DESIGN-BUILD READY FOUNDATION INVESTIGATION AND DESIGN REPORT
STRUCTURAL CULVERTS AND SOUTH TRANSITION EMBANKMENTS
HIGHWAY 69 FOUR-LANING – OWNER'S ENGINEER SERVICES
DISTRICT OF PARRY SOUND, ONTARIO
GWP 5404-05-00 AND GWP 5347-08-00
ASSIGNMENT NO.: 5013-E-0036, WORK ORDER NO. 23

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EXECUTIVE SUMMARY

The section of the four-laning of Highway 69 from Wallbridge Township to Mowat Township includes a total of 30 structural culverts. The south transition section includes three (3) embankments over swamps and a connection road to the existing Highway 69. The project is located along the new and existing alignment of Highway 69 in the District of Parry Sound, Ontario.

The investigations and reports for three (3) of the 30 new culverts have been completed and these reports were already issued. This Change Order No. 23 (CO 23) of the Owner's Engineer assignment No. 5013-E-0036 involves the remaining 27 new culverts. A total of 25 proposed culvert sites will be along the new alignment of Highway 69 and two (2) culverts will be replaced on the existing Highway 69.

Also included in the CO 23 are the foundation treatments of three (3) swamps within the proposed approximately 925 m long Transition, and 250 m long Connection sections at the south end of the new Highway 69 alignment.

A review of the information available from the previous investigations was undertaken to determine the additional foundation investigation work required for the delivery of the design-build ready package. The reviews undertaken by PML in December 2017 and January 2018 were presented to MTO and the final approval was received from MTO on April 25, 2018. In summary,

- PML had previously completed and issued the Foundation Investigations and Design Reports (FIDR) for three (3) of the 30 Structural Culverts
- Of the 27 remaining culverts, Foundation Investigation Reports (FIRs) for seven (7) new culvert sites were completed by others and require preparation of preliminary Foundation Design Reports (FDRs)
- Five (5) culvert sites have adequate borehole information from previous investigations and require preparation of FIDRs with no additional boreholes
- And 15 culverts required investigation and preparation of FIDRs
- Also, three (3) embankments over swamp crossings for the south transition require FIDRs

It is noted that the three (3) completed FIDRs are for proposed culverts in the Henvey Township. The remaining 27 structural culverts are distributed amongst three Townships as follows: One (1) in Wallbridge Township, 15 in Henvey Township, and 11 culverts in the Mowat Township.

The purposes of these 30 structures are as follows:

- Three (3) culverts for Mammal and Cattle crossings,
- Twenty culverts for Fisheries/Wildlife crossings, and
- Seven (7) culverts for Fisheries only.

The scope of the assignment does not include providing recommendations for treatment of swamp crossings identified at the culverts within the new alignment of Highway 69. Refer to the FIDR report completed by others for design recommendations, construction, and monitoring of embankments across the swamps within the new alignment. A list of the relevant reference reports is included in the attached General Report.

Where conflicts occur between this report and previous reports prepared by others, this report shall take precedence for the purposes of this project.

This report consists of a general component relevant to all sites and specific components for each site. These general and site-specific components should be read in conjunction.

While the information presented in this report may be used for planning and design-build ready purposes, it is neither sufficient nor intended for detail design purposes. The FDRs are considered to be prepared for Design-Build ready packages and should be considered preliminary.

The boreholes were advanced to obtain representative subsurface conditions for design-build ready purposes and not necessarily located within the footprint of foundation elements as required for detail design purposes. Accordingly, it is recommended that further subsurface investigations and development of design recommendations be carried out during the detail design phase of the project to meet the requirements of the project agreement for the identified structures and for any additional structures, as applicable.

NOTES:

1. This Final Report includes the preliminary FIDRs for the 17 structural culverts and three (3) embankments over swamp crossings for which field investigation was required. The existing relevant subsurface information and laboratory test results were included in the report.
2. A total of three (3) structural culvert sites could not be accessed for field investigation and have been omitted from this report:

   SHEET D – CVW-5 - Wildlife Crossing (Station: ± 18+220 Hwy 69 NBL/SBL – Wallbridge)

   SHEET N – CVH-51 - Fisheries/Wildlife Culvert (Station: ± 19+580 Hwy 69 SBL – Henvey)

   SHEET O – CVH-52 - Fisheries/Wildlife Culvert (Station: ± 19+617 Hwy 69 NBL – Henvey)

