAND, trace to some silt, trace clay Compact Brown Wet		4	SS	17								
			5	SS	22		178						
177.4													
3.7	SAND and SILT, trace clay Very loose Brown Wet		6	SS	2		177						
			7	SS	3								
175.7							176						
5.4	SILT, some sand, trace clay Loose Grey Wet		8	SS	6								
							175						
174.4													
6.7	SILTY CLAY Firm to stiff Grey Moist		9	SS	2		174						
							173						
			10	SS	2								
							172						
							171						
			11	SS	WH								
							170						
169.4							169						
11.7	SILT, trace to some sand, trace to some clay Loose to compact Grey Wet		12	SS	3								
							168						
	Clayey silt seams encountered at a depth of 13.3 m		13	SS	5		167						

Continued Next Page

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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No S204-06		SHEET 2 OF 3		METRIC	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074775.9 ; E 225174.5</u>		ORIGINATED BY <u>MR</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring</u>		COMPILED BY <u>OK</u>			
DATUM <u>Geodetic</u>		DATE <u>February 21 to 23, 2010</u>		CHECKED BY <u>TVA</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						WATER CONTENT (%)			GR	SA	SI	CL
								○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × REMOULDED											
	--- CONTINUED FROM PREVIOUS PAGE ---																			
164.6	SILT, trace to some sand, trace to some clay Loose to compact Grey Wet		14	SS	12															
16.5	SILTY CLAY, trace sand Stiff Grey Moist																			
			15	SS	6															
			16	TO	PH															
			17	SS	5															
			18	TO	PH															
			19	SS	7															

Continued Next Page

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

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No S204-06		SHEET 3 OF 3		METRIC	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074775.9 ; E 225174.5</u>		ORIGINATED BY <u>MR</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring</u>		COMPILED BY <u>OK</u>			
DATUM <u>Geodetic</u>		DATE <u>February 21 to 23, 2010</u>		CHECKED BY <u>TVA</u>			

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

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

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No S204-07		SHEET 1 OF 3		METRIC	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074781.3 ; E 225154.1</u>		ORIGINATED BY <u>MR</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring</u>		COMPILED BY <u>OK</u>			
DATUM <u>Geodetic</u>		DATE <u>March 2 and 3, 2010</u>		CHECKED BY <u>TVA</u>			

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			SHEAR STRENGTH kPa					WATER CONTENT (%)							
													20	40	60		80	100	W _p	W
181.0	GROUND SURFACE																			
0.0	TOPSOIL		1A	SS	6															
180.6			1B	SS	5															
0.4	SILTY CLAY, containing rootlets and silty sand seams Firm Brown to grey Moist		2	SS	5															
179.2			3A	SS	6															
1.8	Silty SAND, trace clay Loose to compact Brown Moist		3B																	
			4	SS	14															
			5	SS	15															
177.3																				
3.7	SAND and SILT, trace clay Very loose to compact Grey Wet		6	SS	11															
			7	SS	3															
175.5																				
5.5	Sandy SILT, trace clay Very loose Grey Wet		8	SS	2															
			9	SS	3															
172.8																				
8.2	Silty SAND, trace clay Loose Grey Wet		10A	SS	4															
171.9			10B																	
9.1	SILTY CLAY Firm to stiff Grey Moist																			
			11	SS	3															
			12	TO	PH															
168.3																				
12.7	Sandy SILT, trace clay Very loose to compact Grey Moist to wet																			
			13	SS	11															
166.1			14A																	

Continued Next Page

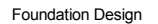
+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

Continued Next Page

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


GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD



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

GT-A-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

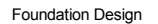
+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

PROJECT		RECORD OF BOREHOLE		No S204-08		SHEET 2 OF 3		METRIC					
W.P.		LOCATION		ORIGINATED BY		COMPILED BY							
DIST		BOREHOLE TYPE		CHECKED BY									
DATUM		DATE											
09-1111-6014		N 5074786.1 ; E 225132.3		MR		OK		TVA					
5404-05-01		127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Tricone, Wash Boring		February 19 and 20, 2010									
Geodetic													
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
--- CONTINUED FROM PREVIOUS PAGE ---													
164.5	Sandy SILT, trace to some clay Loose to compact Grey Wet		14	SS	11		166						0 24 70 6
16.6	SILTY CLAY Stiff Grey Moist						165						
161.1			15	SS	5		164						
20.0	SAND and SILT, trace to some clay Compact Grey Wet						163						
158.4			16	SS	19		162						
22.7	SILTY CLAY, trace sand Stiff to very stiff Grey Moist						161						
							160						
			17	SS	8		159						
							158						
							157						
			18	SS	5		156						
							155						
							154						0 4 45 51
							153						
							152						

Continued Next Page

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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD





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

Continued Next Page

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

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No S204-09		SHEET 3 OF 4		METRIC	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074804.5 ; E 225144.9</u>		ORIGINATED BY <u>MR</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring</u>		COMPILED BY <u>OK</u>			
DATUM <u>Geodetic</u>		DATE <u>February 3 and 4, 2010</u>		CHECKED BY <u>TVA</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W _p	W	W _L		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	WATER CONTENT (%)					
							20 40 60 80 100				20 40 60			
	SILTY CLAY Stiff to very stiff Grey Moist		18	SS	6		151							
							150							
							149							
							148							
			19	SS	7		147							
							146							
							145							
			20	SS	7		144							
							143							
							142							
	SILT, trace to some clay, trace sand Dense Grey Wet		21	SS	9		141							
							140							
							139							
			22	TO	PH		138							
							137							
138.7 42.4														
136.8 44.3														


Continued Next Page

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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT		RECORD OF BOREHOLE		No S204-09		SHEET 4 OF 4		METRIC													
W.P.		LOCATION		ORIGINATED BY																	
DIST		BOREHOLE TYPE		COMPILED BY																	
DATUM		DATE		CHECKED BY																	
09-1111-6014		N 5074804.5 ; E 225144.9		MR																	
5404-05-01		127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		OK																	
Geodetic		February 3 and 4, 2010		TVA																	
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					
								20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W _p W W _L 20 40 60			kN/m ³			GR SA SI CL		
135.2	Silty SAND, trace clay Compact Grey Wet		24	SS	27		136														
45.9	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 3.4 m below ground surface (Elev. 177.7 m) upon completion of drilling.																				

GTA-MTO 001 09-1111-6014.GPJ GAL-MASS.GDT 7/25/12 SAC/DD

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No S204-10		SHEET 1 OF 1		METRIC											
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074702.1 ; E 225225.8</u>		ORIGINATED BY <u>MR</u>													
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Hand Excavation</u>		COMPILED BY <u>OK</u>													
DATUM <u>Geodetic</u>		DATE <u>February 3, 2010</u>		CHECKED BY <u>TVA</u>													
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 (%)				
184.8	GROUND SURFACE																
0.0	TOPSOIL																
0.2	END OF EXCAVATION PROBABLE BEDROCK																
	NOTES: 1. Hand digging carried out at proposed location to expose bedrock. 2. Excavation dry upon completion. 3. Bedrock outcrop observed within the vicinity of Borehole S204-10.																

GTA-MTO 001 09-1111-6014.GPJ GAL-MASS.GDT 7/25/12 SAC/DD

PROJECT		RECORD OF BOREHOLE		No S204-11		SHEET 1 OF 1		METRIC						
W.P. 5404-05-01		LOCATION		N 5074707.9 ; E 225206.5		ORIGINATED BY		MR						
DIST		HWY 69		BOREHOLE TYPE		127 mm O.D. Continuous Flight Solid Stem Augers		COMPILED BY						
DATUM		Geodetic		DATE		February 16, 2010		CHECKED BY						
								TVA						
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 (%)				
183.6	GROUND SURFACE							20 40 60 80 100						
0.0	TOPSOIL							20 40 60 80 100						
0.2	Silty SAND, trace to some clay, containing rootlets		1A											
182.7	Loose Brown		1B	SS	4									
0.9	Moist to wet		2A											
182.2	Silt, some clay, trace sand		2B	SS	6									
1.4	Loose Grey													
181.5	Moist CLAYEY SILT, trace sand, trace gravel, containing rootlets		3	SS	13									
2.3	Stiff Brown Moist													
END OF BOREHOLE SPOON AND AUGER REFUSAL END OF DCPT Refusal to Further Penetration (Hammer Bouncing)														
NOTES: 1. Water level in open borehole at a depth of 0.8 m below ground surface (Elev. 182.8 m) upon completion of drilling. 2. A Dynamic Cone Penetration Test was advanced 1.5 m west of Borehole S204-11 to confirm depth to refusal; refusal encountered at a depth of 2.3 m below ground surface (Elev. 181.3 m).														

PROJECT		RECORD OF BOREHOLE		No S204-12		SHEET 1 OF 1		METRIC			
W.P.		LOCATION		ORIGINATED BY		DIST		BOREHOLE TYPE			
DATE		COMPILED BY		CHECKED BY		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT			
ELEVATION		WATER CONTENT (%)		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)					
181.9		GROUND SURFACE									
0.0		Sand and gravel (FILL)		1A		AS					
181.3		SNOW and ICE		1B							
0.6		Sand, trace to some silt, trace gravel (FILL)		2		SS		5			
180.5		Brown Moist									
1.4		CLAYEY SILT, trace to some sand		3		SS		4			
179.2		Firm Brown Moist									
2.7		SILTY CLAY, trace sand		4		SS		6			
178.2		Firm Grey Moist									
3.7		SILT, some clay, trace to some sand		5		SS		1			
175.9		Loose Grey Wet									
6.0		Granite Gneiss (BEDROCK)		6		SS		WH			
172.9		Bedrock cored from depths of 6.0 m to 9.0 m		1		NQRC		REC 94%			
9.0		For bedrock coring details, refer to Record of Drillhole S204-12		2		NQRC		REC 100%			
172.9		END OF BOREHOLE									
9.0		NOTE:									
		1. Water level in open borehole at a depth of 2.4 m below ground surface (Elev. 179.5 m) upon completion of drilling.									

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: S204-12

SHEET 1 OF 1

LOCATION: N 5074725.4 ;E 225216.6

DRILLING DATE: February 17, 2010

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D25 Bomb

DRILLING CONTRACTOR: Walker Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	JN - Joint FLT - Fault SHR- 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 MB- Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.																FEATURES	NOTES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
						FLUSH RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX PER Meter	DIP w.r.t. CORE AXIS	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY K, cm/sec				WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
							TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr	Ja	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³	W1	W2	W3			W4	W5	W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
6		Continued from Record of Borehole S204-12		175.90																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													</

DEPTH SCALE

1 : 50



LOGGED: MR

CHECKED: TVA

GTA-RCK 030 09-1111-6014.GPJ GAL-MISS.GDT 7/24/12 SAC/DD

PROJECT		RECORD OF BOREHOLE		No S204-13		SHEET 1 OF 2		METRIC						
W.P.		LOCATION		ORIGINATED BY										
DIST		BOREHOLE TYPE		COMPILED BY										
DATUM		DATE		CHECKED BY										
09-1111-6014		N 5074743.5 ; E 225228.6		MR										
5404-05-01		127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		OK										
Geodetic		February 18, 2010		TVA										
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	20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	GR SA SI CL
181.5	GROUND SURFACE													
0.0	TOPSOIL													
181.0	Silty sand, some clay, containing rootlets (FILL)		1A	SS	6		181							
0.6	Loose Brown Moist		1B											
	TOPSOIL		2A	SS	7									
179.9	CLAYEY SILT, trace to some sand, containing rootlets to a depth of 0.8 m		2B				180							
1.6	Firm Brown Moist		3	SS	4									
	SILTY CLAY						179							
	Firm to stiff Grey Moist													
178.3	Silty SAND, trace clay		4	SS	11		178							
3.2	Compact Brown Wet													
177.6	SILT, trace to some sand, trace to some clay		5	SS	6		177							
3.9	Very loose to loose Grey Wet		6	SS	2									
			7	SS	1		176							
174.8	CLAY		8	SS	1		175							
6.7	Firm Grey Moist													
			9	SS	WH		173							
			10	TO	PH		171							
			11	SS	WH		170							
			12	SS	2		169							
167.4	END OF BOREHOLE SPOON AND CASING REFUSAL		13	SS	50/0.0		168							
14.1														

Continued Next Page

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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD



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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No S204-14		SHEET 1 OF 2		METRIC	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074748.3 ; E 225206.7</u>		ORIGINATED BY <u>RA</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring</u>		COMPILED BY <u>OK</u>			
DATUM <u>Geodetic</u>		DATE <u>February 10, 2010</u>		CHECKED BY <u>TVA</u>			

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		W _p	W	W _L		
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × REMOULDED					
181.4	GROUND SURFACE													
0.0	TOPSOIL		1	SS	9									
0.3	SAND, trace to some silt, containing clayey silt pockets													
180.6	Loose Brown Moist		2	SS	6									
0.8	CLAY, trace to some silt, containing silt seams													
	Firm Brown becoming grey at depth of 0.9 m Moist													
179.0														
2.4	SAND, trace to some silt, trace clay		3	SS	24									
178.4	Compact Brown Moist													
3.0	SILT, trace to some sand, trace clay		4	SS	22									0 12 84 4
177.7	Compact Brown Moist													
3.7	SAND and SILT, trace clay Loose to compact Grey Wet		5	SS	11									
			6	SS	5									
			7	SS	4									
			8	SS	7									0 31 66 3
			9	SS	5									
173.3														
8.1	CLAY Firm to stiff Grey Moist Silty sand seams encountered between depths of 8.1 m and 12.2 m below ground surface		10	SS	3									
			11	SS	WH									
			12	SS	1									
			13	TO	PH								16.7	
			14	SS	WH									

Continued Next Page

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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT		RECORD OF BOREHOLE		No S204-14		SHEET 2 OF 2		METRIC									
W.P. 09-1111-6014		LOCATION		N 5074748.3 ; E 225206.7		ORIGINATED BY		RA									
DIST		HWY 69		BOREHOLE TYPE		127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY									
DATUM		Geodetic		DATE		February 10, 2010		CHECKED BY									
								TVA									
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					
	CLAY Firm to stiff Grey Moist						166			3 + 3 +							
							165										
							164										
			15	SS	3		163			3 + 3 +							
							162										
							161										
			16	SS	4		160										
							159			4 + 3 +							
157.9							158										
23.5	BOULDER		17	RC	-		157										
157.5							156										
23.9	SAND, some gravel, trace to some silt, trace clay Compact Grey Wet		18	SS	18		155										
155.6							154										
155.3	BOULDER		19	RC	-		153										
154.9	Silty SAND, trace gravel Very dense Grey Wet		20	SS	154/0.20		152										
26.5	END OF BOREHOLE SPOON REFUSAL						151										
	NOTE: 1. Water level in open borehole at a depth of 3.4 m below ground surface (Elev. 178.0 m) upon completion of drilling.						150										

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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S204-15		SHEET 1 OF 3		METRIC	
W.P. 5404-05-01		LOCATION N 5074754.0 ; E 225187.0		ORIGINATED BY MR			
DIST HWY 69		BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY OK			
DATUM Geodetic		DATE February 18, 2010		CHECKED BY TVA			

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 (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)					
								20 40 60 80 100	w _p w w _L						
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED									
181.4	GROUND SURFACE						181								
0.0	TOPSOIL		1A	SS	5										
180.9			1B												
0.7	SAND, containing pockets of clayey silt Loose Brown Moist		2	SS	6										
	SILTY CLAY Firm Grey Moist		3	SS	2			180							
178.7								179							
2.7	SAND, trace silt, trace clay Compact Brown		4A												
178.2			4B	SS	12			178							
3.2	SAND and SILT, trace clay Very loose to compact Grey Wet		5	SS	7			177							
			6	SS	11			176							
			7	SS	3			175							
174.7								174							
6.7	SILTY CLAY Firm Brown to grey Moist		8	SS	1			173							
172.7															
8.7	SILT, trace to some sand, trace to some clay Very loose to compact Grey Wet		9	TO	PM*		172								
			10	SS	2		171								
			11	SS	4		170								
			12	SS	10		169								
			13	SS	8		168								
			14A				167								

Continued Next Page

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

GTA-MTO 001 09-1111-6014.GPJ GAL-MASS.GDT 7/25/12 SAC/DD

PROJECT		RECORD OF BOREHOLE		No S204-15		SHEET 3 OF 3		METRIC									
W.P. 09-1111-6014		LOCATION		N 5074754.0 ; E 225187.0		ORIGINATED BY		MR									
DIST		HWY 69		BOREHOLE TYPE		127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY									
DATUM		Geodetic		DATE		February 18, 2010		CHECKED BY									
								TVA									
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					
			19	SS	22		151										0 2 91 7
							150										
149.3 32.1	END OF BOREHOLE SPOON AND CASING REFUSAL NOTES: * Unable to recover a Shelby tube sample between depths of 9.3 m and 9.9 m (Elev. 172.1 m and 171.5 m) below ground surface. 1. Water level in open borehole at a depth of 3.2 m below ground surface (Elev. 178.2 m) upon completion of drilling.		20	SS	25/0.0												

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No S204-16		SHEET 1 OF 3		METRIC	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074771.9 ; E 225198.2</u>		ORIGINATED BY <u>MR</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring</u>		COMPILED BY <u>OK</u>			
DATUM <u>Geodetic</u>		DATE <u>March 1, 2010</u>		CHECKED BY <u>TVA</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × REMOULDED	20	40	60			80	100	w _p
181.0	GROUND SURFACE																
0.0	TOPSOIL		1A														
180.7			1B	SS	5												
0.3	CLAYEY SILT, some sand, containing silt seams and rootlets																
180.2	Firm		2	SS	3												
0.8	Brown Moist																
	SILTY CLAY																
	Firm																
	Grey																
	Moist																
178.5			3A														
2.5	SAND, trace to some silt, trace clay		3B	TO	PH												
	Compact																
	Brown		4	SS	15												
	Moist to wet																
177.3																	
3.7	SAND and SILT, trace clay																
	Very loose to compact		5	SS	5												
	Grey																
	Wet																
			6	SS	3												
			7	SS	5												
			8	SS	3												
			9	SS	11												
171.3																	
9.8	SILT, some clay, trace sand																
	Very loose																
	Grey		10A														
170.6	Wet																
10.4	SILTY CLAY		10B	SS	2												
	Stiff																
	Grey																
	Moist																
169.7																	
11.3	CLAYEY SILT, trace sand																
	Stiff																
	Grey		11	SS	1												
	Wet																
167.9																	
13.1	CLAY, some silt																
	Firm to stiff		12	SS	2												
	Brown to grey																
	Moist																
			</														

Continued Next Page

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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No S204-16		SHEET 2 OF 3		METRIC	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074771.9 ; E 225198.2</u>		ORIGINATED BY <u>MR</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring</u>		COMPILED BY <u>OK</u>			
DATUM <u>Geodetic</u>		DATE <u>March 1, 2010</u>		CHECKED BY <u>TVA</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		
	--- CONTINUED FROM PREVIOUS PAGE ---		13	SS	1			20 40 60 80 100						
	CLAY, some silt Firm to stiff Brown to grey Moist						165		4 + 3 +					
							164							
	Becoming grey below a depth of 17.8 m		14	TO	PH		163							
							162		4 + 3 +					
							161							
			15	SS	4		160							
							159							0 0 46 54
							158		3 + 4 +					
							157							
			16	SS	5		156							
							155		3 + 3 +					
							154							
			17	SS	9		153							
							152		2 + 3 +					

Continued Next Page

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

PROJECT		RECORD OF BOREHOLE		No S204-16		SHEET 3 OF 3		METRIC													
W.P.		LOCATION		ORIGINATED BY		DIST		BOREHOLE TYPE		COMPILED BY											
DATUM		DATE		CHECKED BY		GRAIN SIZE DISTRIBUTION (%)		REMARKS													
09-1111-6014		N 5074771.9 ; E 225198.2		MR		HWY 69		127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		OK											
Geodetic		March 1, 2010		TVA																	
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 (%)			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			γ kN/m ³					
150.7	Silt interlayers encountered at a depth of 29.9 m (Elev. 151.1 m)		18A	SS	14																
30.3	SILT, trace to some sand, trace clay Compact Grey Wet		18B																		
							150														
							149														
							148														
147.5	END OF BOREHOLE		19	SS	11														0 12 86 2		
33.5	NOTE: 1. Water level in open borehole at a depth of 3.8 m below ground surface (Elev. 177.2 m) upon completion of drilling.																				

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S204-17		SHEET 1 OF 3		METRIC	
W.P. 5404-05-01		LOCATION N 5074790.3 ; E 225210.8		ORIGINATED BY MR			
DIST HWY 69		BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY OK			
DATUM Geodetic		DATE February 23 and 24, 2010		CHECKED BY TVA			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								20 40 60 80 100	20 40 60 80 100	W _p	W	W _L		
181.1	GROUND SURFACE													
180.8	TOPSOIL													
0.5	Silty SAND, trace to some clay, containing rootlets Loose Dark brown Moist		1A 1B 1C	SS	6									
			2	SS	7									
179.1	SILTY CLAY, trace to some sand, containing rootlets Firm Brown to grey Moist		3A 3B	SS	4									
2.0	Silty SAND, trace clay Very loose to compact Brown to grey Wet Clayey silt pockets encountered between depths of 2.3 m and 2.9 m		4	SS	12									
			5	SS	15									
			6	SS	6									
			7	SS	3									
			8	SS	8									
			9	SS	5									
172.9	SILT, some clay, trace sand Very loose Grey Wet		10A 10B	SS	3									
172.0	CLAY Firm to stiff Grey Moist		11	SS	3									
169.5	SILT Grey Moist		12	TO	PH									
169.1	CLAY Firm to stiff Grey Moist		13	SS	2									
166.3														
14.8														

Continued Next Page


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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S204-17		SHEET 2 OF 3		METRIC											
W.P. 5404-05-01		LOCATION N 5074790.3 ; E 225210.8		ORIGINATED BY MR													
DIST _____ HWY 69		BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY OK													
DATUM Geodetic		DATE February 23 and 24, 2010		CHECKED BY TVA													
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 (%)					
	--- 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>				<div style="display: flex; justify-content: space-between;"> W_p W W_L </div>						
164.5	SAND and SILT Loose Grey Wet		14	SS	5												
166																	
165																	
164																	
163	SILTY CLAY Firm to very stiff Grey Moist		15	SS	3												
162																	
161																	
160			16	SS	6												
159																	
158																	
157		17	SS	6												0 0 51 49	
156																	
155																	
154		18	SS	11													
153																	
152																	

Continued Next Page

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

PROJECT		RECORD OF BOREHOLE		No S204-17		SHEET 3 OF 3		METRIC					
W.P.		LOCATION		ORIGINATED BY		DIST		COMPILED BY					
DATE		BOREHOLE TYPE		CHECKED BY		DATUM		TVA					
09-1111-6014		N 5074790.3 ; E 225210.8		MR		HWY 69		OK					
Geodetic		February 23 and 24, 2010		TVA									
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
--- CONTINUED FROM PREVIOUS PAGE ---													
147.9	SILTY CLAY Firm to very stiff Grey Moist		19	TO	PH*		151						
			20	SS	9								
33.2	SILT, some clay, trace sand Loose Grey Wet		21A	SS	4		148						
			21B										
146.4	Silty SAND, trace clay Compact to dense Grey Wet						147						
34.7							146						
			22	SS	24		145						
							144						
							143						
							142						
141.5			23	SS	34								
39.6	END OF BOREHOLE												
NOTES: * Unable to recover a Shelby tube sample between depths of 29.8 m and 30.3 m (Elev. 151.3 m and 150.8 m) below ground surface. 1. Water level in open borehole at a depth of 2.0 m below ground surface (Elev. 179.1 m) upon completion of drilling.													

PROJECT 09-1111-6014			RECORD OF BOREHOLE No S204-18		SHEET 1 OF 4		METRIC									
W.P. 5404-05-01			LOCATION N 5074795.1 ; E 225189.0		ORIGINATED BY MR/RA											
DIST _____ HWY 69			BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY OK											
DATUM Geodetic			DATE February 6 and 7, 2010		CHECKED BY TVA											
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 (%)
181.1	GROUND SURFACE							20	40	60	80	100				
0.0	TOPSOIL		1A	SS	5		181									
0.3	SILTY CLAY, containing rootlets and silty sand layers to a depth of 0.8 m Firm Brown to grey Moist		1B	SS			180									
			2	SS	6											
			3A	TO	PH											
179.0			3B				179									
2.1	Silty SAND, trace clay Loose to compact Brown Wet		4	SS	8		178									
			5	SS	18											
177.4							177									
3.7	SILT, some sand, trace to some clay Loose to compact Brown Wet		6	SS	13											
			7	SS	4		176									
							175									
	Becoming grey below a depth of 5.5 m		8	SS	15											
							174									
			9	SS	5		173									
							172									
			10	SS	9											
171.4							171									
9.7	CLAY Firm to stiff Grey Moist		11	SS	2		170									
							169									
			12	SS	1											
							168									
			13	SS	2											
							167									

Continued Next Page

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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT		RECORD OF BOREHOLE		No S204-18		SHEET 2 OF 4		METRIC																	
W.P.		LOCATION		ORIGINATED BY		MR/RA																			
DIST		BOREHOLE TYPE		COMPILED BY		OK																			
DATUM		DATE		CHECKED BY		TVA																			
PROJECT 09-1111-6014		N 5074795.1 ; E 225189.0		February 6 and 7, 2010																					
W.P. 5404-05-01		DIST HWY 69		BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring																					
DATUM Geodetic		DATE February 6 and 7, 2010		CHECKED BY TVA																					
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 ---																									
161.3	CLAY Firm to stiff Grey Moist		14	SS	WH																				
165																									
163																									
162			15	SS	3																				
161																									
160			16	TO	PH*																				
159			17	SS	7																				
158																									
157			18	SS	5																				
156																									
155																									
154			19	TO	PH																				
153																									
152																									
158.2	SILT, trace to some sand, trace clay Loose Grey Wet																								
157																									
156																									
155																									
154																									
153																									
152																									
158.2	SILTY CLAY Stiff to very stiff Grey Moist																								
157																									
156																									
155																									
154																									
153																									
152																									

Continued Next Page

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

GTA-MTO 001 09-1111-6014.GPJ GAL-MASS.GDT 7/25/12 SAC/DD

PROJECT		RECORD OF BOREHOLE		No S204-18		SHEET 3 OF 4		METRIC								
W.P. 09-1111-6014		LOCATION		N 5074795.1 ; E 225189.0		ORIGINATED BY		MR/RA								
DIST		HWY 69		BOREHOLE TYPE		127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY								
DATUM		Geodetic		DATE		February 6 and 7, 2010		CHECKED BY								
								TVA								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100				
	SILTY CLAY Stiff to very stiff Grey Moist		20	SS	7		151									0 1 54 45
							150			4						
										3						
							149									
							148									
			21	SS	5		147									
										3						
										>96						
							146									
							145									
	Silt interlayers encountered below a depth of 36.1 m		22	SS	9		144									
143.2							143									
37.9	SAND and SILT, trace clay Compact Grey Wet						142									0 35 65 0
			23	SS	21		141									
							140									
							139									
138.3			24	SS	12											
42.8	END OF BOREHOLE															

Continued Next Page

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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No S204-18		SHEET 4 OF 4		METRIC	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074795.1 ; E 225189.0</u>		ORIGINATED BY <u>MR/RA</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring</u>		COMPILED BY <u>OK</u>			
DATUM <u>Geodetic</u>		DATE <u>February 6 and 7, 2010</u>		CHECKED BY <u>TVA</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								○ UNCONFINED	● QUICK TRIAXIAL	+	×	FIELD VANE	REMOULDED	W _p	W		W _L			
	--- CONTINUED FROM PREVIOUS PAGE ---																			
	NOTES: * Unable to recover a Shelby tube sample between depths of 20.9 m and 21.3 m (Elev. 160.2 m and 159.8 m) below ground surface. 1. Water level in open borehole at a depth of 3.7 m below ground surface (Elev. 177.4 m) upon completion of drilling.																			

GTA-MTO 001 09-1111-6014.GPJ GAL-MASS.GDT 7/25/12 SAC/DD

PROJECT 09-1111-6014		RECORD OF DCPT No S204-DC01		SHEET 1 OF 1		METRIC											
W.P. 5404-05-01		LOCATION N 5074717.5 ; E 225162.8		ORIGINATED BY MR													
DIST HWY 69		BOREHOLE TYPE Hand Excavation		COMPILED BY OK													
DATUM Geodetic		DATE February 2, 2010		CHECKED BY TVA													
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 (%)				
186.4	GROUND SURFACE																
8.9	TOPSOIL																
	END OF EXCAVATION PROBABLE BEDROCK																
	NOTES: 1. Bedrock outcrop observed in the vicinity of the DCPT; bedrock confirmed by hand excavation at the DCPT location. 2. Excavation dry upon completion.																


GTA-MTO 001 09-1111-6014.GPJ GAL-MASS.GDT 7/25/12 SAC/DD

Continued Next Page

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

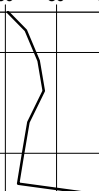
GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT <u>09-1111-6014</u>		RECORD OF DCPT No S204-DC02		SHEET 2 OF 3		METRIC	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074752.4 ; E 225183.1</u>		ORIGINATED BY <u>MR</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Portable Equipment, Dynamic Cone Penetration Test</u>		COMPILED BY <u>OK</u>			
DATUM <u>Geodetic</u>		DATE <u>March 1, 2010</u>		CHECKED BY <u>TVA</u>			

SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa			W _p	W	W _L	WATER CONTENT (%)			
									○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × REMOULDED					
	--- CONTINUED FROM PREVIOUS PAGE --- Dynamic Cone Penetration Test (DCPT)														
								166							
								165							
								164							
								163							
								162							
								161							
								160							
								159							
								158							
								157							
								156							
								155							
								154							
								153							
								152							

Continued Next Page

+³, x³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT 09-1111-6014		RECORD OF DCPT No S204-DC02		SHEET 3 OF 3		METRIC														
W.P. 5404-05-01		LOCATION N 5074752.4 ; E 225183.1		ORIGINATED BY MR																
DIST _____ HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test		COMPILED BY OK																
DATUM Geodetic		DATE March 1, 2010		CHECKED BY TVA																
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>													
149.6	Dynamic Cone Penetration Test (DCPT)					151														
31.8	END OF DCPT Refusal to Further Penetration (100 Blows / 0.13 m)					150														

Continued Next Page

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

PROJECT 09-1111-6014		RECORD OF DCPT No S204-DC03		SHEET 2 OF 2		METRIC							
W.P. 5404-05-01		LOCATION N 5074762.9 ; E 225141.5		ORIGINATED BY MR									
DIST _____ HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test		COMPILED BY OK									
DATUM Geodetic		DATE February 2, 2010		CHECKED BY TVA									
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>						
152.7													
28.3	END OF DCPT Refusal to Further Penetration (130 Blows / 0.30 m)												

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT <u>09-1111-6014</u>				RECORD OF DCPT No S204-DC04		SHEET 1 OF 2		METRIC					
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074799.2 ; E 225165.3</u>				ORIGINATED BY <u>MR</u>							
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Portable Equipment, Dynamic Cone Penetration Test</u>				COMPILED BY <u>OK</u>							
DATUM <u>Geodetic</u>		DATE <u>February 2, 2010</u>				CHECKED BY <u>TVA</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					
181.1	GROUND 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 ● QUICK TRIAXIAL × REMOULDED </div>						
0.0	Dynamic Cone Penetration Test (DCPT)					181							
						180							
						179							
						178							
						177							
						176							
						175							
						174							
						173							
						172							
						171							
						170							
						169							
						168							
						167							

Continued Next Page

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

PROJECT 09-1111-6014		RECORD OF DCPT No S204-DC04		SHEET 2 OF 2		METRIC								
W.P. 5404-05-01		LOCATION N 5074799.2 ; E 225165.3		ORIGINATED BY MR										
DIST _____ HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test		COMPILED BY OK										
DATUM Geodetic		DATE February 2, 2010		CHECKED BY TVA										
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		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 </div> <div style="display: flex; justify-content: space-between;"> ● QUICK TRIAXIAL × REMOULDED </div>						
	Dynamic Cone Penetration Test (DCPT)						156							
							157							
							158							
							159							
							160							
							161							
							162							
							163							
							164							
							165							
							166							
155.2 25.9	END OF DCPT													

GTA-MTO 001 09-1111-6014.GPJ GAL-MASS.GDT 7/25/12 SAC/DD

PROJECT <u>09-1111-6014</u>		RECORD OF DCPT No S204-DC05		SHEET 1 OF 1		METRIC	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074720.1 ; E 225237.2</u>		ORIGINATED BY <u>MR</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Portable Equipment, Dynamic Cone Penetration Test</u>		COMPILED BY <u>OK</u>			
DATUM <u>Geodetic</u>		DATE <u>February 16, 2010</u>		CHECKED BY <u>TVA</u>			

SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa					W _p	W	W _L	GR SA SI CL							
											○ UNCONFINED	● QUICK TRIAXIAL	+ FIELD VANE	× REMOULDED		WATER CONTENT (%)					
182.1	GROUND SURFACE																				
0.0	Dynamic Cone Penetration Test (DCPT)																				
178.9	END OF DCPT Refusal to Further Penetration (Hammer Bouncing)																				
3.2																					



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



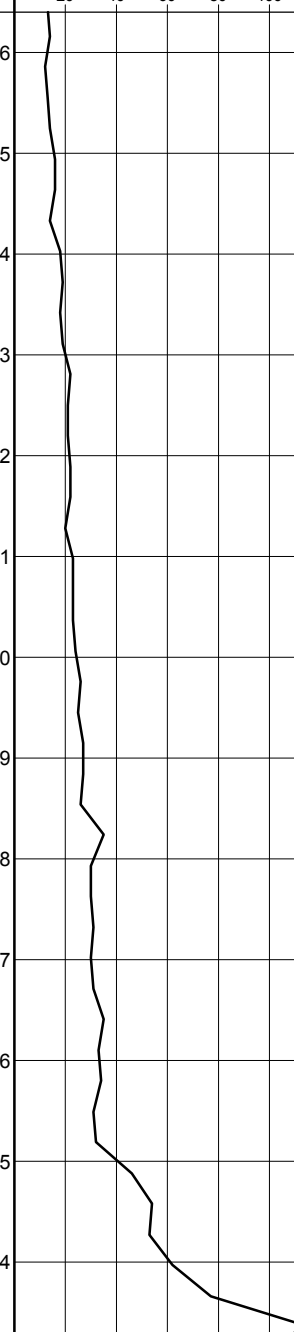
PROJECT 09-1111-6014		RECORD OF DCPT No S204-DC07		SHEET 1 OF 2		METRIC	
W.P. 5404-05-01		LOCATION N 5074767.0 ;E 225220.0		ORIGINATED BY		MR	
DIST HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test		COMPILED BY		OK	
DATUM Geodetic		DATE February 25, 2010		CHECKED BY		TVA	

[illegible]

Continued Next Page

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

GT-A-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT 09-1111-6014		RECORD OF DCPT No S204-DC07		SHEET 2 OF 2		METRIC							
W.P. 5404-05-01		LOCATION N 5074767.0 ; E 225220.0		ORIGINATED BY MR									
DIST _____ HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test		COMPILED BY OK									
DATUM Geodetic		DATE February 25, 2010		CHECKED BY TVA									
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		W _p	W		
--- 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>						
153.2	28.2												

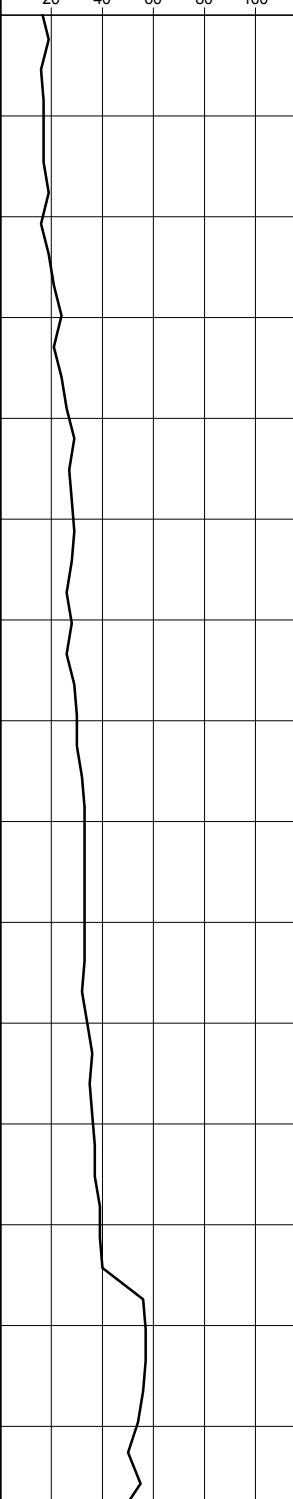
GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD



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

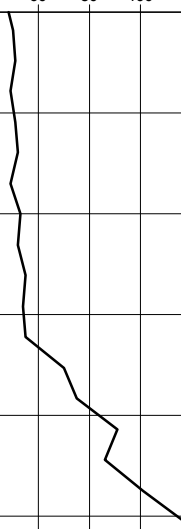
GT-A-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT <u>09-1111-6014</u>		RECORD OF DCPT No S204-DC08		SHEET 2 OF 3		METRIC	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074777.2 ; E 225177.8</u>		ORIGINATED BY <u>MR</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Portable Equipment, Dynamic Cone Penetration Test</u>		COMPILED BY <u>OK</u>			
DATUM <u>Geodetic</u>		DATE <u>February 21, 2010</u>		CHECKED BY <u>TVA</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m³	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	GR SA SI CL							
	--- CONTINUED FROM PREVIOUS PAGE --- Dynamic Cone Penetration Test (DCPT)							<div><div>SHEAR STRENGTH kPa</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × REMOULDED</div></div>										
																		

Continued Next Page

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

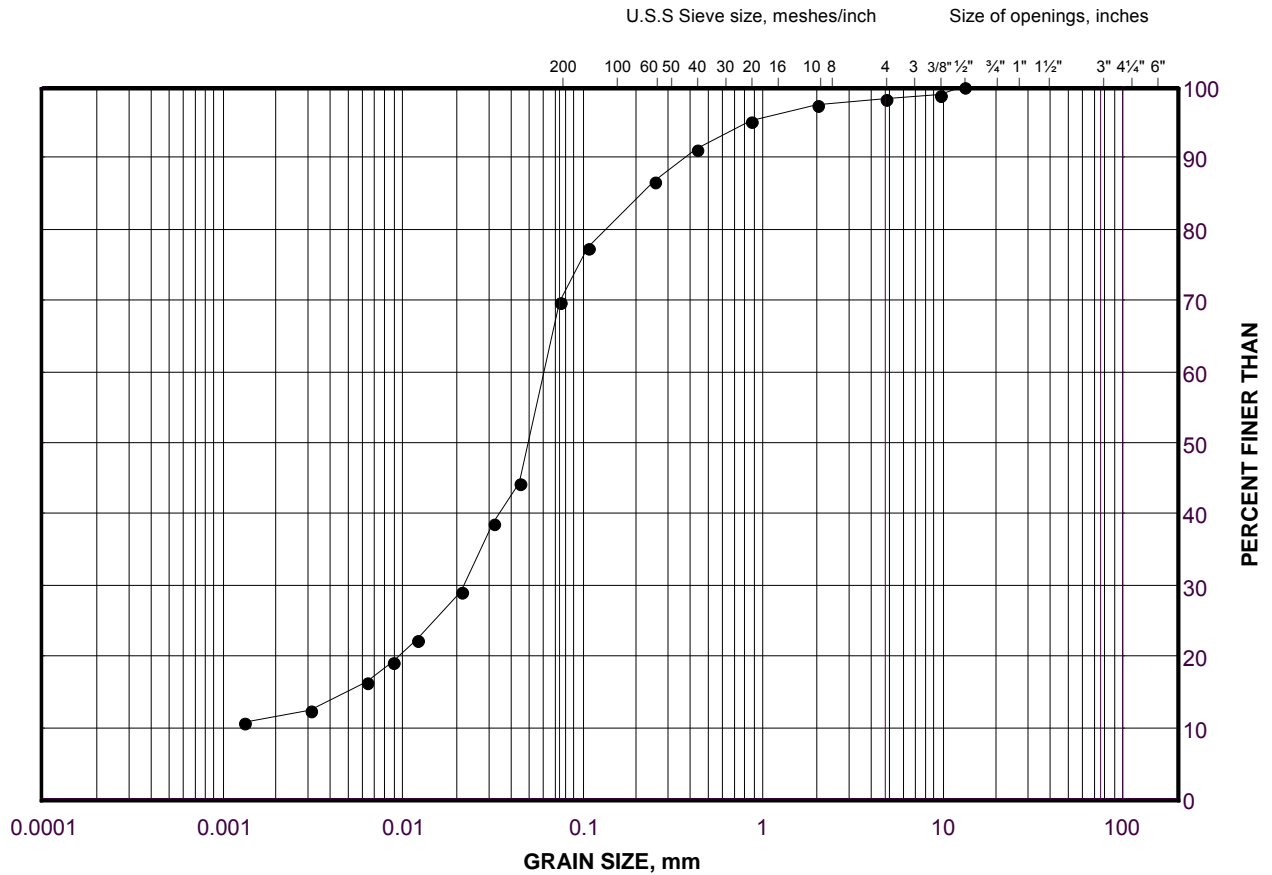
PROJECT 09-1111-6014		RECORD OF DCPT No S204-DC08		SHEET 3 OF 3		METRIC							
W.P. 5404-05-01		LOCATION N 5074777.2 ; E 225177.8		ORIGINATED BY MR									
DIST _____ HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test		COMPILED BY OK									
DATUM Geodetic		DATE February 21, 2010		CHECKED BY TVA									
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		W _p	W		
	--- 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>						
145.7	Dynamic Cone Penetration Test (DCPT)												
35.4	END OF DCPT Refusal to Further Penetration (129 Blows / 0.30 m)												

GRAIN SIZE DISTRIBUTION

Sandy Silt

Highway 69 (SBL) STA 11+725 to 11+825 (Swamp 204)

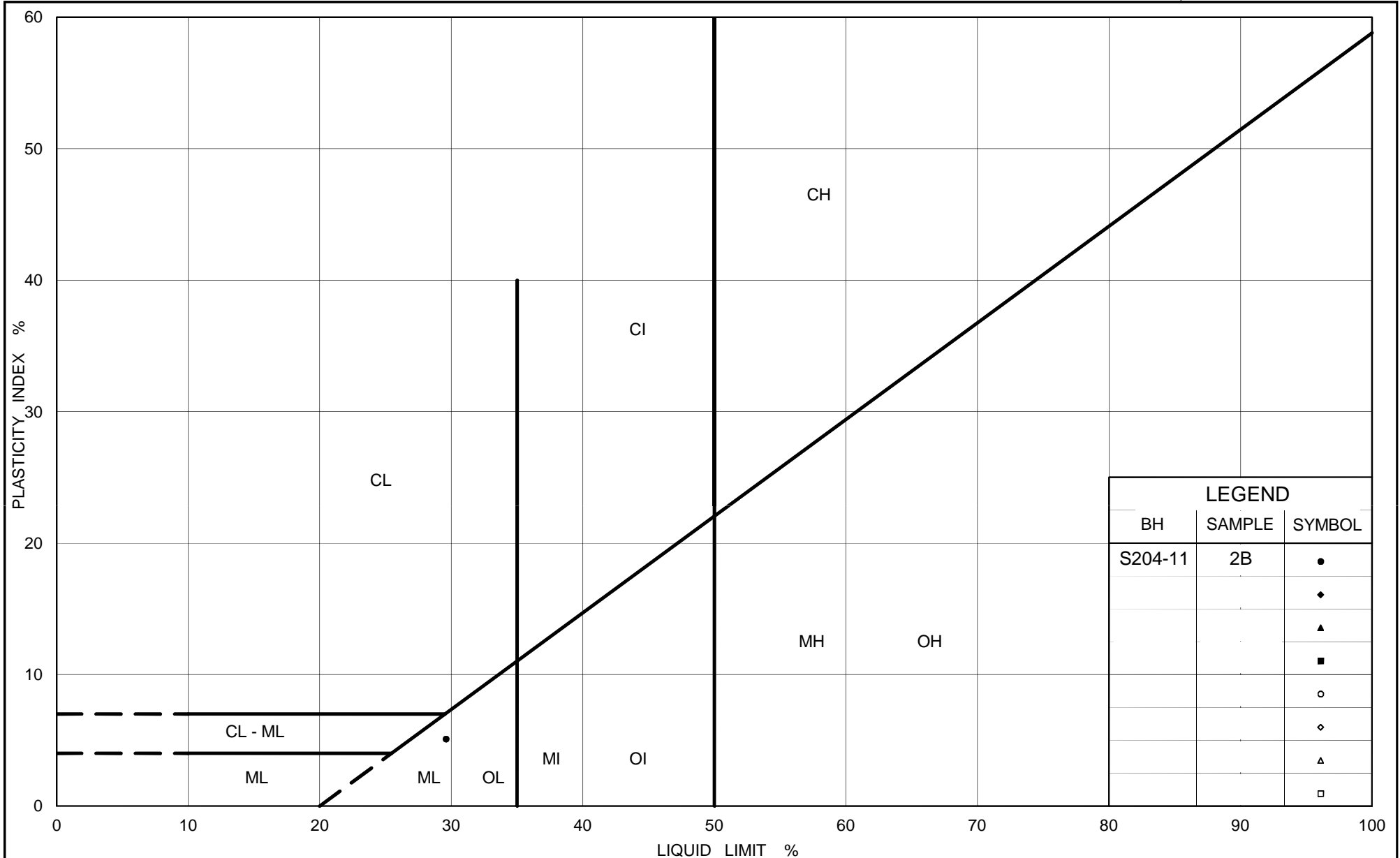
FIGURE D.S204-01



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S204-01	1B	183.5



Ministry of Transportation

Ontario

PLASTICITY CHART Silt (Slight Plasticity)

Highway 69 (SBL) STA 11+725 to 11+825 (Swamp 204)