PART 1 - GENERAL DESIGN-BUILD READY FOUNDATION INVESTIGATION AND DESIGN REPORT
STRUCTURAL CULVERTS AND SOUTH TRANSITION EMBANKMENTS
HIGHWAY 69 FOUR-LANING – OWNER'S ENGINEER SERVICES
DISTRICT OF PARRY SOUND, ONTARIO
ASSIGNMENT NO.: 5013-E-0036, WORK ORDER NO. 23

GENERAL DESIGN-BUILD READY FOUNDATION INVESTIGATION

1.0 INTRODUCTION

The Ministry of Transportation Ontario (MTO) retained Parsons Canada Ltd. (Parsons) as the Prime Consultant to provide Owner's Engineer services for the re-alignment and four-laning of Highway 69 for a total distance of approximately 19.7 km, from 1.7 km north of Highway 529 northerly to 3.9 km north of Highway 522.

This section extends from the north end of the Township of Wallbridge and through the Townships of Henvey and Mowat, in the District of Parry Sound, Ontario.

Parsons retained Peto MacCallum Ltd. (PML) on behalf of MTO to provide geotechnical engineering services for the assignment as part of Agreement No. 5013-E-0036, Work Order No. 23. The terms of reference and scope of work for the foundation investigation and design services are outlined in the Proposed Scope of Work for Foundation Investigation and Design Reports, Structural Culverts and South Transition and Connection Embankments, dated March 15, 2018.

The research carried out by PML included the review of the geotechnical studies previously prepared by Golder Associates Limited (Golder) along the proposed new Highway 69 alignment and by PML, including completed and partially completed Foundations Investigation and Design Reports (FIDRs). The relevant available data included boreholes carried out for foundation investigations of embankments to be placed over swamp/wetland areas and was used to complete this report.

Table 1A identifies, for completeness only, the proposed structural culvert reports that were previously competed and are not included in this report. Table 1B lists the culverts for which only FDRs were prepared for this report based on available Golder (FIR). FIDRs were prepared for the culverts listed in Table 1C based on available data in GEOCRES 41H-134. Table 1D lists all of the culverts which field investigation was completed, and Table 1E provides the details of the proposed embankments over swamps at the south transition. Table 1F lists all of the culvert sites that could not be accessed by drilling equipment.

Table 1A: Summary of Completed New Structural Culvert Reports

PML NO.	WP	STATION (HWY)	SITE NUMBER	STRUCTURE NAME (TYPE)	SIZE (m)	TOWNSHIP
2 CVH-8	5011-16-01	STA ± 11+207 Hwy 69 NBL/SBL	44-624/C	Fisheries / Wildlife (SAR) Culvert (202)	3.0 m x 2.4 m	Henvey
3	GWP 5404-05-00	STA ± 11+272 Hwy 69 NBL	44-623/C1	Farm Access / Cattle Crossing	5.0 m x 5.0 m	Henvey
4	GWP 5404-05-00	STA ± 11+272 Hwy 69 SBL	44-623/C2	Farm Access / Cattle Crossing	5.0 m x 5.0 m	Henvey

Note: These three culvert reports were previously completed by others and were not addressed further in this report.

Table 1B: Summary of Culverts requiring FDR only

PML NO.	WP	STATION (HWY)	SITE NUMBER	STRUCTURE NAME (TYPE)	SIZE (m)	TOWNSHIP
5 CVH-17	5076-13-01	STA ± 13+810 Hwy 69 NBL	44-626/C1	Fisheries / Wildlife (SAR) Culvert (301)	3.0 m x 2.4 m	Henvey
6 CVH-18	5076-13-02	STA ± 13+810 Hwy 69 SBL	44-626/C2		3.0 m x 2.4 m	Henvey
18 CVM-1	5114-17-13	STA ± 10+405 Hwy 69 NBL/SBL	44-0655/00	Fisheries Culvert	3.0 m x 1.2 m	Mowat
19 CVM-2	5075-13-03	STA ± 12+587 Hwy 69/522I/C–S-EW Ramp	44-0627/C3	Fisheries / Wildlife (SAR) Culvert (401)	3.0 m x 2.4 m	Mowat
20 CVM-3	5075-13-01	STA ± 12+660 Hwy 69 NBL	44-0627/C1		3.0 m x 2.4 m	Mowat
21 CVM-4	5075-13-02	STA ± 12+718 Hwy 69 /SBL	44-0627/C2		3.0 m x 2.4 m	Mowat
28 CVM-10	5071-22-01	STA ± 16+414 Hwy 69 NBL	44-548/C	Fisheries / Wildlife (SAR) Culvert	3.0 m x 2.4 m	Mowat

Note: Only the FDRs for culverts listed in Table 1B were prepared for this report.

Table 1C: Summary of Culverts requiring FIDR

PML NO.	WP	STATION (HWY)	SITE NUMBER	STRUCTURE NAME (TYPE)	SIZE (m)	TOWNSHIP
10 CVH-26	5114-17-04	STA ± 16+850 Hwy 69 NBL	44-0649/01	Fisheries / Wildlife (SAR) Culvert	3.0 m x 2.4 m	Henvey
11 CVH-31	5114-17-06	STA ± 17+430 Ramp S-EW Bekanon IC	44-0650/00	Fisheries Culvert	3.0 m x 2.4 m	Henvey
13 CVH-46	5114-17-08	STA ± 18+400 Hwy 69 NBL	44-0652/01	Fisheries / Wildlife (SAR) Culvert	3.0 m x 2.4 m	Henvey
14 CVH-47	5114-17-09	STA ± 18+400 Hwy 69 SBL	44-0652/02		3.0 m x 2.4 m	Henvey
15 CVH-50	5114-17-10	STA ± 19+485 Hwy 69 NBL/SBL	44-0653/00	Fisheries / Wildlife (SAR) Culvert	3.0 m x 2.4 m	Henvey

Note: FIDRs for culverts listed in Table 1C were prepared based on available data provided in GEOCRES 41H-134.

Table 1D: Summary of New Structural Culverts Requiring Field Investigation

PML NO.	WP	STATION (HWY)	SITE NUMBER	STRUCTURE NAME (TYPE)	SIZE (m)	TOWNSHIP
7 CVH-21	5114-17-02	STA ± 15+540 Hwy 69 NBL	44-0648/01	Fisheries Culvert	3.0 m x 1.8 m	Henvey
8 CVH-22	5114-17-03	STA ± 15+540 Hwy 69 SBL	44-0648/02		3.0 m x 1.8 m	Henvey
9 CVH-25	5114-17-05	STA ± 16+850 Hwy 69 SBL	44-0649/02	Fisheries / Wildlife (SAR) Culvert	3.0 m x 2.4 m	Henvey
12 CVH-32	5114-17-07	STA ± 10+042 Bekanon Forest Access	44-0651/00	Fisheries Culvert	3.0 m x 2.4 m	Henvey
24 CVM-6	5114-17-16	STA ± 13+790 Hwy 69 NBL	44-0658/01	Fisheries / Wildlife (SAR) Culvert	3.0 m x 2.4 m	Mowat
25 CVM-7	5114-17-17	STA ± 13+790 Hwy 69 SBL	44-0658/02		3.0 m x 2.4 m	Mowat
26 CVM-8	5114-17-18	STA ± 15+340 Hwy 69 NBL	44-0659/01	Fisheries / Wildlife (SAR) Culvert	3.0 m x 2.4 m	Mowat
27 CVM-9	5114-17-19	STA ± 15+380 Hwy 69 SBL	44-0659/02	Fisheries / Wildlife (SAR) Culvert	3.0 m x 2.4 m	Mowat
29 C184	5263-17-01	STA ± 16+000 Exist Hwy 69 NBL/SBL	44X-0666/C0	Fisheries Culvert	3.0 m x 2.1 m	Henvey
30 C189	5263-17- 02	STA ± 19+215 Exist Hwy 69 NBL/SBL	44X-0667/C0	Fisheries Culvert	3.0 m x 2.1 m	Henvey

PML NO.	WP	STATION (HWY)	SITE NUMBER	STRUCTURE NAME (TYPE)	SIZE (m)	TOWNSHIP
22 CVM-13	5114-17-14	STA ± 9+805 Hwy 522	44-0656/00	Fisheries / Wildlife (SAR) Culvert	3.0 m x 2.4 m	Mowat
23 CVM-18	5114-17-15	STA ± 10+403 Forest Access Road	44-0657/00	Fisheries / Wildlife (SAR) Culvert	3.0 m x 2.4 m	Mowat

Table 1E: Summary of New Embankments Over Swamps

PML NO.	GWP	STATION (HWY)	SITE NUMBER	EMBANKMENT	SIZE (m)	TOWNSHIP
TR1	5404-05-00	±9+150 to ±9+260	N/A	South Transition	110	Walbridge
TR2	5404-05-00	±9+310 to ±9+435	N/A	South Transition (*)	125	Walbridge
TR3	5404-05-00	±9+650 to ±9+730	N/A	South Transition	80	Walbridge

Note(s): (*) Includes South Connection Road swamps re-using previous boreholes.