Figure No. D.S204-02

Project No. 09-1111-6014

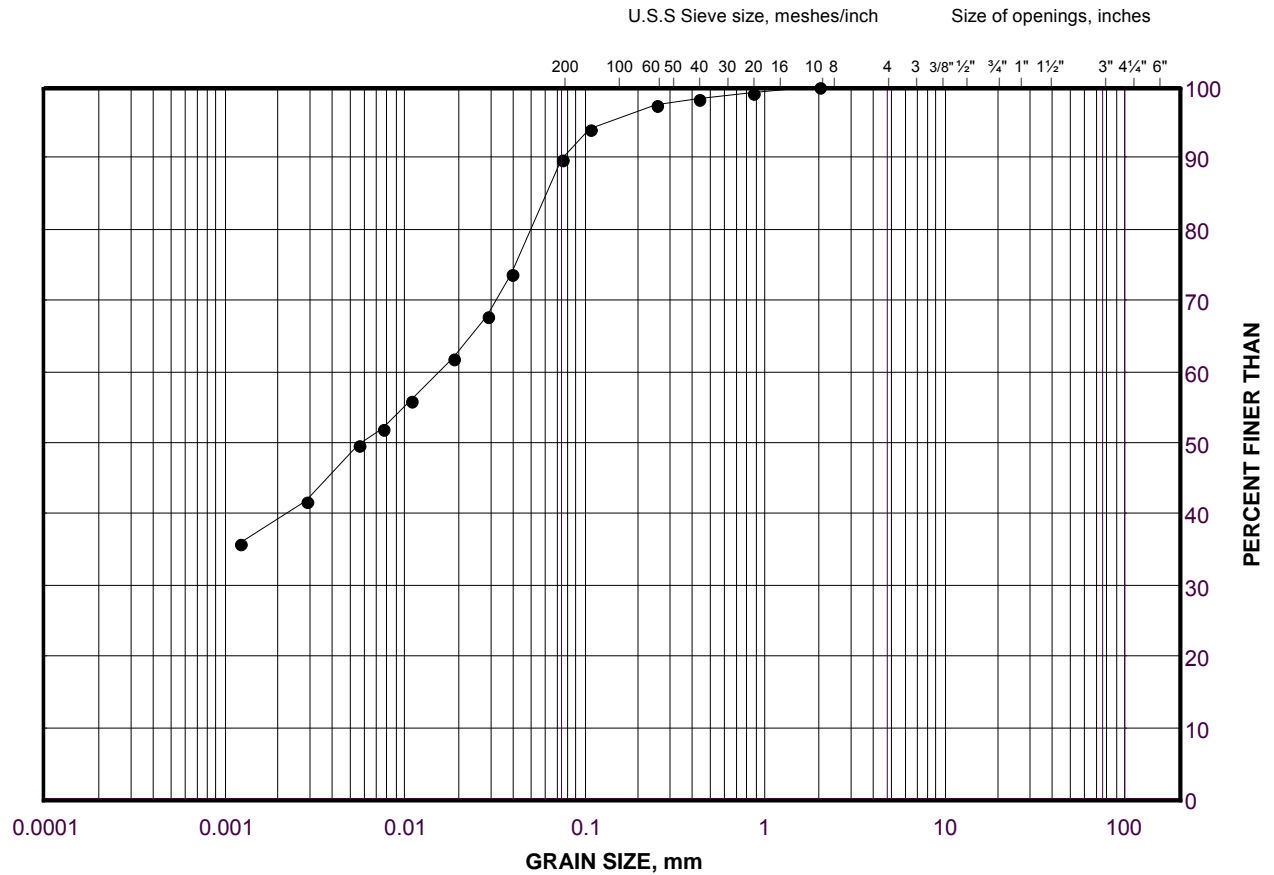
Checked By: TVA

GRAIN SIZE DISTRIBUTION

Silty Clay (Near Surface)

Highway 69 (SBL) STA 11+725 to 11+825 (Swamp 204)

FIGURE D.S204-03



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

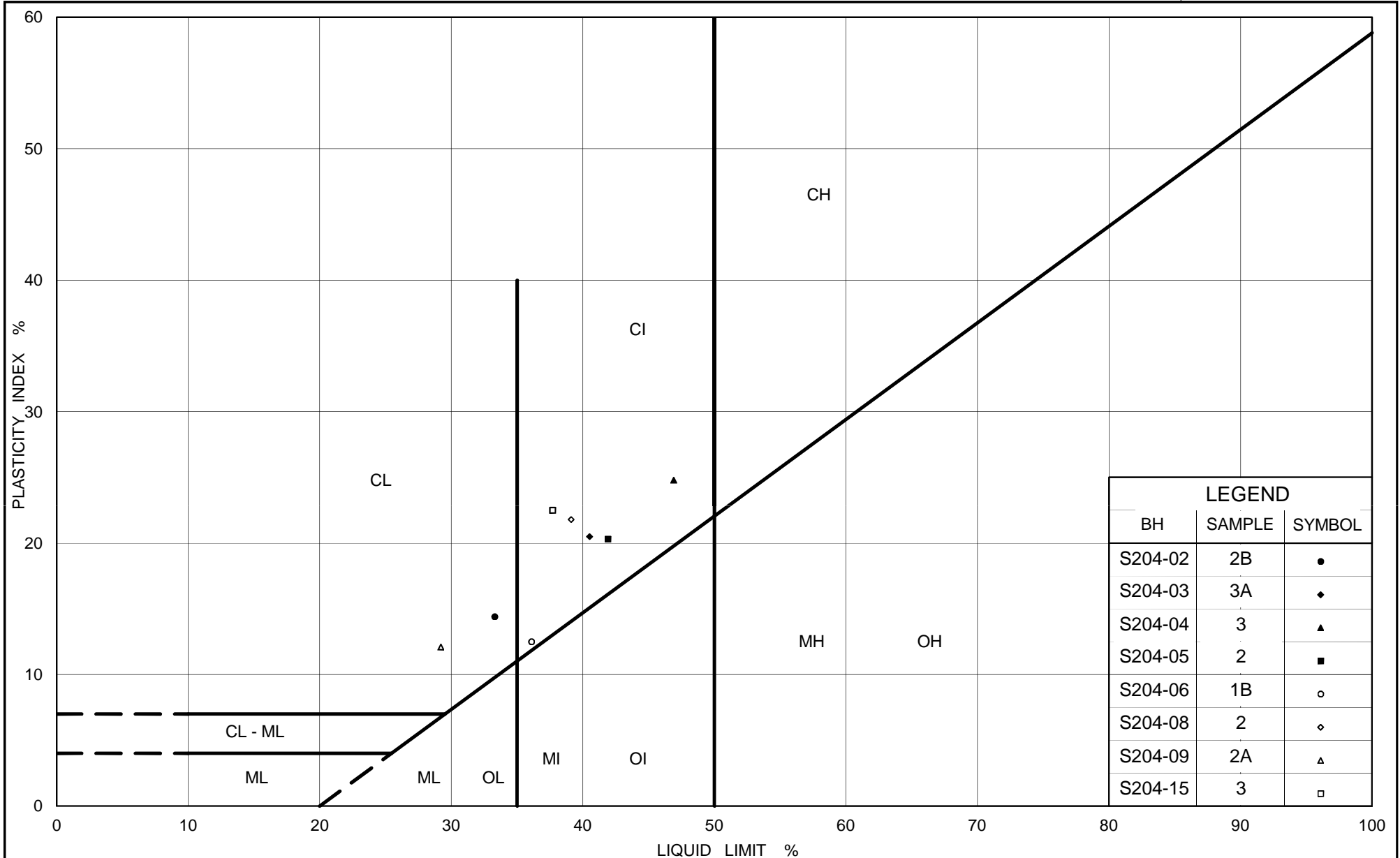
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S204-03	3A	179.9

Project Number: 09-1111-6014

Checked By: TVA

Golder Associates

Date: 04-Aug-11



Ministry of Transportation

Ontario

PLASTICITY CHART
 Clayey Silt to Silty Clay
 Highway 69 (SBL) STA 11+725 to 11+825 (Swamp 204)

Figure No. D.S204-04

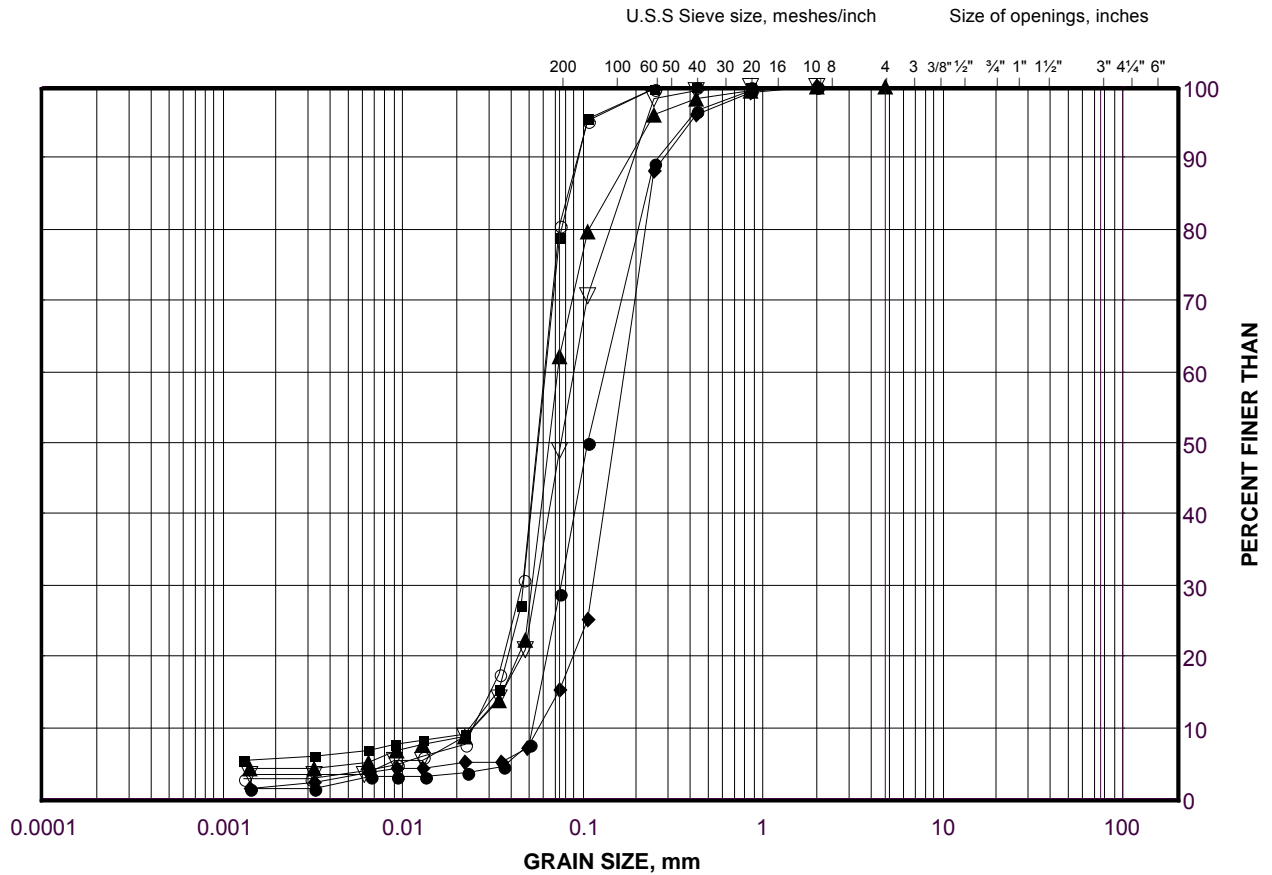
Project No. 09-1111-6014

Checked By: TVA

GRAIN SIZE DISTRIBUTION

Sand to Sandy Silt to Sand and Silt to Silty Sand (Upper)
Highway 69 (SBL) STA 11+725 to 11+825 (Swamp 204)

FIGURE D.S204-05



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

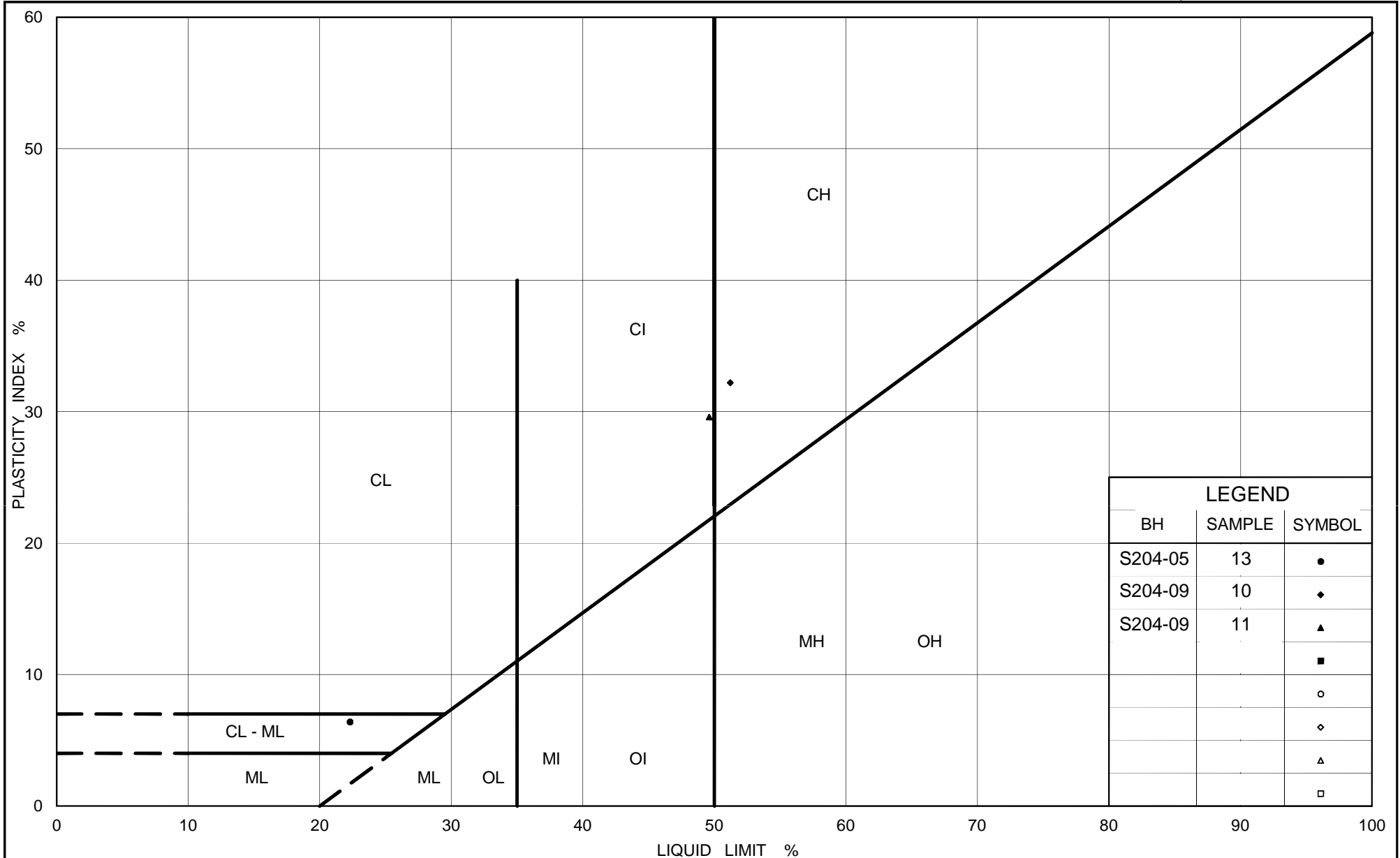
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S204-07	4	178.4
■	S204-09	5	177
◆	S204-08	7	176.2
▲	S204-06	7	176.2
▽	S204-05	7	176.3
○	S204-07	9	173.5

Project Number: 09-1111-6014

Checked By: TVA

Golder Associates

Date: 22-Dec-11



Ministry of Transportation

Ontario

PLASTICITY CHART
 Clayey Silt to Clay (Upper)
 Highway 69 (SBL) STA 11+725 to 11+825 (Swamp 204)

Figure No. D.S204-06

Project No. 09-1111-6014

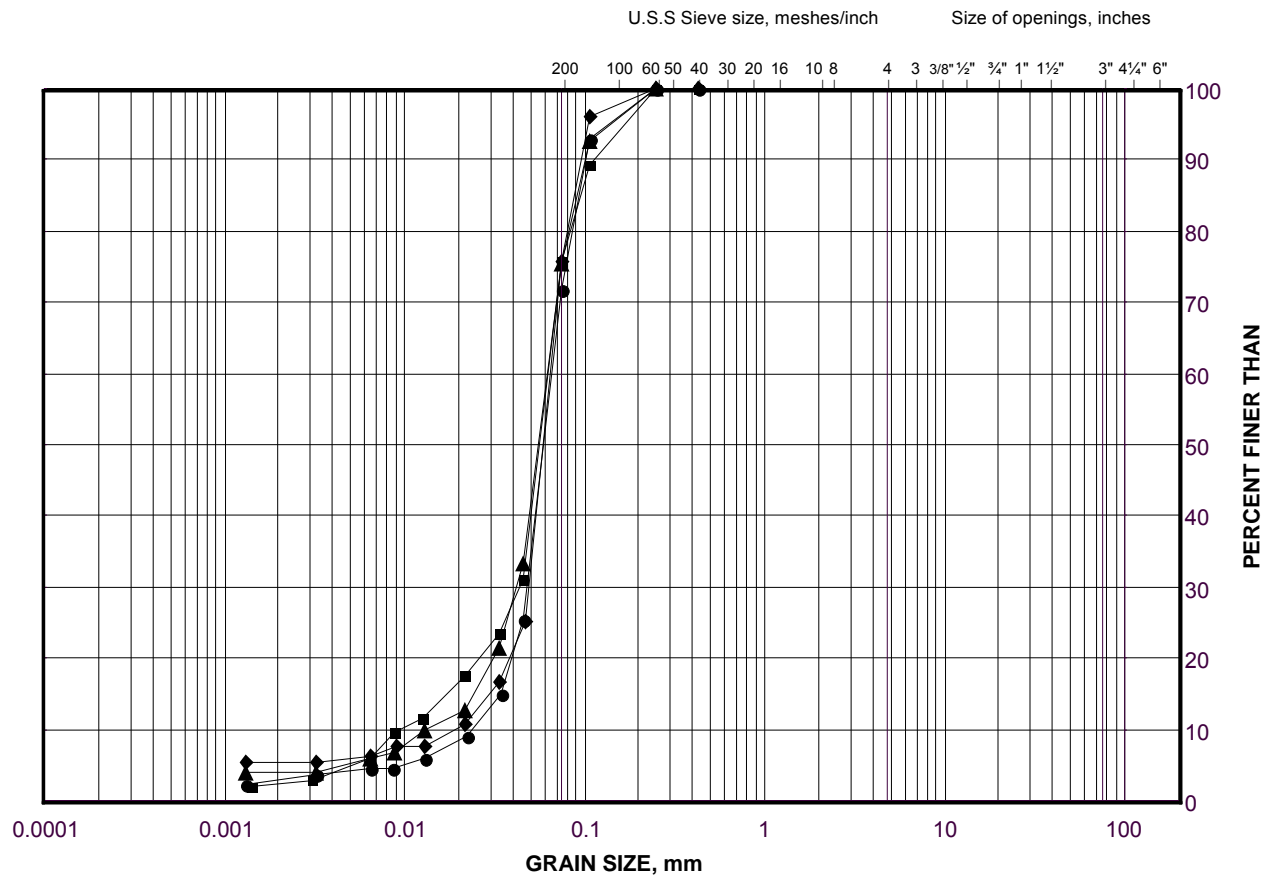
Checked By: TVA

GRAIN SIZE DISTRIBUTION

Sandy Silt (Lower)

Highway 69 (SBL) STA 11+725 to 11+825 (Swamp 204)

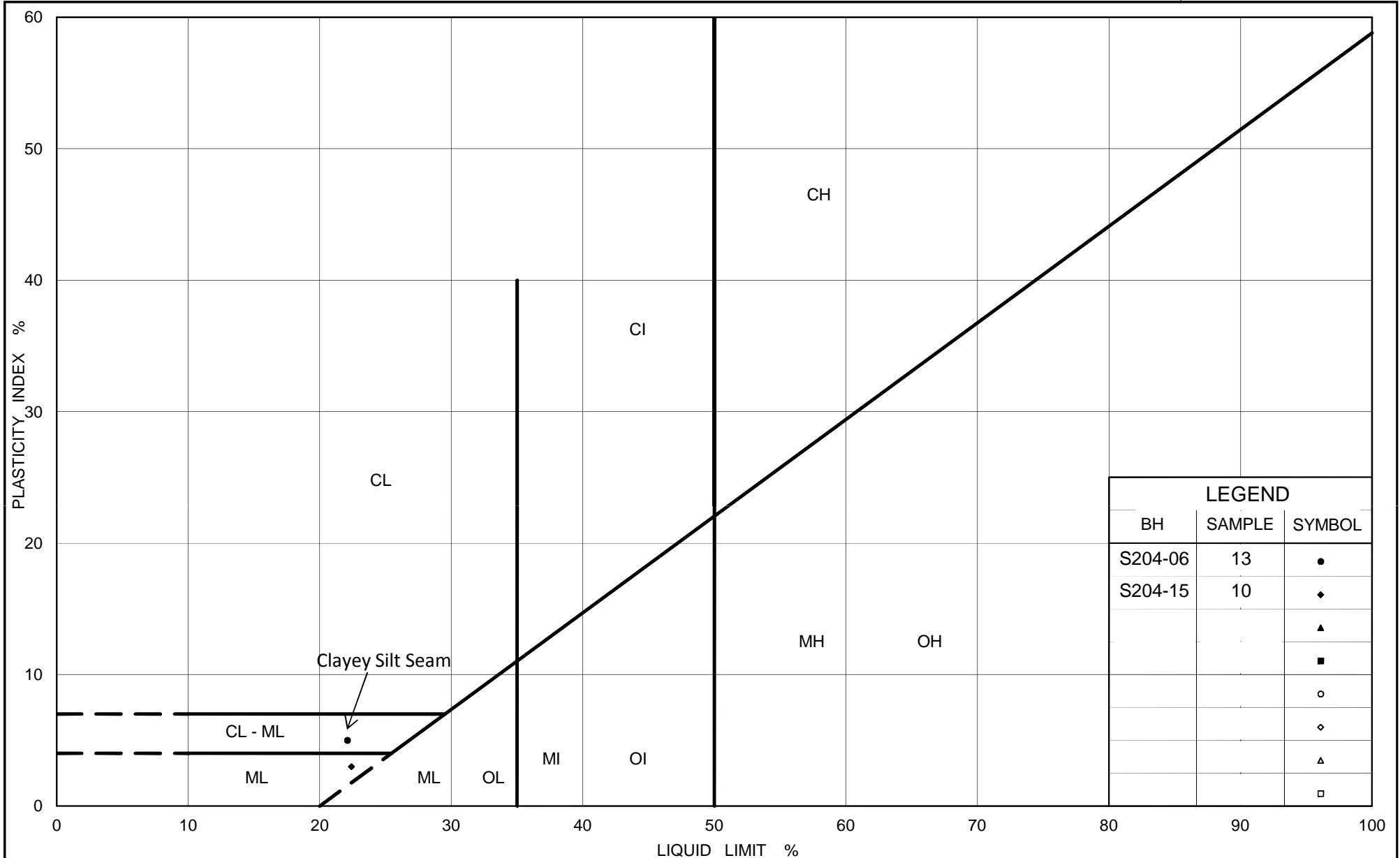
FIGURE D.S204-07



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S204-09	13	166.0
■	S204-07	13	167.4
◆	S204-08	14	166.0
▲	S204-05	15	166.1



Ministry of Transportation

Ontario

PLASTICITY CHART Silt (Lower)

Highway 69 (SBL) STA 11+725 to 11+825 (Swamp 204)

Figure No. D.S204-08

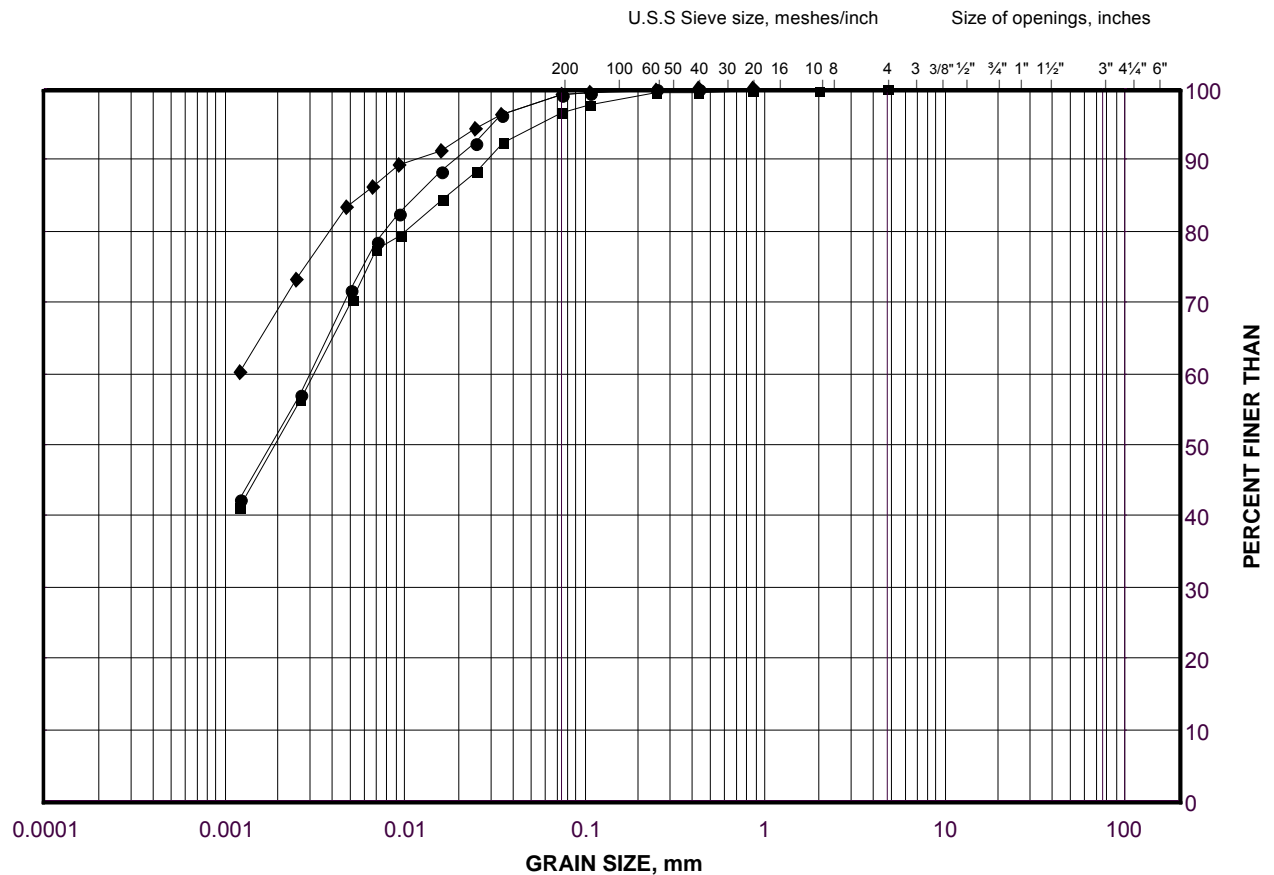
Project No. 09-1111-6014

Checked By: TVA

GRAIN SIZE DISTRIBUTION

Silty Clay to Clay (Lower)
Highway 69 (SBL) STA 11+725 to 11+825 (Swamp 204)

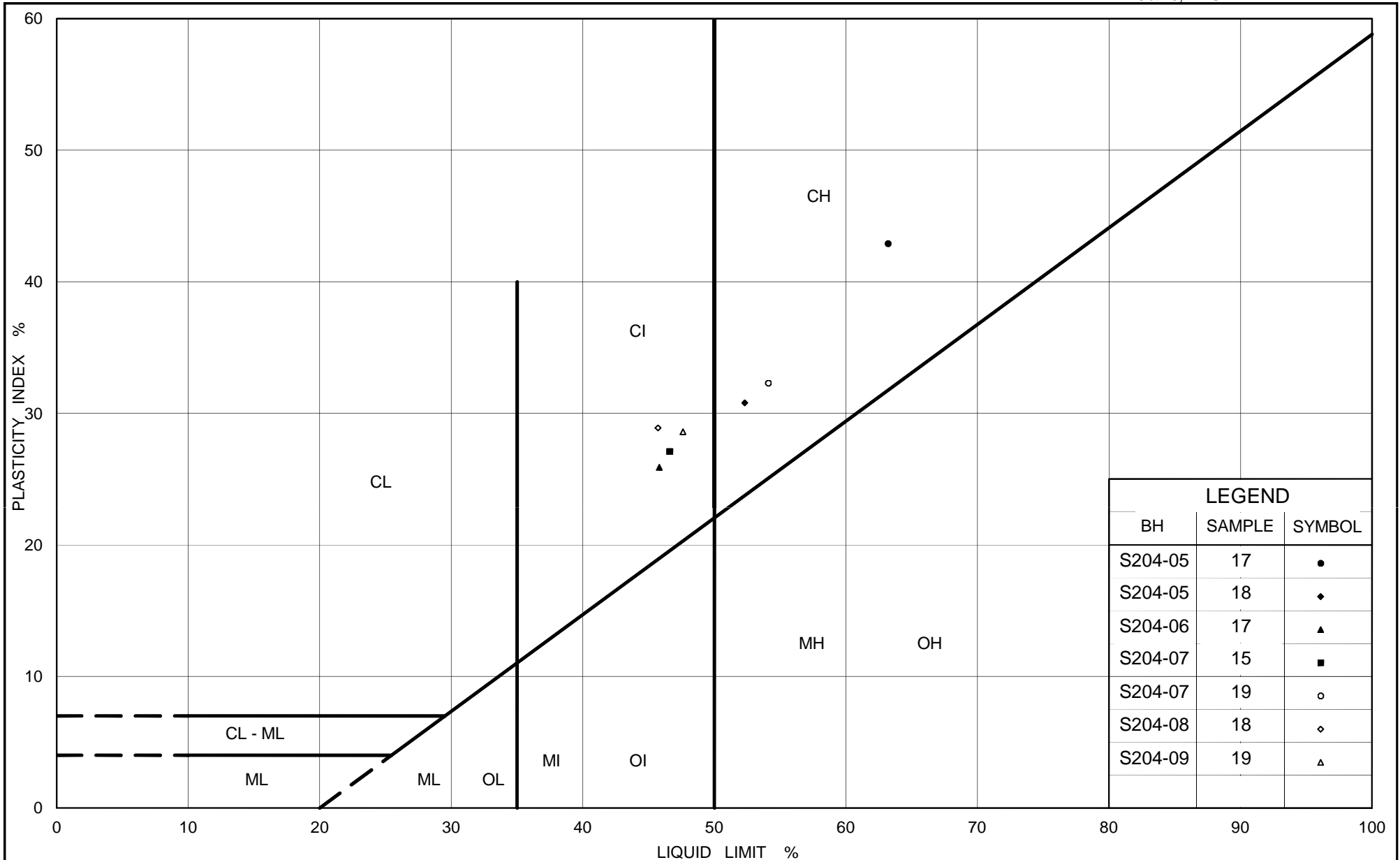
FIGURE D.S204-09



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S204-06	17	159.6
■	S204-08	18	153.8
◆	S204-05	20	150.9



Ministry of Transportation

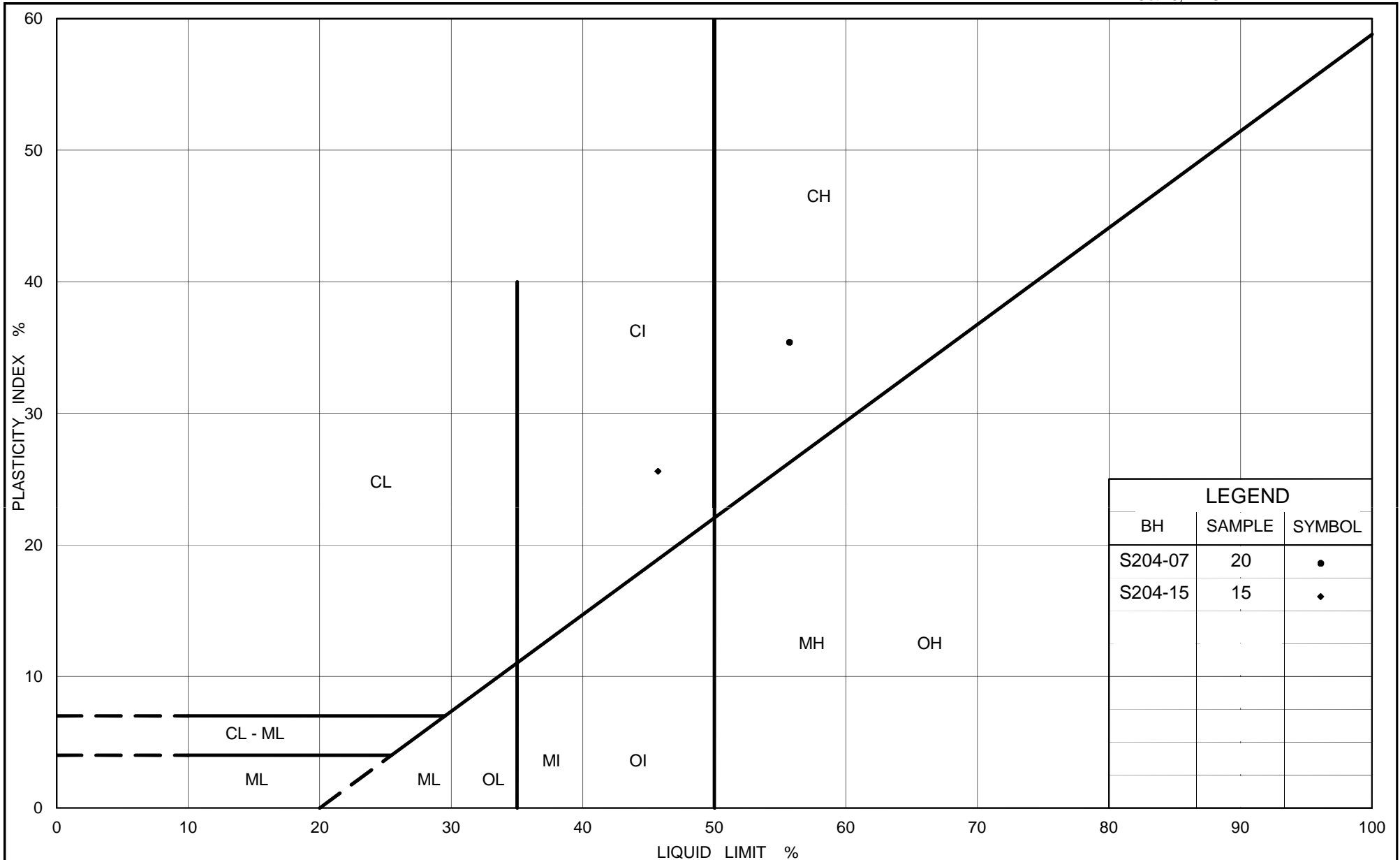
Ontario

PLASTICITY CHART
 Silty Clay to Clay (Lower)
 Highway 69 (SBL) STA 11+725 to 11+825 (Swamp 204)

Figure No. D.S204-10A

Project No. 09-1111-6014

Checked By: TVA



Ministry of Transportation

Ontario

PLASTICITY CHART Clay (Lower)

Highway 69 (SBL) STA 11+725 to 11+825 (Swamp 204)

Figure No. D.S204-10B

Project No. 09-1111-6014

Checked By: TVA

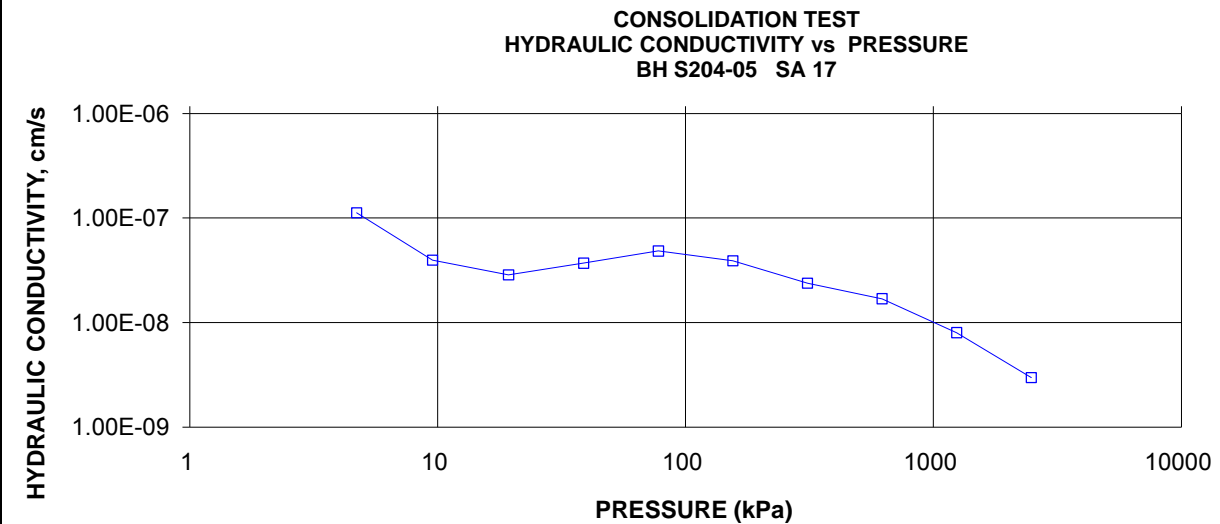
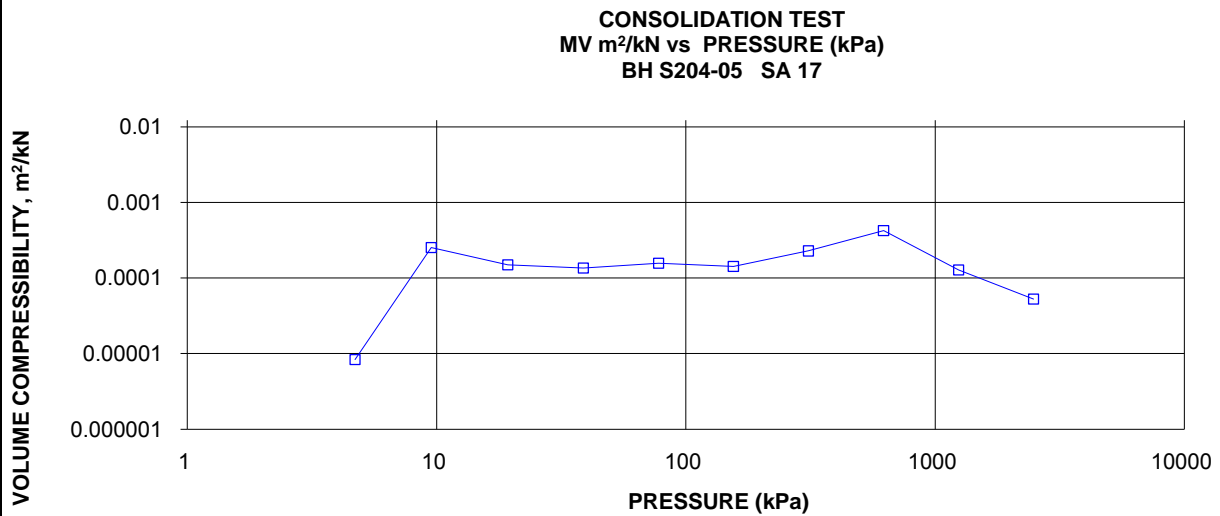
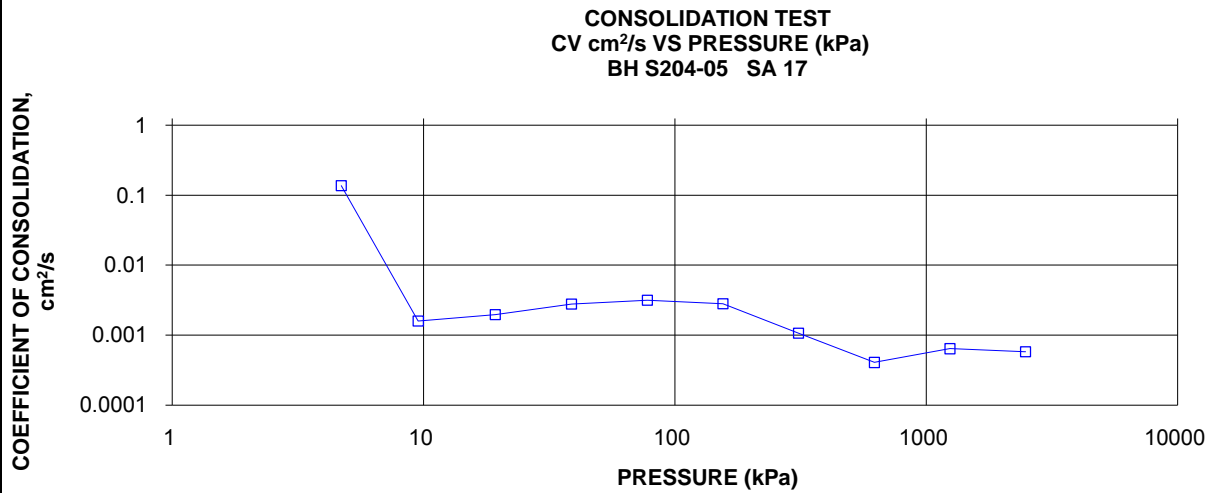
CONSOLIDATION TEST SUMMARY					FIGURE D.S204-11		
Highway 69 (SBL) STA 11+725 to 11+825 (Swamp 204)					Sheet 1 of 4		
SAMPLE IDENTIFICATION							
Project Number	09-1111-6014				Sample Number	17	
Borehole Number	S204-05				Sample Depth, m	21.1	
TEST CONDITIONS							
Test Type	Standard				Load Duration, hr	24	
Oedometer Number	4						
Date Started	4/8/2010						
Date Completed	4/24/2010						
SAMPLE DIMENSIONS AND PROPERTIES - INITIAL							
Sample Height, cm	2.54				Unit Weight, kN/m ³	16.56	
Sample Diameter, cm	6.34				Dry Unit Weight, kN/m ³	10.59	
Area, cm ²	31.57				Specific Gravity, measured	2.77	
Volume, cm ³	80.19				Solids Height, cm	0.990	
Water Content, %	56.37				Volume of Solids, cm ³	31.25	
Wet Mass, g	135.37				Volume of Voids, cm ³	48.93	
Dry Mass, g	86.57				Degree of Saturation, %	99.7	
TEST COMPUTATIONS							
	Corr.		Average				
Pressure	Height	Void	Height	t ₉₀	cv.	mv	k
kPa	cm	Ratio	cm	sec	cm ² /s	m ² /kN	cm/s
0.00	2.540	1.566	2.540				
4.71	2.540	1.566	2.540	10	1.37E-01	8.36E-06	1.12E-07
9.53	2.537	1.563	2.538	856	1.60E-03	2.53E-04	3.96E-08
19.31	2.533	1.559	2.535	694	1.96E-03	1.49E-04	2.87E-08
38.76	2.526	1.552	2.530	487	2.79E-03	1.36E-04	3.70E-08
77.68	2.511	1.536	2.519	427	3.15E-03	1.57E-04	4.84E-08
155.14	2.483	1.508	2.497	470	2.81E-03	1.42E-04	3.91E-08
310.28	2.393	1.417	2.438	1185	1.06E-03	2.28E-04	2.38E-08
621.15	2.059	1.079	2.226	2579	4.07E-04	4.24E-04	1.69E-08
1241.95	1.857	0.876	1.958	1270	6.40E-04	1.28E-04	8.01E-09
2483.01	1.692	0.709	1.775	1156	5.78E-04	5.24E-05	2.97E-09
1241.95	1.708	0.725	1.700				
310.28	1.761	0.779	1.735				
77.68	1.825	0.844	1.793				
19.37	1.883	0.902	1.854				
4.71	1.912	0.931	1.897				
Note: k calculated using cv based on t ₉₀ values.							
SAMPLE DIMENSIONS AND PROPERTIES - FINAL							
Sample Height, cm	1.91				Unit Weight, kN/m ³	18.98	
Sample Diameter, cm	6.34				Dry Unit Weight, kN/m ³	14.07	
Area, cm ²	31.57				Specific Gravity, measured	2.77	
Volume, cm ³	60.35				Solids Height, cm	0.990	
Water Content, %	34.94				Volume of Solids, cm ³	31.25	
Wet Mass, g	116.82				Volume of Voids, cm ³	29.09	
Dry Mass, g	86.57						
Prepared By: LFG					Golder Associates		Checked By: TVA