Table 1F: Summary of New Structural Culverts Inaccessible For Field Investigation

PML NO.	WP	STATION (HWY)	SITE NUMBER	STRUCTURE NAME (TYPE)	SIZE (m)	TOWNSHIP
1 CVW-5	5114-17-01	STA ± 18+220 Hwy 69 NBL/SBL	44-0647/00	Wildlife (SAR) Crossing	3.0 m x 2.4 m	Wallbridge
16 CVH-51	5114-17-12	STA ± 19+580 Hwy 69 SBL	44-0654/02	Fisheries / Wildlife (SAR) Culvert	3.0 m x 2.4 m	Henvey
17 CVH-52	5114-17-11	STA ± 19+617 Hwy 69 NBL	44-0654/01	Fisheries / Wildlife (SAR) Culvert	3.0 m x 2.4 m	Henvey

This report is organized in two (2) parts, which should be read in conjunction with each other, as follows:

PART 1: GENERAL Design-Build Ready Foundation Investigation and Design Report (GENERAL Design-Build ready FIDR).

The GENERAL Design-Build Ready FIDR component presents descriptions of the regional geology / geomorphology and general groundwater conditions within the project limits and design-build ready (preliminary) recommendations for applications common to all the culvert sites.

PART 2: SITE-SPECIFIC Foundation Investigation and Preliminary Foundation Design Report (SITE- SPECIFIC FIDR) sheets.

The **SITE-SPECIFIC FIDR** sheets summarize design-build ready descriptions of subsurface conditions and provide preliminary foundation design recommendations for each culvert and three swamps located within the south Transition Section.

Refer to respective **SITE-SPECIFIC FIDR** sheets for borehole locations plans and details of borehole locations at respective sites. Where FIRs were completed by others, this report provides copies of the foundation investigation information. Please refer to the Section 1.1.2 Sources of Information for further details of the previous reports.

Record of Borehole sheets and laboratory test results from previous and current investigations carried out for this assignment are included with the **SITE-SPECIFIC FIDR** sheets.

Refer to **APPENDIX A** for dynamic cone penetration test results.

Refer to **APPENDIX B** for list of MTO specifications as noted in this report.

1.1 Project Description

This project generally involves re-alignment and four-laning of Highway 69 for a distance of approximately 19.7 km, a 925 m long Transition Section, and 250 m Connection Road at the south end of the new highway alignment, to allow for traffic to and from the existing two-lane Highway 69.

The proposed new highway construction for this Change Order No. 23 includes a total of 30 structural culverts for the purpose of Mammal and Cattle crossings, Fisheries/Wildlife crossings, and for Fisheries only. Details of the culverts and swamp investigations were provided in the previous Section 1 of this report.

The site conditions for the swamp crossings and high fill areas within the new alignment of Highway 69 were previously investigated by Golder Associates Ltd. (Golder) and FIDRs for various Contracts were submitted to URS Canada Inc. Details are provided in Section 1.1.2 of this report. Golder identified 10 swamp crossings (Swamp 301 to Swamp 310) within the highway four-laning corridor.

A total of 77 boreholes, auger probes and Dynamic Cone Penetration Tests (DCPT) were carried out by Golder that are relevant to the proposed culvert locations and swamp alignments and are also available from reports in the MTO GEOCRES data base identified in Section 1.1.2. Based on existing subsurface data and a review of the available topography at the new culvert sites, PML proposed to advance 39 boreholes to a maximum depth of 10 m, as agreed with MTO by e-mail dated March 2, 2018. As previously indicated, previous representative boreholes were used for this report. The scope of this assignment includes preparation of Design Build ready FIDRs.

Based on the available vertical profile of the Transition and Connection roads, the heights of these proposed embankments will range from 0.0 m to 2.0 m with possible rock cuts in some sections. Based on the existing data, the proposed embankments typically straddle a series of bedrock outcrops and swamps. The discontinuous soil cover in the boreholes were typically organic soils and sparse firm clayey silts and loose fine sands with depths ranging from zero (0.0 m) at rock outcrops to 1.0 m.

The alignment of the south Transition embankment requires the investigation of three (3) swamp crossings within the proposed alignment of the approximately 925.0 m long Transition Route as described previously. It was considered that the approximately 250.0 m long Connection Route has sufficient subsurface data for a design-build ready report and no additional boreholes were programmed for this roadway.

1.1.1 Field Investigation Procedures

The number of boreholes required to be advanced at each site was based on the existing geological data and available borehole information from previous investigations and was also determined by the proposed type of structure. The investigation program was reviewed and approved by MTO.