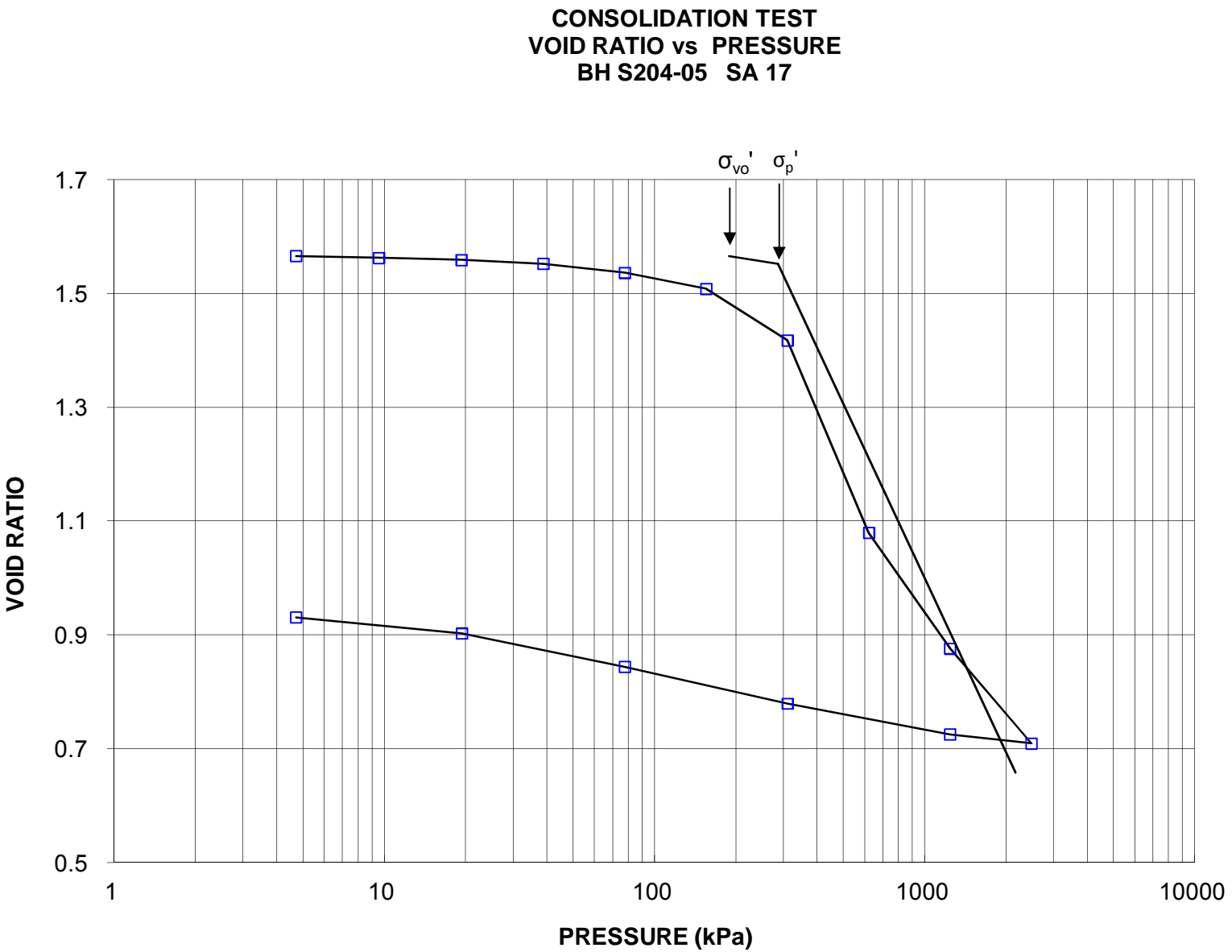
CONSOLIDATION TEST SUMMARY

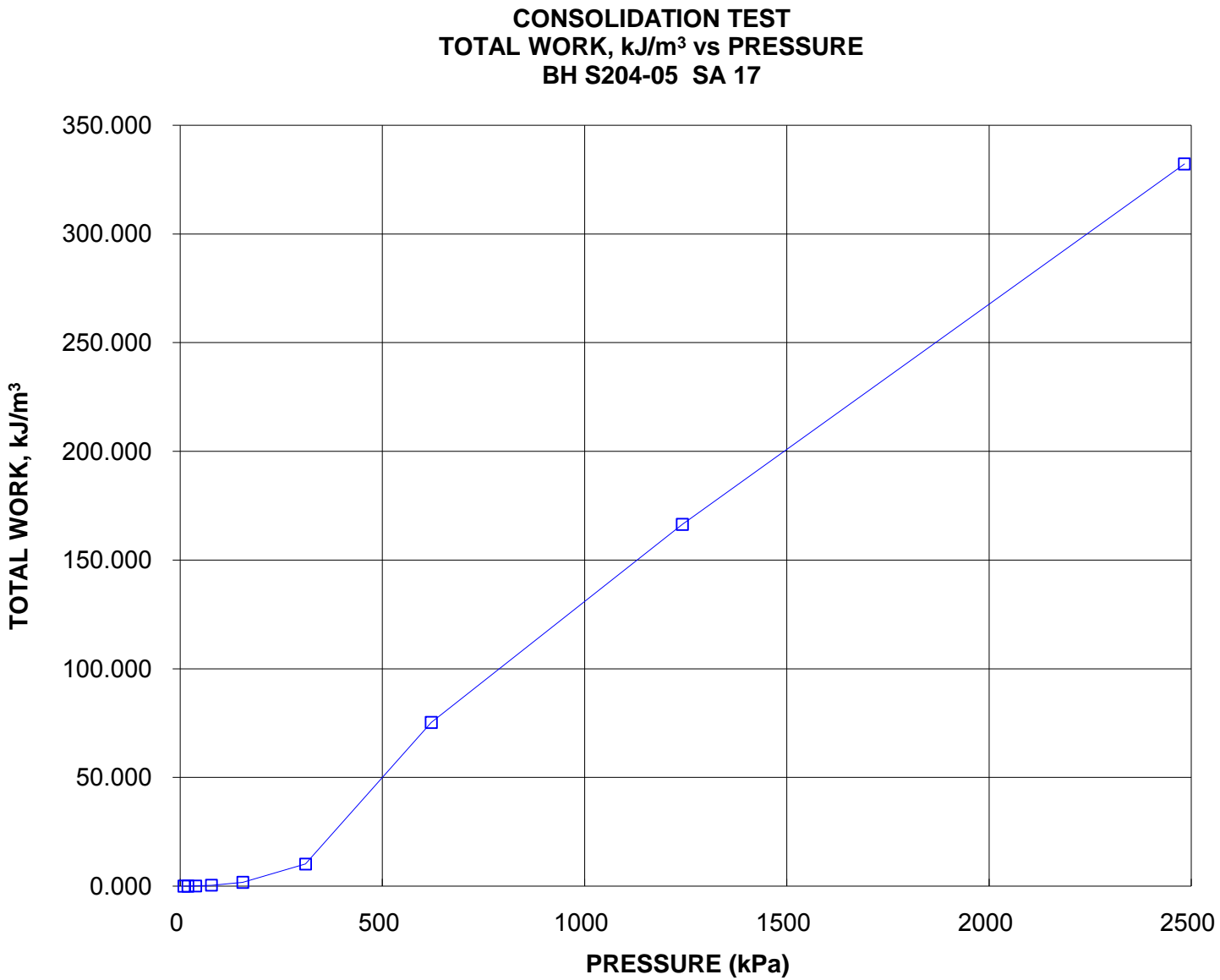
Highway 69 (SBL) STA 11+725 to 11+825 (Swamp 204)

FIGURE D.S204-11

Sheet 2 of 4







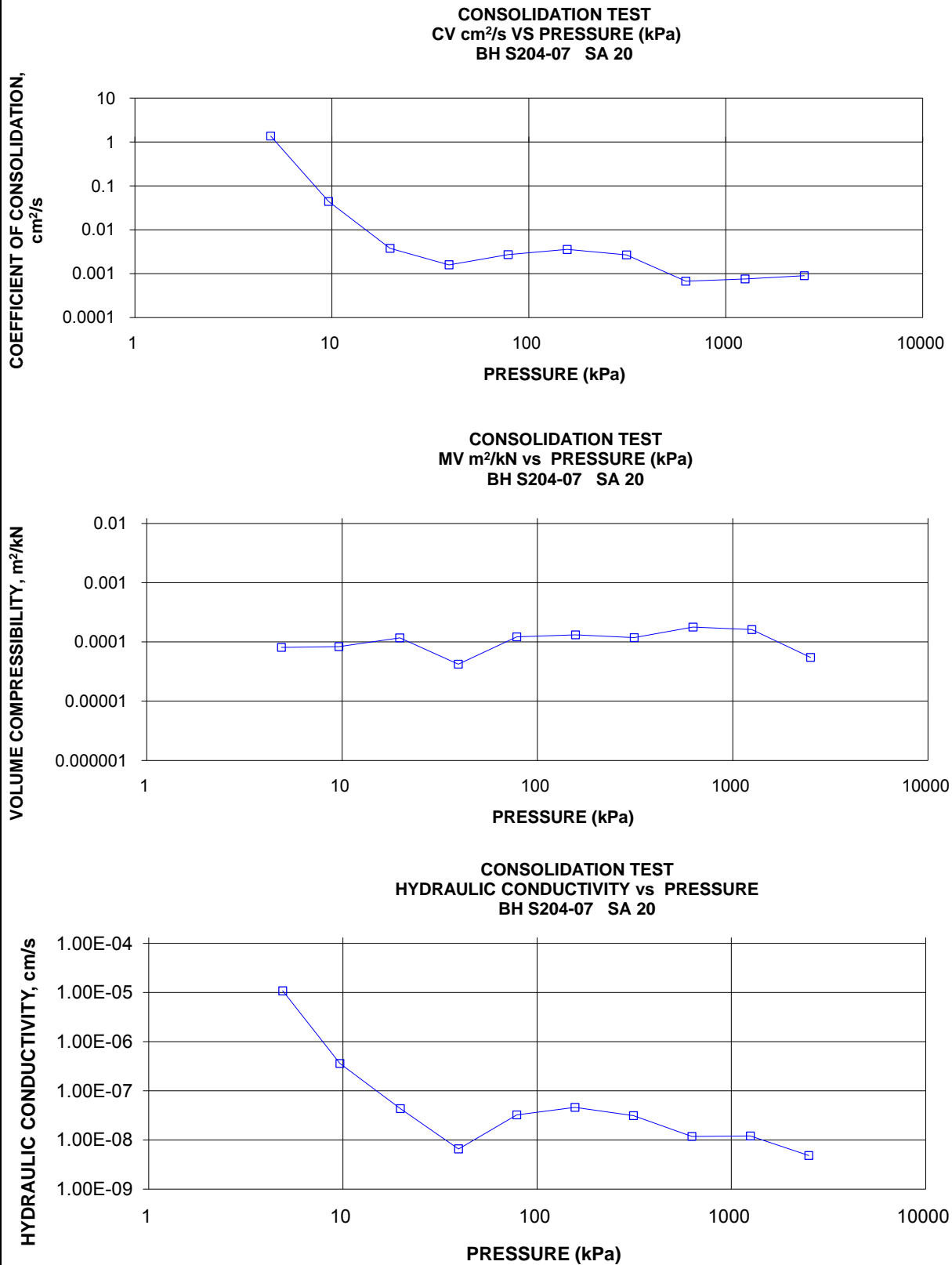
CONSOLIDATION TEST SUMMARY					FIGURE D.S204-12		
Highway 69 (SBL) STA 11+725 to 11+825 (Swamp 204)					Sheet 1 of 4		
SAMPLE IDENTIFICATION							
Project Number	09-1111-6014			Sample Number	20		
Borehole Number	S204-07			Sample Depth, m	30.1		
TEST CONDITIONS							
Test Type	Standard			Load Duration, hr	24		
Oedometer Number	11						
Date Started	4/8/2010						
Date Completed	4/21/2010						
SAMPLE DIMENSIONS AND PROPERTIES - INITIAL							
Sample Height, cm	2.54			Unit Weight, kN/m ³	17.57		
Sample Diameter, cm	6.31			Dry Unit Weight, kN/m ³	12.08		
Area, cm ²	31.27			Specific Gravity, measured	2.77		
Volume, cm ³	79.43			Solids Height, cm	1.129		
Water Content, %	45.49			Volume of Solids, cm ³	35.31		
Wet Mass, g	142.32			Volume of Voids, cm ³	44.12		
Dry Mass, g	97.82			Degree of Saturation, %	100.9		
TEST COMPUTATIONS							
	Corr.		Average				
Pressure	Height	Void	Height	t ₉₀	cv.	mv	k
kPa	cm	Ratio	cm	sec	cm ² /s	m ² /kN	cm/s
0.00	2.540	1.249	2.540				
4.89	2.539	1.248	2.540	1	1.37E+00	8.05E-05	1.08E-05
9.64	2.538	1.247	2.539	31	4.41E-02	8.29E-05	3.58E-07
19.74	2.535	1.245	2.537	362	3.77E-03	1.17E-04	4.32E-08
39.38	2.533	1.243	2.534	856	1.59E-03	4.21E-05	6.56E-09
78.50	2.521	1.232	2.527	501	2.70E-03	1.22E-04	3.22E-08
156.63	2.495	1.209	2.508	375	3.56E-03	1.32E-04	4.58E-08
313.38	2.448	1.168	2.471	482	2.69E-03	1.18E-04	3.10E-08
626.47	2.307	1.043	2.377	1778	6.74E-04	1.77E-04	1.17E-08
1252.49	2.051	0.816	2.179	1325	7.60E-04	1.61E-04	1.20E-08
2506.04	1.877	0.662	1.964	907	9.01E-04	5.46E-05	4.83E-09
1252.49	1.887	0.671	1.882				
313.38	1.936	0.714	1.911				
78.50	1.998	0.769	1.967				
19.74	2.053	0.818	2.025				
4.89	2.083	0.845	2.068				
Note: k calculated using cv based on t ₉₀ values.							
SAMPLE DIMENSIONS AND PROPERTIES - FINAL							
Sample Height, cm	2.08			Unit Weight, kN/m ³	19.47		
Sample Diameter, cm	6.31			Dry Unit Weight, kN/m ³	14.73		
Area, cm ²	31.27			Specific Gravity, measured	2.77		
Volume, cm ³	65.14			Solids Height, cm	1.129		
Water Content, %	32.19			Volume of Solids, cm ³	35.31		
Wet Mass, g	129.31			Volume of Voids, cm ³	29.82		
Dry Mass, g	97.82						
Prepared By: LFG					Golder Associates		
					Checked By: TVA		

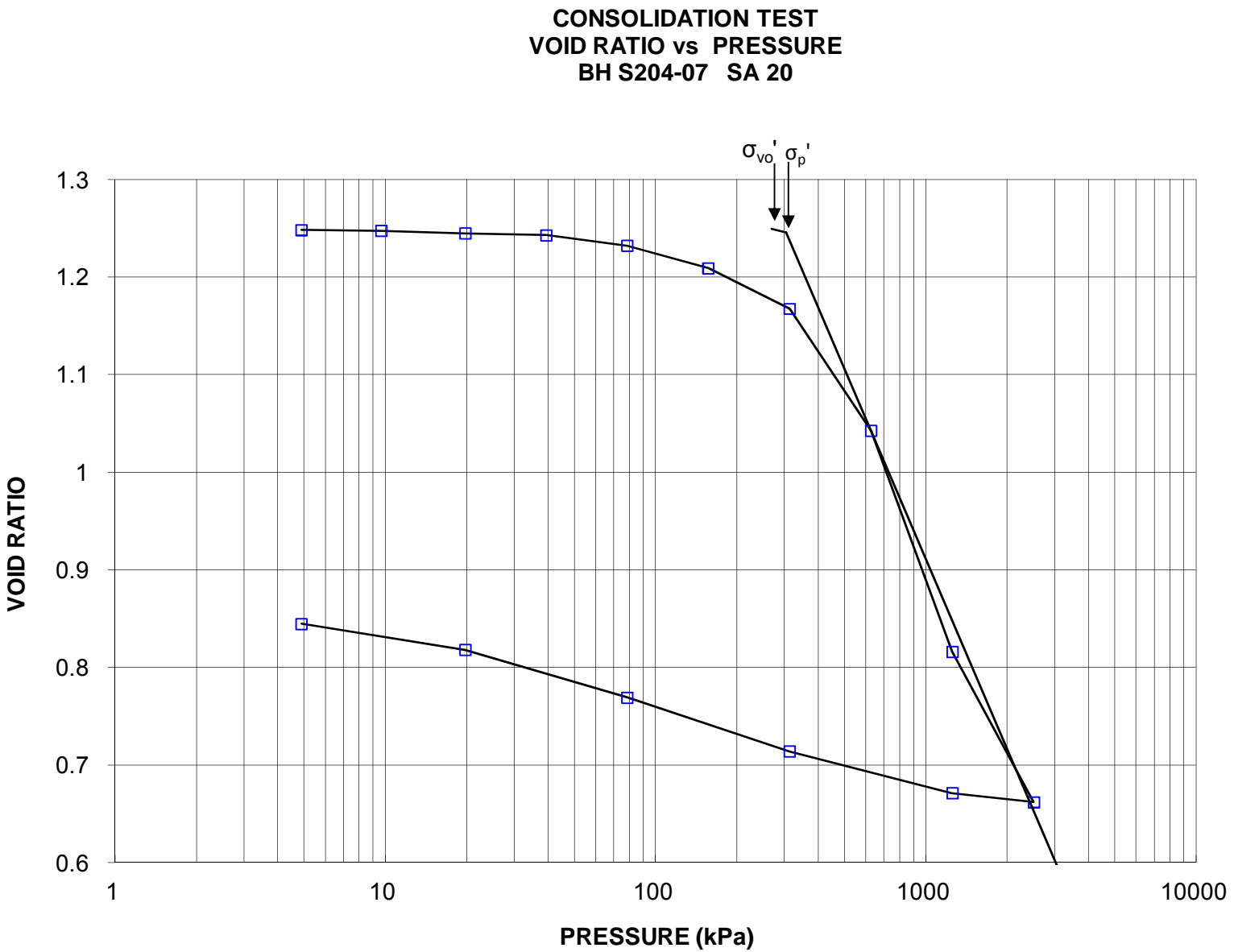
CONSOLIDATION TEST SUMMARY

Highway 69 (SBL) STA 11+725 to 11+825 (Swamp 204)

FIGURE D.S204-12

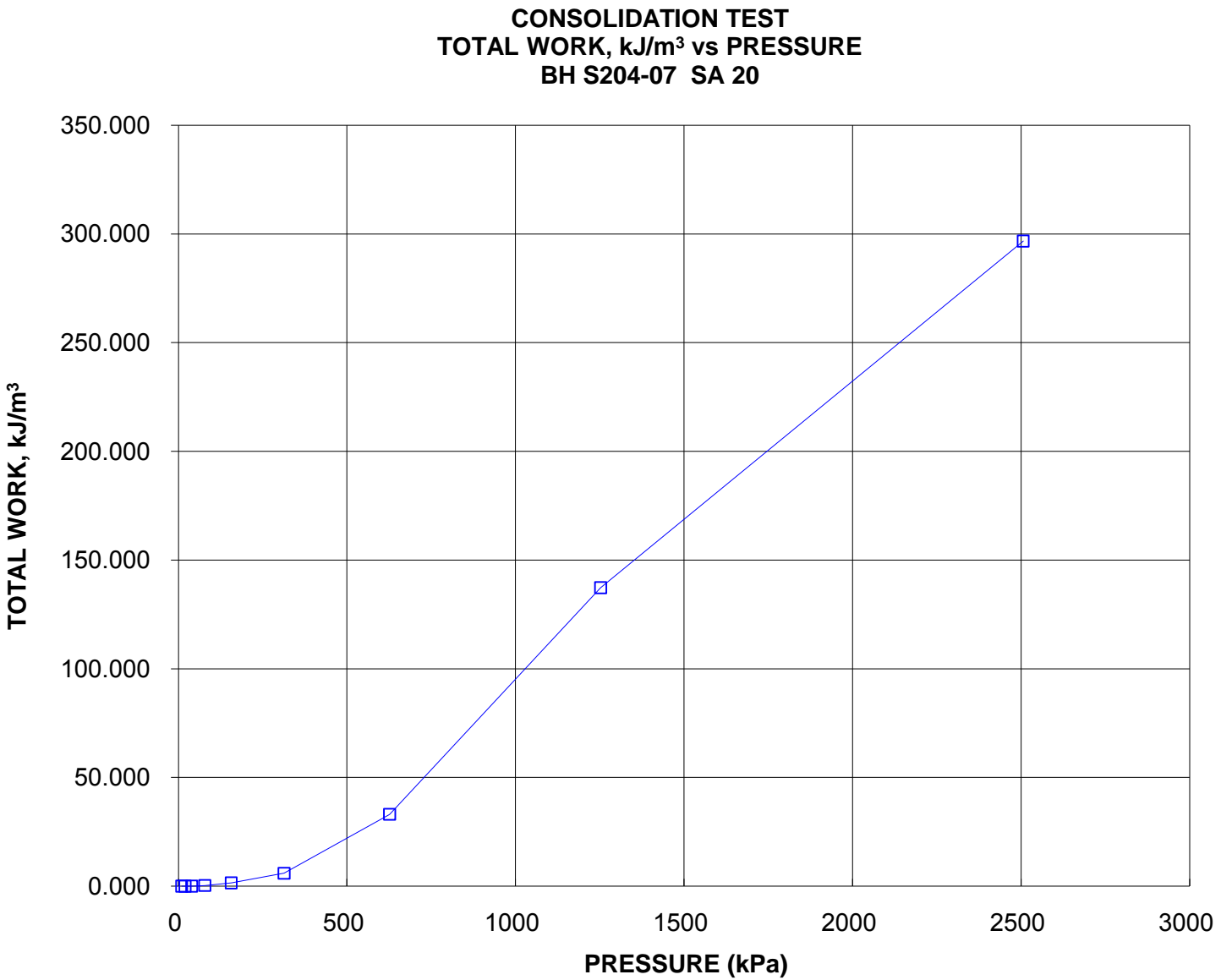
Sheet 2 of 4





CONSOLIDATION TEST SUMMARY
TOTAL WORK VS PRESSURE

FIGURE D.S204-12
Sheet 4 of 4

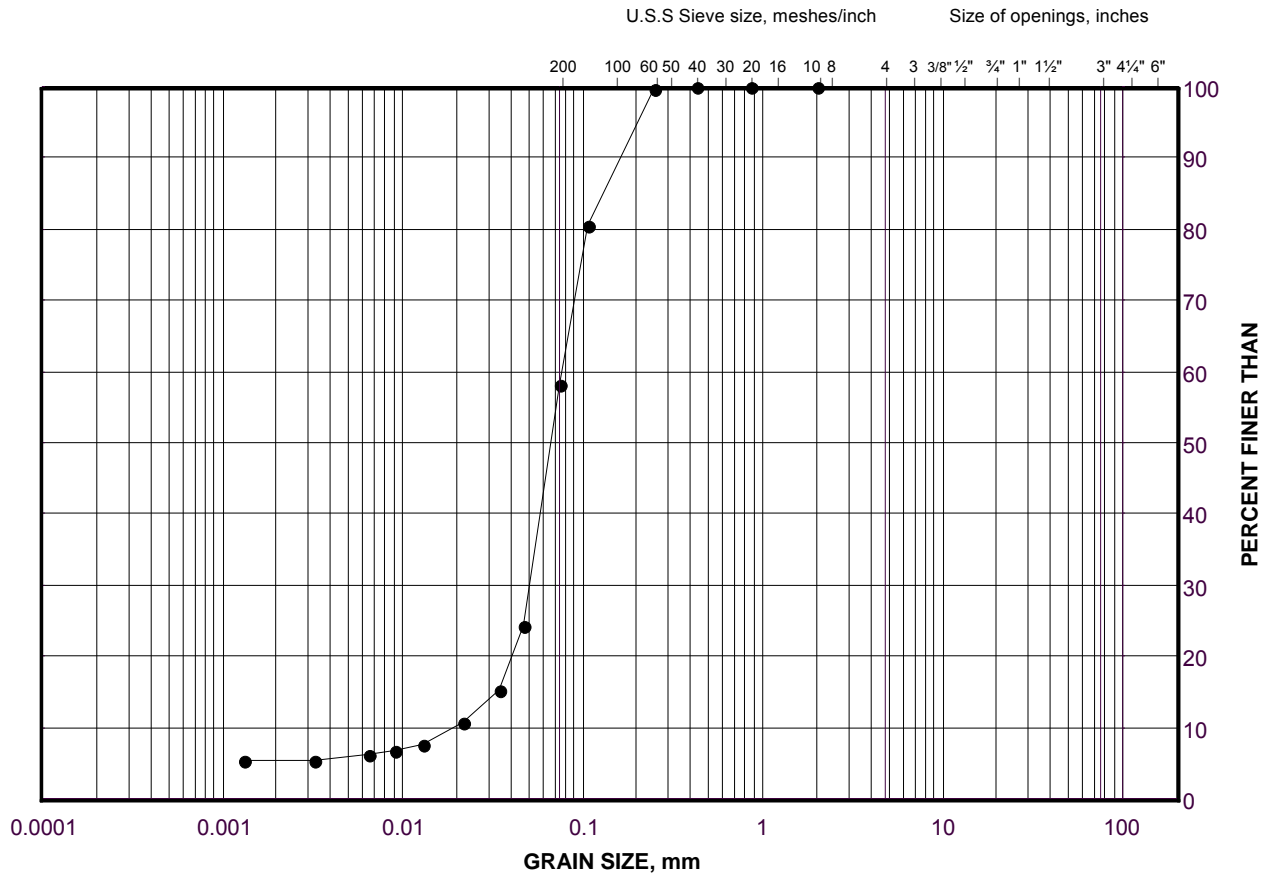


GRAIN SIZE DISTRIBUTION

Sand and Silt (Interlayer)

Highway 69 (SBL) STA 11+725 to 11+825 (Swamp 204)

FIGURE D.S204-13



SILT AND CLAY SIZES			FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED			SAND SIZE			GRAVEL SIZE		SIZE

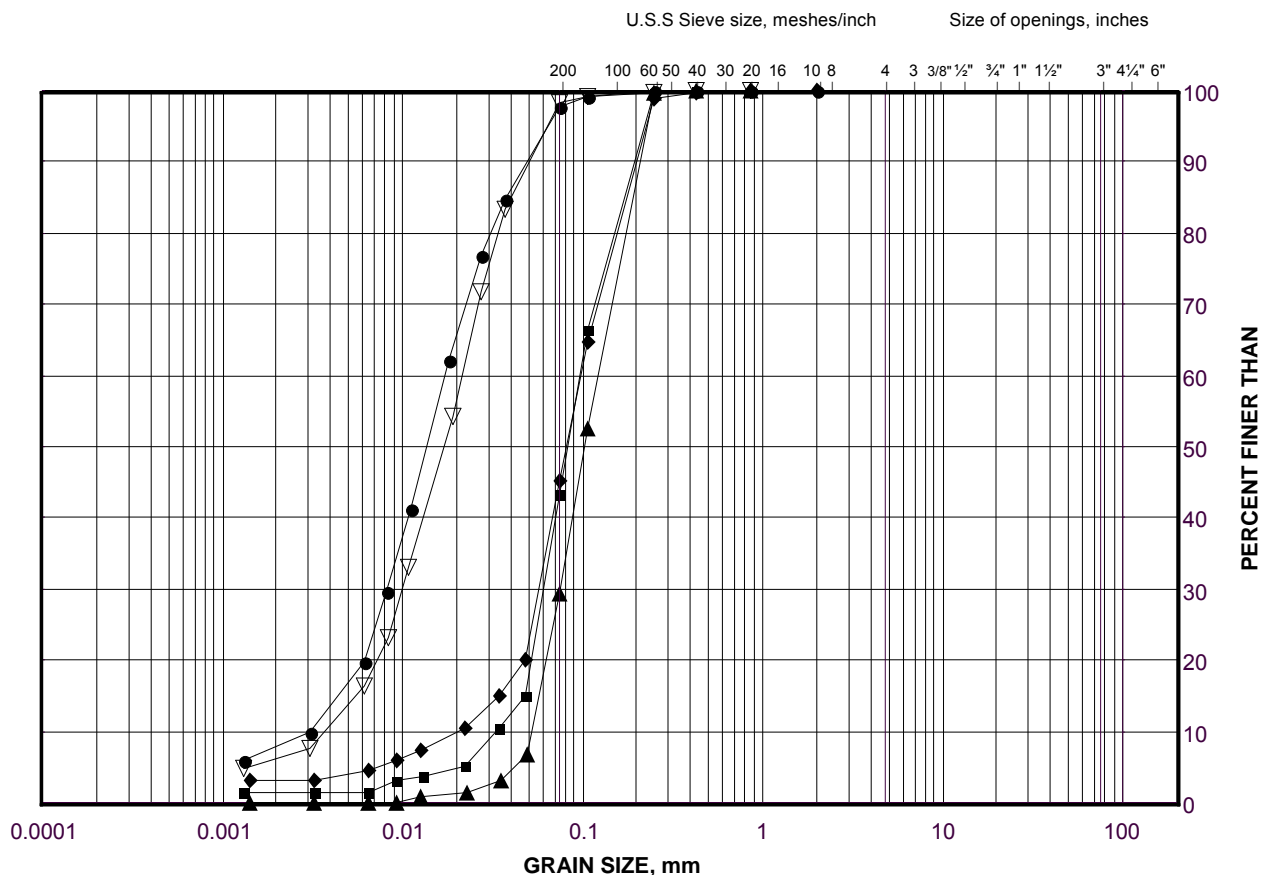
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S204-07	17	159.4

GRAIN SIZE DISTRIBUTION

Silt to Silty Sand to Sand and Silt
Highway 69 (SBL) 11+725 to 11+825 (Swamp 204)

FIGURE D.S204-14



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

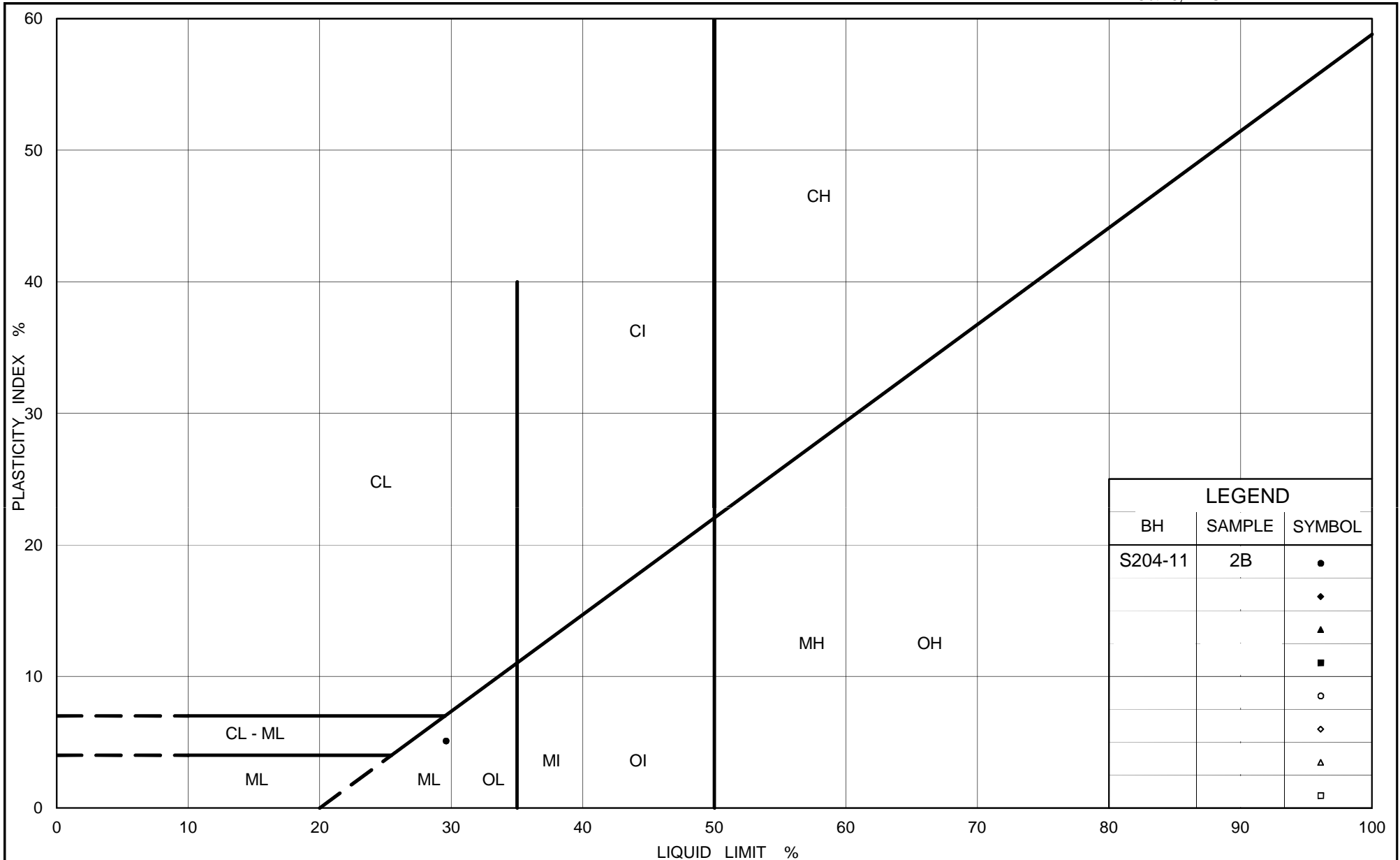
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S204-15	19	151.1
■	S204-08	22	141.9
◆	S204-06	22	144.8
▲	S204-05	22	144.8
▽	S204-09	23	138.0

Project Number: 09-1111-6014

Checked By: TVA

Golder Associates

Date: 17-May-11



Ministry of Transportation

Ontario

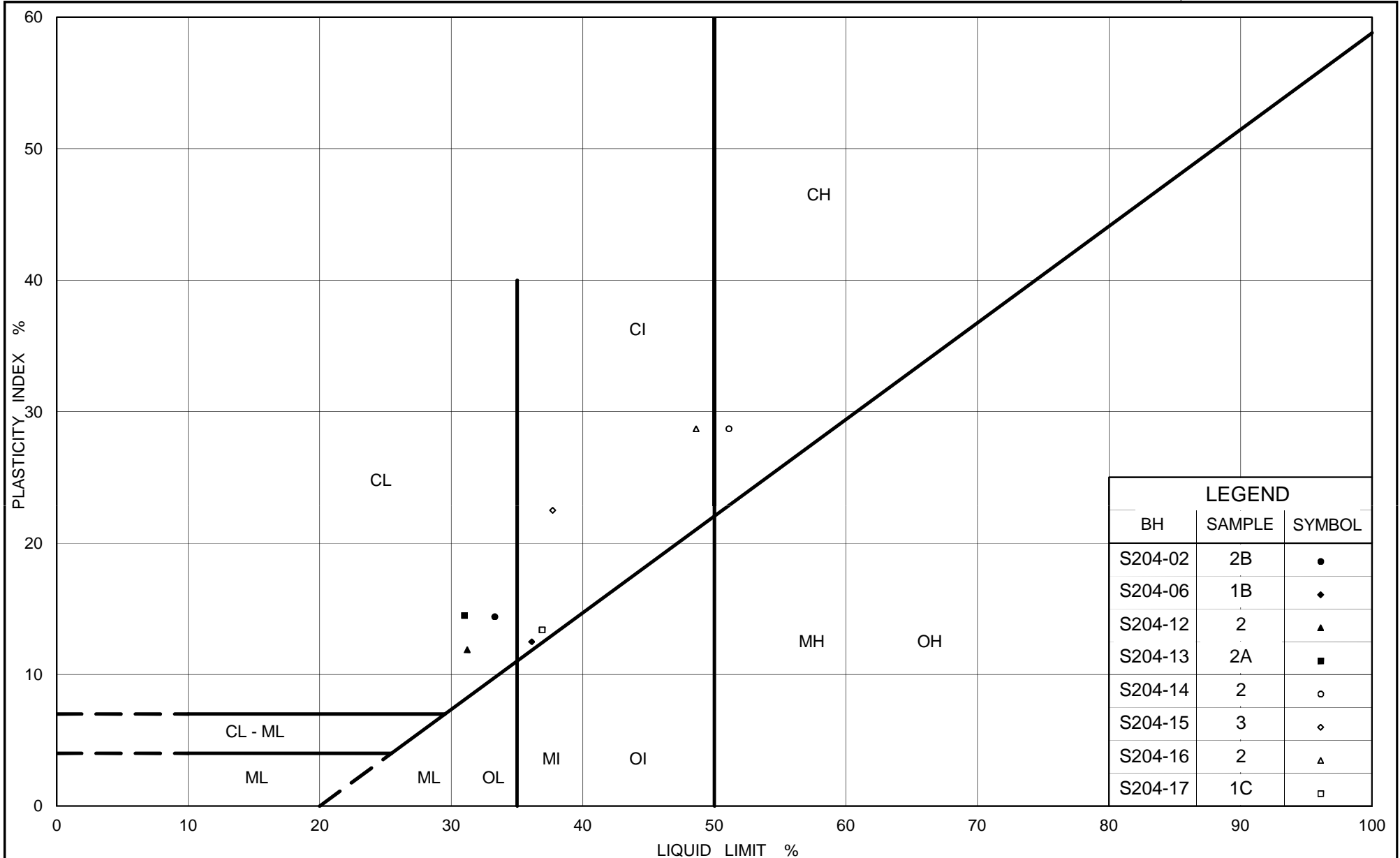
PLASTICITY CHART Silt (Slight Plasticity)

Highway 69 (NBL) STA 11+700 to 11+800 (Swamp 204)

Figure No. D.S204-15

Project No. 09-1111-6014

Checked By: TVA



Ministry of Transportation

Ontario

PLASTICITY CHART
 Clayey Silt to Clay (Near Surface)
 Highway 69 (NBL) STA 11+700 to 11+800 (Swamp 204)

Figure No. D.S204-16

Project No. 09-1111-6014

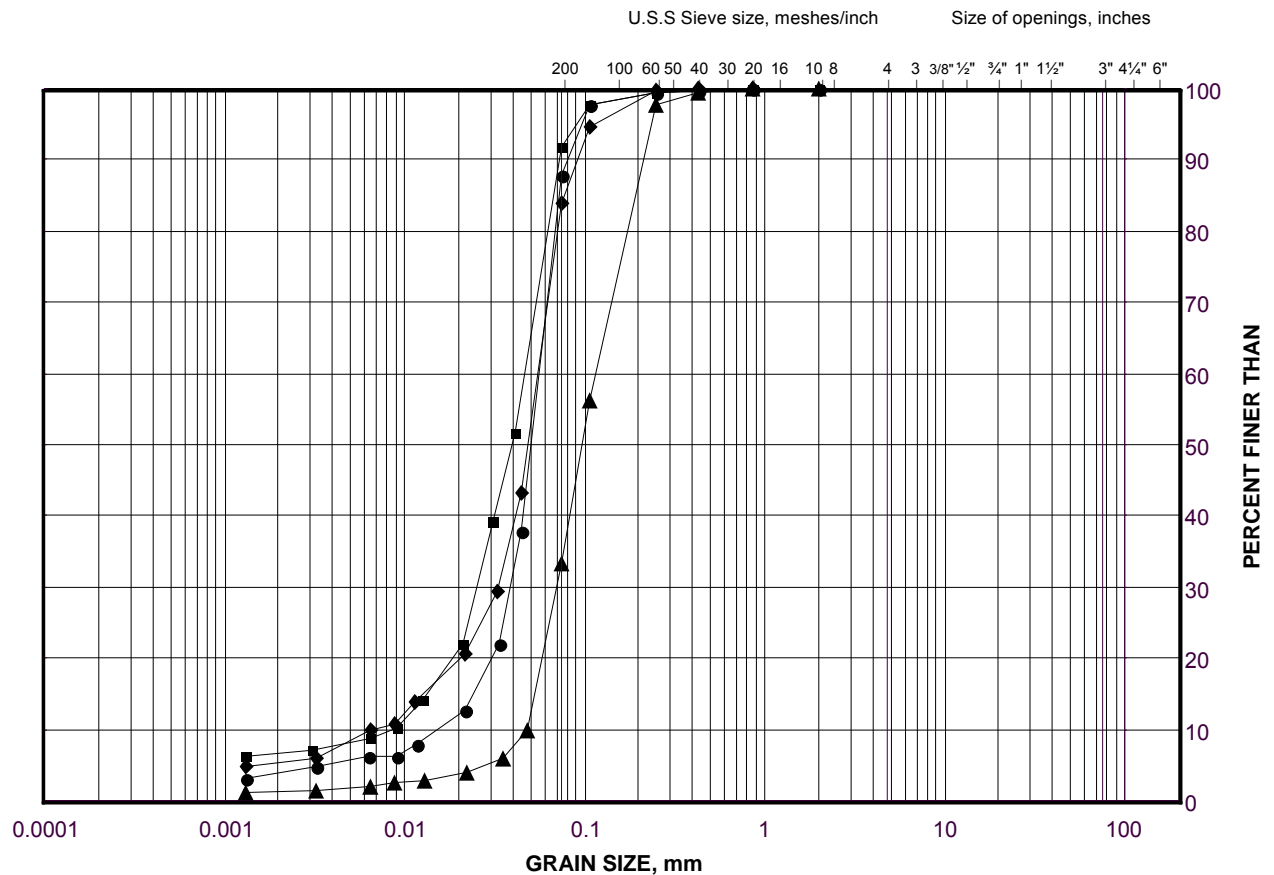
Checked By: TVA

GRAIN SIZE DISTRIBUTION

Sand and Silt to Silt (Upper)

Highway 69 (NBL) STA 11+700 to 11+800 (Swamp 204)

FIGURE D.S204-17A



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

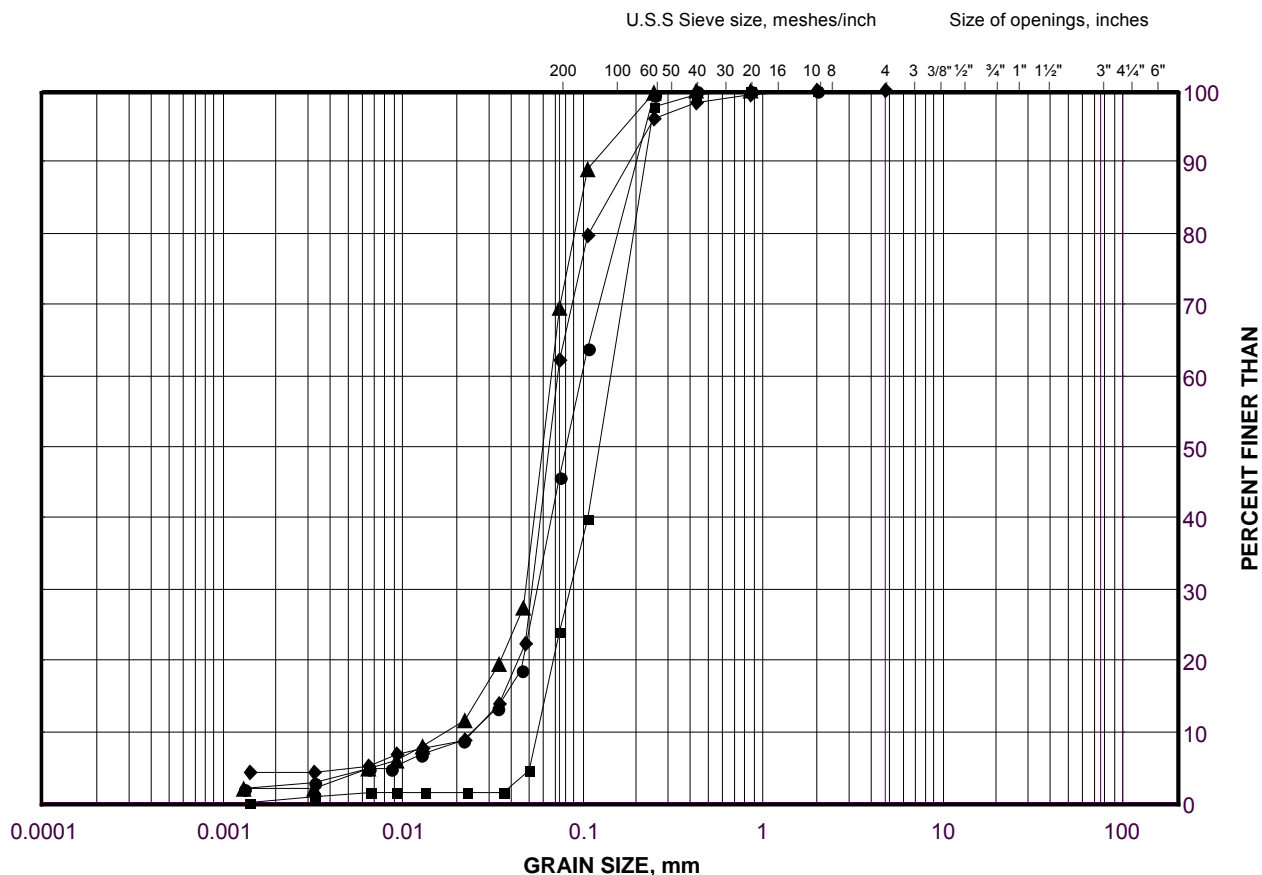
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S204-14	4	178.0
■	S204-13	5	177.2
◆	S204-18	6	177.0
▲	S204-16	6	176.1

GRAIN SIZE DISTRIBUTION

Sand and Silt to Silt to Silty Sand (Upper)
Highway 69 (NBL) STA 11+700 to 11+800 (Swamp 204)

FIGURE D.S204-17B



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

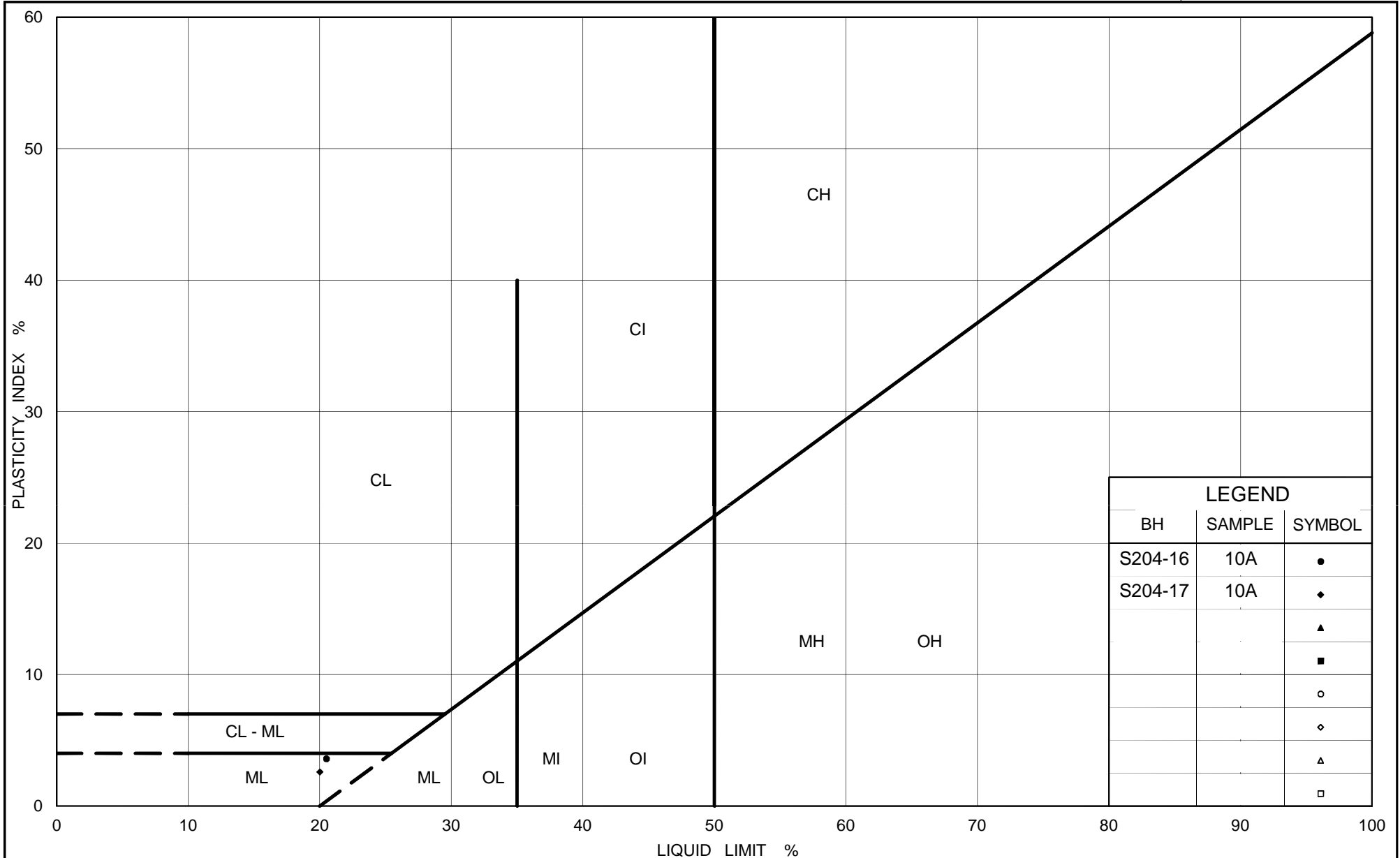
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S204-15	6	176.5
■	S204-17	7	176.2
◆	S204-06	7	176.2
▲	S204-14	8	175.0

Project Number: 09-1111-6014

Checked By: TVA

Golder Associates

Date: 17-May-11



Ministry of Transportation

Ontario

PLASTICITY CHART

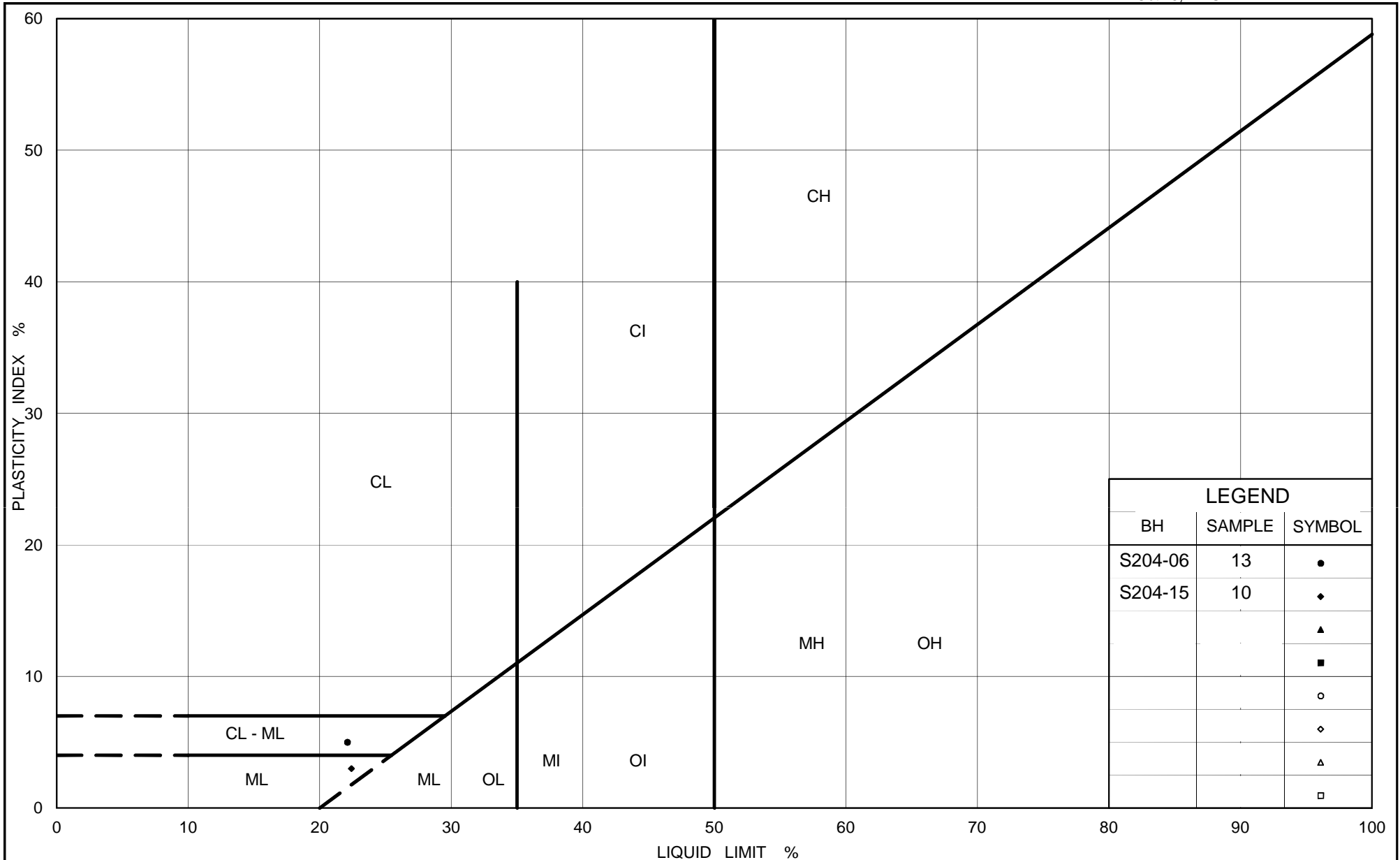
Silt (Upper)

Highway 69 (NBL) STA 11+700 to 11+800 (Swamp 204)

Figure No. D.S204-18

Project No. 09-1111-6014

Checked By: TVA



Ministry of Transportation

Ontario

PLASTICITY CHART Silt (Lower)

Highway 69 (NBL) STA 11+700 to 11+800 (Swamp 204)

Figure No. D.S204-19

Project No. 09-1111-6014

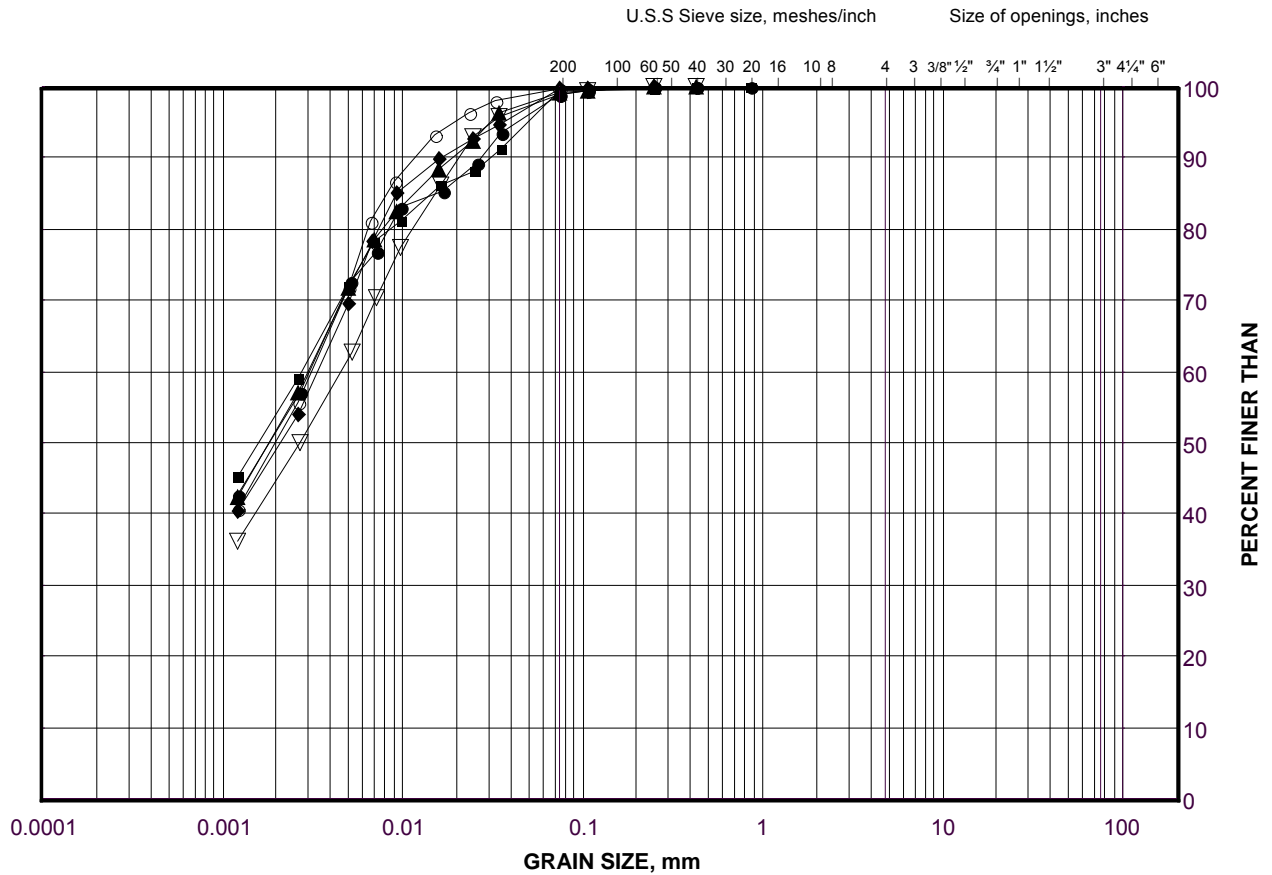
Checked By: TVA

GRAIN SIZE DISTRIBUTION

Silty Clay to Clay

Highway 69 (NBL) STA 11+700 to 11+800 (Swamp 204)

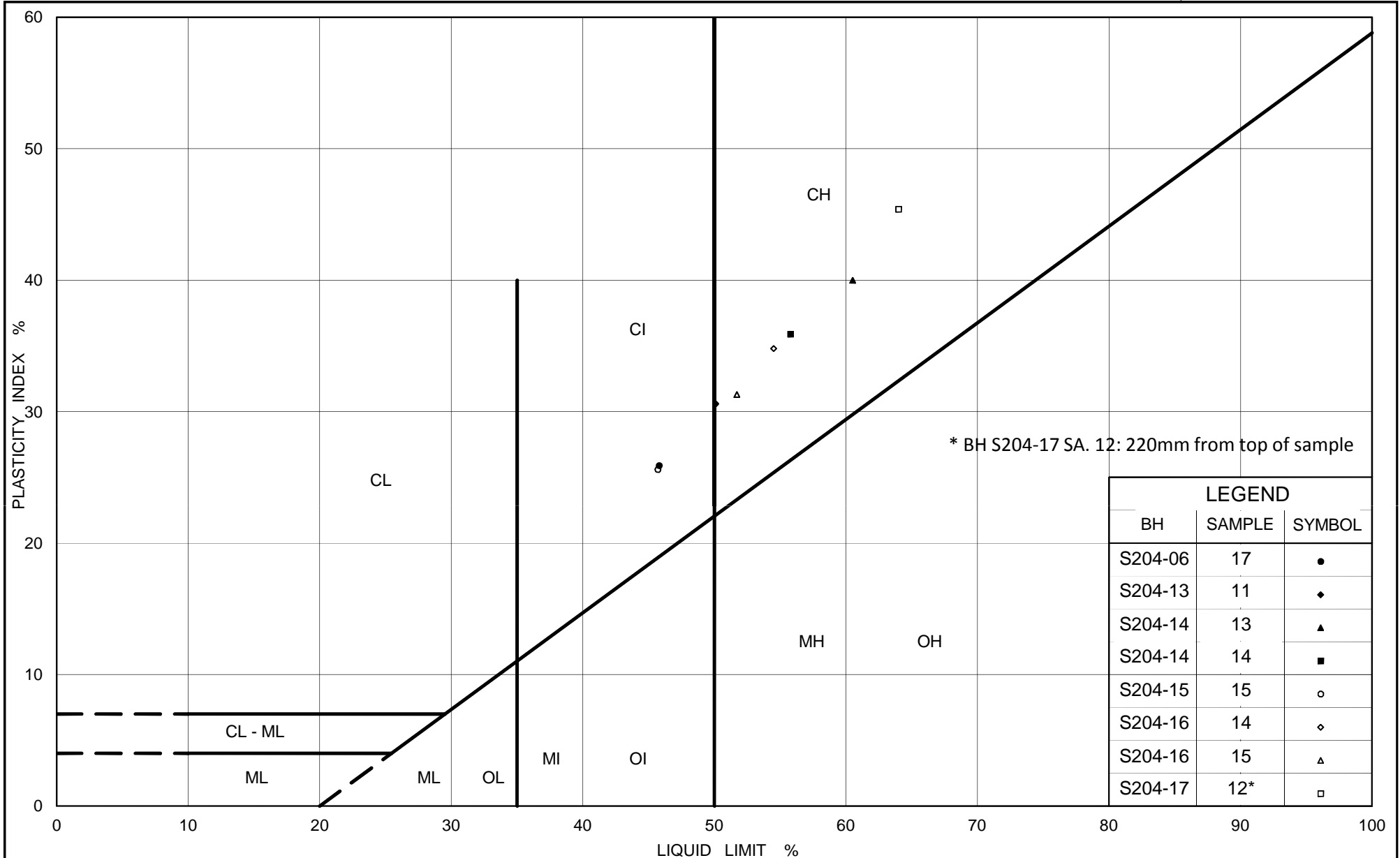
FIGURE D.S204-20



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S204-18	13	167.5
■	S204-16	15	159.8
◆	S204-17	17	157.1
▲	S204-06	17	159.6
▽	S204-18	20	150.8
○	S204-12	5	177.8



Ministry of Transportation

Ontario

PLASTICITY CHART

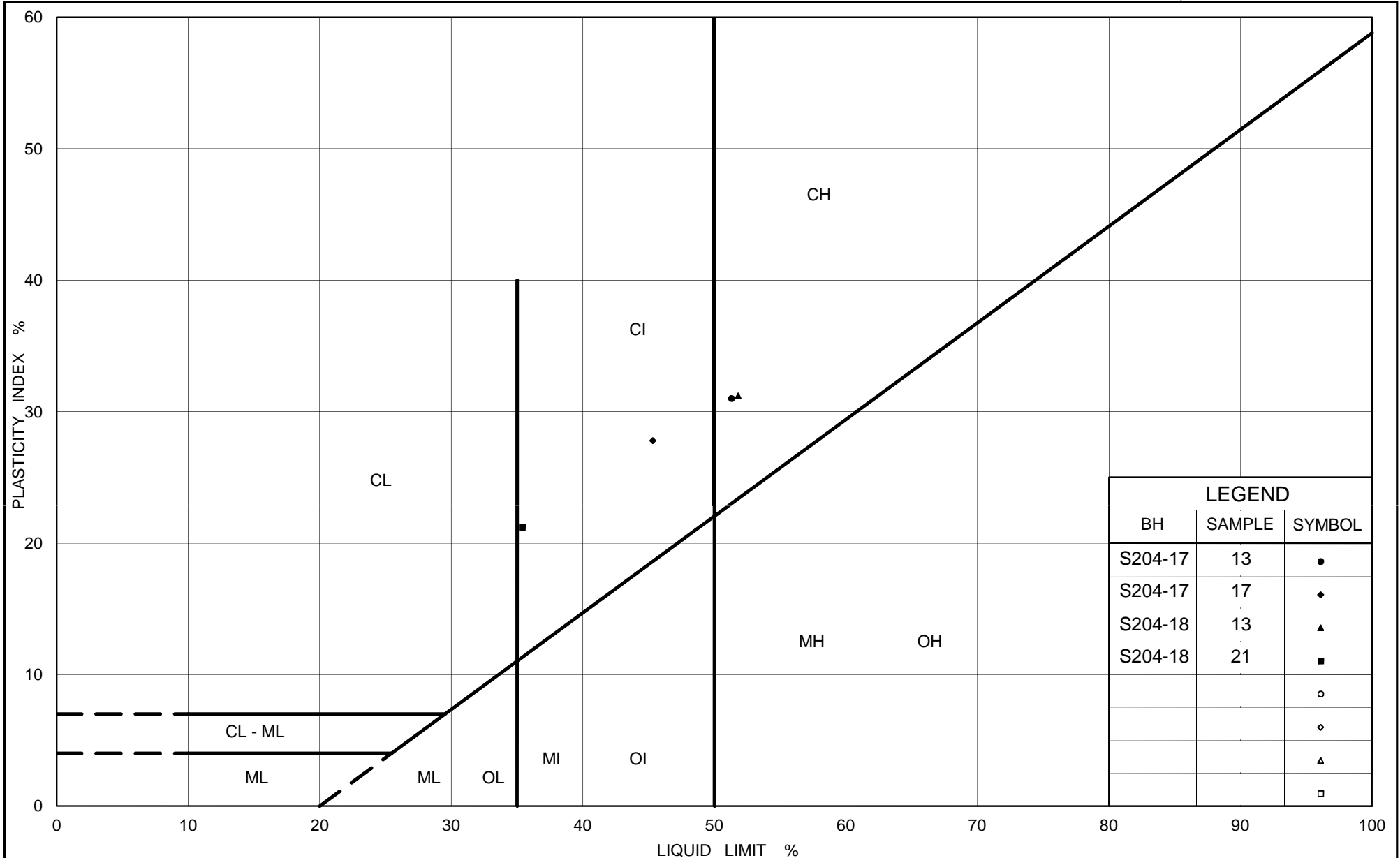
Silty Clay to Clay

Highway 69 (NBL) STA 11+700 to 11+800 (Swamp 204)

Figure No. D.S204-21A

Project No. 09-1111-6014

Checked By: TVA



Ministry of Transportation

Ontario

PLASTICITY CHART

Silty Clay to Clay

Highway 69 (NBL) STA 11+700 to 11+800 (Swamp 204)

Figure No. D.S204-21B

Project No. 09-1111-6014

Checked By: TVA

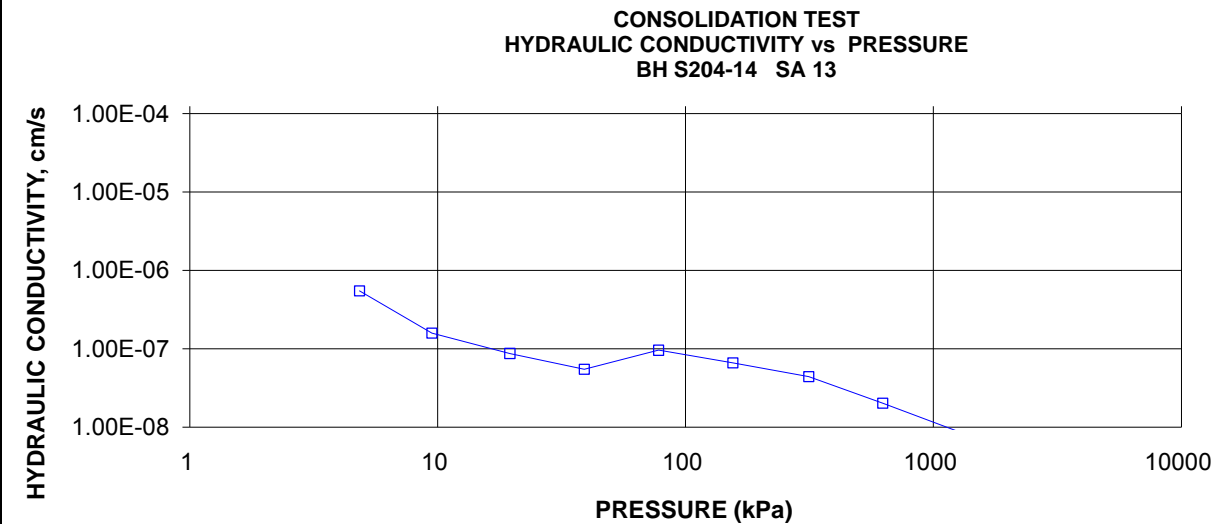
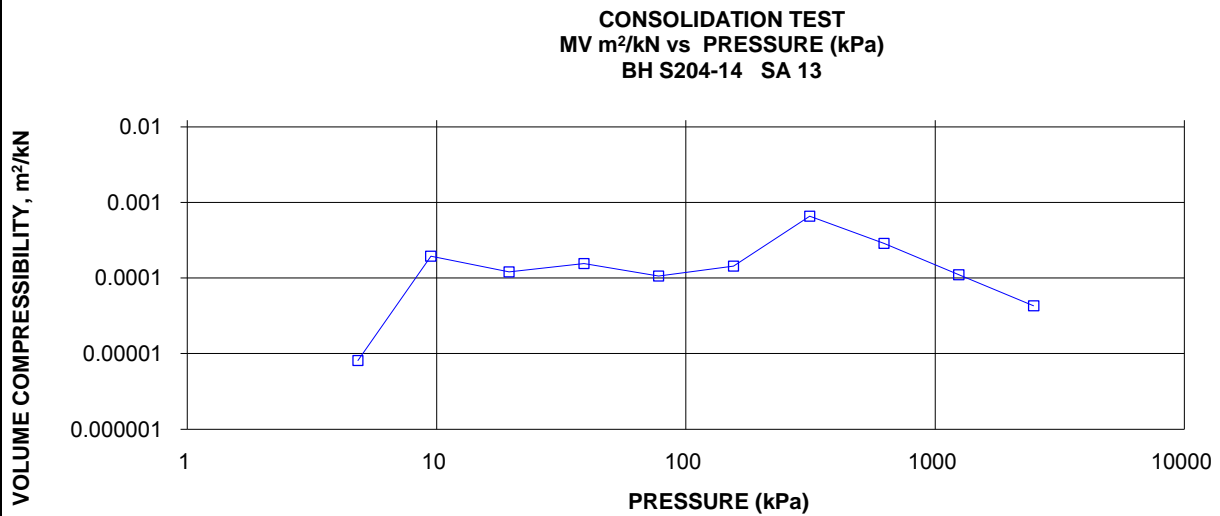
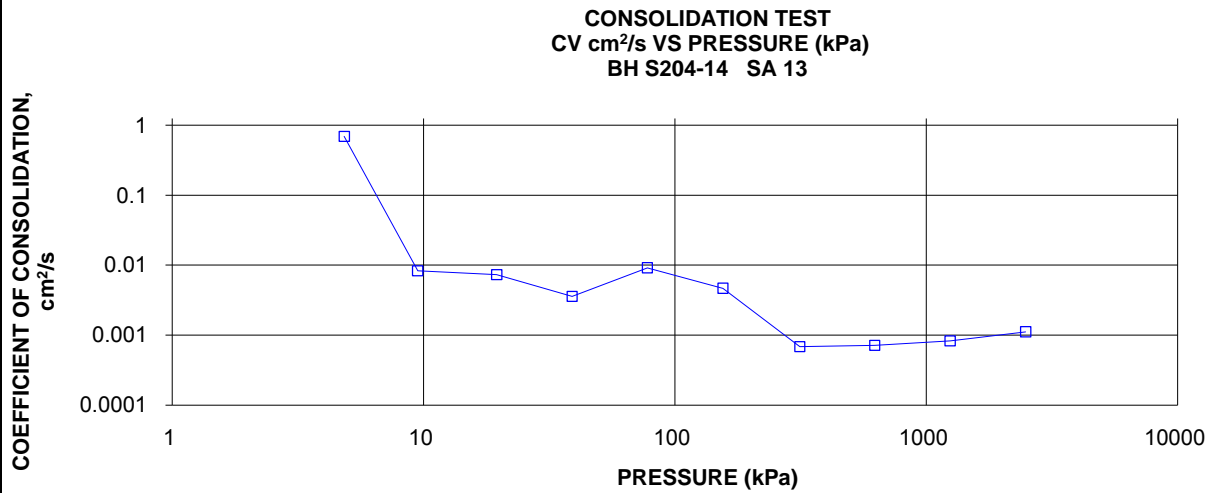
CONSOLIDATION TEST SUMMARY					FIGURE D.S204-22		
Highway 69 (NBL) STA 11+700 to 11+800 (Swamp 204)					Sheet 1 of 4		
SAMPLE IDENTIFICATION							
Project Number	09-1111-6014				Sample Number	13	
Borehole Number	S204-14				Sample Depth, m	13.4	
TEST CONDITIONS							
Test Type	Standard				Load Duration, hr	24	
Oedometer Number	12						
Date Started	4/8/2010						
Date Completed	4/21/2010						
SAMPLE DIMENSIONS AND PROPERTIES - INITIAL							
Sample Height, cm	2.55				Unit Weight, kN/m ³	16.74	
Sample Diameter, cm	6.34				Dry Unit Weight, kN/m ³	10.96	
Area, cm ²	31.57				Specific Gravity, measured	2.75	
Volume, cm ³	80.50				Solids Height, cm	1.037	
Water Content, %	52.70				Volume of Solids, cm ³	32.73	
Wet Mass, g	137.43				Volume of Voids, cm ³	47.78	
Dry Mass, g	90				Degree of Saturation, %	99.3	
TEST COMPUTATIONS							
	Corr.		Average				
Pressure	Height	Void	Height	t ₉₀	cv.	mv	k
kPa	cm	Ratio	cm	sec	cm ² /s	m ² /kN	cm/s
0.00	2.550	1.460	2.550				
4.84	2.550	1.460	2.550	2	6.89E-01	8.10E-06	5.47E-07
9.48	2.548	1.457	2.549	166	8.30E-03	1.94E-04	1.58E-07
19.55	2.545	1.454	2.546	187	7.35E-03	1.21E-04	8.69E-08
39.01	2.537	1.447	2.541	382	3.58E-03	1.55E-04	5.45E-08
77.76	2.526	1.437	2.532	148	9.18E-03	1.06E-04	9.56E-08
155.17	2.498	1.410	2.512	286	4.68E-03	1.43E-04	6.57E-08
313.71	2.233	1.154	2.365	1732	6.85E-04	6.56E-04	4.40E-08
624.24	2.006	0.935	2.120	1328	7.17E-04	2.86E-04	2.01E-08
1244.36	1.833	0.768	1.919	943	8.28E-04	1.10E-04	8.92E-09
2485.19	1.697	0.637	1.765	591	1.12E-03	4.29E-05	4.69E-09
1244.36	1.702	0.641	1.699				
313.71	1.748	0.686	1.725				
77.76	1.806	0.742	1.777				
19.55	1.849	0.784	1.827				
4.84	1.878	0.811	1.863				
Note: k calculated using cv based on t ₉₀ values.							
SAMPLE DIMENSIONS AND PROPERTIES - FINAL							
Sample Height, cm	1.88				Unit Weight, kN/m ³	19.54	
Sample Diameter, cm	6.34				Dry Unit Weight, kN/m ³	14.89	
Area, cm ²	31.57				Specific Gravity, measured	2.75	
Volume, cm ³	59.28				Solids Height, cm	1.037	
Water Content, %	31.26				Volume of Solids, cm ³	32.73	
Wet Mass, g	118.13				Volume of Voids, cm ³	26.55	
Dry Mass, g	90						
Prepared By: LFG					Golder Associates		Checked By: TVA

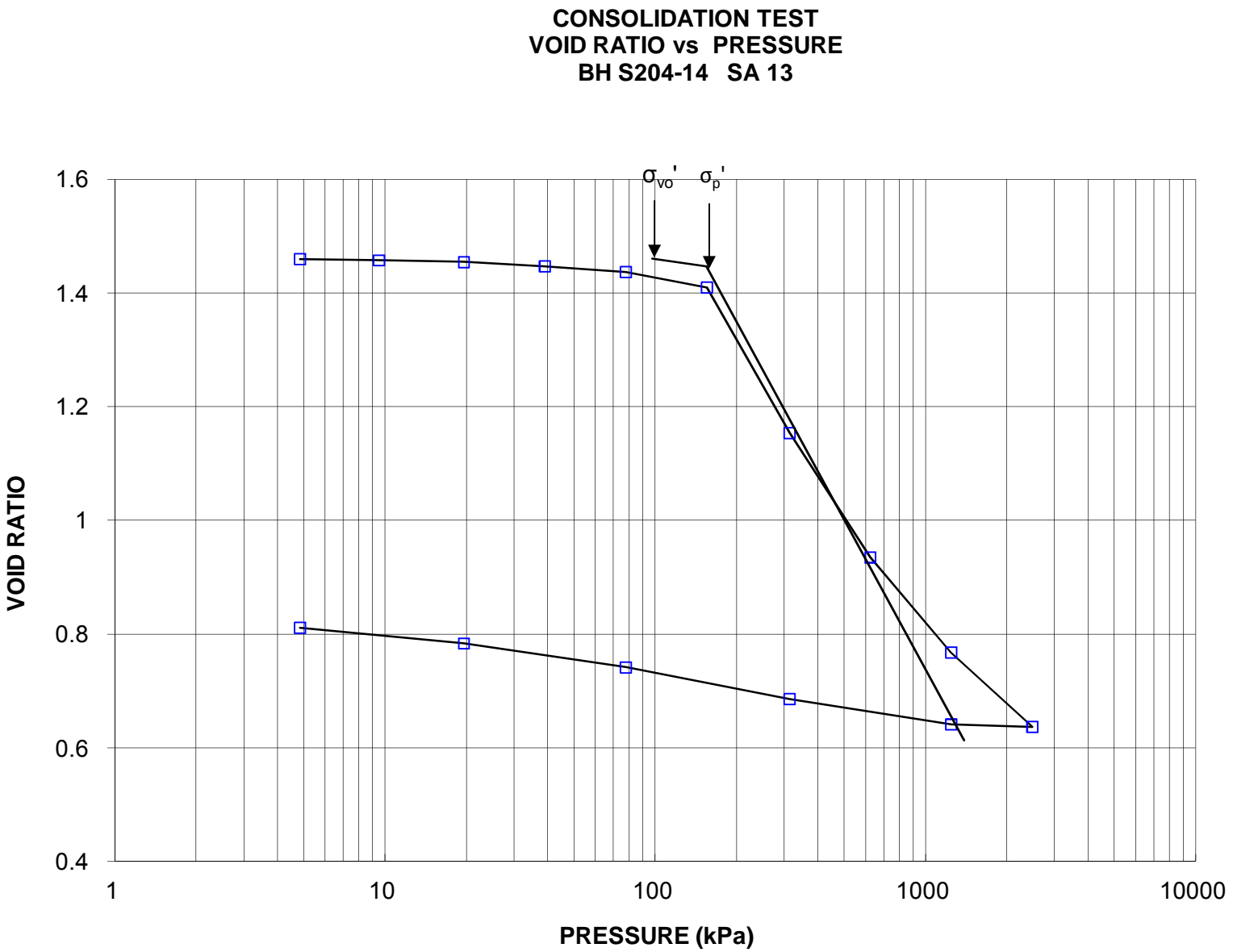
CONSOLIDATION TEST SUMMARY

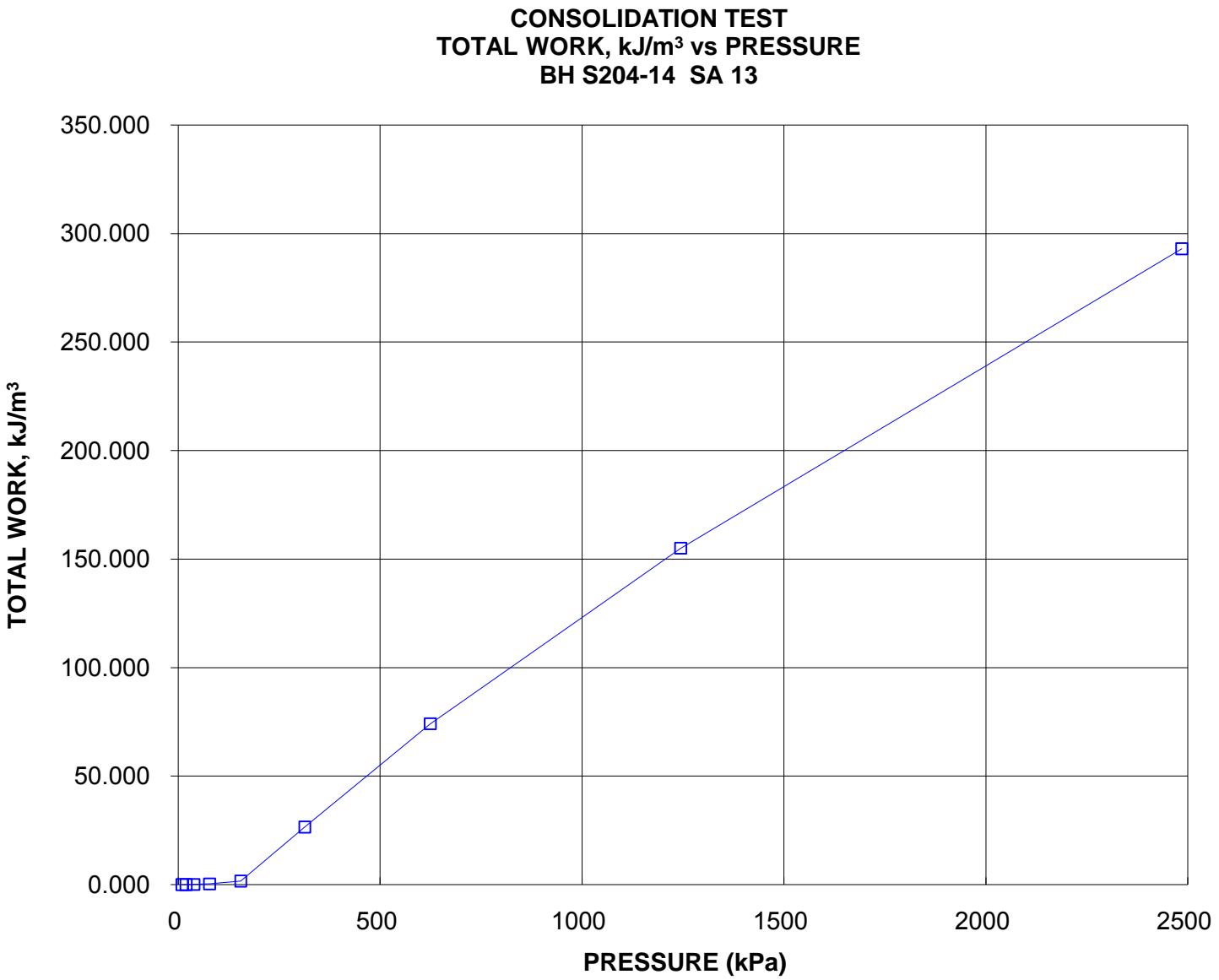
Highway 69 (NBL) STA 11+700 to 11+800 (Swamp 204)

FIGURE D.S204-22

Sheet 2 of 4





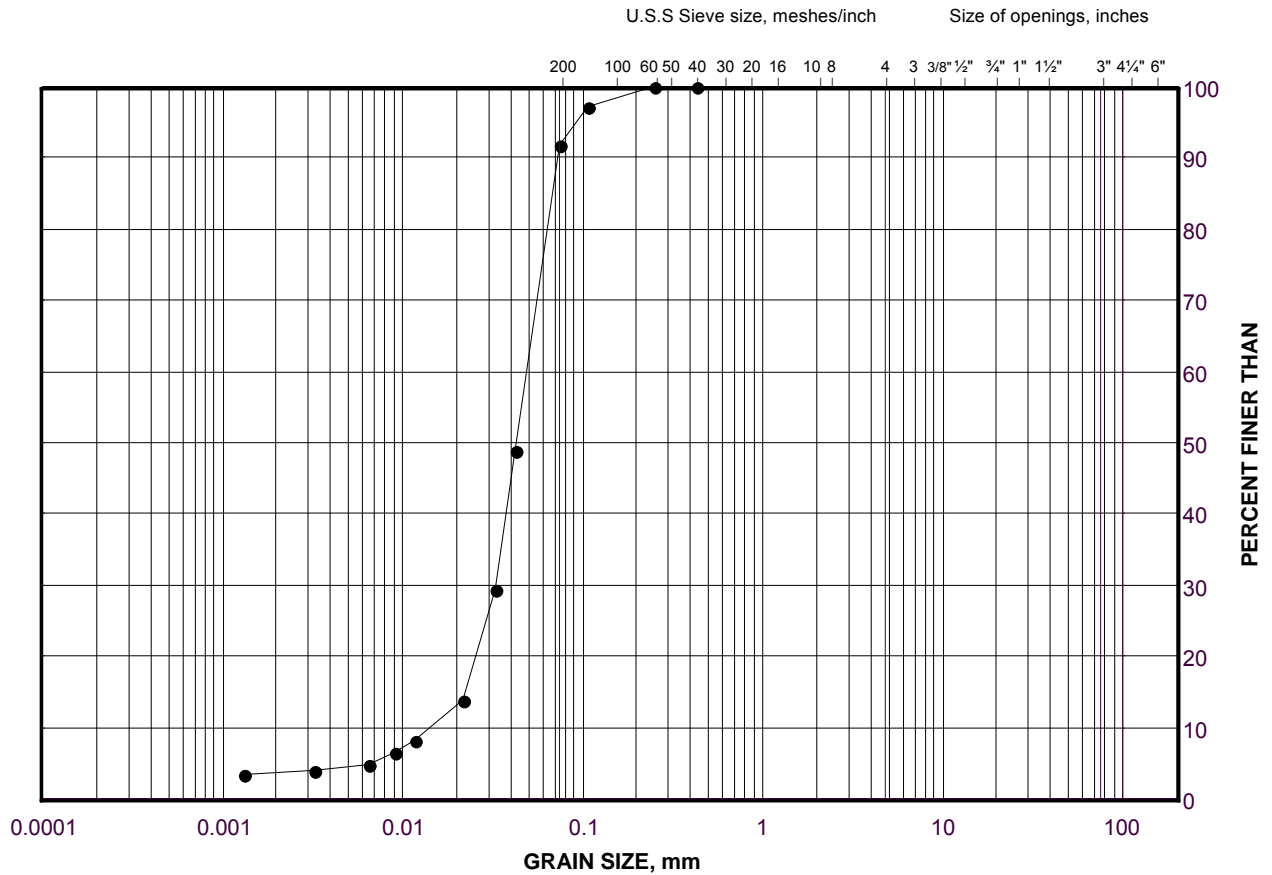


GRAIN SIZE DISTRIBUTION

Silt (Interlayer)

Highway 69 (NBL) STA 11+700 to 11+800 (Swamp 204)

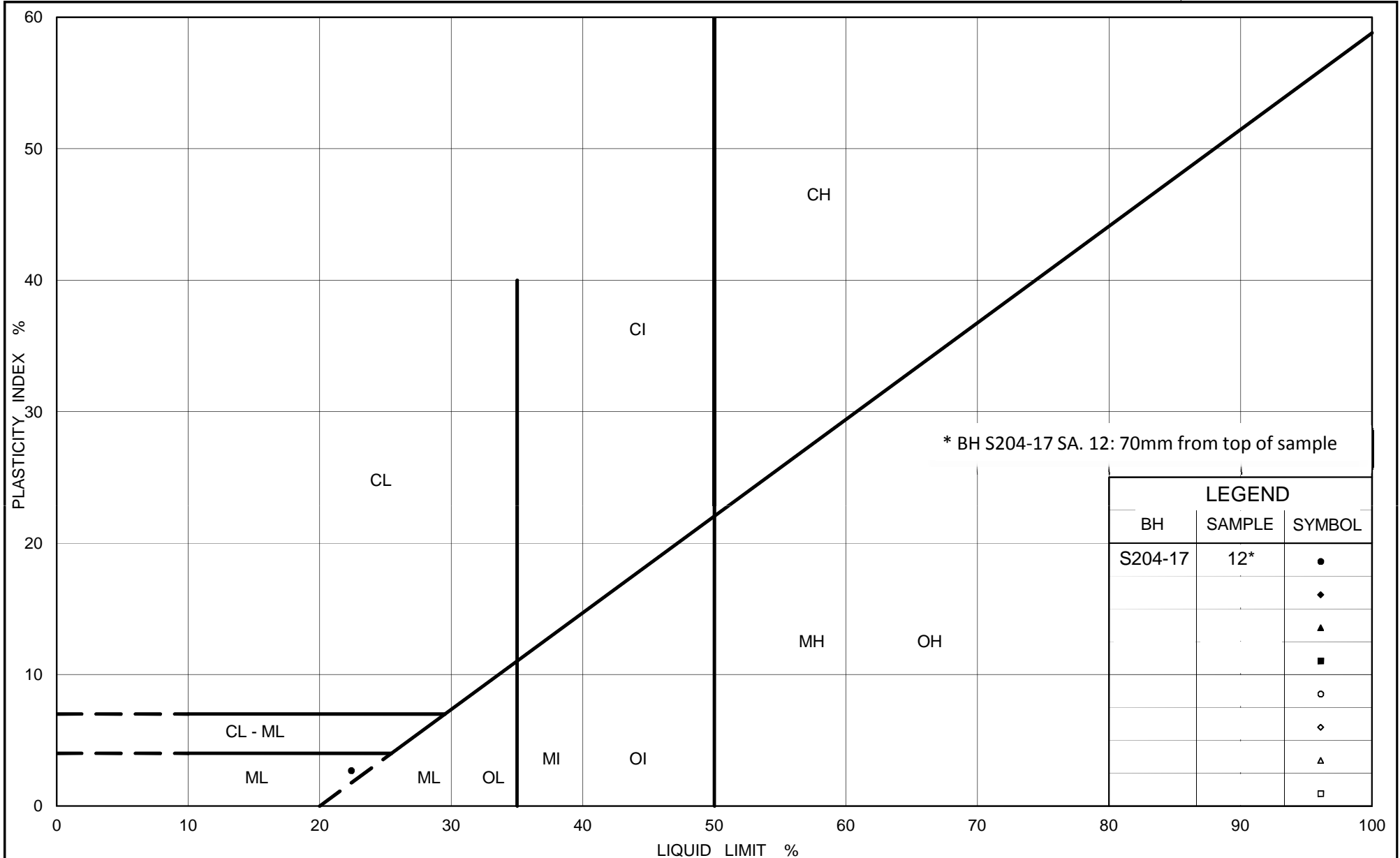
FIGURE D.S204-23



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S204-18	17	159.5



Ministry of Transportation

Ontario

PLASTICITY CHART Silt (Slight Plasticity)

Highway 69 (NBL) STA 11+700 to 11+800 (Swamp 204)

Figure No. D.S204-24

Project No. 09-1111-6014

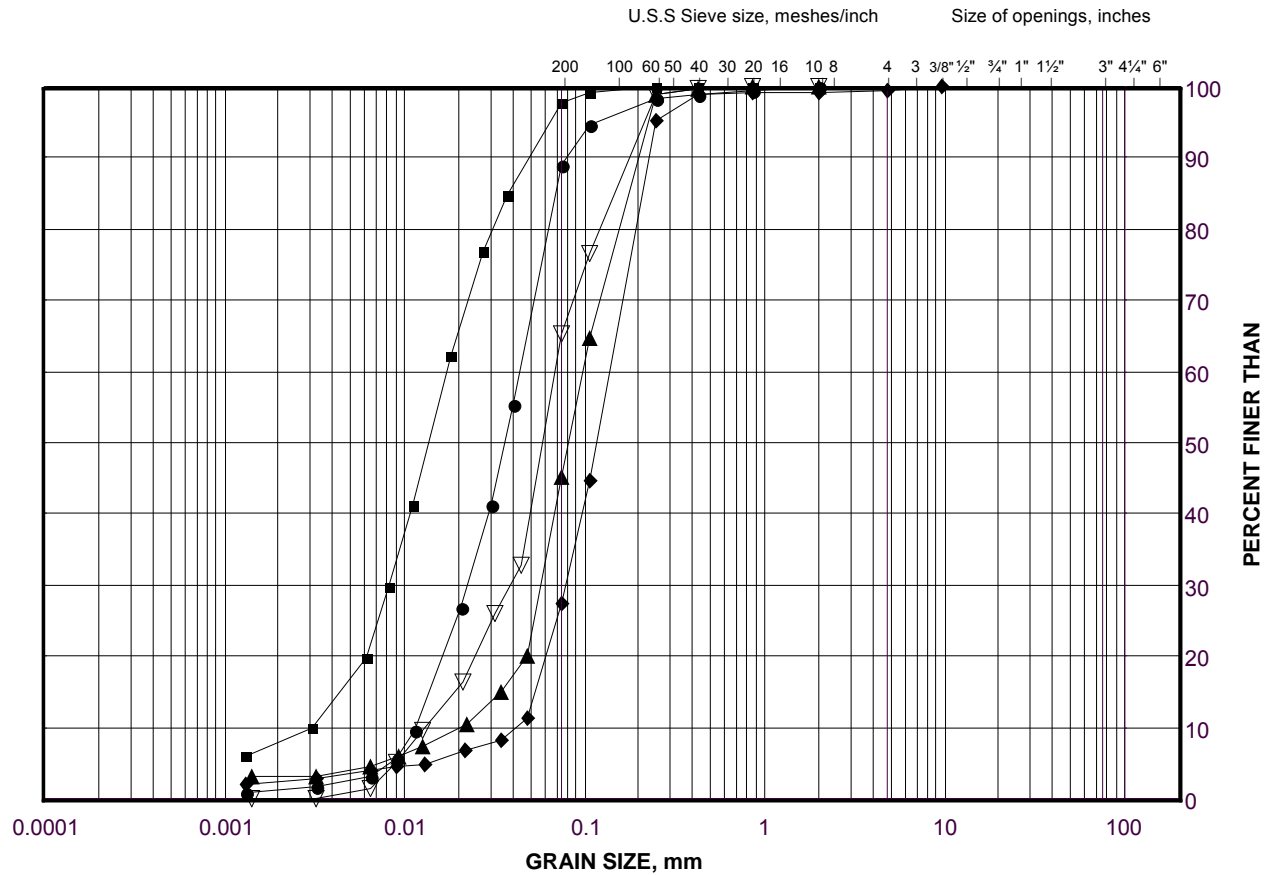
Checked By: TVA

GRAIN SIZE DISTRIBUTION

Silt to Sand and Silt to Silty Sand

Highway 69 (NBL) STA 11+700 to 11+800 (Swamp 204)