The field investigation commenced in September 2018, after due notice was provided to the First Nations offices.

1.1.2 Sources of Information

References considered in the preparation of this report include the FIDRs prepared by others for the project embankments over swamps and the FIRs prepared by Golder for seven (7) culvert locations. These sources of information are listed for each of the culverts in the respective SITE-SPECIFIC FIDR Sheets in Part 2 of this report and summarized in the following Table 1.1.2

Table 1.1.2: List of Reference Reports

PML NO.	REFERENCE REPORT	APPLICABLE SITE(S)	GEOCRES NO.
1	FIDR for Swamp Crossings and High Fills Areas -Contract 3 Highway 69 Four-Laning from 1.7 km North of Highway 529 Northerly to 3.9 km north of Highway 522, GWP 5404-05-00, WP 5404-05-01, submitted to URS by Golder Associates Ltd. February 11, 2014	44-626/C1 and C2	41H-134
2	FIDR for Swamp Crossings and High Fills Areas - Contract 4 Highway 69 Four-Laning from 1.7 km North of Highway 529 Northerly to 3.9 km north of Highway 522, GWP 5347-08-00, WP 5347-08-01, submitted to URS by Golder Associates Ltd. November 29, 2013	CVM -2, 3 and 4	41H-135
3	FIDR for Swamp Crossings and High Fills Areas and Deep Cut -Contract 5 Highway 69 Four-Laning from 1.7 km North of Highway 529 Northerly to 3.9 km north of Highway 522, GWP 5347-08-00, WP 5005-10-01, submitted to AECOM by Golder Associates Ltd. July 27, 2016	CVM- 1	41H-164
4	FIR for Culverts: Site No. 44-626/C1 and C2 – Contract 3, 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 by Golder Associates Ltd. October 1, 2013	44-626/C1 and C2 (CVH-17-18)	41H-128
5	FIR for Culvert at Station 10+405 Contract 5, Highway 69 Four-Laning from 1.7 km North of Highway 529 to 3.0 km North of Highway 522 GWP 5005-10-00 submitted to URS by Golder Associates Ltd. on January 12, 2016	CVM- 1	41H-157

Table 1.1.2: List of Reference Reports

PML NO.	REFERENCE REPORT	APPLICABLE SITE(S)	GEOCRES NO.
6	FIR for Culverts Contract 4 Highway 69 Four-Laning from 1.7 km North of Highway 529 Northerly to 3.9 km north of Highway 522, GWP 5347-08-00, WP 5347-08-01, submitted to URS by Golder Associates Ltd. on October 9, 2013	CVM -2, 3 and 4	41H-133
7	FIR for Culvert Replacement - Contract 4, Existing Highway 69 NBL Station 16+414 Township of Mowat, Highway 69 Four-Laning from 1.7 km North of Highway 529 to 3.9 Km North of Highway 522, GWP 5347-08-00, WP 5347-05-08-01, submitted to URS by Golder Associates Ltd. on October 9, 2013	Existing Hwy 69 culvert	41H-132
	PREVIOUSLY COMPLETED FIDR DOCUMENTS		
8	FIDR for Culverts – Contract 2, Highway 69 Four-Laning from 1.7 km North of Highway 529 to 3.9 km North of Highway 522, GWP 5404-05-00 WP 5404-05-01 submitted to URS Canada Inc. by Golder Associates Ltd. on September 22, 2015	Culverts STA 11+207 and STA 11+220	41H-119
9	FIDR for Cattle crossing Culvert at Station 11+272, Highway 69 Four-Laning from 1.7 km North of Highway 529 to 3.9 km North of Highway 522 Township of Henvey Ontario Agreement No. 5013-E-0036 WO #12 submitted to Parsons Canada Ltd. by Peto MacCallum Ltd. on June 19, 2017	Culvert STA 11+272 NBL and SBL	41H-169
10	Technical Memorandum - Factual Addendum Memorandum for South Limit Transition and Connection, GWP 5404-05-00 - Highway 69 Four-Laning, dated October 7, 2013	Transition and Connection Roads	Not assigned
11	FIDR for Swamp Crossings Highway 69 Four-Laning From 5.3 Km South of Highway 529 (North Junction) Northerly to 2.2 Km North of Highway 529, 7.5 Km G.W.P. 5112-07-00 Magnetawan First Nation / Wallbridge Township, Ontario submitted to AECOM by Peto MacCallum Ltd. on March 11, 2015	Transition and Connection Roads	41H-148

Relevant Record of Borehole sheets from the previous investigations are presented with the **SITE-SPECIFIC FIDR** sheets, along with the associated laboratory test results for each of the culverts and swamp crossings being completed and reported. Interpretation from previous boreholes was included in relevant site-specific investigations and was supplemented by additional boreholes in subsequent investigations carried out by PML for this assignment, as applicable.