FIGURE D.S204-25A



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S204-16	19	147.8
■	S204-15	19	151.1
◆	S204-17	22	144.8
▲	S204-06	22	144.8
▽	S204-18	23	141.6

Project Number: 09-1111-6014

Checked By: TVA

Golder Associates

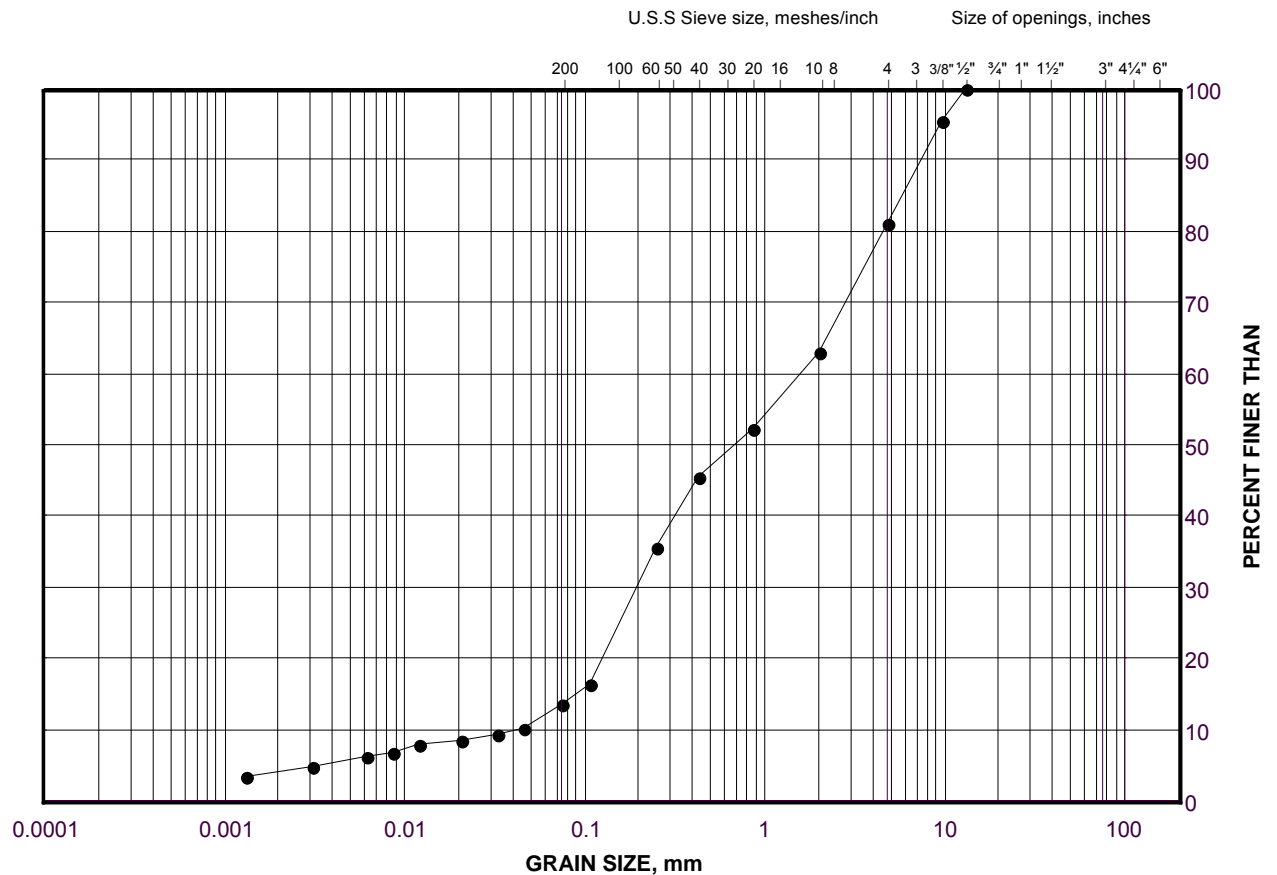
Date: 17-May-11

GRAIN SIZE DISTRIBUTION

Sand

Highway 69 (NBL) STA 11+700 to 11+800 (Swamp 204)

FIGURE D.S204-25B



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

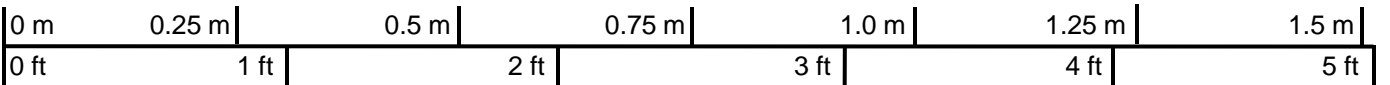
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S204-14	18	156.7


Borehole S204-12



Box 1: 6.00 m – 8.96 m



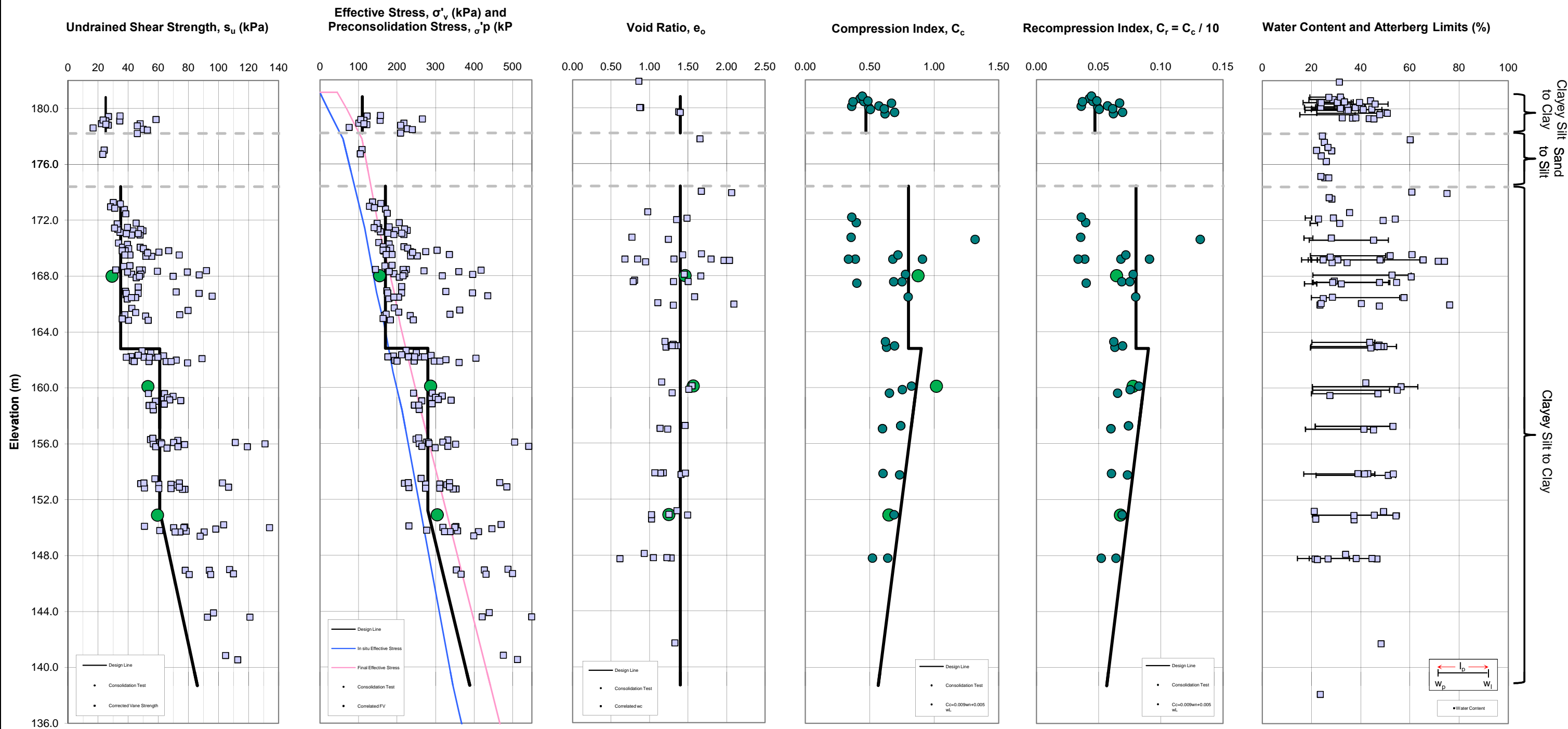
Scale

PROJECT				Swamp Crossings and High Fill Areas Highway 69 Four-Laning GWP 5404-05-00; WP 5404-05-01		
TITLE				Core Photo – Swamp 204 Highway 69 (NBL) STA 11+700 to 11+800		
				PROJECT No. 09-1111-6014		FILE No. ----
				DESIGN	AT	
				CADD	--	
				CHECK	AT	
				REVIEW	TVA	
				SCALE	NTS	REV.
				FIGURE D.S204-26		

\\capw\sites\091111601\highway69\FourLaning\Contract 2\Reporting\Final\Swamp Crossings and High Fill Areas\Tables and Figures\09-1111-6014-Contract 2 Swamp204-Parameters and Design Lines-PRIORITY A-REV_FINAL.xls\Swamp 20

SUMMARY PLOT OF ENGINEERING PARAMETERS FOR
COHESIVE DEPOSITS
Highway 69 SBL - STA 11+725 to 11+825 (Swamp 204)
Highway 69 NBL - STA 11+700 to 11+800 (Swamp 204)

FIGURE D1

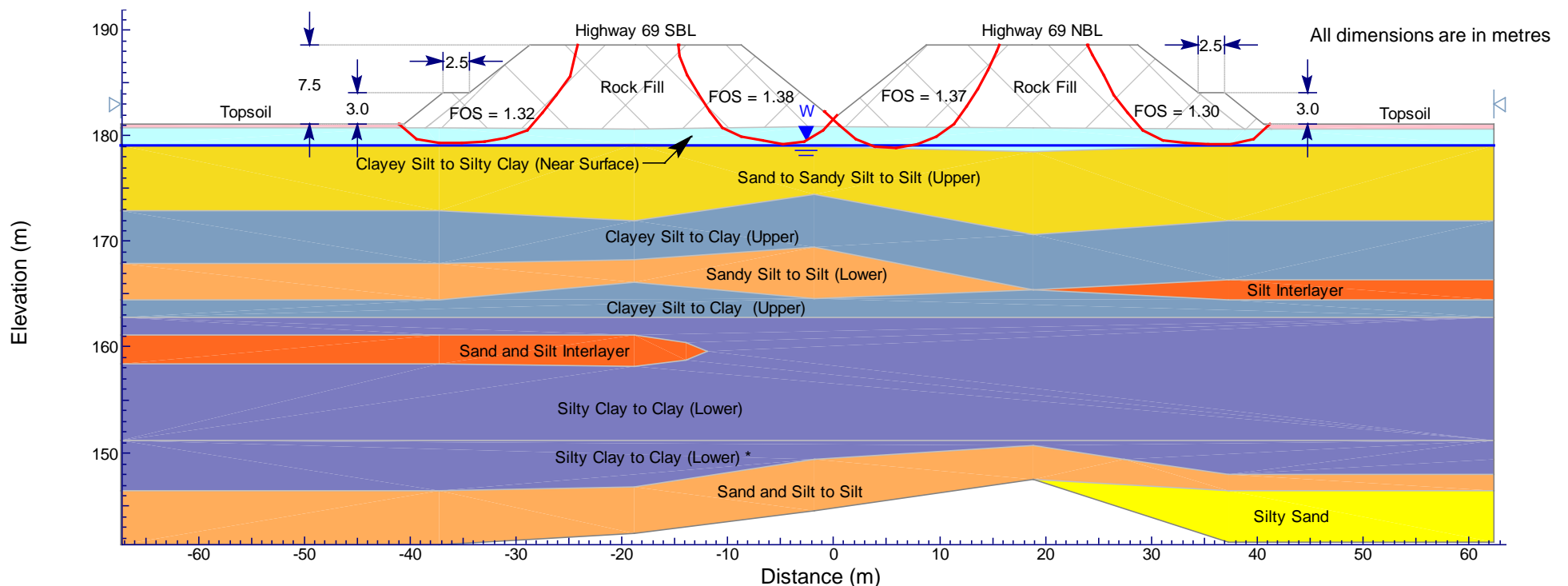




Highway 69 SBL – STA 11+725 to 11+825 (Swamp 204) Highway 69 NBL – STA 11+750 to 11+800 (Swamp 204) Slope Stability (Outside Toe Berms)

Figure D2

Material Name	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (degrees)
Rock Fill	19	0	40
Topsoil	15	1	27
Clayey Silt to Silty Clay (Near Surface)	17.5	25	-
Sand Sandy Silt to Silt (Upper)	18.5	0	28
Clayey Silt to Clay (Upper)	17	35	-
Sandy Silt to Silt (Lower)	18	0	29
Sand and Silt/Silt Interlayer	18	0	29
Silty Clay to Clay (Lower)	17	61	-
Silty Clay to Clay (Lower) *	17	61 – 70.6	-
Sand and Silt to Silt	18	0	29
Silty Sand	19	0	30

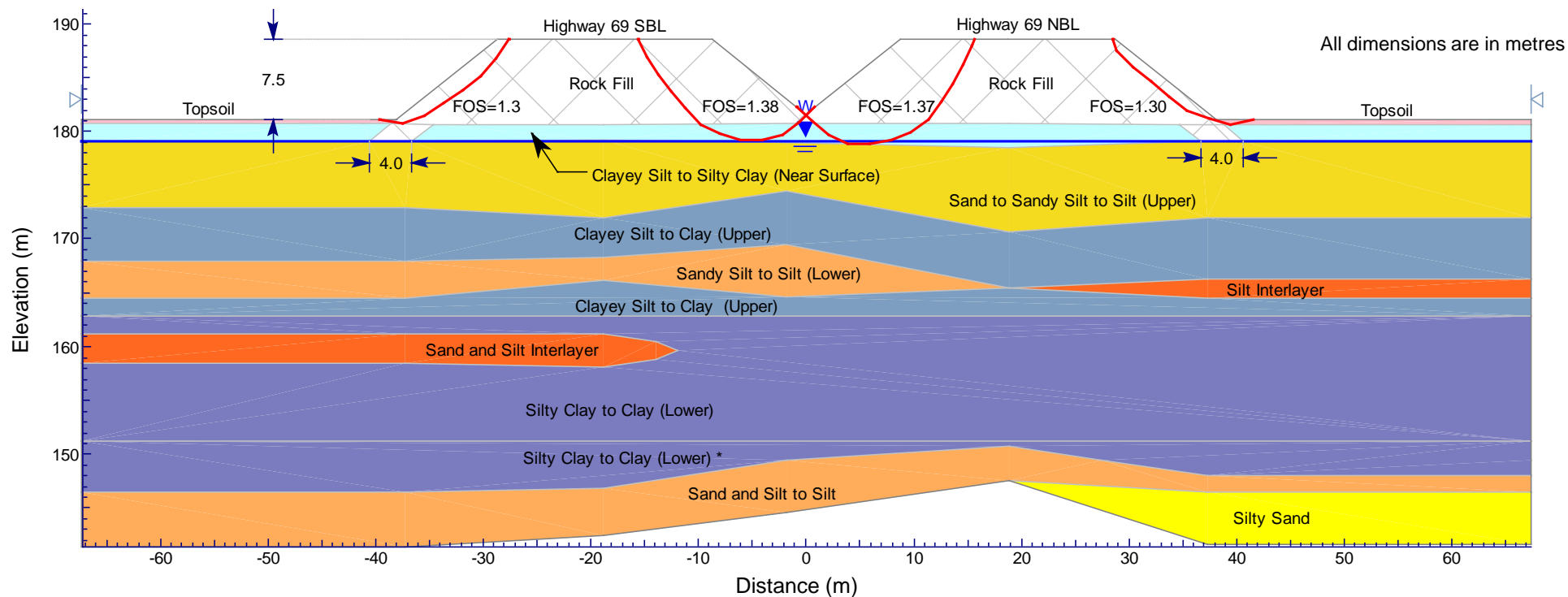




Highway 69 SBL – STA 11+725 to 11+825 (Swamp 204) Highway 69 NBL – STA 11+700 to 11+800 (Swamp 204) Slope Stability (Localized Sub-Excavation Along Outside Toes)

Figure D3

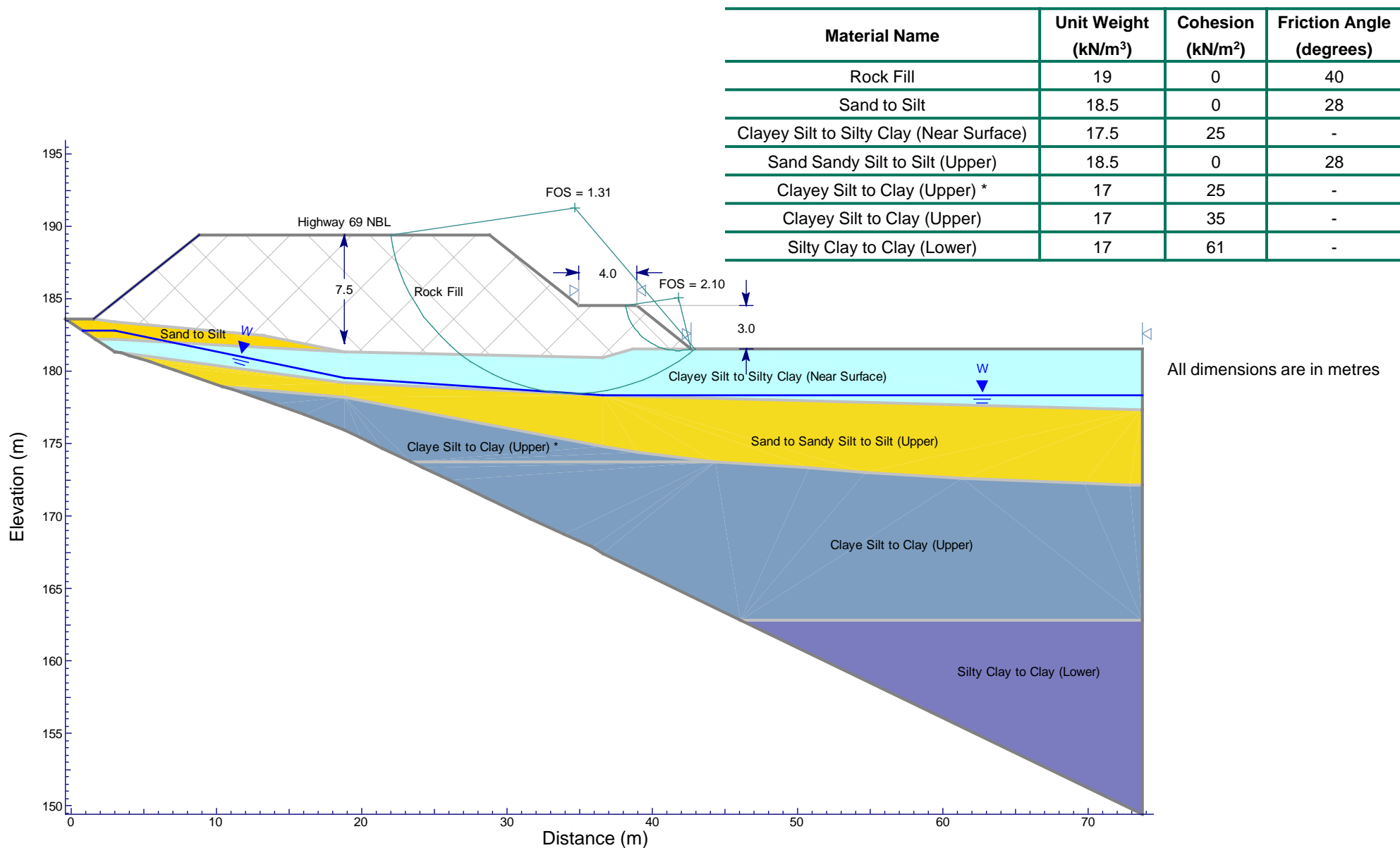
Material Name	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (degrees)
Rock Fill	19	0	40
Topsoil	15	1	27
Clayey Silt to Silty Clay (Near Surface)	17.5	25	-
Sand Sandy Silt to Silt (Upper)	18.5	0	28
Clayey Silt to Clay (Upper)	17	35	-
Sandy Silt to Silt (Lower)	18	0	29
Sand and Silt/Silt Interlayer	18	0	29
Silty Clay to Clay (Lower)	17	61	-
Silty Clay to Clay (Lower) *	17	61 – 70.6	-
Sand and Silt to Silt	18	0	29
Silty Sand	19	0	30





Highway 69 NBL – STA 11+700 to 11+750 (Swamp 204) Slope Stability (Outside Toe Berm)

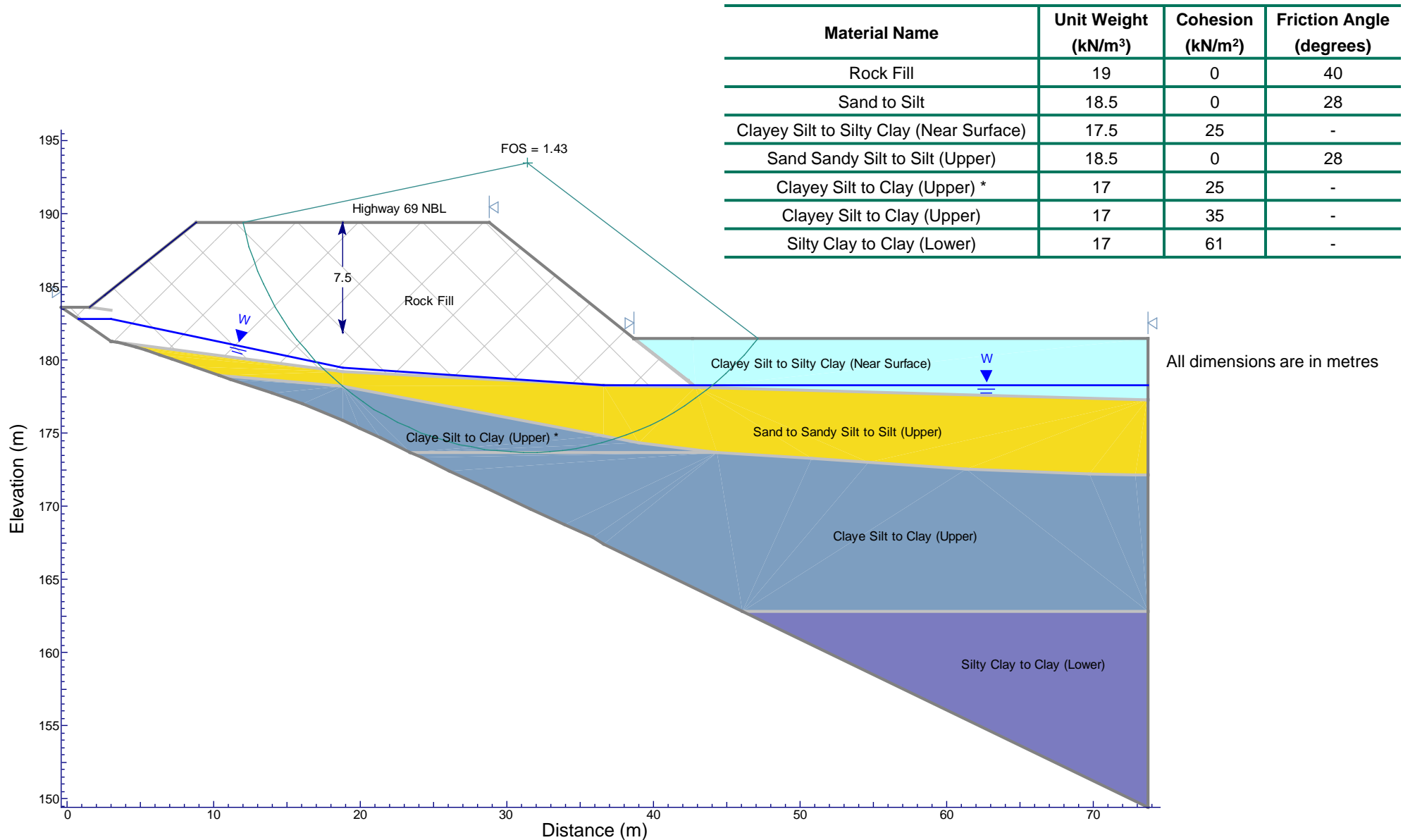
Figure D4





Highway 69 NBL – STA 11+700 to 11+750 (Swamp 204) Slope Stability (Sub-Excavation of Near Surface Cohesive Deposit)

Figure D5

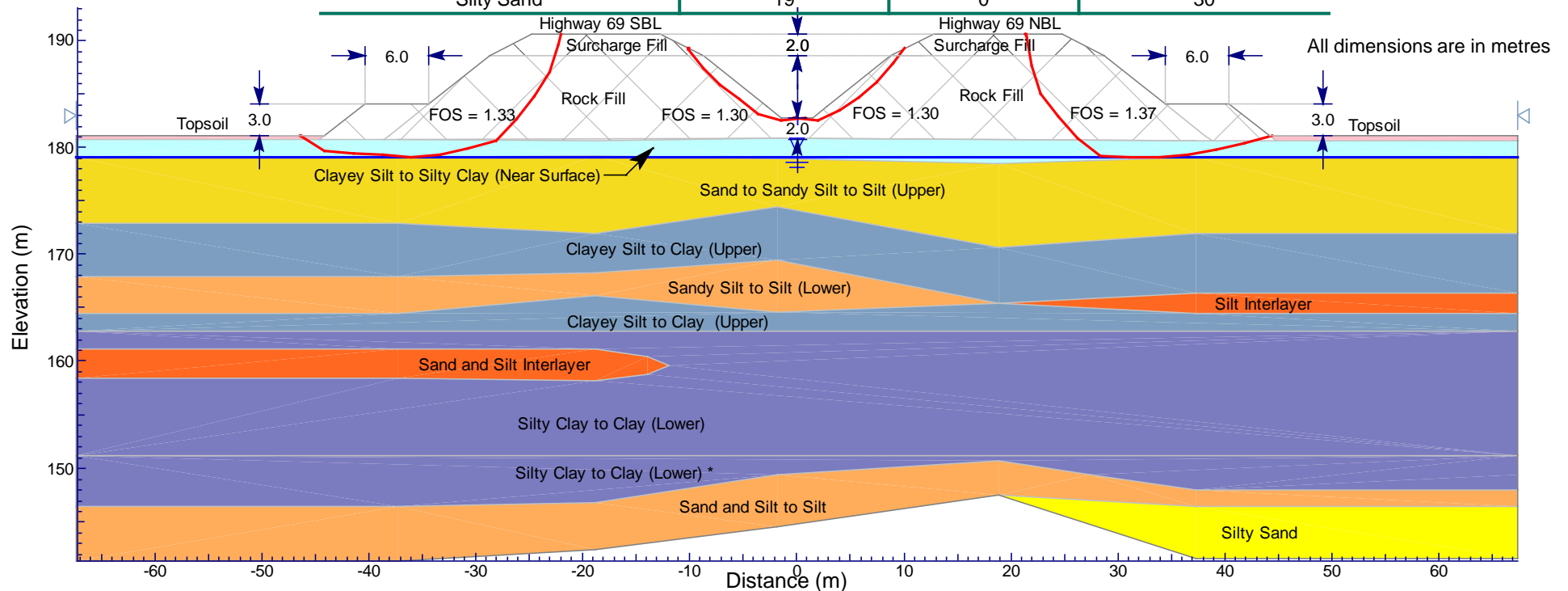




Highway 69 SBL – STA 11+725 to 11+825 (Swamp 204) Highway 69 NBL – STA 11+750 to 11+800 (Swamp 204) Slope Stability (2 m Surcharge and Outside Toe Berms/Median Infill)

Figure D6

Material Name	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (degrees)
Surcharge Fill	21	0	34
Rock Fill	19	0	40
Topsoil	15	1	27
Clayey Silt to Silty Clay (Near Surface)	17.5	25	-
Sand Sandy Silt to Silt (Upper)	18.5	0	28
Clayey Silt to Clay (Upper)	17	35	-
Sandy Silt to Silt (Lower)	18	0	29
Sand and Silt/Silt Interlayer	18	0	29
Silty Clay to Clay (Lower)	17	61	-
Silty Clay to Clay (Lower) *	17	61 – 70.6	-
Sand and Silt to Silt	18	0	29
Silty Sand	19	0	30

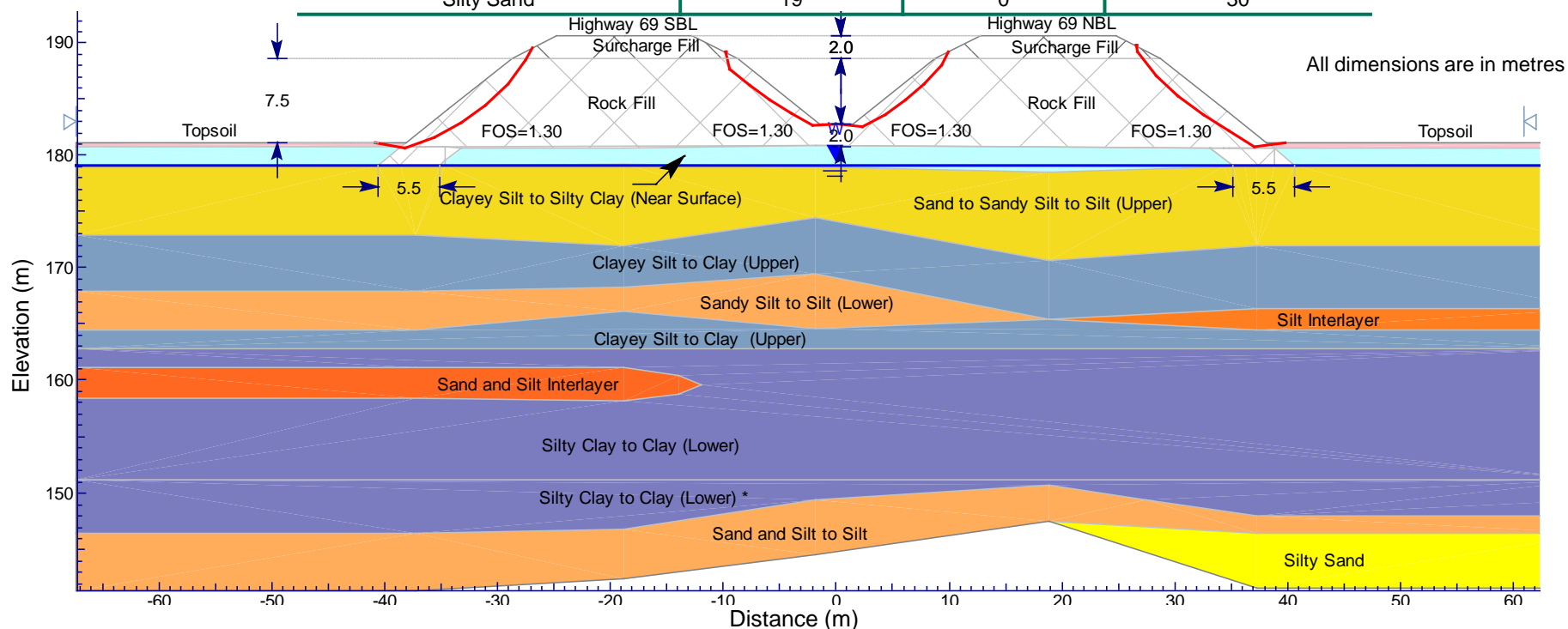




Highway 69 SBL – STA 11+725 to 11+825 (Swamp 204) Highway 69 NBL – STA 11+750 to 11+800 (Swamp 204) Slope Stability (2 m Surcharge and Localized Sub-Excavation/Median Infill)

Figure D7

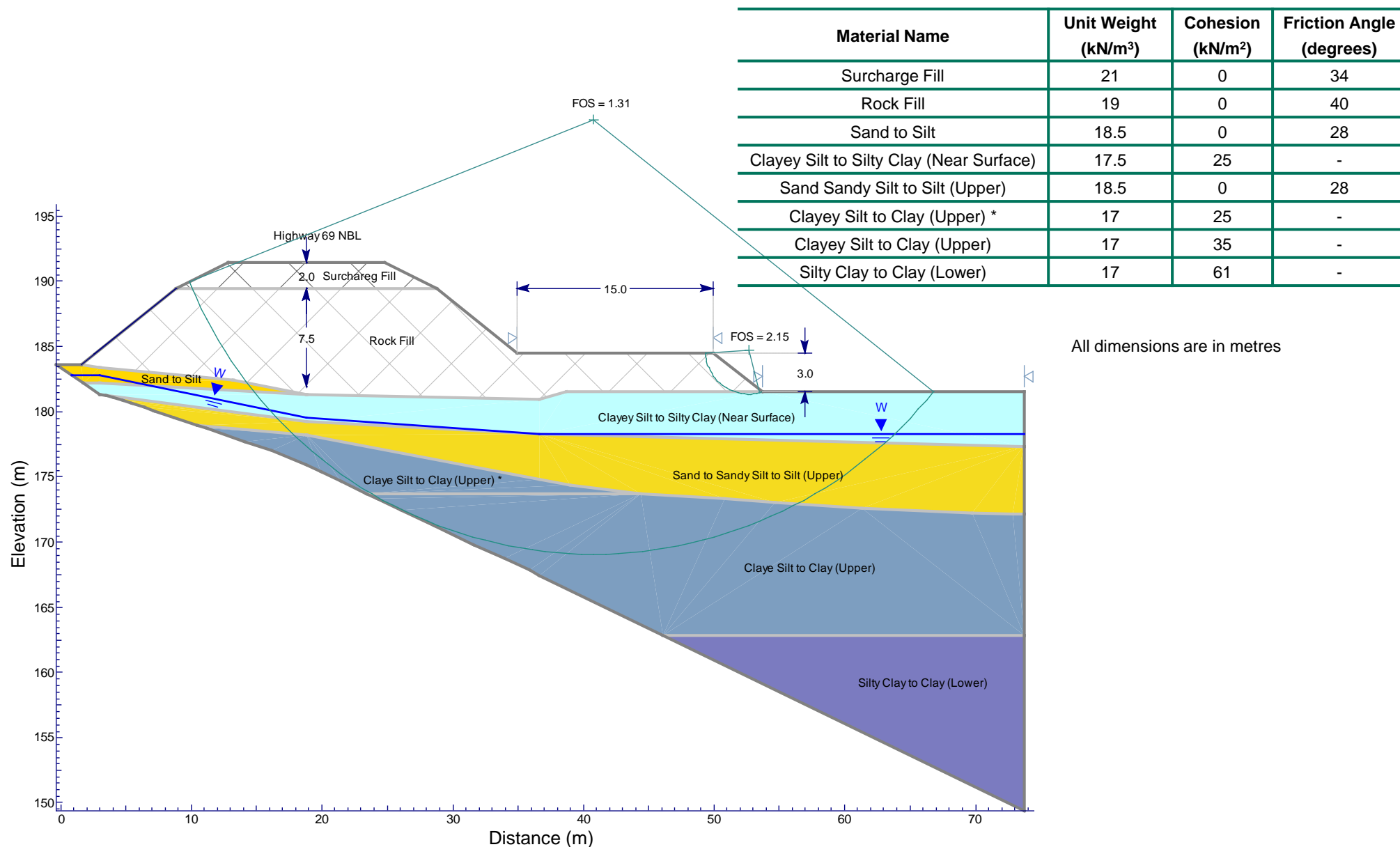
Material Name	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (degrees)
Surcharge Fill	21	0	34
Rock Fill	19	0	40
Topsoil	15	1	27
Clayey Silt to Silty Clay (Near Surface)	17.5	25	-
Sand Sandy Silt to Silt (Upper)	18.5	0	28
Clayey Silt to Clay (Upper)	17	35	-
Sandy Silt to Silt (Lower)	18	0	29
Sand and Silt/Silt Interlayer	18	0	29
Silty Clay to Clay (Lower)	17	61	-
Silty Clay to Clay (Lower) *	17	61 – 70.6	-
Sand and Silt to Silt	18	0	29
Silty Sand	19	0	30





Highway 69 NBL – STA 11+700 to 11+750 (Swamp 204) Slope Stability (2 m Surcharge and Outside Toe Berms)

Figure D8

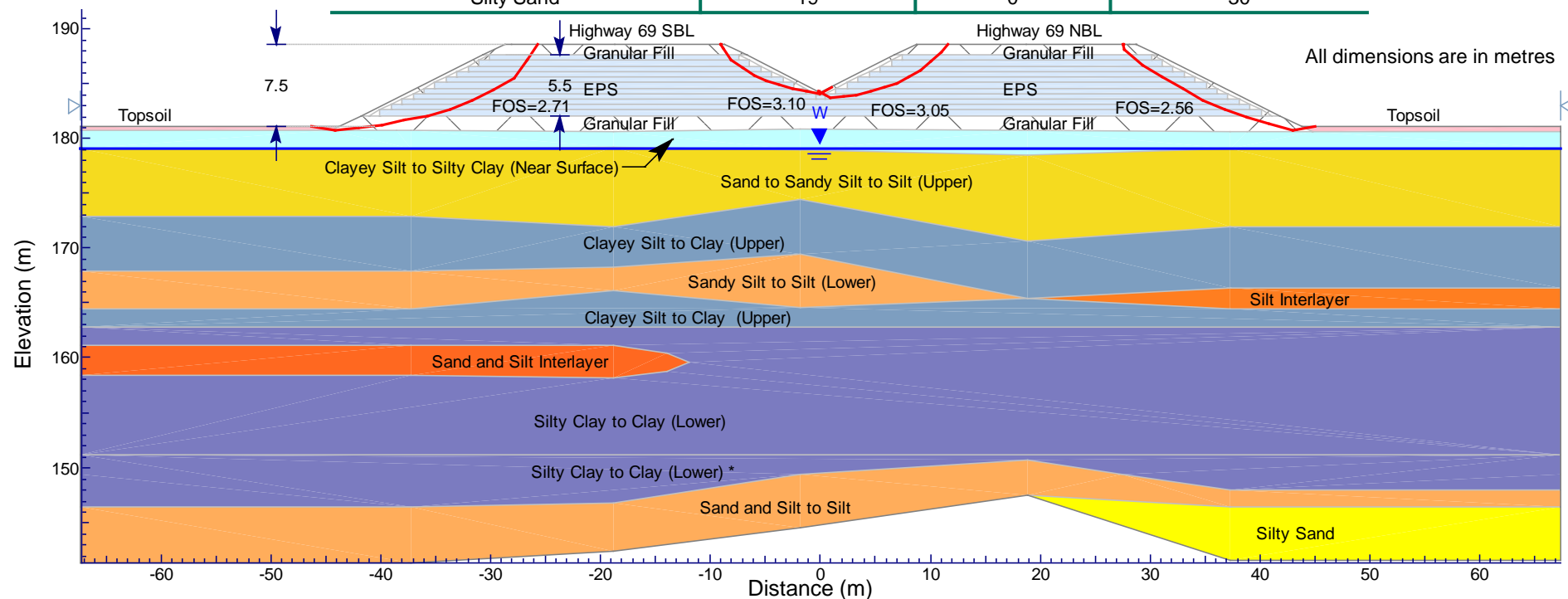




Highway 69 SBL – STA 11+725 to 11+825 (Swamp 204) Highway 69 NBL – STA 11+750 to 11+800 (Swamp 204) Slope Stability (5.5 m of EPS Fill)

Figure D9

Material Name	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (degrees)
Granular Fill	21	0	34
EPS	0.5	15	0
Topsoil	15	1	27
Clayey Silt to Silty Clay (Near Surface)	17.5	25	-
Sand Sandy Silt to Silt (Upper)	18.5	0	28
Clayey Silt to Clay (Upper)	17	35	-
Sandy Silt to Silt (Lower)	18	0	29
Sand and Silt/Silt Interlayer	18	0	29
Silty Clay to Clay (Lower)	17	61	-
Silty Clay to Clay (Lower) *	17	61 – 70.6	-
Sand and Silt to Silt	18	0	29
Silty Sand	19	0	30





FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

Table D1
Evaluation of Stability/Settlement Mitigation Options
Highway 69 SBL – STA 11+725 to 11+825 and Highway 69 NBL – STA 11+700 to 11+800 (Swamp 204)

Stability/Settlement Mitigation Option	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
Full Sub-Excavation (up to 42.4 m deep)	Not feasible	<ul style="list-style-type: none"> ■ Reduced total settlement. ■ Toe berms are not required. 	<ul style="list-style-type: none"> ■ Generation of very large volume of excess excavation spoil. ■ Very large quantity of rock fill required. ■ Long delay in construction associated with up to 42.5 m deep sub-excavation and replacement with rock fill operation. ■ Specialized equipment and additional effort required for deep sub-excavation and replacement. ■ Additional post-construction settlement of rock fill itself. ■ Sub-excavation in close proximity to Still River may require special protection measures. ■ Will required additional right-of-way to accommodate deep sub-excavation. 	<ul style="list-style-type: none"> ■ Additional costs associated with sub-excavation (specialized drag-line equipment required), disposal and replacement of weak/soft, compressible deposits. ■ Additional cost for acquiring additional right-of-way for deep excavation. 	<ul style="list-style-type: none"> ■ Deep sub-excavation in close proximity to Still River may not be permitted. ■ Higher risk with maintaining stability of excavation slopes. ■ Preloading would be required to reduce large post-construction settlement of rock fill. ■ Very low risk with respect to maintaining stability of proposed embankments.



FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS

HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

Table D1
Evaluation of Stability/Settlement Mitigation Options
Highway 69 SBL – STA 11+725 to 11+825 and Highway 69 NBL – STA 11+700 to 11+800 (Swamp 204)

Stability/Settlement Mitigation Option	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
<p>Preloading (21,000 days or about 57 years) with Toe Berms (up to 3 m high by 4 m wide) or Localized Sub-Excavation below embankment toes (up to 2.6 m deep and 4 m wide)</p> <p>About 1,505 mm of primary and secondary consolidation settlement and about 265 mm of immediate settlement.</p>	Not practical	<ul style="list-style-type: none"> Standard construction operation. Avoids generation of large volume of excess excavation spoil. 	<ul style="list-style-type: none"> Excessive delay in construction to reach post-construction settlement criteria, or regular maintenance of roadway required throughout preload period. Toe berms or localized sub-excavation below embankment toes are required to maintain stability of embankment. Re-grading is required prior to final pavement structure construction to account for large settlement associated with preloading (about 1.5 m of EPS top-up required). Instrumentation and monitoring program required to assess end of preload period. 	<ul style="list-style-type: none"> Schedule impacts will increase overall project costs, or additional costs for regular maintenance of roadway throughout preload period. Additional cost for EPS top-up and re-grading. Additional cost for instrumentation and associated monitoring program. 	<ul style="list-style-type: none"> Small risk of maintaining stability of fills on weak/soft foundation soils. Large magnitude of secondary consolidation (creep) settlement is expected to occur after primary consolidation settlement is complete. Subject to the monitoring data collected during the preload period, the preload embankment may need to be left in place for an extended period of time.



FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS

HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

Table D1
Evaluation of Stability/Settlement Mitigation Options
Highway 69 SBL – STA 11+725 to 11+825 and Highway 69 NBL – STA 11+700 to 11+800 (Swamp 204)

Stability/Settlement Mitigation Option	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
<p>Surcharging (2 m high for 4,400 days or about 12 years) with Toe Berms (3 m high by 6 m) and Median Infill (2 m high)</p> <p>About 1,350 mm of primary and secondary consolidation settlement and about 305 mm of immediate settlement.</p>	Not practical	<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"> Excessive delay in construction to reach post-construction settlement criteria, or regular maintenance of roadway required throughout surcharge period. Increased handling of surcharge fills (Granular 'B') upon completion of surcharge period. Toe berms and a median infill are required to maintain stability of surcharged embankment. Re-grading is required prior to final pavement structure construction to account for large settlement associated with preloading (about 1.5 m of EPS top-up). Instrumentation and monitoring program required to assess end of surcharge period. 	<ul style="list-style-type: none"> Schedule impacts will increase overall project costs, or additional costs for regular maintenance of roadway throughout surcharge period. Additional cost for EPS top-up and re-grading. Additional cost associated with construction for 2 m high surcharge and toe berms as compared with preload option. Additional cost for instrumentation and associated monitoring program. Additional cost maybe required for acquiring additional right-of-way to accommodate toe berms. 	<ul style="list-style-type: none"> Higher risk with respect to maintaining stability of embankment with surcharge on weak/soft foundation soils. Large magnitude of secondary consolidation (creep) settlement is expected occur after primary consolidation settlement is complete. Subject to the monitoring data collected during the surcharge period, the surcharge embankment may need to be left in place for an extended period of time.



FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS

HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

Table D1
Evaluation of Stability/Settlement Mitigation Options
Highway 69 SBL – STA 11+725 to 11+825 and Highway 69 NBL – STA 11+700 to 11+800 (Swamp 204)

Stability/Settlement Mitigation Option	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
<p>Wick Drains with Surcharging 2 m high (290 days) followed by Lightweight Fill (4 m of EPS including 1.5 m of EPS top-up)</p> <p>About 1,070 mm of primary and secondary consolidation settlement and about 305 mm of immediate settlement.</p>	2	<ul style="list-style-type: none"> Reduced time for primary consolidation to complete. Toe berms may not be required if staged construction is employed. Requires confirmation during detail wick drain design. 	<ul style="list-style-type: none"> Detail wick drain investigation and design will be required. Large toe berms may be required if preload embankment plus surcharge is constructed instantaneously. Specialized equipment required for very deep wick drain installation. Additional time required for installation of wick drains. Increased magnitude of secondary consolidation (creep) settlement as a result of the accelerated completion of primary consolidation settlement. Delay in construction schedule to allow for sufficient settlement to occur to meet post-construction settlement criteria. 	<ul style="list-style-type: none"> Schedule impacts may increase overall project costs. Additional costs associated with detail wick drain investigation and design. Additional costs associated with specialized equipment for very deep wick drain installation. Additional cost for the installation of wick drains, instrumentation and associated monitoring program. Additional costs associated with construction and materials for 2 m high surcharge and partial deconstruction of surcharge embankment upon completion of surcharge period. Additional costs associated with 4 m of EPS (1.5 m high top-up) 	<ul style="list-style-type: none"> Some risk with respect to stability of surcharge embankments on weak/soft foundation soils if staged construction is employed. Higher risk associated with the complexity with a wick drain/lightweight fill design. Wick drains installation up to about 45 m deep is approaching practical installation limits. Specialist wick drain installation contractor will be required. Subject to the monitoring data collected during the surcharge period, the surcharge embankment may need to be left in place for an extended period of time.



FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

Table D1
Evaluation of Stability/Settlement Mitigation Options
Highway 69 SBL – STA 11+725 to 11+825 and Highway 69 NBL – STA 11+700 to 11+800 (Swamp 204)

Stability/Settlement Mitigation Option	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
			<ul style="list-style-type: none"> ■ Instrumentation and monitoring program required to monitor staged construction and to assess end of surcharge period. ■ Increased handling of surcharge fill (Granular 'B') to remove surcharge. 	<p>included) and the construction of final embankment.</p> <ul style="list-style-type: none"> ■ Additional cost maybe required for acquiring additional right-of-way to accommodate toe berms. ■ Estimated cost is about \$ 750,000 for wick drains, \$ 3,700,000 for EPS plus cost for handling of surcharge construction. 	
Partial Preloading (4.5 m high for 95 days) followed by Lightweight Fill Construction (5.5 m of EPS)	1	<ul style="list-style-type: none"> ■ Improved stability. ■ Reduced total settlement of foundation soils. ■ May shorten construction schedule. 	<ul style="list-style-type: none"> ■ Very high cost of EPS construction materials. ■ Some additional effort required to remove the partial preload embankments in order to construct the EPS embankment. ■ Instrumentation and monitoring program required to assess end of preload period. 	<ul style="list-style-type: none"> ■ Relative cost of EPS fill is about an order of magnitude higher than fill required for the other options. ■ Estimated cost for EPS is about \$ 5,400,000 minus cost of rock fill to construct embankments in base case. 	<ul style="list-style-type: none"> ■ Very low risk with respect to stability of partial preload embankments and final EPS embankments on weak/soft foundation soils. ■ Low risk with respect to unexpected post-construction settlements.

[http://capws/sites/0911116014highway69fourlaning/contract 2/reporting/final/swamp crossings and high fill areas/tables and figures/09-1111-6014-1 tbl d1 evaluation of mitigation options-swamp 204 sbl and nbl.docx](http://capws/sites/0911116014highway69fourlaning/contract%20reporting/final/swamp%20crossings%20and%20high%20fill%20areas/tables%20and%20figures/09-1111-6014-1%20tbl%20d1%20evaluation%20of%20mitigation%20options-swamp%20204%20sbl%20and%20nbl.docx)

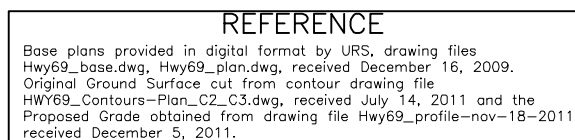
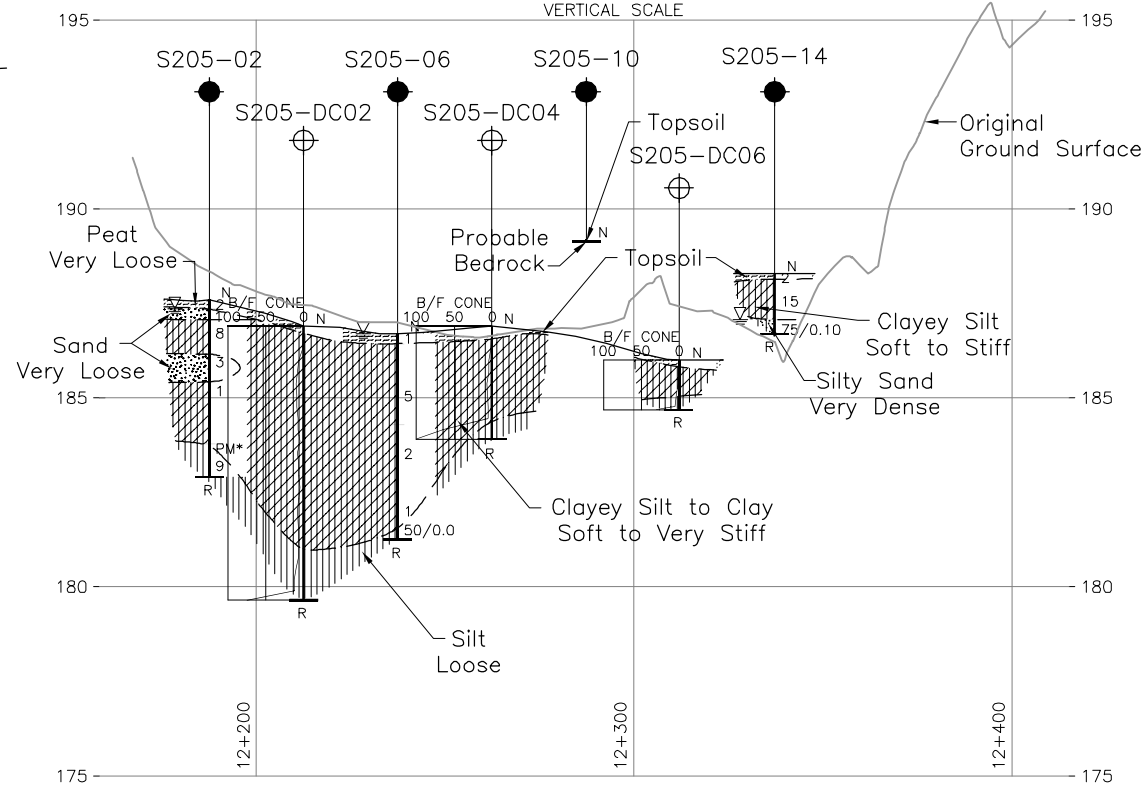
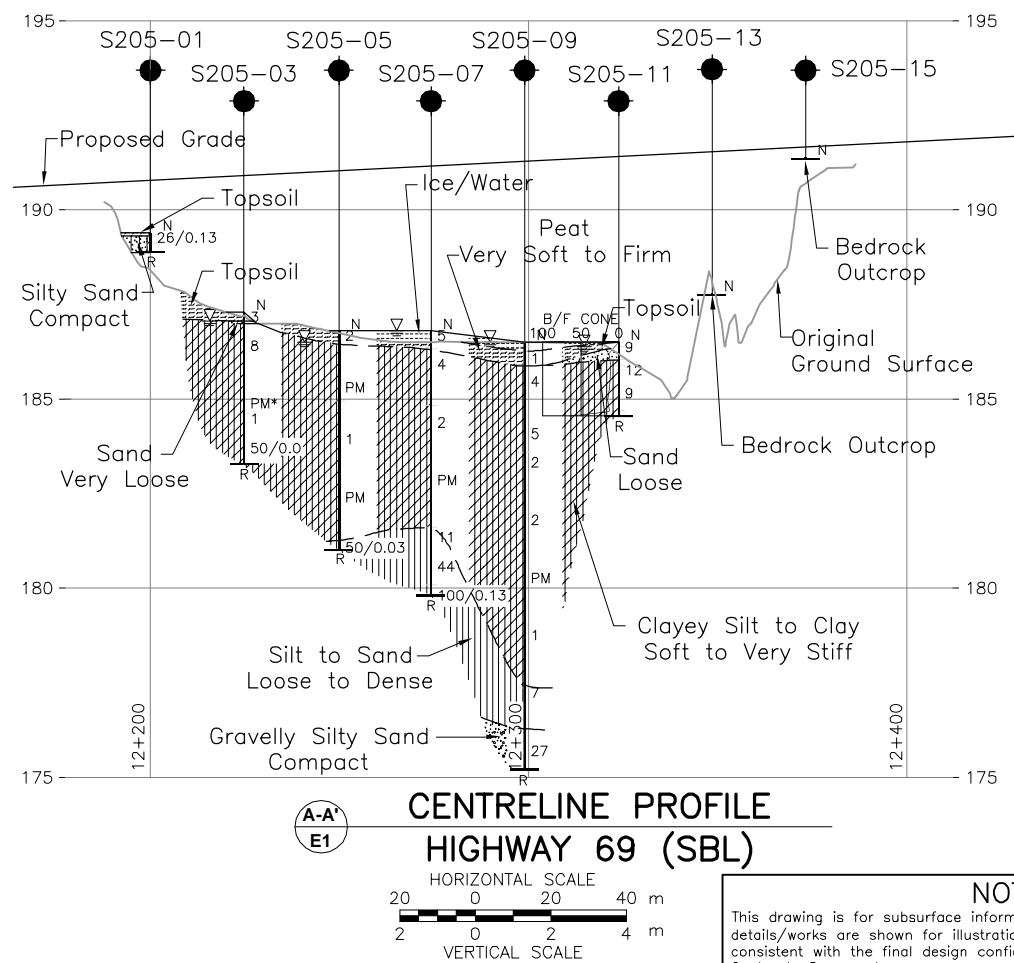
Prepared By: TZ/CN

Reviewed By: JPD/JMAC

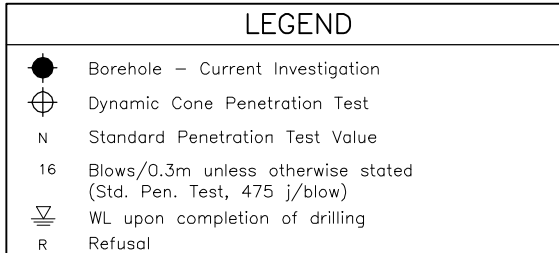


APPENDIX E

Highway 69 SBL – STA 12+200 to 12+375 (Swamp 205)



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
S205-01	189.4	5075140.8	224987.3
S205-02	187.6	5075157.7	224991.2
S205-03	187.3	5075161.9	224974.5
S205-04	188.4	5075164.9	224956.0
S205-05	186.8	5075183.9	224962.1
S205-06	186.7	5075200.2	224965.2
S205-07	186.8	5075203.6	224947.8
S205-08	186.5	5075205.6	224928.7
S205-09	186.5	5075224.1	224934.0
S205-10	189.2	5075241.8	224937.9
S205-11	186.5	5075244.4	224919.9
S205-12	185.0	5075245.5	224900.3
S205-13	187.8	5075264.5	224905.5
S205-14	188.3	5075281.6	224907.8
S205-15	191.4	5075284.4	224890.8
S205-DC01	191.4	5075144.4	224969.4
S205-DC02	186.9	5075179.2	224978.6
S205-DC03	186.7	5075185.5	224942.7
S205-DC04	186.9	5075221.3	224951.9
S205-DC05	186.7	5075225.9	224914.9
S205-DC05A	186.7	5075223.8	224914.5
S205-DC06	186.0	5075262.6	224924.0
S205-DC06A	186.0	5075261.2	224922.7
S205-DC07	184.8	5075266.4	224887.3

[illegible]

PROJECT		RECORD OF BOREHOLE		No S205-01		SHEET 1 OF 1		METRIC						
W.P. 09-1111-6014		LOCATION		N 5075140.8 ; E 224987.3		ORIGINATED BY		MR						
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment		COMPILED BY						
OK		DATE		January 20, 2010		CHECKED BY		TVA						
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						
189.4	GROUND SURFACE													
0.0	TOPSOIL		1A	SS	26/0.13		189							
0.5	Silty SAND, trace gravel, containing rootlets Compact Brown Moist END OF BOREHOLE SPOON REFUSAL END OF DCPT Refusal to Further Penetration (Hammer Bouncing) NOTES: 1. Open borehole dry upon completion of drilling. 2. Borehole advanced using portable drilling equipment with a half-weight hammer. SPT 'N' value shown has been adjusted to reflect value that would be obtained with a standard weight hammer. 3. Two Dynamic Cone Penetration Tests were advanced 1.5 m north and 1.5 m south of Borehole S205-01 to confirm depth to refusal; refusal encountered at a depth of 0.2 m and 0.5 m below ground surface (Elev. 189.2 m and Elev. 188.9 m), respectively.													

PROJECT		RECORD OF BOREHOLE		No S205-02		SHEET 1 OF 1		METRIC													
W.P.		LOCATION		ORIGINATED BY		MR															
DIST		BOREHOLE TYPE		COMPILED BY		OK															
DATUM		DATE		CHECKED BY		TVA															
09-1111-6014		N 5075157.7 ; E 224991.2																			
5404-05-01		Portable Equipment, BW Casing, Wash Boring																			
Geodetic		January 20, 2010																			
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	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	GR	SA	SI	CL
187.6	0.0	GROUND SURFACE																			
	0.5	PEAT containing rootlets (Fibrous) Very soft Black Wet		1A 1B 1C	SS	2		187													
	1.4	SAND, trace to some silt, slightly organic Very loose Brown Moist		2	SS	8		186													
	1.8	CLAYEY SILT, trace gravel, trace sand, containing rootlets Firm to stiff Brown to grey Moist		3	SS	3		185													
	2.2	SAND, trace gravel, trace silt, containing pockets of clayey silt Very loose Brown Wet		4	SS	1		184													
	3.8	CLAY, some silt, trace sand Soft Grey Wet		5	TO	PM*		183													
	4.7	SILT, trace to some sand, trace to some clay Loose Grey Wet		6	SS	9															
END OF BOREHOLE SPOON REFUSAL NOTES: * Unable to recover a Shelby tube sample between depths of 3.8 m and 4.3 m (Elev. 183.8 m and 183.3 m) below ground surface. 1. Water level in open borehole at a depth of 0.2 m below ground surface (Elev. 187.4 m) upon completion of drilling. 2. An additional borehole was drilled 1.0 m south of Borehole S205-02 to obtain a Shelby tube sample between depths of 2.3 m and 2.7 m below ground surface (Elev. 185.3 m and Elev. 184.9 m).																					

PROJECT		RECORD OF BOREHOLE		No S205-03		SHEET 1 OF 1		METRIC	
W.P.		LOCATION		ORIGINATED BY		DIST		BOREHOLE TYPE	
DATE		COMPILED BY		CHECKED BY		DATUM		DATE	
09-1111-6014		N 5075161.9 ; E 224974.5		MR		HWY 69		Portable Equipment, BW Casing, Wash Boring	
Geodetic		January 21, 2010		TVA					

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
187.3	GROUND SURFACE													
0.0	TOPSOIL		1A 1B 1C	SS	3									
0.3	SAND, some silt Very loose Grey Moist													
	SILTY CLAY, trace sand, containing silt interlayers, rootlets and wood fragments to a depth of 0.6 m Firm to stiff Brown to grey Moist		2	SS	8									
184.6														
2.7	CLAY, trace sand, trace silt, containing silt interlayers Soft Grey Moist		3	SS	PM*									
			4	SS	1									
183.3														
4.0	END OF BOREHOLE SPOON REFUSAL		5	SS	50/0.0									
NOTES: * Unable to recover a Shelby tube sample between depths of 2.3 m and 2.7 m (Elev. 187.0 m and 184.6 m) below ground surface. 1. Water level in open borehole at a depth of 0.2 m below ground surface (Elev. 187.1 m) upon completion of drilling.														

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S205-04		SHEET 1 OF 1		METRIC										
W.P. 5404-05-01		LOCATION N 5075164.9 ; E 224956.0		ORIGINATED BY MR												
DIST HWY 69		BOREHOLE TYPE Hand Excavation		COMPILED BY OK												
DATUM Geodetic		DATE January 21, 2010		CHECKED BY TVA												
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								
188.4	GROUND SURFACE															
8.9	PEAT (Root Mat) END OF EXCAVATION PROBABLE BEDROCK NOTES: 1. Hand digging carried out at proposed borehole location to expose bedrock; visible bedrock outcrop in the vicinity of borehole S205-04. 2. Excavation dry upon completion.															

GTA-MTO 001 09-1111-6014.GPJ GAL-MASS.GDT 7/25/12 SAC/DD

PROJECT		RECORD OF BOREHOLE		No S205-05		SHEET 1 OF 1		METRIC					
W.P.		LOCATION		ORIGINATED BY									
DIST		BOREHOLE TYPE		COMPILED BY									
DATUM		DATE		CHECKED BY									
09-1111-6014		N 5075183.9 ; E 224962.1		MR									
5404-05-01		Portable Equipment, BW Casing, Wash Boring		OK									
Geodetic		January 21, 2010		TVA									
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
186.8	GROUND SURFACE												
0.0	TOPSOIL		1A	SS	2								
186.4			1B										
0.4	SILTY CLAY, trace sand, containing rootlets to a depth of 1.2 m Firm to very stiff Brown to grey Moist		2	TO	PM		186						
185.0							185						
1.9	CLAY, some silt Soft to firm Brown Moist		3	SS	1		184						
							183						
			4	TO	PM		182						
181.3													
5.8	SILT, trace to some sand, trace to some clay Loose Grey Wet END OF BOREHOLE SPOON REFUSAL NOTE: 1. Water level in open borehole at a depth of 0.3 m below ground surface (Elev. 186.5 m) upon completion of drilling.		5	SS	50/0.03								

PROJECT		RECORD OF BOREHOLE		No S205-06		SHEET 1 OF 1		METRIC					
W.P.		LOCATION		ORIGINATED BY		MR							
DIST		BOREHOLE TYPE		COMPILED BY		OK							
DATUM		DATE		CHECKED BY		TVA							
09-1111-6014		N 5075200.2 ; E 224965.2											
5404-05-01		Portable Equipment, BW Casing, Wash Boring											
Geodetic		January 22, 2010											
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
186.7	GROUND SURFACE												
186.4	PEAT, (Fibrous) Very soft Dark brown Wet		1A	SS	1								
0.3			1B	SS									
	SILTY CLAY, containing rootlets to a depth of 1.1 m Stiff to very stiff Brown Moist to wet												
			2	SS	5								
184.3													
2.4	CLAY, some silt Firm Grey Wet												
			3	SS	2								
	Silt interlayers encountered at a depth of 4.6 m												
			4	SS	1								
181.2													
5.5	END OF BOREHOLE SPOON REFUSAL		5	SS	50/0.0								
	NOTE: 1. Water level in open borehole at ground surface (Elev. 186.7 m) upon completion of drilling.												

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

PROJECT		RECORD OF BOREHOLE		No S205-07		SHEET 1 OF 1		METRIC													
W.P.		LOCATION		ORIGINATED BY		MR															
DIST		BOREHOLE TYPE		COMPILED BY		OK															
DATUM		DATE		CHECKED BY		TVA															
09-1111-6014		N 5075203.6 ; E 224947.8																			
5404-05-01		Portable Equipment, BW Casing, Wash Boring																			
HWY 69		January 22, 2010																			
Geodetic																					
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	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	GR	SA	SI	CL
186.8	0.0	ICE SURFACE																			
	0.5	PEAT, containing wood fragments (Fibrous) Firm Brown Moist		1	SS	5											688				
		SILTY CLAY, trace sand, containing rootlets Very stiff Brown and grey Moist		2	SS	4															
184.8	2.0	CLAY, trace sand, containing silt interlayers Soft Brown to grey Moist		3	SS	2															
				4	TO	PM											15.3				
181.6	5.2	SILT, some sand, trace gravel, trace clay Compact to dense Grey Wet		5	SS	11															
				6	SS	44												5	14	76	5
179.8	7.0	SAND, some silt, trace gravel Dense Grey Wet		7	SS	100/0.1															
		END OF BOREHOLE SPOON REFUSAL																			
NOTE: 1. Water level in open borehole at ice surface (Elev. 186.8 m) upon completion of drilling.																					

PROJECT		RECORD OF BOREHOLE		No S205-08		SHEET 1 OF 1		METRIC														
W.P.		LOCATION		ORIGINATED BY																		
DIST		BOREHOLE TYPE		COMPILED BY																		
DATUM		DATE		CHECKED BY																		
09-1111-6014		N 5075205.6 ; E 224928.7		MR																		
5404-05-01		Portable Equipment, BW Casing, Wash Boring		OK																		
Geodetic		January 22, 2010		TVA																		
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	SHEAR STRENGTH kPa					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	GR	SA	SI	CL		
186.5 0.0	ICE SURFACE ICE							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					20 40 60 WATER CONTENT (%)									
185.9 0.6	WATER PEAT Soft Brown Moist SILTY CLAY, trace sand, containing rootlets to a depth of 2.1 m Stiff Brown and grey Moist Silt interlayers encountered at a depth of 1.4 m		1	SS	3		186							○								
			2	SS	7		185	4 +														
			3	SS	4		184								○							
183.3 3.2	CLAY, trace sand Firm Grey Moist		4	SS	1		183	3 + 3 +														
			5	SS	2		181	3 + 3 +								○						
			6	SS	2		180	2 + 2 +														
178.6 7.9	END OF BOREHOLE SPOON REFUSAL NOTE: 1. Water level in open borehole at ice surface (Elev. 186.5 m) upon completion of drilling.		7	SS	50/0.0		179															

PROJECT		RECORD OF BOREHOLE		No S205-09		SHEET 1 OF 1		METRIC														
W.P.		LOCATION		ORIGINATED BY		DIST		BOREHOLE TYPE														
5404-05-01		N 5075224.1 ; E 224934.0		MR		HWY 69		Portable Equipment, BW Casing, Wash Boring														
DATUM		DATE		COMPILED BY		CHECKED BY																
Geodetic		January 23, 2010		OK		TVA																
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					
186.5	0.0	ICE SURFACE							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W _p — W — W _L 20 40 60			kN/m ³			GR SA SI CL		
		ICE																				
		WATER																				
185.9	0.6	PEAT, containing wood fragments (Fibrous) Very soft Dark brown Wet		1A	SS	1		186														
				1B	SS	4																
		SILTY CLAY, trace sand, containing wood fragments and rootlets to a depth of 0.9 m Very stiff Brown and grey Moist		2	SS	4																
								185														
		Silt interlayers encountered at a depth of 2.1 m (Elev. 184.4 m)		3	SS	5		184														
183.6	2.9	CLAY Firm Brown to grey Moist		4	SS	2		183														
								182														
				5	SS	2																
								181														
				6	TO	PM		180														
								179														
				7	SS	1																
								178														
177.4	9.1	SILT, trace to some sand, trace to some clay, trace gravel Loose Grey Wet		8	SS	7		177														
176.3	10.2	Gravelly Silty SAND, trace clay, containing silty sand interlayers Compact Grey Wet						176														
				9	SS	27																
175.2	11.3	END OF BOREHOLE SPOON AND CASING REFUSAL																				
		NOTE: 1. Water level in open borehole at ice surface (Elev. 186.5 m) upon completion of drilling.																				

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S205-10		SHEET 1 OF 1		METRIC										
W.P. 5404-05-01		LOCATION N 5075241.8 ; E 224937.9		ORIGINATED BY MR												
DIST _____ HWY 69		BOREHOLE TYPE Hand Excavation		COMPILED BY OK												
DATUM Geodetic		DATE January 23, 2010		CHECKED BY TVA												
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 (%)			
189.2	GROUND SURFACE						20	40	60	80	100	20	40	60		
8.9	TOPSOIL															
	END OF BOREHOLE PROBABLE BEDROCK															
	NOTE:															
	1. Hand digging carried out at proposed borehole location to expose bedrock.															
	2. Excavation dry upon completion.															

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT		RECORD OF BOREHOLE		No S205-11		SHEET 1 OF 1		METRIC						
W.P. 09-1111-6014		LOCATION		N 5075244.4 ; E 224919.9		ORIGINATED BY		MR						
DIST _____ HWY 69		BOREHOLE TYPE		Portable Equipment, BW Casing, Wash Boring		COMPILED BY		OK						
DATUM Geodetic		DATE		January 24, 2010		CHECKED BY		TVA						
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						
186.5	GROUND SURFACE													
0.0	TOPSOIL		1A											
186.0	SAND, trace silt, containing rootlets		1B	SS	9									
0.6	Loose Brown Moist		1C											
	CLAYEY SILT, trace to some sand		2	SS	12									
	Stiff Brown and grey Moist		3A	SS	9									
184.7	SILT CLAY, trace sand, containing rootlets to a depth of 1.2 m		3B											
2.0	Stiff Brown to grey Moist													
	Silt interlayers encountered at a depth of 1.4 m (Elev. 185.1 m)													
	END OF BOREHOLE SPOON REFUSAL													
	END OF DCPT Refusal to Further Penetration (Hammer Bouncing)													
	NOTES:													
	1. Water level in open borehole at a depth of 0.1 m below ground surface (Elev. 186.4 m) upon completion of drilling.													
	2. A Dynamic Cone Penetration Test was advanced 1.5 m west of Borehole S205-11 to confirm depth to refusal; refusal encountered at a depth of 2.0 m below ground surface (Elev. 184.5 m).													
	3. Attempted to push in situ vane test a depth of 1.7 m below ground surface (Elev. 184.8 m) but hit refusal.													

PROJECT		RECORD OF BOREHOLE		No S205-12		SHEET 1 OF 1		METRIC						
W.P. 09-1111-6014		LOCATION		N 5075245.5 ; E 224900.3		ORIGINATED BY		MR						
DIST _____ HWY 69		BOREHOLE TYPE		Portable Equipment, BW Casing, Wash Boring		COMPILED BY		OK						
DATUM Geodetic		DATE		January 23, 2010		CHECKED BY		TVA						
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		W _p	W	W _L		
185.0	ICE SURFACE													
0.0	ICE													
0.3	TOPSOIL		1	SS	8									
	SAND, trace to some silt, trace to some clay, containing organics and wood fragments up to a depth of 0.6 m													
183.6	Loose Brown Wet		2	SS	6									
1.4	SILTY CLAY, trace sand													
	Stiff Grey Moist		3	SS	2									
181.7														
			4	SS	50/0.13									
3.5	END OF BOREHOLE SPOON REFUSAL													
	END OF DCPT Refusal to Further Penetration (Hammer Bouncing)													
	NOTES: 1. Water level in open borehole at ice surface (Elev. 185.0 m) upon completion of drilling. 2. A Dynamic Cone Penetration Test was advanced 1.5 m north of Borehole S205-12 to confirm depth to refusal; refusal encountered at a depth of 3.5 m below ground surface (Elev. 181.5 m).													



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

PROJECT		RECORD OF BOREHOLE		No S205-14		SHEET 1 OF 1		METRIC								
W.P. 5404-05-01		LOCATION		N 5075281.6 ; E 224907.8		ORIGINATED BY		MR								
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, BW Casing, Wash Boring		COMPILED BY								
DATUM		Geodetic		DATE		January 24, 2010		CHECKED BY								
								TVA								
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													
0.2	CLAYEY SILT, trace to some sand, containing rootlets and slightly organic Soft to stiff Grey Moist		1B	SS	2											
			2	SS	15											
187.1																
	Silty SAND, some gravel, trace clay, containing rootlets and wood fragments Very dense Brown Wet		3	SS	75/0.10											
186.7	END OF BOREHOLE SPOON REFUSAL															
1.6																
NOTES: 1. Water level in open borehole at a depth of 1.2 m below ground surface (Elev. 187.1 m) upon completion of drilling. 2. Bedrock outcrop noted within the vicinity of Borehole S205-14. 3. Upper 1.2 m of borehole advanced using portable drilling equipment with a half-weight hammer. SPT 'N' values shown have been adjusted to reflect values that would be obtained with a standard weight hammer.																



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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

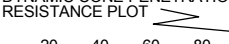
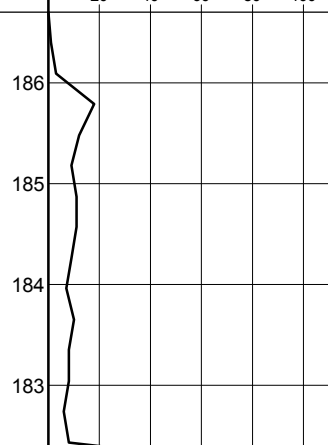


+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD



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

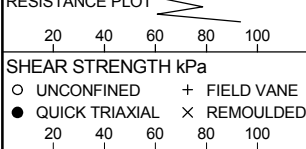
PROJECT 09-1111-6014		RECORD OF DCPT No S205-DC03		SHEET 1 OF 1		METRIC				
W.P. 5404-05-01		LOCATION N 5075185.5 ; E 224942.7		ORIGINATED BY MR						
DIST HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test		COMPILED BY OK						
DATUM Geodetic		DATE January 20, 2010		CHECKED BY TVA						
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT  SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p — W — 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						
186.7 0.0	GROUND SURFACE Dynamic Cone Penetration Test (DCPT)									
182.2 4.5	END OF DCPT Refusal to Further Penetration (100 Blows / 0.28 m)									

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT <u>09-1111-6014</u>		RECORD OF DCPT No S205-DC04		SHEET 1 OF 1		METRIC	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5075221.3 ; E 224951.9</u>		ORIGINATED BY <u>MR</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Portable Equipment, Dynamic Cone Penetration Test</u>		COMPILED BY <u>OK</u>			
DATUM <u>Geodetic</u>		DATE <u>January 20, 2010</u>		CHECKED BY <u>TVA</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL						× REMOULDED		
186.9	GROUND SURFACE																	
0.0	Dynamic Cone Penetration Test (DCPT)																	
											</							

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT 09-1111-6014		RECORD OF DCPT No S205-DC05		SHEET 1 OF 1		METRIC				
W.P. 5404-05-01		LOCATION N 5075225.9 ; E 224914.9		ORIGINATED BY MR						
DIST HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test		COMPILED BY OK						
DATUM Geodetic		DATE January 20, 2010		CHECKED BY TVA						
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 WATER CONTENT (%)	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE						
186.7	GROUND SURFACE									
0.0	Dynamic Cone Penetration Test (DCPT)									
185.9	END OF DCPT Refusal to Further Penetration (Hammer Bouncing)									
0.8	NOTES: 1. An additional Dynamic Cone Penetration Test was drilled 1.5 m south east of DCPT S205-DC05 to confirm depth to refusal; see Record of DCPT S205-DC05A for details. 2. Bedrock outcrop observed approximately 3.0 m west of DCPT S205-DC05.									

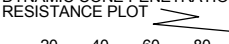
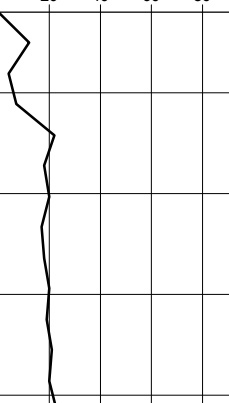
GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT <u>09-1111-6014</u>										RECORD OF DCPT No S205-DC05A SHEET 1 OF 1										METRIC									
W.P. <u>5404-05-01</u>					LOCATION <u>N 5075223.8 ; E 224914.5</u>					ORIGINATED BY <u>MR</u>																			
DIST <u> </u> HWY <u>69</u>					BOREHOLE TYPE <u>Portable Equipment, Dynamic Cone Penetration Test</u>					COMPILED BY <u>OK</u>																			
DATUM <u>Geodetic</u>					DATE <u>January 20, 2010</u>					CHECKED BY <u>TVA</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 (%) GR SA SI CL								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	20	40	60			80	100	W _p	W	W _L														
186.7	GROUND SURFACE																												
0.0	Dynamic Cone Penetration Test (DCPT)																												
185.7																													
1.0	END OF DCPT Refusal to Further Penetration (Hammer Bouncing)																												

PROJECT 09-1111-6014		RECORD OF DCPT No S205-DC06		SHEET 1 OF 1		METRIC											
W.P. 5404-05-01		LOCATION N 5075262.6 ; E 224924.0		ORIGINATED BY MR													
DIST HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test		COMPILED BY OK													
DATUM Geodetic		DATE January 24, 2010		CHECKED BY TVA													
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					W _p W W _L				
186.0	GROUND SURFACE																
0.0	Dynamic Cone Penetration Test (DCPT)																
185.2	END OF DCPT																
0.8	Refusal to Further Penetration (Hammer Bouncing)																
	NOTES: 1. DCPT advanced using portable drilling equipment with a half-weight hammer. Blows shown have been adjusted to reflect values that would be obtained with a standard weight hammer. 2. An additional Dynamic Cone Penetration Test was drilled 1.5 m west of DCPT S205-DC06 to confirm depth to refusal; see Record of DCPT S205-DC06A for details. 3. Bedrock outcrop observed approximately 2.0 m west of DCPT S205-DC06.																

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT 09-1111-6014		RECORD OF DCPT No S205-DC06A				SHEET 1 OF 1		METRIC									
W.P. 5404-05-01		LOCATION N 5075261.2 ; E 224922.7				ORIGINATED BY MR											
DIST _____ HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test				COMPILED BY OK											
DATUM Geodetic		DATE January 24, 2010				CHECKED BY TVA											
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 (%)
186.0	GROUND SURFACE						20	40	60	80	100						GR SA SI CL
0.0	Dynamic Cone Penetration Test (DCPT)																
184.7						185											
1.3	END OF DCPT Refusal to Further Penetration (Hammer Bouncing) NOTE: 1. DCPT advanced using portable drilling equipment with a half-weight hammer. Blows shown have been adjusted to reflect values that would be obtained with a standard weight hammer.																

PROJECT		RECORD OF DCPT No S205-DC07		SHEET 1 OF 1		METRIC				
W.P. 09-1111-6014		LOCATION N 5075266.4 ; E 224887.3		ORIGINATED BY MR						
DIST HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test		COMPILED BY OK						
DATUM Geodetic		DATE January 24, 2010		CHECKED BY TVA						
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT  SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p — W — 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						
184.8 0.0	GROUND SURFACE Dynamic Cone Penetration Test (DCPT)									
180.8 4.0	END OF DCPT Refusal to Further Penetration (Hammer Bouncing) NOTE: 1. Bedrock outcrop observed in the vicinity of DCPT S205-DC07.									

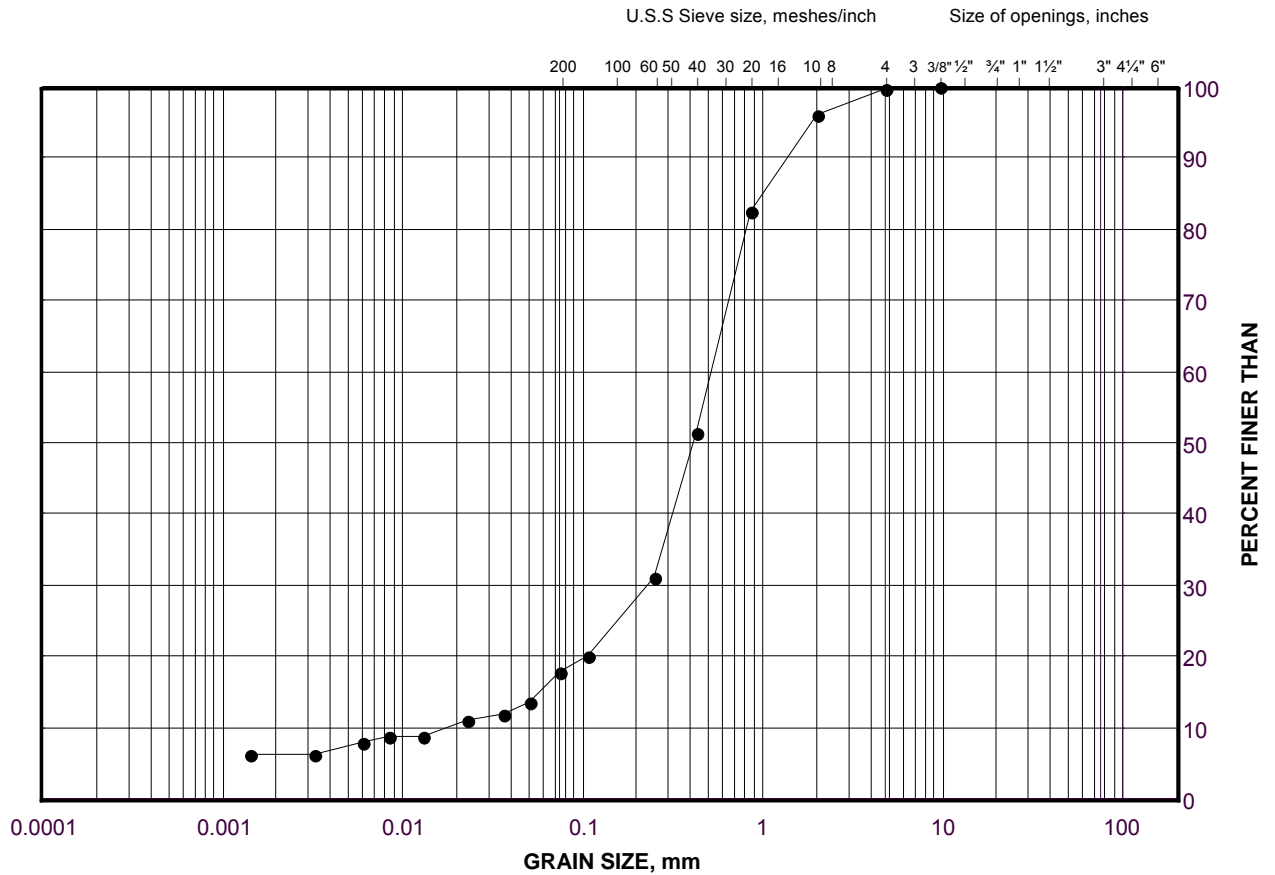
GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

GRAIN SIZE DISTRIBUTION

Sand

Highway 69 (SBL) STA 12+200 to 12+375 (Swamp 205)

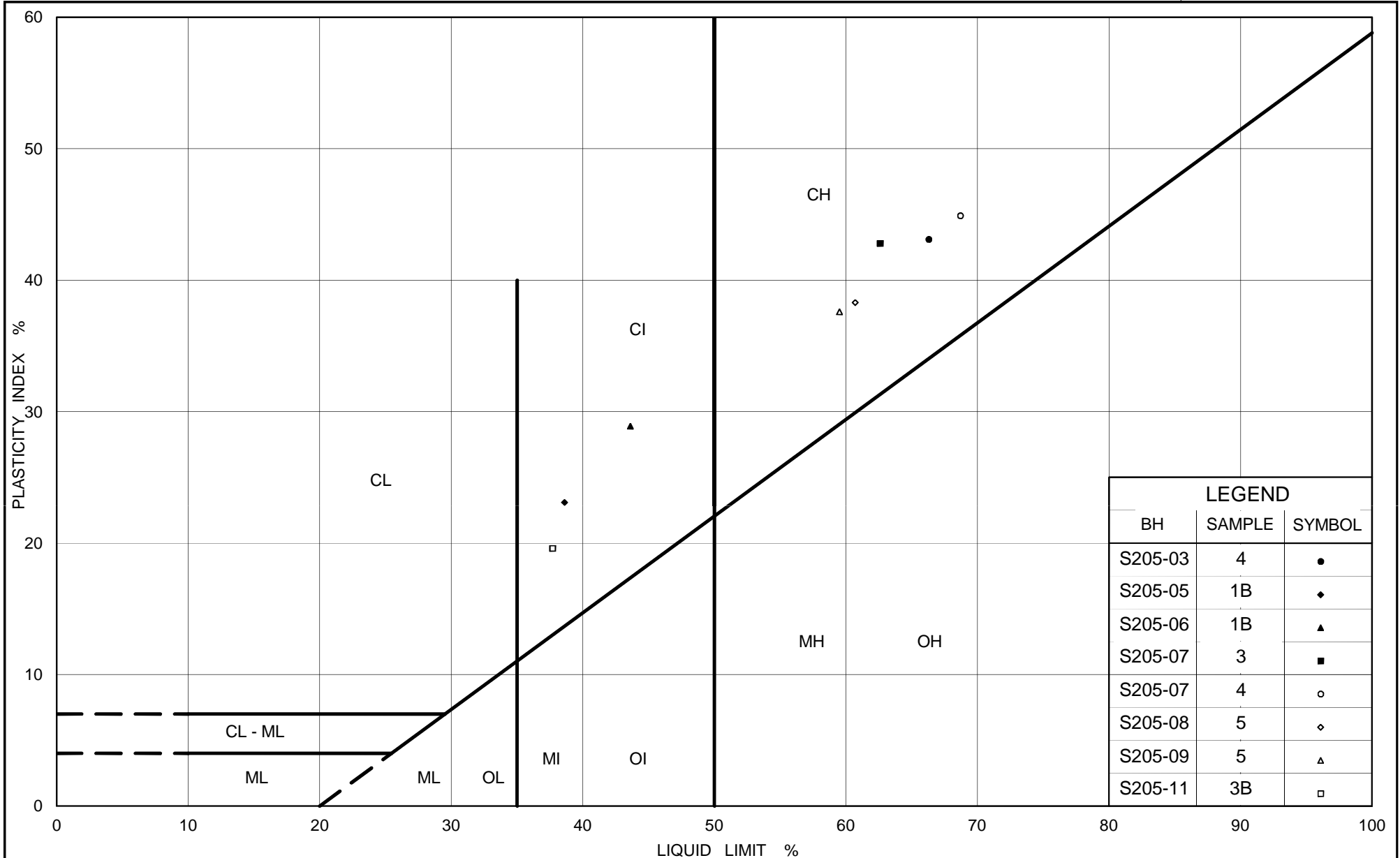
FIGURE E.S205-01



SILT AND CLAY SIZES			FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED			SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S205-12	2	183.9



Ministry of Transportation

Ontario

PLASTICITY CHART

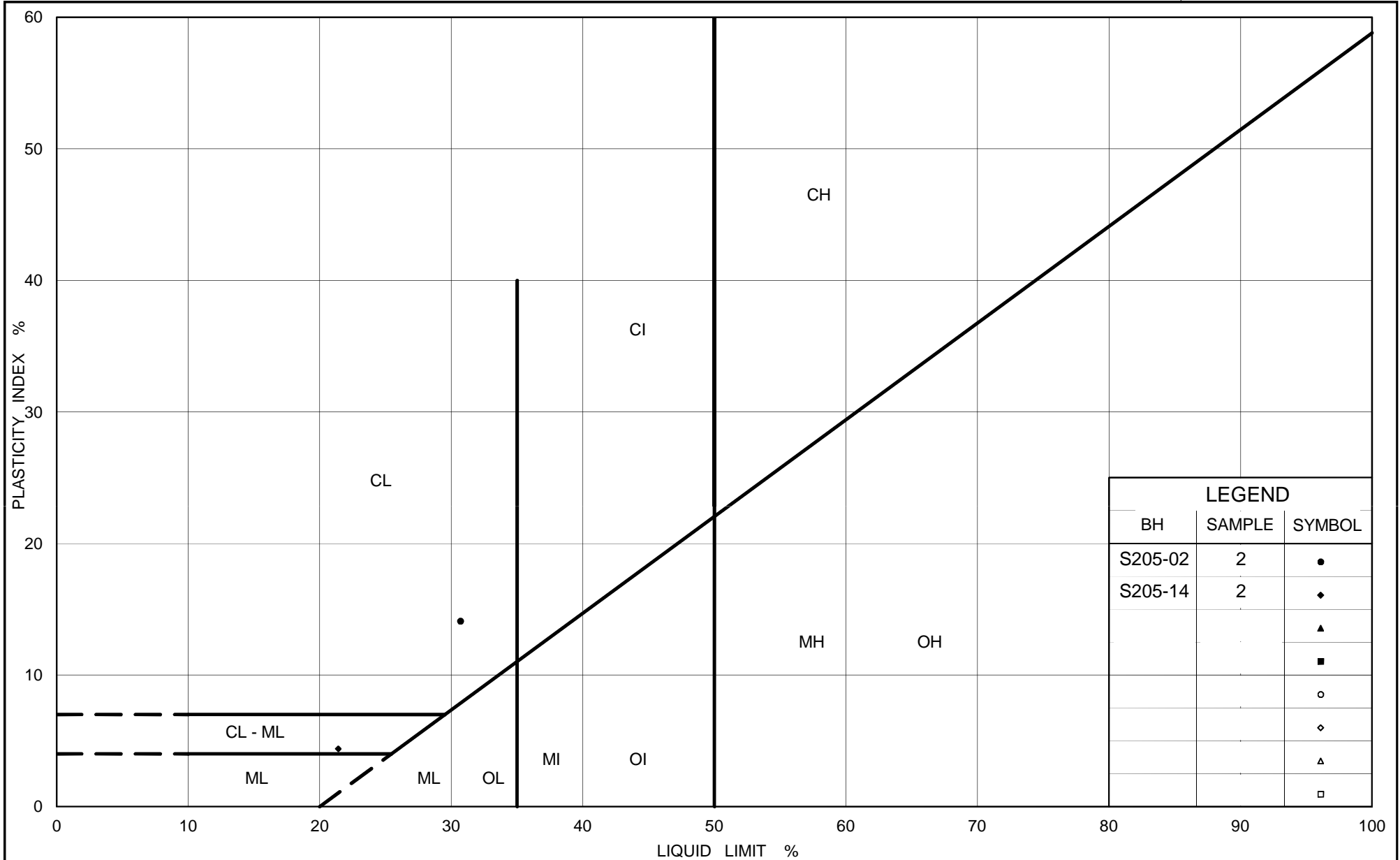
Silty Clay to Clay

Highway 69 (SBL) STA 12+200 to 12+375 (Swamp 205)