In addition to the completed FIDRs, the Terms of Reference called for the reports for five (5) of the new culverts to be prepared using existing boreholes already drilled within the swamps crossing the new Highway 69 alignment near the proposed culvert locations.

1.1.3 Field Investigations

Existing and proposed borehole locations are presented in **PART 2 - SITE-SPECIFIC FIDR** sheets of this report. Boreholes from both previous investigations (where available) and current investigations were plotted on each site-specific borehole location plan.

Although the soil descriptions from the previous and current investigations are similar, some differences exist.

The boreholes for the field investigations were within the MTO Right-of-Way. Permission-To-Enter permits were provided by MTO/Parsons for the sites that required private accessed to be investigated.

The fieldwork investigations for the culverts listed in Table 1D and the proposed south transition embankments, Table 1E, were carried out using truck-mounted and track-mounted drill rigs, portable tripod, and manual probe equipment, including Kessler K-100 Dynamic cone penetrometer (DCP). Portable tripod and DCP equipment was utilized where sites were inaccessible by drill rigs. Some locations were only accessible with DCP equipment to assess the subsoil conditions. Refer to the SITE-SPECIFIC sheets for investigation details.

For the sites listed in Table 1F, multiple attempts were made to access the site locations by foot; however, no accessible paths were available.

Soil samples in the new boreholes, which were investigated with drill rigs and manual tripod, were obtained at selected intervals using a split-spoon sampler in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586 – Standard Test Method for Standard Penetration Test). However, at the culvert locations where use of drill rigs and tripod were not feasible, soil samples were obtained by means of manually pushed Shelby (thin wall) tubes or grabbing samples after digging with a shovel.

Groundwater levels in the open boreholes were observed throughout the drilling operations. If artesian groundwater conditions were encountered in the boreholes, the flow of artesian water would be sealed at the source. Details of the artesian conditions and the sealing operations are presented on the Record of Borehole sheets, where applicable.

Where applicable, the drilled boreholes were abandoned upon completion of drilling in accordance with Ontario Regulation 903 – Wells (as amended by Ontario Regulation 372) and MTO guidelines.

D.S. Dorland Surveyors carried out the survey of the proposed borehole locations advanced by PML, and provided the coordinates and ground surface elevations at the new borehole locations which were referred to the MTM NAD83 northing and easting coordinates. The borehole locations and the ground surface elevations (referenced to Geodetic datum) at the borehole locations are presented in the Record of Borehole sheets.

Each SITE-SPECIFIC culvert and swamp report is identified with a Sheet Number A through Y for ease of reference in this report. Refer to Table 1.1.3 for a combined list of embankments over swamps and culvert sites and their locations.

Walker Drilling Inc., based in Utopia, Ontario, provided the truck/track D25T drill rigs equipped with hollow stem augers and rotary drilling for rock coring, and portable tripod equipment with casing and SPT apparatus. Direct Traffic Management Inc. from Hamilton, Ontario provided traffic control in accordance with Ontario Traffic Manual Book 7 (2014), where required. Kessler K-100 DCP equipment and accessories were provided by PML.

TABLE 1.1.3: List of Embankments Over Swamps and Culverts

PML SITE NO.	STATION	HIGHWAY ALIGNMENT	TOWNSHIP	SITE-SPECIFIC SHEET NO.	SITE NUMBER	REFERENCE DOCUMENT
TR-1	±9+150 to ±9+260	South Transition	Wallbridge	A	N/A	FIDR GEOCRES No.41H-148 Golder Tech Memo dated Oct 7, 2013
TR-2	±9+310 to ±9+435	South Transition and Connection	Wallbridge	B	N/A	
TR-3	±9+650 to ±9+730	South Transition	Wallbridge	C	N/A	
CVW-5	±18+220	Highway 69 NBL/SBL	Wallbridge	D	44-0647/00	N/A
CVH-17	±13+810	Hwy 69 NBL	Henvey	E	44-626/C1	FIR GEOCRES No. 41H-128
CVH-18	±13+810	Hwy 69 SBL	Henvey	E	44-626/C2	FIR GEOCRES No. 41H-128
CVH-21	15+540	Hwy 69 NBL	Henvey	F	44-0648/01	N/A
CVH-22	±15+540	Hwy 69 SBL	Henvey	F	44-0648/02	N/A
C184	±16+000	Existing Hwy 69 NBL/SBL	Henvey	G	44X-0666/C0	N/A
CVH-25	± 16+850	Hwy 69 NBL	Henvey	H	44-0649/02	N/A
CVH-26	± 16+850	Hwy 69 SBL	Henvey	H	44-0649/01	GEOCRES No. 41H-134 **(Note 1)**
CVH-31	±17+430	I/C-S-EW Bekanon Ramp	Henvey	I	44-065/00	GEOCRES No. 41H-134**(Note 1)**
CVH-32	±10+042	Bekanon Forest Access	Henvey	J	44-0651/00	N/A
CVH-46	±18+400	Hwy 69 NBL	Henvey	K	44-0652/01	GEOCRES No. 41H-134 **(Note 1)**
CVH-47	±18+400	Hwy 69 SBL	Henvey	K	44-0652/02	GEOCRES No. 41H-134 **(Note 1)**

TABLE 1.1.3: List of Embankments Over Swamps and Culverts

PML SITE NO.	STATION	HIGHWAY ALIGNMENT	TOWNSHIP	SITE-SPECIFIC SHEET NO.	SITE NUMBER	REFERENCE DOCUMENT
C189	±19+215	Existing Hwy 69 NBL/SBL	Henvey	L	44X-0667/C0	N/A
CVH-50	±19+485	Hwy 69 NBL/SBL	Henvey	M	44-0653/00	GEOCRES No. 41H-134 **(Note 1)**
CVH-51	±19+580	Hwy 69 SBL	Henvey	N	44-654/02	N/A
CVH-52	±19+617	Hwy 69 NBL	Henvey	O	44-654/01	N/A
CVM-1	±10+405	Hwy 69 NBL/SBL	Mowat	P	44-0655/00	FIR GEOCRES No. 41H-157
CVM-2	±12+587	Hwy 69/522 I/C-S-EW Ramp	Mowat	Q	44-627/C3	FIR GEOCRES No. 41H-133
CVM-3	±12+660	Hwy 69 NBL	Mowat	R	44-627/C1	FIR GEOCRES No. 41H-133
CVM-4	±12+718	Hwy 69 SBL	Mowat	S	44-627/C2	FIR GEOCRES No. 41H-133
CVM-13	±9+805	Hwy 522	Mowat	T	44-0656/00	N/A
CVM-18	±10+403	Forest Access Road	Mowat	U	44-0657/00	N/A
CVM-6	±13+790	Hwy 69 NBL	Mowat	V	44-0658/01	N/A
CVM-7	±13+790	Hwy 69 SBL	Mowat	V	44-0658/02	N/A
CVM-8	±15+340	Hwy 69 NBL	Mowat	W	44-0659/01	FIDR GEOCRES No. 41H-100
CVM-9	±15+380	Hwy 69 SBL	Mowat	X	44-0659/02	N/A
CVM-10	±16+414	Hwy 69 NBL	Mowat	Y	Structure C200	FIR GEOCRES No. 41H-132

Note(s): **1.** Representative swamp crossing boreholes will be re-used for structural culvert investigations.
2. Site Nos. highlighted in orange represent the site locations that were not accessible for field work.

1.2 LABORATORY TESTING

The reported laboratory tests to determine the index properties of the recovered soil samples were performed in accordance with the MTO test procedures, which follow American Society for Testing Materials (ASTM) test procedures, with the exception of the hydrometer test (LS-702). The existing results of the Atterberg limits and grain size distribution analyses are presented in Appendix A. All test results were also summarized on the attached Record of Borehole sheets in Appendix A.

1.3 Site Geology and Stratigraphy

1.3.1 Regional Geology

The sites of the proposed structures discussed in this report are located within the Townships of Wallbridge, Henvey, and Mowat, in the Parry Sound District of Ontario. The structures fall within the north section of the Georgian Bay Fringe physiographic region, as delineated in *The Physiography of Southern Ontario*[1]. This physiographic region extends along the east side of Georgian Bay through the Parry Sound and Muskoka areas, then eastward, in patches, from Muskoka into the area north of the Kawartha Lakes. The two major physiographic landforms associated within the project area of this region are the Bare Rock Ridges and Shallow Till, and the Sand Plains.

The Quaternary Geology map published by the Ontario Ministry of Northern Development and Mines (MNDM) indicates that the sub-surface conditions in the vicinity of project area predominantly consist of Bedrock (undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift), and Glaciomarine deposits (silt and clay, minor sand basin and quiet water deposits).