Figure No. E.S205-02A

Project No. 09-1111-6014

Checked By: TVA



Ministry of Transportation

Ontario

PLASTICITY CHART Clayey Silt

Highway 69 (SBL) STA 12+200 to 12+375 (Swamp 205)

Figure No. E.S205-02B

Project No. 09-1111-6014

Checked By: TVA

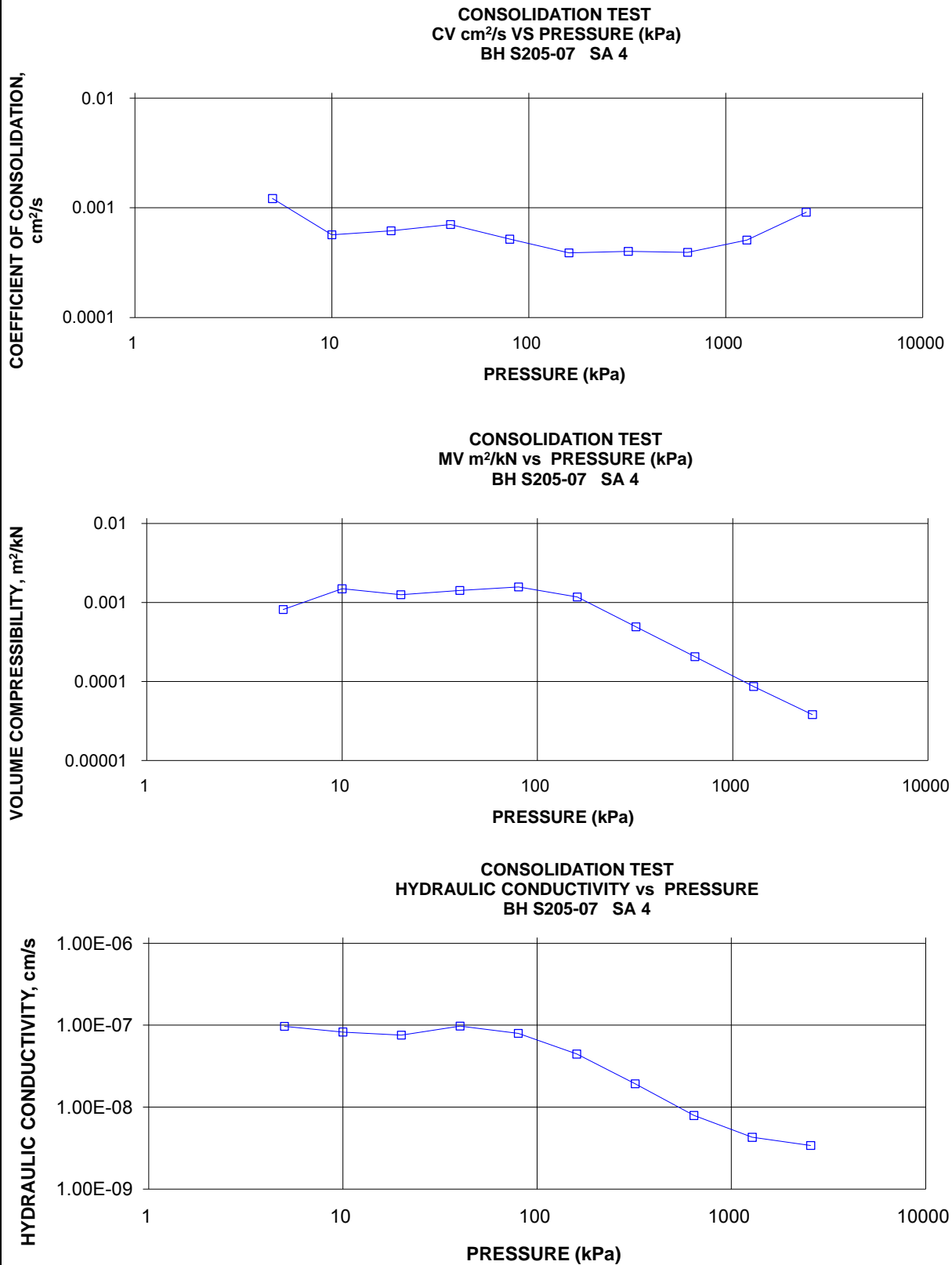
CONSOLIDATION TEST SUMMARY					FIGURE E.S205-03		
Highway 69 (SBL) STA 12+200 to 12+375 (Swamp 205)					Sheet 1 of 4		
SAMPLE IDENTIFICATION							
Project Number	09-1111-6014				Sample Number	4	
Borehole Number	S205-07				Sample Depth, m	4.1	
TEST CONDITIONS							
Test Type	Standard				Load Duration, hr	24	
Oedometer Number	8						
Date Started	4/9/2010						
Date Completed	4/22/2010						
SAMPLE DIMENSIONS AND PROPERTIES - INITIAL							
Sample Height, cm	1.25				Unit Weight, kN/m ³	15.27	
Sample Diameter, cm	4.97				Dry Unit Weight, kN/m ³	8.66	
Area, cm ²	19.40				Specific Gravity, measured	2.74	
Volume, cm ³	24.31				Solids Height, cm	0.404	
Water Content, %	76.33				Volume of Solids, cm ³	7.83	
Wet Mass, g	37.84				Volume of Voids, cm ³	16.48	
Dry Mass, g	21.46				Degree of Saturation, %	99.4	
TEST COMPUTATIONS							
	Corr.		Average				
Pressure	Height	Void	Height	t ₉₀	cv.	mv	k
kPa	cm	Ratio	cm	sec	cm ² /s	m ² /kN	cm/s
0.00	1.253	2.104	1.253				
5.00	1.248	2.091	1.250	273	1.21E-03	8.14E-04	9.69E-08
10.00	1.239	2.068	1.243	577	5.68E-04	1.48E-03	8.26E-08
20.00	1.223	2.029	1.231	520	6.18E-04	1.25E-03	7.58E-08
40.08	1.187	1.941	1.205	437	7.05E-04	1.41E-03	9.77E-08
80.00	1.109	1.747	1.148	540	5.18E-04	1.56E-03	7.93E-08
160.00	0.992	1.457	1.051	602	3.89E-04	1.17E-03	4.45E-08
320.00	0.894	1.214	0.943	470	4.01E-04	4.89E-04	1.92E-08
640.89	0.812	1.010	0.853	392	3.93E-04	2.05E-04	7.90E-09
1280.00	0.743	0.840	0.777	252	5.08E-04	8.59E-05	4.28E-09
2560.00	0.682	0.689	0.712	118	9.12E-04	3.80E-05	3.40E-09
1280.00	0.690	0.710	0.686				
322.33	0.711	0.761	0.701				
80.01	0.746	0.849	0.729				
20.00	0.769	0.905	0.758				
5.00	0.788	0.951	0.778				
Note: k calculated using cv based on t ₉₀ values.							
SAMPLE DIMENSIONS AND PROPERTIES - FINAL							
Sample Height, cm	0.79				Unit Weight, kN/m ³	18.85	
Sample Diameter, cm	4.97				Dry Unit Weight, kN/m ³	13.78	
Area, cm ²	19.40				Specific Gravity, measured	2.74	
Volume, cm ³	15.28				Solids Height, cm	0.404	
Water Content, %	36.81				Volume of Solids, cm ³	7.83	
Wet Mass, g	29.36				Volume of Voids, cm ³	7.45	
Dry Mass, g	21.46						
Prepared By: LFG					Golder Associates		Checked By: TVA

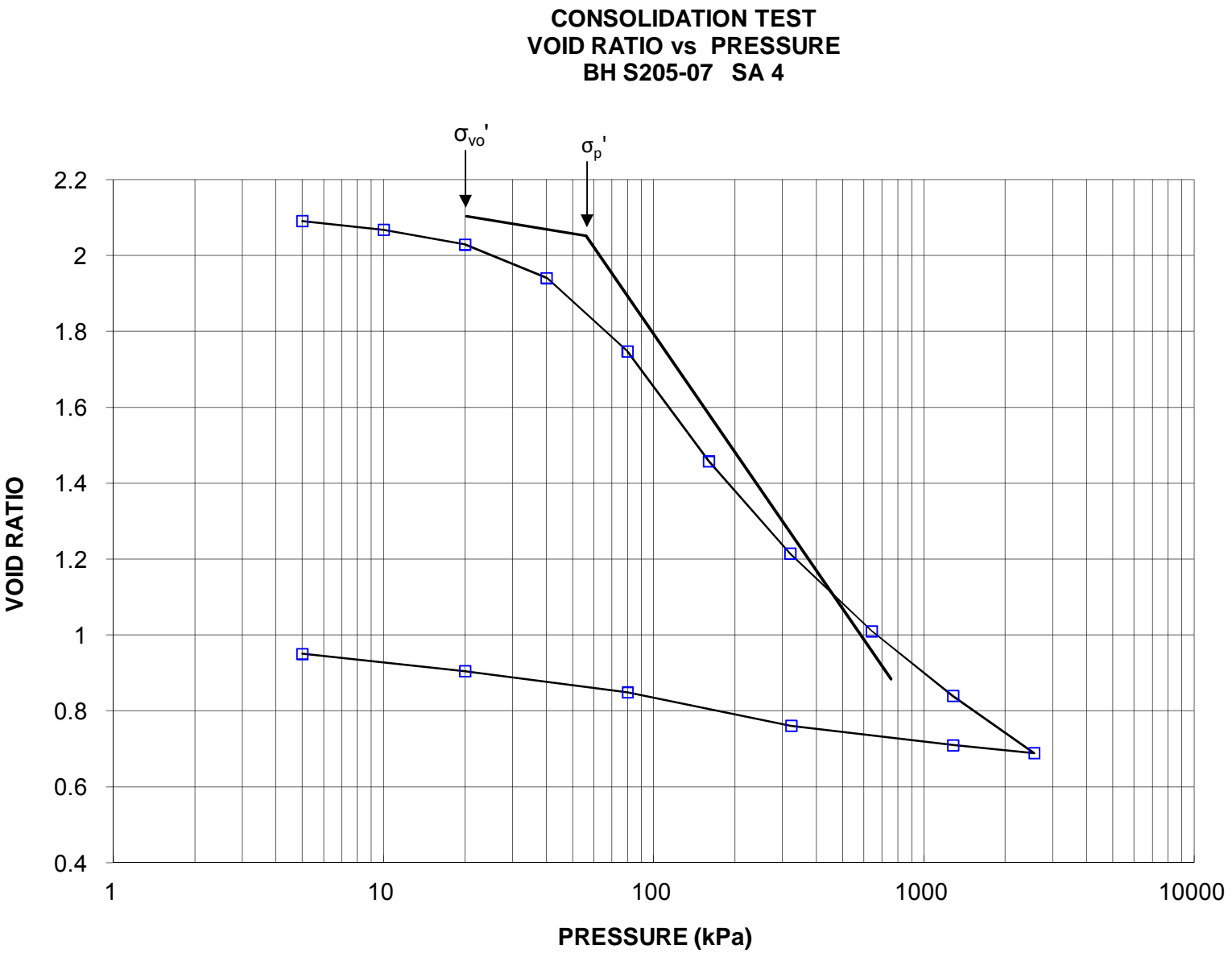
CONSOLIDATION TEST SUMMARY

Highway 69 (SBL) STA 12+200 to 12+375 (Swamp 205)

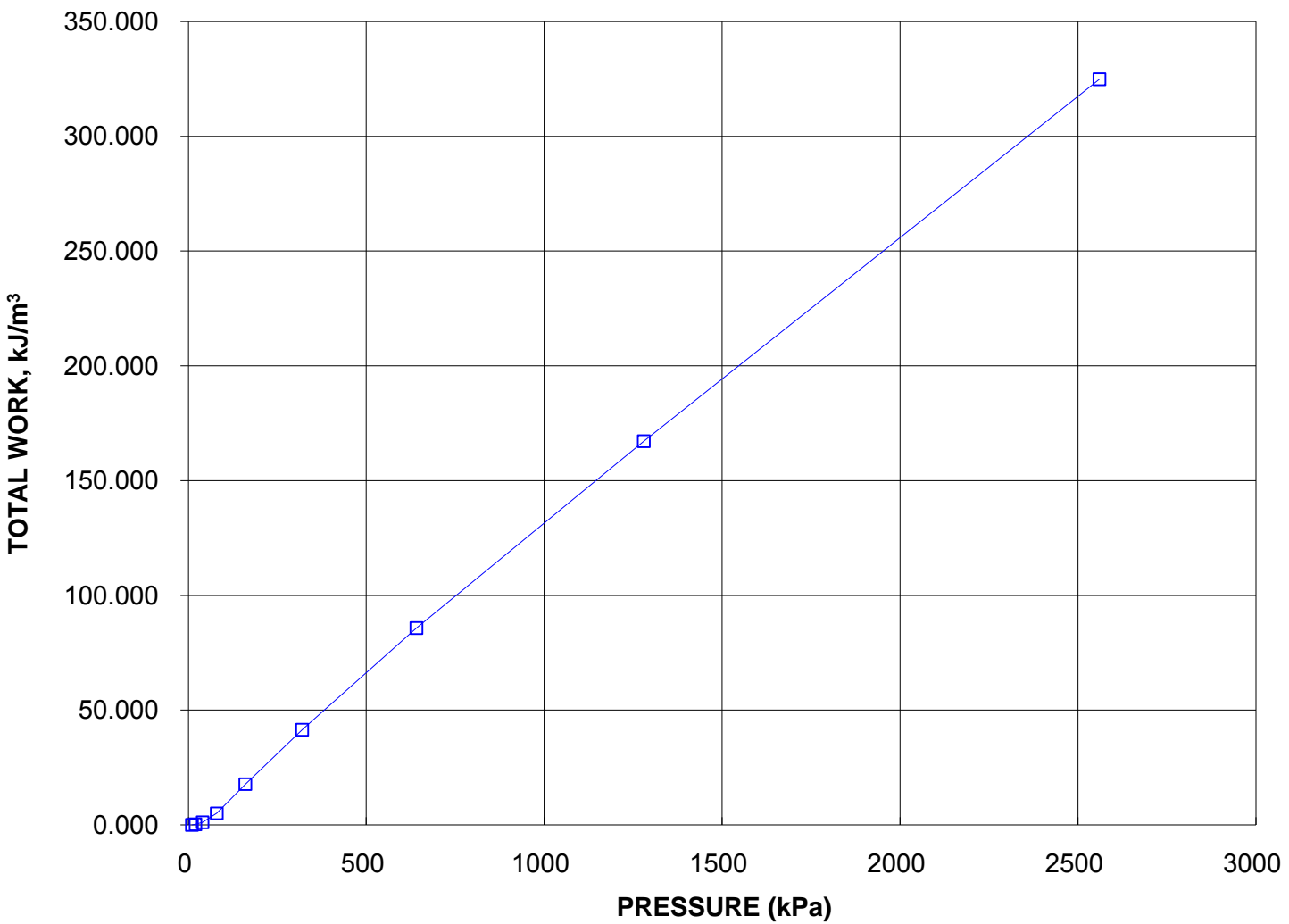
FIGURE E.S205-03

Sheet 2 of 4





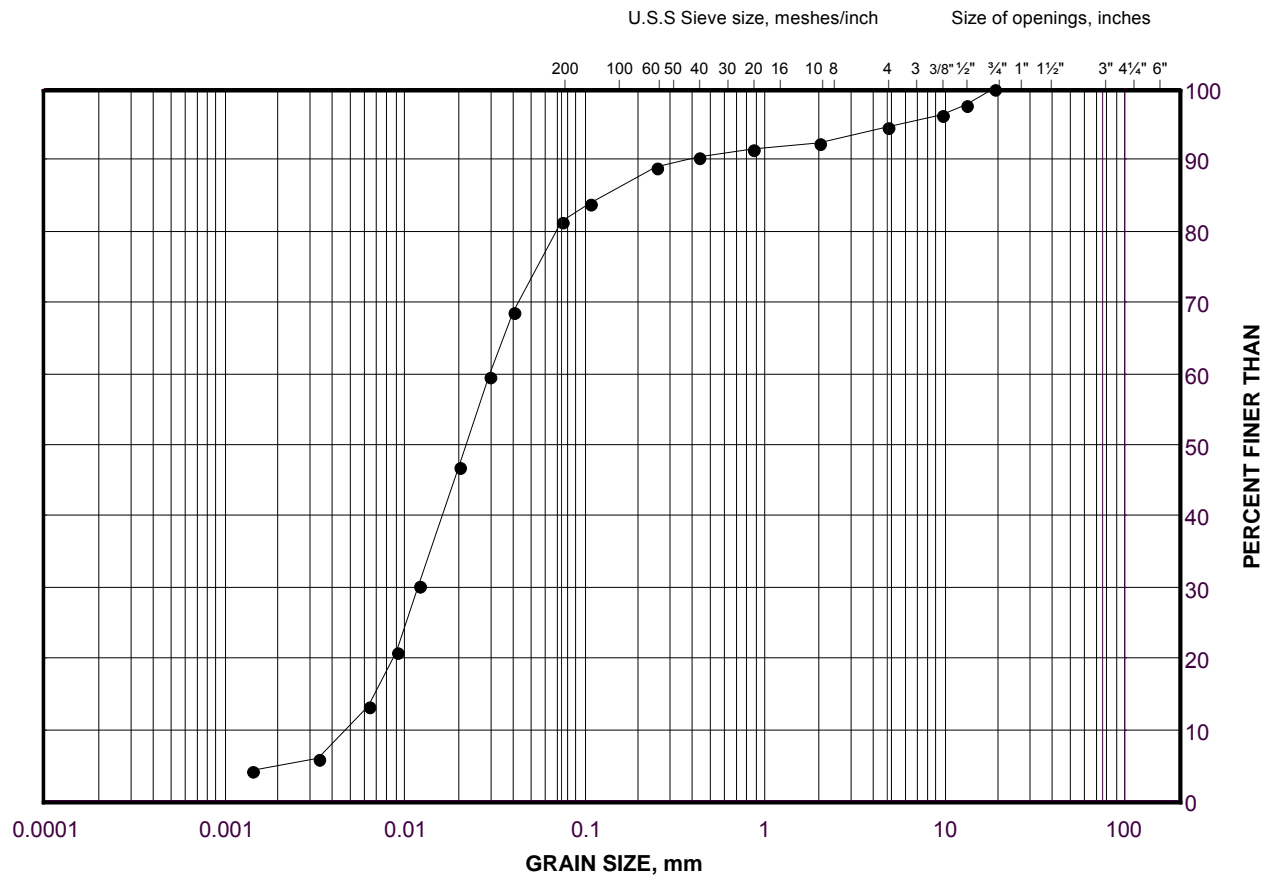
CONSOLIDATION TEST
TOTAL WORK, kJ/m^3 vs PRESSURE
BH S205-07 SA 4



GRAIN SIZE DISTRIBUTION

Silt
Highway 69 (SBL) STA 12+200 to 12+375

FIGURE E.S205-04



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S205-07	6	179.6

Project Number: 09-1111-6014

Checked By: TVA

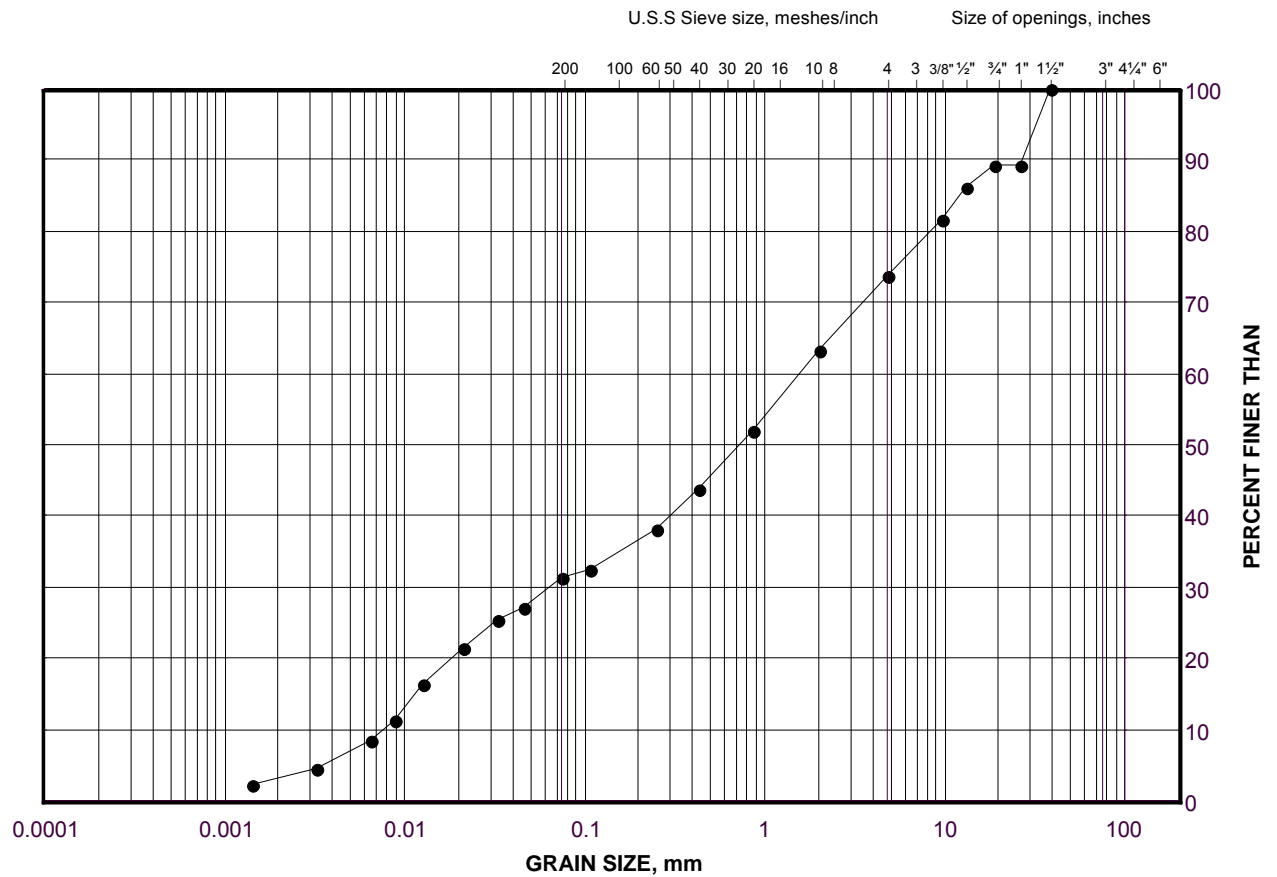
Golder Associates

Date: 17-May-11

GRAIN SIZE DISTRIBUTION

Gravelly Silty Sand
Highway 69 (SBL) STA 12+200 to 12+375

FIGURE E.S205-05



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S205-09	9	175.5

Project Number: 09-1111-6014

Checked By: TVA

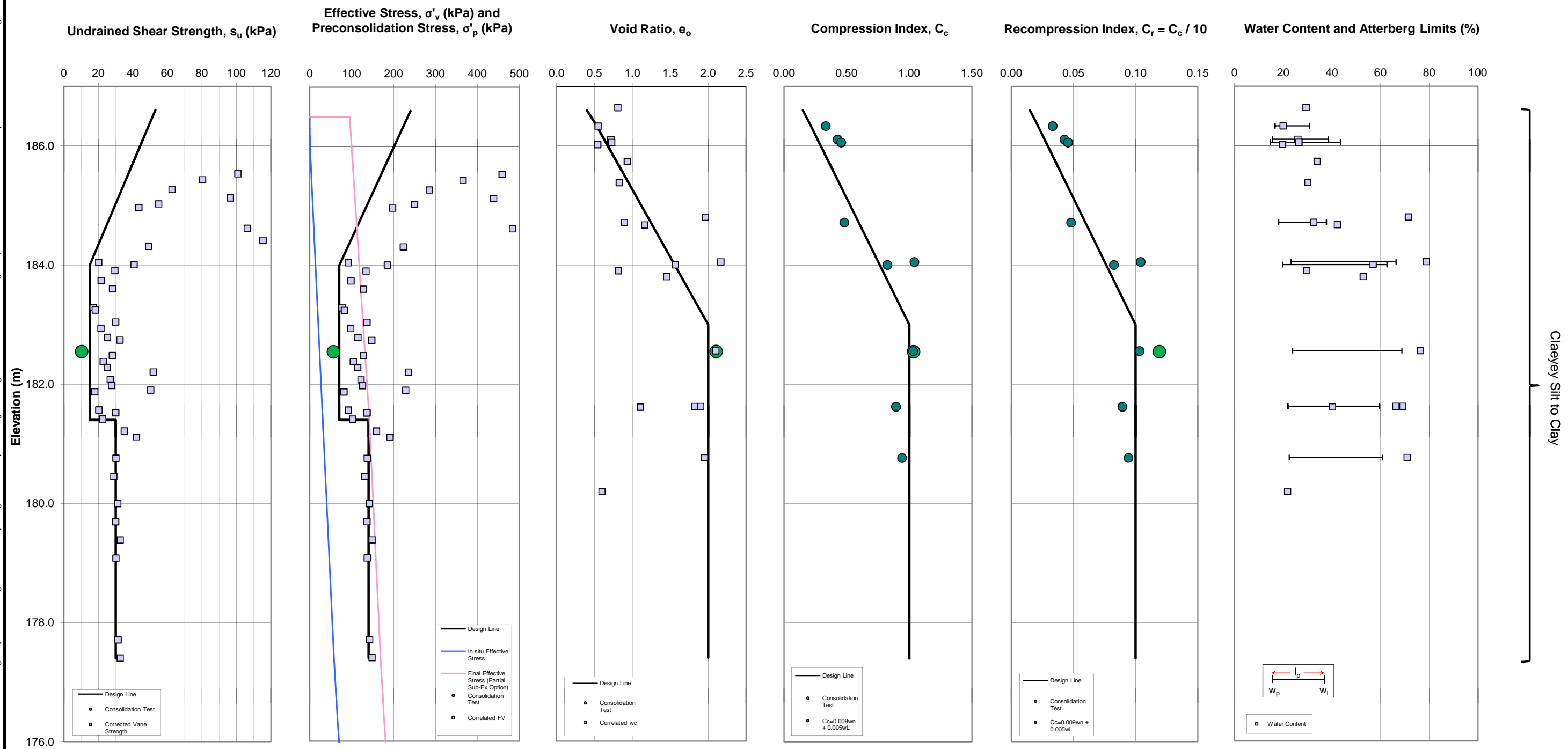
Golder Associates

Date: 17-May-11

\\capws\daw\www\Rootsites\0911116014Highway69\FourLaning\Contract 2\Reporting\Final\Swamp Crossings and High Fill Areas\Tables and Figures\09-1111-6014-Contract 2-Swamp205-Parameters and Design Lines-PRIORITY A-REV_FINAL

SUMMARY PLOT OF ENGINEERING PARAMETERS FOR
COHESIVE DEPOSITS
Highway 69 SBL - STA 12+200 to 12+375 (Swamp 205)

FIGURE E1



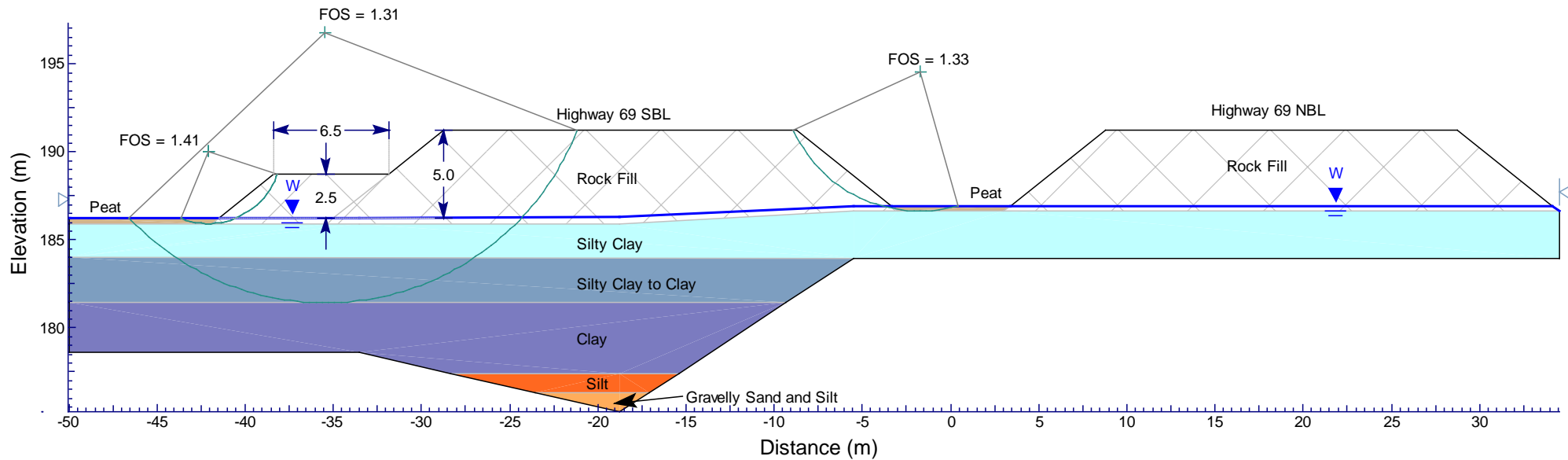


Highway 69 SBL – STA 12+200 to 12+375 (Swamp 205) Slope Stability (Outside Toe Berm)

Figure E2

All dimensions are in metres

Material Name	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (degrees)
Rock Fill	19	0	40
Peat	12	1	27
Silty Clay	16.5	53 – 15	-
Silty Clay to Clay	16.5	15	-
Clay	16.5	30	-
Silt	18	0	28
Gravelly Sand and Silt	19	0	32



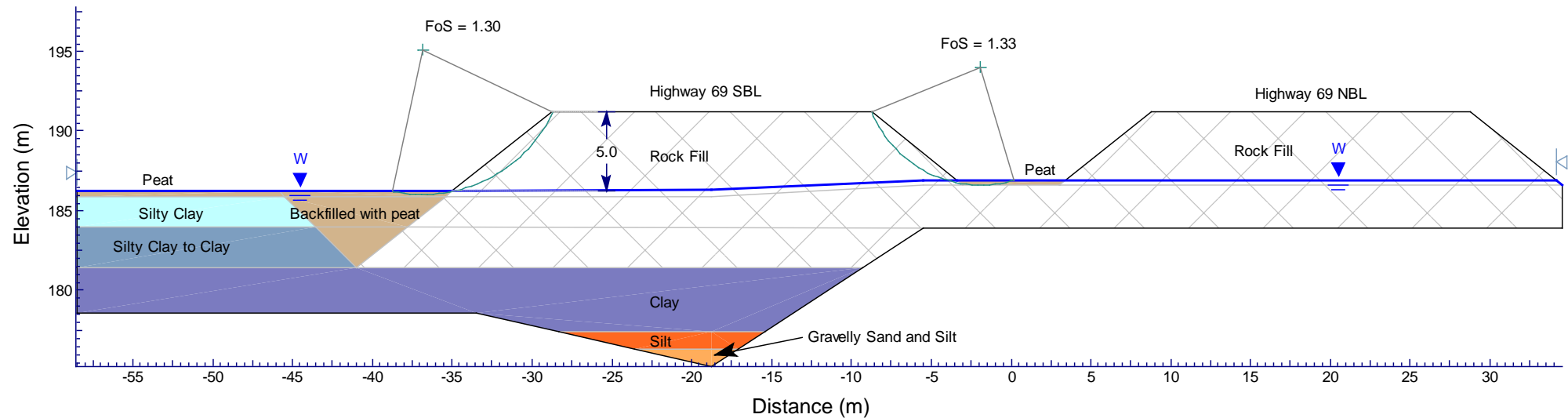


Highway 69 SBL – STA 12+200 to 12+375 (Swamp 205) Slope Stability (Partial Sub-Excavation)

Figure E3

All dimensions are in metres

Material Name	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (degrees)
Rock Fill	19	0	40
Peat	12	1	27
Silty Clay	16.5	53 – 15	-
Silty Clay to Clay	16.5	15	-
Clay	16.5	30	-
Silt	18	0	28
Gravelly Sand and Silt	19	0	32



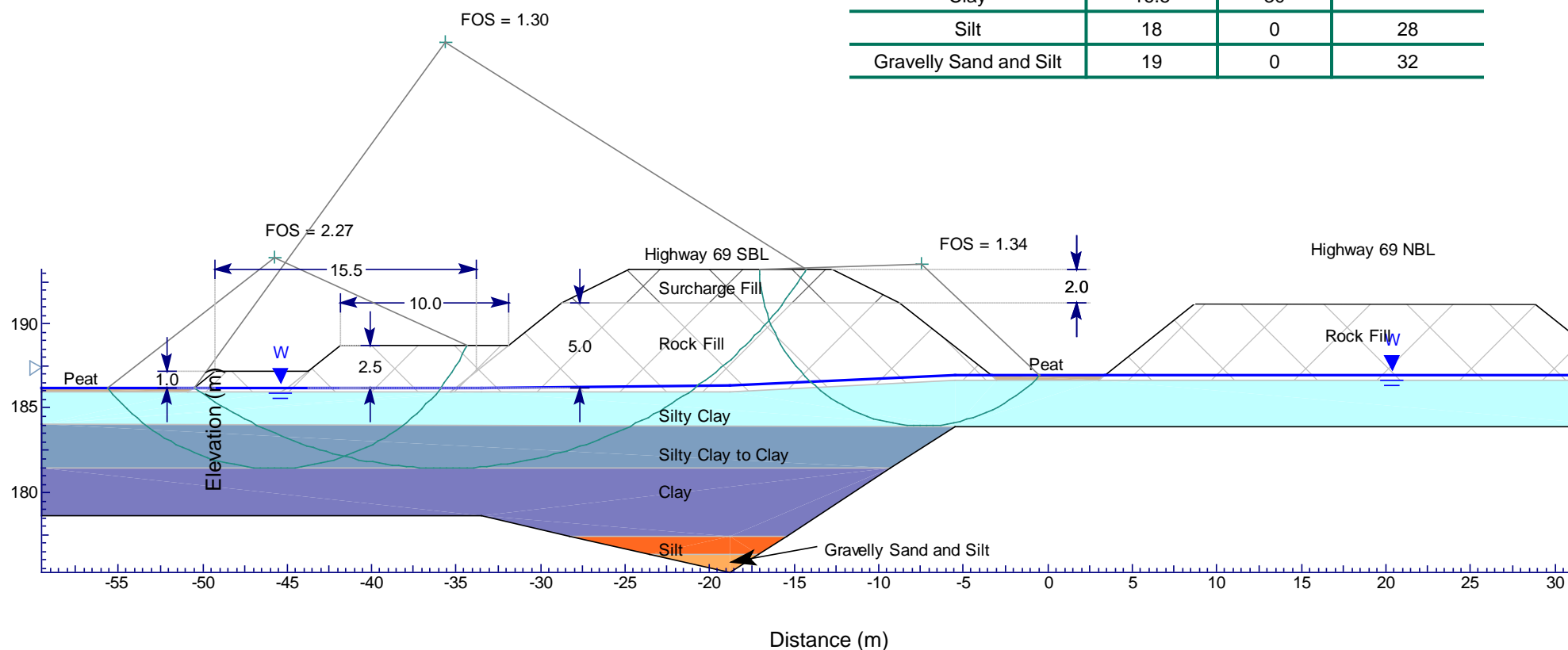


Highway 69 SBL – STA 12+200 to 12+375 (Swamp 205) Slope Stability (2 m Surcharge and Outside Toe Berm)

Figure E4

All dimensions are in metres

Material Name	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (degrees)
Surcharge Fill	21	0	34
Rock Fill	19	0	40
Peat	12	1	27
Silty Clay	16.5	53 – 15	-
Silty Clay to Clay	16.5	15	-
Clay	16.5	30	-
Silt	18	0	28
Gravelly Sand and Silt	19	0	32



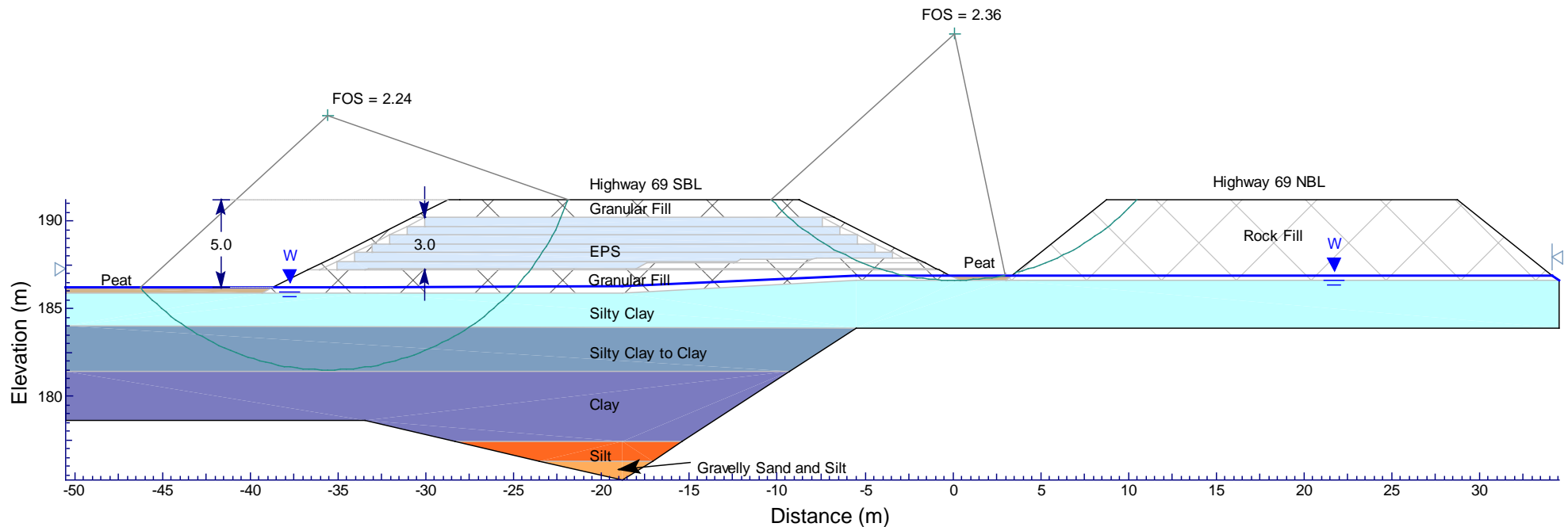


Highway 69 SBL – STA 12+200 to 12+375 (Swamp 205) Slope Stability (3 m of EPS Fill)

Figure E5

All dimensions are in metres

Material Name	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (degrees)
Granular Fill	21	0	34
EPS	0.5	15	0
Rock Fill	19	0	40
Peat	12	1	27
Silty Clay	16.5	53 – 15	-
Silty Clay to Clay	16.5	15	-
Clay	16.5	30	-
Silt	18	0	28
Gravelly Sand and Silt	19	0	32





FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS

HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

Table E1
Evaluation of Stability/Settlement Mitigation Options
Highway 69 SBL – STA 12+200 to 12+375 (Swamp 205)

Stability/Settlement Mitigation Option	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
Full Sub-Excavation (up to 9 m deep)	2	<ul style="list-style-type: none"> ■ Reduced total settlement. ■ No delay in construction. ■ Toe berm is not required. 	<ul style="list-style-type: none"> ■ Generation of large volume of excess excavation spoil. ■ Greater quantity of rock fill required. ■ 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 post-construction settlement of rock fill. ■ Some risk with maintaining stability of excavation slopes. ■ Very low risk with respect to maintaining stability of proposed embankment.
Partial Sub-Excavation (up to 5 m deep) with Preloading (200 days)	1	<ul style="list-style-type: none"> ■ Standard construction operation. ■ Smaller volume of excavation/spoil disposal and replacement backfill as compared with full sub-excavation option. ■ Toe berms are not required. Consistent with proposed Pavement Engineering mitigation measure for adjacent NBL embankment. 	<ul style="list-style-type: none"> ■ Delay in construction to reach post-construction settlement criteria for the remaining up to 4 m thick clay deposit. ■ Some excess excavation spoil still generated requiring disposal. 	<ul style="list-style-type: none"> ■ Schedule impacts may increase overall project costs. ■ Reduced cost for smaller quantity of embankment fill material as compared with full sub-excavation option. ■ Reduced costs for disposal / management of excavation spoil as compared with full sub-excavation option. 	<ul style="list-style-type: none"> ■ Low risk with respect to maintaining stability of fill on weak/soft foundation soils. ■ Subject to the monitoring data collected during the preload period, the preload embankment may need to be left in place for an extended period of time.



FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS

HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

Table E1
Evaluation of Stability/Settlement Mitigation Options
Highway 69 SBL – STA 12+200 to 12+375 (Swamp 205)

Stability/Settlement Mitigation Option	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
Preloading (750 days or about 2.1 years) with Toe Berm (2.5 m high by 6.5 m wide)	Not practical	<ul style="list-style-type: none"> Standard construction operation. Avoids generation of large volume of excess excavation spoil. 	<ul style="list-style-type: none"> Long delay in construction to reach post-construction settlement criteria. A toe berm along the outer embankment toe is required to maintain stability of embankment. Instrumentation and monitoring program required to assess end of preload period. Not consistent with proposed Pavement Engineering mitigation measure for adjacent NBL embankment. 	<ul style="list-style-type: none"> Schedule impacts will increase overall project costs. Additional cost for instrumentation and associated monitoring program. 	<ul style="list-style-type: none"> Some risk with maintaining stability of fills on weak/soft foundation soils. Subject to the monitoring data collected during the preload period, the preload embankment may need to be left in place for an extended period of time.
Surcharging (2 m high for 245 days) with Large Toe Berm (1 m high by 15.5 m wide lower tier and 1.5 m high by 10 m wide upper tier)	4	<ul style="list-style-type: none"> Standard construction operation. Reduced time to reach post-construction settlement criteria as compared with preloading only alternative. Avoids generation of large volume of excess 	<ul style="list-style-type: none"> Delay in construction to reach post-construction settlement criteria. Increased handling of surcharge fill (Granular 'B') upon completion of surcharge period. May require additional right-of-way to 	<ul style="list-style-type: none"> Schedule impacts may increase overall project costs. Increased costs associated with construction for 2 m high surcharge and a large toe berm as compared with preload option. 	<ul style="list-style-type: none"> Higher risk with respect to maintaining stability of embankment with surcharge on weak/soft foundation soils. Subject to the monitoring data collected during the surcharge period, the surcharge embankment



FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS

HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

Table E1
Evaluation of Stability/Settlement Mitigation Options
Highway 69 SBL – STA 12+200 to 12+375 (Swamp 205)

Stability/Settlement Mitigation Option	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
		excavation spoil.	accommodate a large toe berm. <ul style="list-style-type: none"> ■ Instrumentation and monitoring program required to assess end of surcharge period. ■ Not consistent with proposed Pavement Engineering mitigation measure for adjacent NBL embankment. 	<ul style="list-style-type: none"> ■ Additional cost for instrumentation and associated monitoring program. ■ Additional cost may be required for acquiring additional right-of-way to accommodate a large berm. 	may need to be left in place for an extended period of time.
Wick Drains with Surcharging (165 days) with Large Toe Berm (1 m high by 15.5 m wide lower tier and 1.5 m high by 10 m wide upper tier) followed by Lightweight Fill Top-Up (0.4 m of EPS)	5	<ul style="list-style-type: none"> ■ Reduced time for primary consolidation settlement to complete. ■ Toe berms may not be required if staged construction is employed. Requires confirmation during detail wick drain design. 	<ul style="list-style-type: none"> ■ Detail wick drain investigation and design will be required. ■ A large toe berm may be required if preload embankment plus surcharge is constructed continuously in one stage. ■ Increased magnitude of secondary consolidation (creep) settlement as a result of the accelerated completion of primary consolidation 	<ul style="list-style-type: none"> ■ Schedule impacts may increase overall project costs. ■ Additional costs associated with detail wick drain investigation and design. ■ Additional costs for the installation of wick drains, instrumentation and associated monitoring program. ■ Additional costs associated with construction and materials for 2 m high surcharge and 0.5 m 	<ul style="list-style-type: none"> ■ Some risk with respect to stability of surcharge embankment on weak/soft foundation soils if staged construction is employed. ■ Higher risk associated with the complexity with a wick drain/lightweight fill design. ■ Subject to the monitoring data collected during the surcharge period, the surcharge embankment may need to be left in



FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

Table E1
Evaluation of Stability/Settlement Mitigation Options
Highway 69 SBL – STA 12+200 to 12+375 (Swamp 205)

Stability/Settlement Mitigation Option	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
			<p>settlement.</p> <ul style="list-style-type: none"> ■ Delay in construction schedule to allow for sufficient settlement to occur to meet post-construction settlement criteria. ■ Total magnitude of secondary (creep) consolidation settlement will be greater than other alternatives. ■ Additional time required for the installation of wick drains. ■ Instrumentation and monitoring program required to monitor staged construction and to assess end of surcharge period. ■ Increased handling of surcharge fill (Granular 'B') to remove surcharge. ■ EPS will be required as part of the construction 	<p>EPS top-up.</p> <ul style="list-style-type: none"> ■ Additional cost may be required for acquiring additional right-of-way to accommodate a large berm. 	<p>place for an extended period of time.</p>



FOUNDATION REPORT – SWAMP CROSSINGS AND HIGH FILL AREAS HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01

Table E1
Evaluation of Stability/Settlement Mitigation Options
Highway 69 SBL – STA 12+200 to 12+375 (Swamp 205)

Stability/Settlement Mitigation Option	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
			<p>of the final embankment.</p> <ul style="list-style-type: none"> Pavement Engineering mitigation measure on adjacent NBL embankment (i.e. full sub-excavation and backfill) may conflict with wick drain installation. 		
Partial Preloading (2.5 m high for 60 days) followed by Lightweight Fill Construction (3 m of EPS)	3	<ul style="list-style-type: none"> Improved stability. Reduced total settlement of foundation soils. May shorten construction schedule. 	<ul style="list-style-type: none"> High cost of EPS construction materials. Additional effort required to remove the partial preload embankment in order to construct the EPS embankment. Not consistent with proposed Pavement Engineering mitigation measure for adjacent NBL embankment. 	<ul style="list-style-type: none"> Relative cost of EPS fill is about an order of magnitude higher than fill required for the other alternatives. 	<ul style="list-style-type: none"> Very low risk with respect to stability of partial preload fill and final EPS embankment on weak/soft foundation soils. Low risk with respect to unexpected post-construction settlements.

[http://capws/sites/0911116014highway69fourlaning/contract 2/reporting/final/swamp crossings and high fill areas/tables and figures/09-1111-6014-1 tbl e1 evaluation of mitigation options-swamp 205 sbl.docx](http://capws/sites/0911116014highway69fourlaning/contract%20reporting/final/swamp%20crossings%20and%20high%20fill%20areas/tables%20and%20figures/09-1111-6014-1%20tbl%20e1%20evaluation%20of%20mitigation%20options-swamp%20205%20sbl.docx)

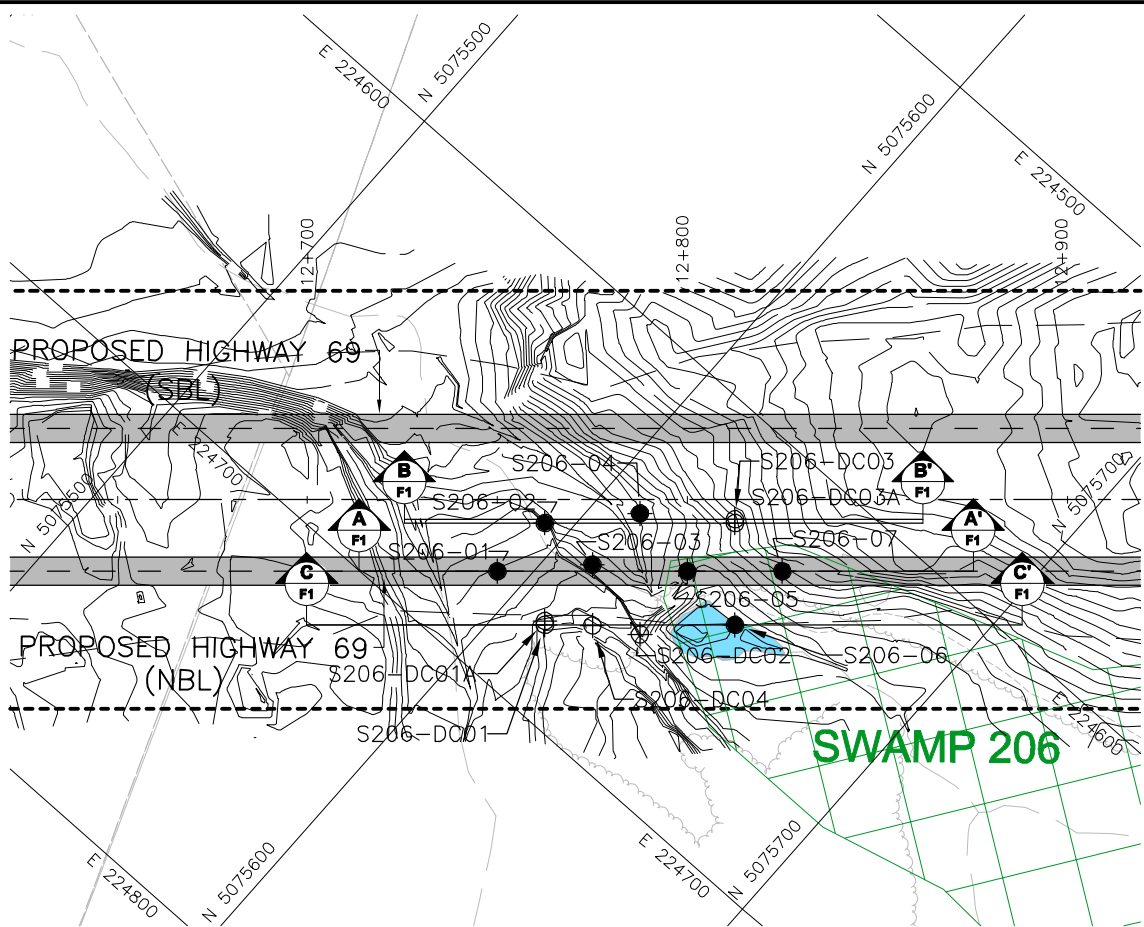
Prepared By: TZ/CN

Reviewed By: JPD/JMAC

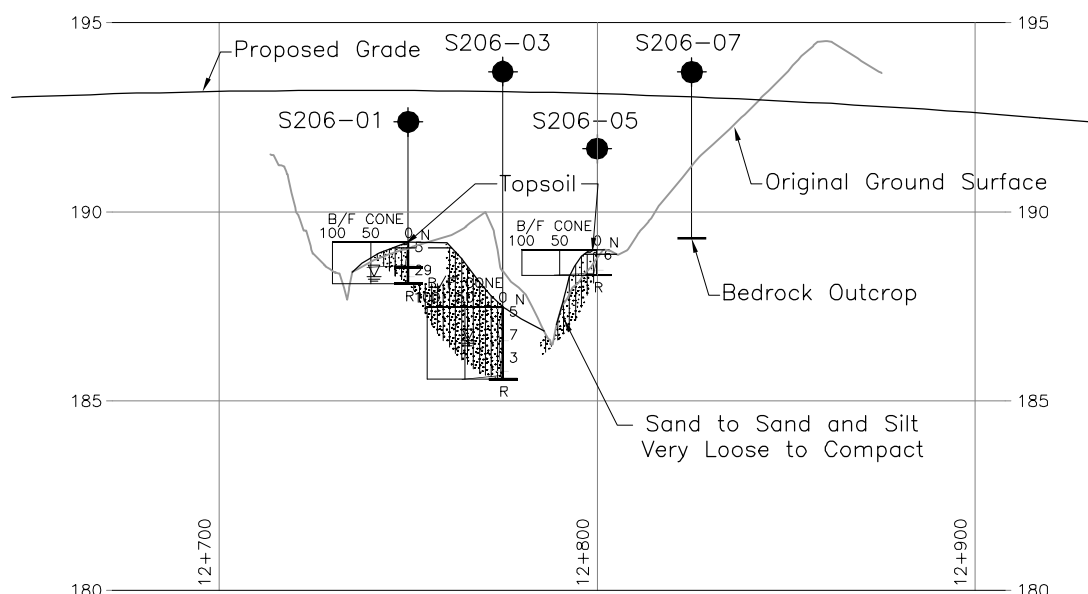


APPENDIX F

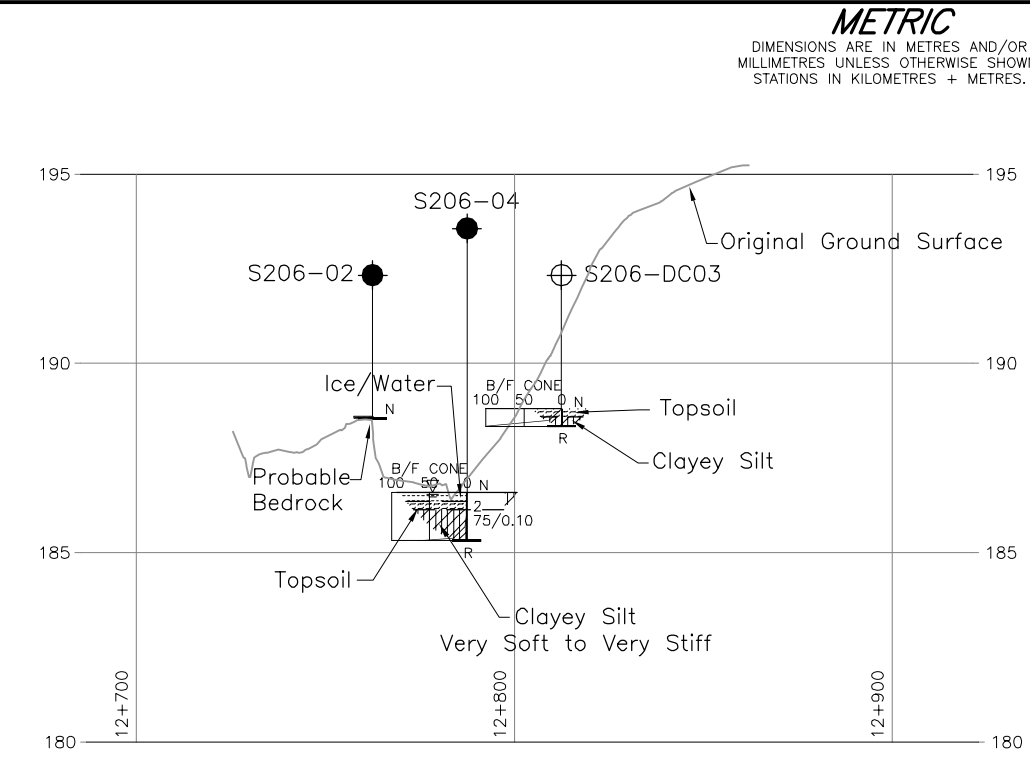
Highway 69 NBL – STA 12+750 to 12+825 (Swamp 206)



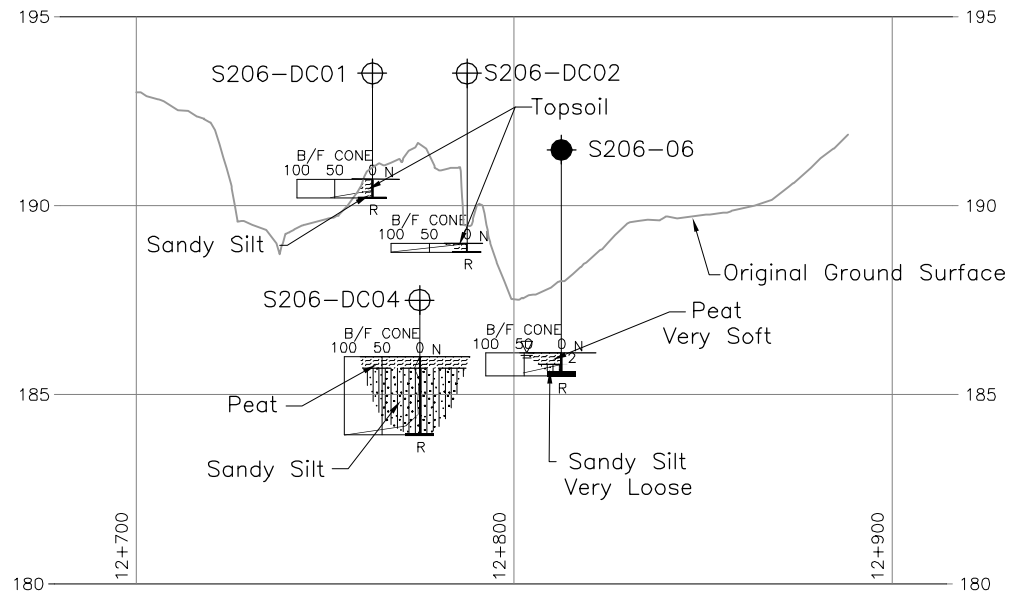
PLAN
 SCALE
 20 0 20 40 m
 2 0 2 4 m



A-A' F1
CENTRELINE PROFILE
HIGHWAY 69 (NBL)
 HORIZONTAL SCALE
 20 0 20 40 m
 VERTICAL SCALE
 2 0 2 4 m



B-B' F1
EMBANKMENT TOE PROFILE
HIGHWAY 69 (NBL)
 HORIZONTAL SCALE
 20 0 20 40 m
 VERTICAL SCALE
 2 0 2 4 m



B-B' F1
EMBANKMENT TOE PROFILE
HIGHWAY 69 (NBL)
 HORIZONTAL SCALE
 20 0 20 40 m
 VERTICAL SCALE
 2 0 2 4 m

REFERENCE

Base plans provided in digital format by URS, drawing files Hwy69_base.dwg, Hwy69_plan.dwg, received December 16, 2009. Original Ground Surface cut from contour drawing file HWY69_Contours-Plan_C2_C3.dwg, received July 14, 2011 and the Proposed Grade obtained from drawing file Hwy69_profile-nov-18-2011.dwg, received December 5, 2011.



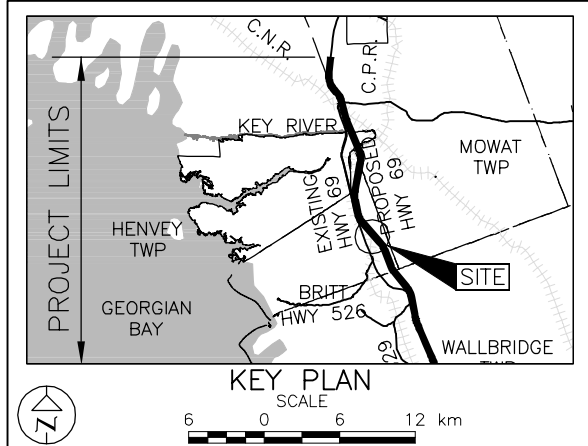
METRIC
 DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 5404-05-01

HIGHWAY 69
 STA 12+750 TO 12+825 (NBL)
BOREHOLE LOCATIONS AND SOIL STRATA



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
S206-01	189.2	5075592.8	224676.0
S206-02	188.6	5075593.8	224658.3
S206-03	187.5	5075610.4	224658.2
S206-04	186.6	5075610.9	224639.8
S206-05	189.0	5075630.3	224643.0
S206-06	186.1	5075649.0	224645.3
S206-07	189.3	5075649.1	224626.4
S206-DC01	190.7	5075611.5	224678.4
S206-DC01A	190.7	5075610.9	224677.6
S206-DC02	189.0	5075631.9	224663.7
S206-DC03	188.8	5075631.3	224625.2
S206-DC03A	188.8	5075630.6	224624.4
S206-DC04	186.0	5075621.0	224670.2

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.

NO.	DATE	BY	REVISION
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
31			
32			
33			
34			
35			
36			
37			
38			
39			
40			
41			
42			
43			
44			
45			
46			
47			
48			
49			
50			
51			
52			
53			
54			
55			
56			
57			
58			
59			
60			
61			
62			
63			
64			
65			
66			
67			
68			
69			
70			
71			
72			
73			
74			
75			
76			
77			
78			
79			
80			
81			
82			
83			
84			
85			
86			
87			
88			
89			
90			
91			
92			
93			
94			
95			
96			
97			
98			
99			
100			

PROJECT 09-1111-6014				RECORD OF BOREHOLE No S206-01				1 OF 1 METRIC									
W.P. 5404-05-01				LOCATION N 5075592.8 ; E 224676.0				ORIGINATED BY MR									
DIST HWY 69				BOREHOLE TYPE Portable Equipment				COMPILED BY OK									
DATUM Geodetic				DATE January 18, 2010				CHECKED BY TVA									
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									
189.2	GROUND SURFACE																
0.0	TOPSOIL		1A														
0.2	SAND, trace silt, containing rootlets		1B	SS	5												
188.6	Loose Brown Moist		2A	SS	29												
188.3			2B														
1.1	SAND and SILT, trace to some clay, trace gravel Compact Brown Moist SAND, some gravel, trace silt Compact Brown Wet END OF BOREHOLE SPOON REFUSAL																
NOTES: 1. Water level in open borehole at a depth of 0.9 m below ground surface (Elev. 188.3 m) upon completion of drilling. 2. A Dynamic Cone Penetration Test was advanced 1.5 m east of Borehole S206-01 to confirm depth to refusal; refusal encountered at a depth of 0.8 m below ground surface (Elev. 188.4 m). 3. Bedrock outcrop observed in the vicinity of Borehole S206-01.																	

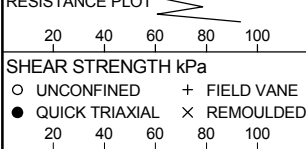


MIS-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD



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

PROJECT		09-1111-6014		RECORD OF BOREHOLE No S206-03		1 OF 1 METRIC								
W.P.		5404-05-01		LOCATION		N 5075610.4 ; E 224658.2								
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment								
DATUM		Geodetic		DATE		January 19, 2010								
				ORIGINATED BY		MR								
				COMPILED BY		OK								
				CHECKED BY		TVA								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _p W W _L	WATER CONTENT (%)	20 40 60		
187.5	GROUND SURFACE													
0.9	TOPSOIL		1	SS	5								OC = 2.5%	
186.6	SAND, trace gravel, trace silt, slightly organic and containing rootlets		2A	SS	7									
0.9	Loose Brown Moist to wet		2B	SS	7								OC = 2.4%	0 59 33 8
185.8	SAND and SILT, trace to some clay, slightly organic Very loose to loose		3	SS	3									
1.9	Grey Wet													
	END OF BOREHOLE SPOON REFUSAL													
	END OF DCPT Refusal to Further Penetration (Hammer Bouncing)													
NOTES: 1. Water level in open borehole at a depth of 1.0 m below ground surface (Elev. 186.5 m) upon completion of drilling. 2. A Dynamic Cone Penetration Test was advanced 1.5 m west of Borehole S206-03 to confirm depth to refusal; refusal encountered at a depth of 1.9 m below ground surface (Elev. 185.6 m). 3. Bedrock outcrop observed south of Borehole S206-03.														

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No S206-04		1 OF 1 METRIC	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5075610.9 ; E 224639.8</u>		ORIGINATED BY <u>MR</u>	
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Portable Equipment</u>		COMPILED BY <u>OK</u>	
DATUM <u>Geodetic</u>		DATE <u>January 19, 2010</u>		CHECKED BY <u>TVA</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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
186.6	ICE SURFACE										
0.0	ICE										
	WATER										
186.1	TOPSOIL		1A	SS	2						
185.8	CLAYEY SILT, trace sand, containing rootlets		1B	SS	2						
0.9	Very soft to very stiff										
185.3	Brown and grey										
1.3	Wet to moist										
	END OF BOREHOLE SPOON REFUSAL										
	END OF DCPT										
	Refusal to Further Penetration (Hammer Bouncing)										
NOTES: 1. Water level in open borehole at ice surface (Elev. 186.6 m) upon completion of drilling. 2. A Dynamic Cone Penetration Test was advanced 1.5 m west of Borehole S206-04 to confirm depth to refusal; refusal encountered at a depth of 1.3 m below ice surface (Elev. 185.3 m).											

PROJECT 09-1111-6014				RECORD OF BOREHOLE No S206-05				1 OF 1 METRIC									
W.P. 5404-05-01		LOCATION N 5075630.3 ;E 224643.0				ORIGINATED BY MR											
DIST HWY 69		BOREHOLE TYPE Portable Equipment				COMPILED BY OK											
DATUM Geodetic		DATE January 19, 2010				CHECKED BY TVA											
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									
189.0	GROUND SURFACE																
0.0	TOPSOIL		1A														
0.1	SAND, trace gravel, trace silt, containing rootlets		1B	SS	6												
188.5	Loose Brown Moist																
0.7	END OF BOREHOLE SPOON REFUSAL END OF DCPT Refusal to Further Penetration (Hammer Bouncing)																
NOTES: 1. Open borehole dry upon completion of drilling. 2. A Dynamic Cone Penetration Test was advanced 1.5 m west of Borehole S206-05 to confirm depth to refusal; refusal encountered at a depth of 0.7 m below ground surface (Elev. 188.3 m). 3. Bedrock outcrop observed in the vicinity of Borehole S206-05.																	

PROJECT 09-1111-6014		RECORD OF BOREHOLE No S206-06				1 OF 1 METRIC											
W.P. 5404-05-01		LOCATION N 5075649.0 ; E 224645.3				ORIGINATED BY MR											
DIST HWY 69		BOREHOLE TYPE Portable Equipment				COMPILED BY OK											
DATUM Geodetic		DATE January 19, 2010				CHECKED BY TVA											
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									
186.1	GROUND SURFACE						20	40	60	80	100						
0.0 185.8	PEAT, containing rootlets, (Fibrous) Very soft Grey Wet		1A	SS	2		186										
185.5 0.6	Sandy SILT, containing rootlets and topsoil Very loose Grey Wet		1B														
	END OF BOREHOLE SPOON REFUSAL																
NOTES: 1. Water level in open borehole at ground surface (Elev. 186.1 m) upon completion of drilling. 2. A Dynamic Cone Penetration Test was advanced 1.5 m west of Borehole S206-06 to confirm depth to refusal; refusal encountered at a depth of 0.5 m below ground surface (Elev. 186.6 m).																	

MIS-MTO.001 09-1111-6014.GPJ GAL-MASS.GDT 7/25/12 SAC/DD



MIS-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

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

PROJECT 09-1111-6014		RECORD OF DCPT No S206-DC01		SHEET 1 OF 1		METRIC										
W.P. 5404-05-01		LOCATION N 5075611.5 ; E 224678.4		ORIGINATED BY MR												
DIST HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test		COMPILED BY OK												
DATUM Geodetic		DATE January 19, 2010		CHECKED BY TVA												
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			
190.7	GROUND SURFACE															
0.0	Dynamic Cone Penetration Test (DCPT)															
190.2	END OF DCPT															
0.5	Refusal to Further Penetration (Hammer Bouncing)															
	NOTES: 1. DCPT advanced using portable drilling equipment with a half-weight hammer. Blows shown have been adjusted to reflect values that would be obtained with a standard weight hammer. 2. An additional Dynamic Cone Penetration Test was advanced 1.0 m west of DCPT S206-DC01 to confirm depth to refusal; see Record of DCPT S206-DC01A for details. 3. Bedrock outcrop observed approximately 1.0 m west of DCPT S206-DC01.															

PROJECT 09-1111-6014		RECORD OF DCPT No S206-DC01A		SHEET 1 OF 1		METRIC										
W.P. 5404-05-01		LOCATION N 5075610.9 ; E 224677.6		ORIGINATED BY MR												
DIST HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test		COMPILED BY OK												
DATUM Geodetic		DATE January 19, 2010		CHECKED BY TVA												
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			
190.7	GROUND SURFACE															
0.0	Dynamic Cone Penetration Test (DCPT)															
190.3	END OF DCPT															
0.4	Refusal to Further Penetration (Hammer Bouncing)															
	NOTE: 1. DCPT advanced using portable drilling equipment with a half-weight hammer. Blows shown have been adjusted to reflect values that would be obtained with a standard weight hammer.															

PROJECT 09-1111-6014		RECORD OF DCPT No S206-DC02		SHEET 1 OF 1		METRIC										
W.P. 5404-05-01		LOCATION N 5075631.9 ; E 224663.7		ORIGINATED BY MR												
DIST _____ HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test		COMPILED BY OK												
DATUM Geodetic		DATE January 19, 2010		CHECKED BY TVA												
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								
189.0	GROUND SURFACE															
0.0	Dynamic Cone Penetration Test (DCPT)															
0.2	END OF DCPT Refusal to Further Penetration (Hammer Bouncing) NOTE: 1. Bedrock outcrop observed in the vicinity of DCPT S206-DC02.															

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT 09-1111-6014		RECORD OF DCPT No S206-DC03		SHEET 1 OF 1		METRIC										
W.P. 5404-05-01		LOCATION N 5075631.3 ; E 224625.2		ORIGINATED BY MR												
DIST HWY 69		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test		COMPILED BY OK												
DATUM Geodetic		DATE January 19, 2010		CHECKED BY TVA												
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								
188.8	GROUND SURFACE															
0.0	Dynamic Cone Penetration Test (DCPT)															
188.3	END OF DCPT Refusal to Further Penetration (100 Blows / 0.15 m)															
0.5	NOTE: 1. An additional Dynamic Cone Penetration Test was drilled 1.5 m west of DCPT S206-DC03 to confirm depth to refusal; see Record of DCPT S206-DC03A for details.															



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

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

PROJECT <u>09-1111-6014</u>		RECORD OF DCPT No S206-DC04		SHEET 1 OF 1		METRIC	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5075621.0 ; E 224670.2</u>		ORIGINATED BY <u>MR</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Portable Equipment, Dynamic Cone Penetration Test</u>		COMPILED BY <u>OK</u>			
DATUM <u>Geodetic</u>		DATE <u>January 19, 2010</u>		CHECKED BY <u>TVA</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL						× REMOULDED		
186.0	ICE SURFACE																	
0.0	Dynamic Cone Penetration Test (DCPT)																	
183.9	END OF DCPT Refusal to Further Penetration (100 Blows / 0.23 m)																	
2.1	NOTE: 1. Bedrock outcrop observed in the vicinity of DCPT S206-DC04.																	

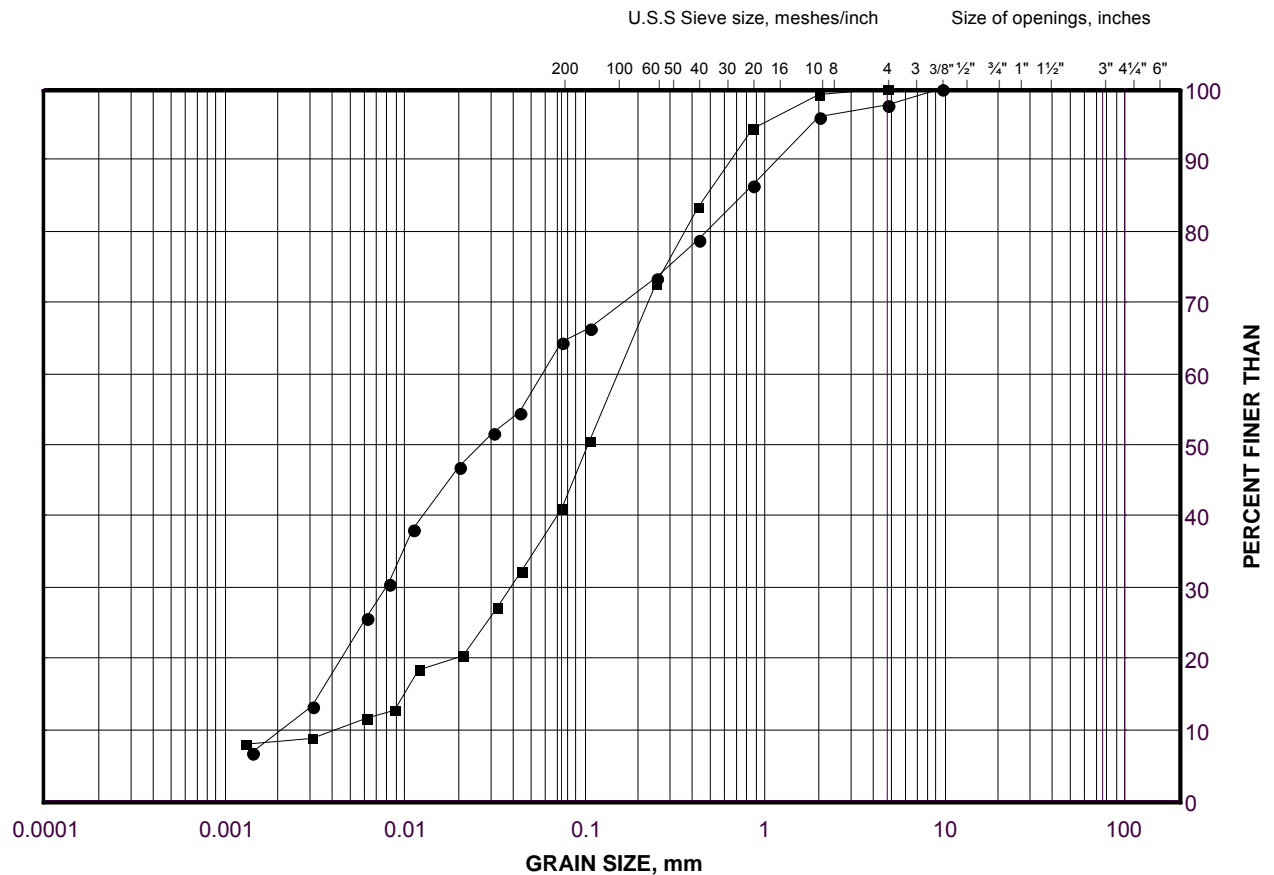
GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

GRAIN SIZE DISTRIBUTION

Sand and Silt

Highway 69 (NBL) STA 12+750 to 12+825 (Swamp 206)

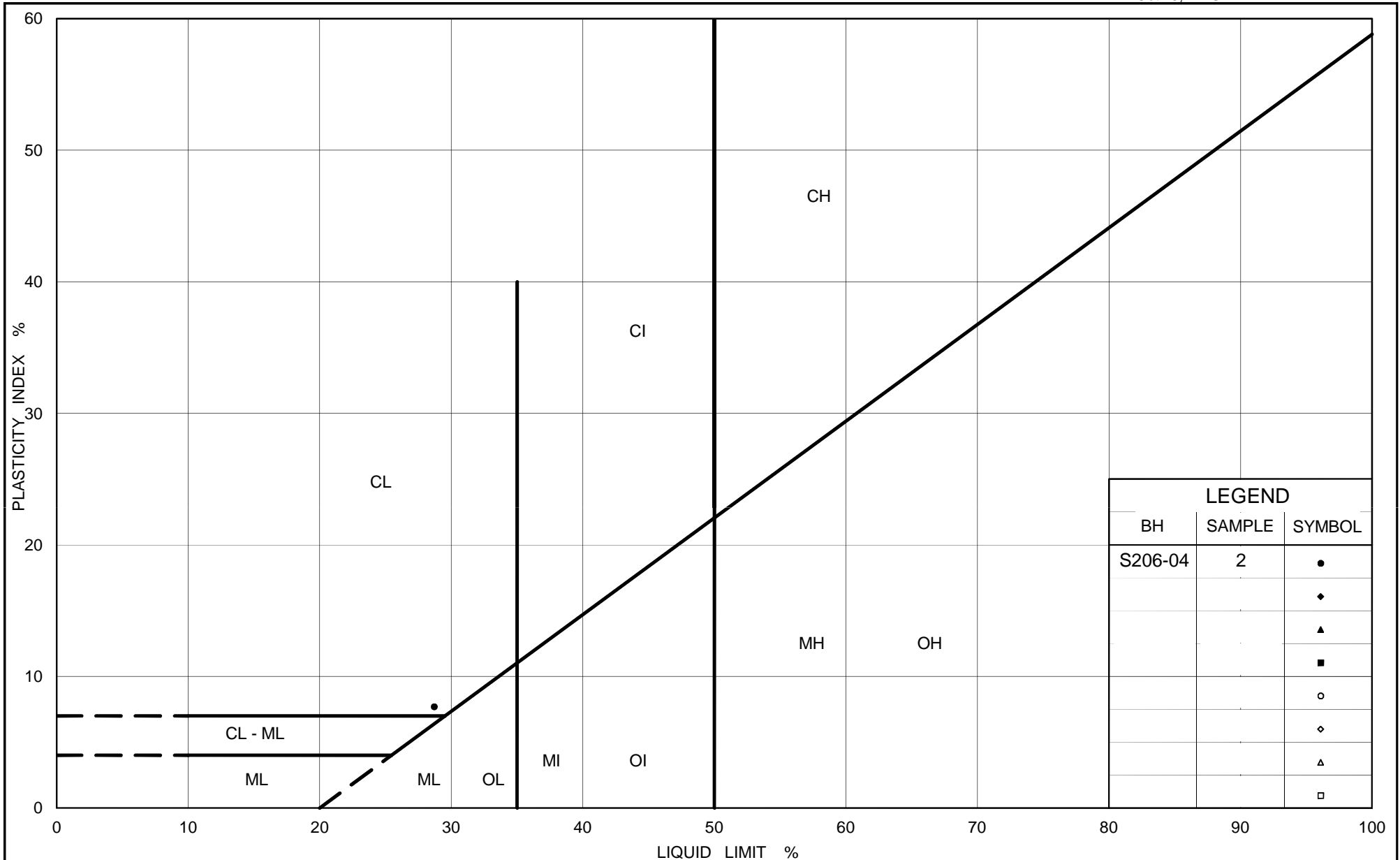
FIGURE F.S206-01



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S206-01	2A	188.4
■	S206-03	2B	186.4



Ministry of Transportation

Ontario

PLASTICITY CHART

Clayey Silt

Highway 69 (NBL) STA 12+750 to 12+825 (Swamp 206)

Figure No. F.S206-02

Project No. 09-1111-6014

Checked By: TVA



APPENDIX G

Non-Standard Special Provisions

Expanded Polystyrene Embankment – Item No.

Special Provision

REQUIREMENTS FOR EXPANDED POLYSTYRENE EMBANKMENT FILL

1.0 SCOPE

This special provision covers the requirements for the supply and construction of the rigid expanded polystyrene embankment fill and associated works as shown on the contract drawings.

2.0 REFERENCES

This special provision refers to the following standards, specifications or publications.

2.1 National Standards of Canada

CAN/CGSB - 51.20 M87

2.2 ASTM

ASTM D6817 Standard Specification for Rigid Cellular Polystyrene Geofoam

ASTM D1621 Test Method for Compressive Properties of Rigid Cellular Plastics

ASTM C203 Test Method for Breaking Load and Flexural Properties of Block Type Thermal Insulation

ASTM C177 Test Method for Steady State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Apparatus

ASTM D2842 Test Method for Water Absorption by Rigid Cellular Plastics

ASTM D2863 Test Method for Measuring the Minimum Oxygen Content

ASTM D2126 Test Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging

2.3 OPSS - Ontario Provincial Standard Specification

OPSS 212 Borrow

OPSS 501 Compaction

OPSS 517 Dewatering

OPSS 1010 Aggregates – Granular A, B, M, and Selected Subgrade Material

OPSS 1860 Geotextiles

3.0 SUBSURFACE CONDITIONS

The subsurface conditions at the site are described in the Foundation Investigation Report for this Contract.

4.0 DEFINITIONS

For the purpose of this special provision, the following definitions apply:

Rigid Expanded Polystyrene: Moulded rigid blocks produced by a process of pre-expansion, aging and forming of petroleum based raw material.

Rigid Extruded Expanded Polystyrene: Rigid boards made by extrusion of expanded polystyrene beads.

Production Lot: The quantity of rigid polystyrene blocks produced in a continuous period of manufacturing the same grade and thickness of product within the same production day.

Quality Verification Engineer: Quality Verification Engineer means an Engineer with a minimum of five (5) years experience related to the design and/or construction of expanded polystyrene systems of similar scope to that in the Contract, or alternatively has demonstrated expertise by providing satisfactory quality verification services for the work at a minimum of two (2) projects of similar scope to the Contract. The Quality Verification Engineer shall be retained by the Contractor to ensure conformance with the contract documents and issue of certificate(s) of conformance.

5.0 QUALIFICATION

The Contractor shall have on site at the commencement of the work, a representative of the supplier of the rigid expanded polystyrene to advise on recommended construction procedure.

The Contractor shall maintain liaison with the supplier throughout the construction of the embankment for advice and guidance as required. Periodic site visits by the supplier should be coordinated as required.

6.0 SUBMISSION AND DESIGN REQUIREMENTS

6.1 Submission of Shop Drawings

At least three (3) weeks before the commencement of work, the Contractor shall submit to the Contract Administrator six (6) copies of the shop drawings and method statement signed and sealed by the Quality Verification Engineer that provides full details of materials and construction procedure.

6.2 Delivery, Storage, Handling, and Protection

The Contractor shall submit the method of delivery, storage, handling and protection from damage by weather, traffic, construction staging and other causes as per the rigid expanded polystyrene manufacturer's requirement.

6.3 Construction

The contractor shall submit full details of the following.

- a) The method of foundation excavation and preparation.
- b) Construction of 300 mm thick levelling pad.
- c) The method of placement of expanded polystyrene blocks including temporary ballasting and protection of blocks during installation. The shop drawings shall indicate laying pattern and block dimensions on a layer-by-layer basis.
- d) The method and limits of placement of polyethylene sheeting.
- e) The method of placement of 125 mm reinforced concrete base pad (or equivalent).
- f) The method of placement of subbase material.
- g) The method of placement of side slope cover.

6.4 Quality Verification Engineer

- (1) The Contractor shall submit details of the sequence and method of installation to the Quality Verification Engineer for review. The submittals shall satisfy the specifications and at a minimum include a detailed description of proposed installation procedures. The details shall be submitted at least three weeks prior to the installation of the rigid expanded polystyrene embankments. The Contractor shall also submit to the Contract Administrator, for information purposes, details of the sequence and method of installation. The submittals shall satisfy the specifications and at a minimum contain the above information as provided to the Contractor's Quality Verification Engineer.
- (2) The Contractor shall submit to the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer a minimum of one week prior to commencement of work under this item. The Certificate shall state that the installation procedures are in conformance with the requirements and specifications of the contract documents. Quality test certificates for each production lot supplied, showing compliance with all requirements of this special provision shall be obtained by the Contractor and submitted to the Contract Administrator prior to installation. Upon completion of the Expanded Polystyrene Embankment the Contractor shall submit to the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer stating that the Expanded Polystyrene Embankment has been constructed in conformance with the installation procedures and specifications of the contract documents.

7.0 MATERIALS

7.1 Granular Levelling Pad

The levelling pad shall consist of a Granular 'A' material with gradation and physical requirements as specified in Special Provision 110S13.

7.2 Rigid Expanded Polystyrene

7.2.1 General

7.2.1.1 The Contractor shall submit:

1. A general statement as to the type, composition, and method of production of the material.
2. The manufacturer's name, address, phone number, identification of a contact person and description of background experience in the manufacturing of the rigid expanded polystyrene.
3. Certification of compliance of physical and mechanical properties.
4. An identification of a laboratory accredited by the Standards Council of Canada to conduct the testing of the physical and mechanical properties of the rigid expanded polystyrene.
5. The physical and mechanical properties of the rigid expanded polystyrene including:
 1. Geometry
 2. Nominal Density
 3. Compressive Strength
 4. Flexural Strength
 5. Thermal Resistance
 6. Dimensional Stability
 7. Flammability
 8. Water Absorption
6. Aging and durability characteristics of the polystyrene including the chemical, biological and ultra-violet degradation resistance of the rigid polystyrene.
7. A sample of the expanded polystyrene material to the Quality Verification Engineer for review.
8. To the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer a minimum of one (1) week prior to commencement of work under this item. The Certificate shall state that the expanded polystyrene material is in conformance with the requirements and specifications of the contract documents.

7.2.1.2 Production Lots

Each block of the same production lot shall be stamped with the same production code showing plant identification, type and date of production. The polystyrene shall be free from defects affecting serviceability.

7.2.2 Detail Requirements

Requirements shall be as shown in Table 1 and as described below.

Table 1 – Material Properties

PROPERTY	UNIT	REQUIREMENTS	TEST PROCEDURE
Geometry - Linear Dimensions - Flatness - Squareness	mm (min)	1200 x 600 x 300 \pm 1% 10 mm in 3 m \pm 0.5%	--
Nominal Density	kg/m ³ (max)	50	--
Compressive Strength at 5% Deformation	kPa (min)	115	ASTM D1621 (Procedure A)
Flexural Strength	kPa (min)	240	ASTM C203
Dimensional Stability	% linear change (max)	1.5	ASTM D2126
Thermal Resistance	m ² .°C/W (min for 25 mm thickness)	0.7	ASTM C177 or C518
Flammability	Limiting Oxygen Index (min)	24	ASTM D2863
Water Absorption	% by Volume (max)	4	ASTM D2842

7.2.2.1 Geometry

The expanded polystyrene shall be supplied in the form of rectangular parallel blocks of minimum acceptable dimensions of 1200 mm x 600 mm x 300 mm. The maximum deviation from the specified linear dimensions shall be \pm 1%.

The flatness of the block faces shall be within \pm 10 mm of a line formed by a 3 m straight edge.

The maximum difference in corner-to-corner dimensions (squareness) shall be 0.5%.

7.2.2.2 Compressive Strength

The minimum compressive strength, measured in accordance with ASTM D1621, Procedure A, shall be 115 kPa at a strain of not more than 5%. The maximum permissible permanent stress level should not exceed 30% of the compressive strength of the material at 5% deformation.

7.2.2.3 Flexural Strength

The minimum flexural strength of the polystyrene shall be 240 kPa. The flexural strength shall be determined in accordance to ASTM C203, Method 1, Procedure B.2.7.4 Dimensional Stability.

7.2.2.4 Dimensional Stability

Dimensional Stability shall be determined in accordance with ASTM D2126, Procedure G. A tolerance of 1.5% shall be satisfied.

7.2.2.5 Thermal Resistance

The thermal resistance shall be 0.7 m².°C/W for a 25 mm thickness using the following equation and using the average value from three specimens:

$$R_{25\text{ mm}} = \frac{R}{\text{thickness (mm)}} \cdot 25\text{mm}$$

The thermal resistance shall be measured in accordance with ASTM C177 or C518.

7.2.2.6 Flammability

The expanded polystyrene shall be classified as to surface burning characteristics in accordance with CAN/ULC – 51022 having a flame spread rating less than 500. The expanded polystyrene shall have a minimum limiting oxygen index measured in accordance with ASTM D2863.

7.2.2.7 Water Absorption

The water absorption as measured by ASTM D2842 shall be limited to 4% by volume.

7.2.2.8 Chemical Resistance

The expanded polystyrene shall be resistant to common inorganic acids and alkalis. A table identifying the chemical resistance as either resistant limited or not resistant shall be submitted.

7.2.2.9 Biological Resistance

The expanded polystyrene shall be resistant to biological degradation caused by organisms or enzymes.

7.2.2.10 Environmental

The expanded polystyrene shall be inert, non-nutritive and highly stable and shall not produce undesirable gases or leachate.

8.0 DELIVERY, STORAGE AND HANDLING

The product shall be suitably marked to identify its type, number and the manufacturer's name or trademark.

The Contractor shall protect the expanded polystyrene from exposure to sunlight to avoid ultraviolet degradation as per manufacturer's recommendation.

Protection of materials and works from damage by weather, traffic, construction staging, fire or vandalism and other causes shall be the responsibility of the Contractor.

9.0 CONSTRUCTION

9.1 Foundation Excavation

Foundation excavation shall be carried out to the design elevations shown on the Contract Drawings. Any softened, loosened or deleterious materials at the foundation footing elevation shall be subexcavated and replaced with Granular 'A' or Granular 'B' material.

9.2 Leveling Pad

Place, level and compact a layer of Granular 'A' material in accordance with OPSS 501 to within ± 30 mm of the design elevation. The leveling pad shall not deviate by more than 10 mm at any place on a 3 m straight edge over the limits of the bottom course of blocks. The leveling pad shall not be placed on frozen ground.

9.3 Installation of Blocks

- (1) The individually marked blocks shall be placed on the prepared leveling pad. The top surface of the first layer of blocks is to be set plane and level. Local trimming of the blocks may be necessary.
- (2) Subsequent successive layers shall be oriented with the long axis of blocks positioned at 90° to the previous layer in order to avoid continuous joints. Block joints shall be offset and staggered between layers.
- (3) A continuous check shall be kept to ensure the evenness of the blocks is satisfactory in each layer. Blocks shall be laid with joints with maximum opening of 10 mm between blocks. Differences in heights between adjacent blocks in the same layer should not exceed 5 mm.
- (4) Sloping end adjustments at the abutments shall be accomplished by leveling terraces in the subsoil in accordance with the block thickness.
- (5) Temporary ballast shall be provided as necessary to prevent movement of expanded polystyrene both in storage and as placed due to windy conditions. Timber fasteners or equivalent shall be used as necessary.
- (6) The expanded polystyrene embankment shall be protected from accidental ignition due to welding, smoking, grinding or cutting tools, etc. The Contractor shall take all necessary precautions to prevent ignition of the expanded polystyrene.
- (7) The expanded polystyrene shall be protected from organic solvents and other aggressive, harmful chemicals during construction. The proposed method of protection during construction shall be submitted to the Contractor's Quality Verification Engineer for review and to the Contract Administrator for information purposes.
- (8) Exposed blocks shall be covered immediately to avoid possible burrowing by animals.
- (9) Individually marked blocks shall be fabricated and placed to ensure the top surface matches the elevation and crossfall shown on the drawings.
- (10) The top surface and side surfaces of the expanded polystyrene shall be covered with 6 mil polyethylene sheeting extending onto adjacent work at the longitudinal ends of the embankment. All joints shall be lapped a minimum of 300 mm to provide a fully sealed enclosure.
- (11) The contractor shall install the concrete base pad as detailed elsewhere in the contract.
- (12) The side slope of the rigid expanded polystyrene embankment shall be covered with granular fill as detailed elsewhere in the Contract Drawings.

10.0 EQUIPMENT

All cutting of polystyrene materials shall be by electric equipment or by hand.

Heavy equipment shall be limited in weight and size and restricted in operation to avoid damaging the expanded polystyrene as per the manufacturer's requirement.

11.0 QUALITY ASSURANCE

11.1 General

The Contract Administrator may undertake an independent testing program of the expanded polystyrene. Sampling and testing will be carried out in conformance with the relevant test procedure. The physical and thermal property testing identified in Table 1 will be conducted. A recognized testing laboratory accredited by the Standards Council of Canada shall conduct the testing.

11.2 Sampling Frequency

Sufficient sample material shall be obtained from blocks randomly selected by the Contract Administrator from each production lot as soon as the material arrives on site. As a minimum, three (3) blocks shall be tested.

11.3 Acceptance/Rejection

Failure of any one of the sample blocks to comply with any requirements of this special provision shall be cause for rejection of the production lot from which it was taken. Replacement of the blocks shall be at the Contractor's expense.

12.0 MEASUREMENT FOR PAYMENT

12.1 Actual Measurement

Measurement will be by volume in cubic metres measured in its original position and based on cross-sections.

13.0 PAYMENT

13.1 Basis of Payment

The Concrete Base pad and granular leveling pad shall be paid for with the appropriate tender items as detailed elsewhere in the contract.

Payment at the contract price for the above tender item shall be full compensation for all labour, materials and equipment to do the work as described above and no extra payments will be made.

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Ltd.
2390 Argentia Road
Mississauga, Ontario, L5N 5Z7
Canada
T: +1 (905) 567 4444