Based on the Bedrock Geology map (MRD126-REV1, 2011) published by the MNDM, the project area is situated within the Central Gneiss Belt bedrock formation (Mesoproterozoic). The bedrock formations within the project area mainly consist of Felsic Igneous rocks (tonalite, granodiorite, monzonite, granite, syenite; derived gneisses), and Migmatitic rocks and gneisses of undetermined protolith (commonly layered biotite gneisses and migmatites; locally includes quartzofeldspathic gneisses, orthogneisses, and paragneisses).

1.3.2 Site-Specific Subsurface Conditions

A summary of the soil and groundwater conditions encountered at each specific site, together with drawings showing borehole locations are presented in the **Part 2 - SITE- SPECIFIC FIDR** Sheets of this report.

1.3.3 Groundwater Conditions

Refer to the **SITE-SPECIFIC FIDR** sheets and Record of Borehole Sheets for details of groundwater conditions encountered during the field investigations. Where boreholes were charged with drilling mud/water, the groundwater could not be established upon completion of drilling.

The water levels observed during and upon completion of drilling are subject to seasonal fluctuations and should be expected to generally rise during the spring and other wet periods of the year.

[1] Chapman, L.J. and Putnam, D.F. *The Physiography of Southern Ontario*, Ontario Geological Survey Special Volume 2, Third Edition, 1984. Accompanied by Map P.2715, Scale 1:600,00

GENERAL DESIGN-BUILD READY FOUNDATION DESIGN REPORT

2.0 GENERAL CONSIDERATIONS

The general design-build ready preliminary foundation design recommendations are based on interpretations of the subsurface information obtained from the foundation investigations carried out for this assignment and data where relevant and available from previous investigations. While the information presented in this report may be used for planning and design for design-build ready purposes, it is neither sufficient nor intended for detail design purposes. The boreholes were advanced to obtain representative subsurface conditions for design-build ready purposes and not necessarily located within the footprint of foundation elements as required for detail design purposes. Accordingly, further subsurface investigations and development of design recommendations will be required during the detail design phase of the project to meet the requirements of the project agreement for the identified structures and for any additional structures.

Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project and for which special provisions could potentially be required for construction. These comments identify only some issues and are not presented as an exhaustive list of construction concerns. The Design Builder will remain responsible for making its own interpretation of construction issues. Recommendations regarding construction aspects of the foundations should be provided in the detail design phase of the project.

2.1 Structure Foundation Recommendations

In general, the foundation design for all highway structures should be carried out in accordance with the requirements of the most recent Canadian Highway Bridge Design Code (CHBDC). The foundation design of railway grade separations should be carried out in conformance to the requirements of the local railway authority and the American Railway Engineering and Maintenance-of-Way Association (AREMA) manual.

2.1.1 Culvert Foundations

Foundations options relevant to each culvert site are provided on the SITE-SPECIFIC FIDR sheets. Foundation recommendations for culverts on native undisturbed soil are provided where subsoil conditions are suitable at the proposed subgrade level. Alternative options also include precast or cast in place concrete box culverts as discussed and outlined on the SITE-SPECIFIC FIDR sheets.

Although concrete box culverts are preferred under the new highway alignment it is noted that the use of Corrugated Structural Plate (CSP) culverts may also be considered for exceptional site conditions if permitted by MTO. General recommendations are included in the following section of this report.

In general, Design-Build ready geotechnical bearing resistance values for precast concrete box culverts are provided for factored Ultimate Limit States (ULS) and at factored Serviceability Limit States (SLS) for differential settlements not exceeding 100 mm. The geotechnical bearing resistance values provided in this report should be re-evaluated and modified as necessary during detail design by the Design-

Build Consultant based on any additional subsurface investigation at the locations of the foundation elements including the possible requirement for settlements of smaller magnitude than those indicated in the SITE-SPECIFIC FIDR sheets.

Refer to Section 2.6 of this report for general foundation frost protection recommendations. Refer to Section 2.7 for seismic considerations.

2.1.1.1 Corrugated Structural Plate (CSP) Culvert Foundations

Where the magnitude of continuing post-construction settlement and the potential associated damage to the precast concrete box culverts cannot be adequately mitigated, a CSP culvert may be used as an alternate as submitted and approved by MTO. The expected load imposed by the proposed CSP arch culverts and the associated fill will likely be lower than that of the load from concrete box culvert of similar hydraulic size. In addition, the magnitude of differential settlements estimated along the length of the culvert for a CSP arch culvert will be lower than that of a precast concrete box structure. Further, a CSP arch culvert will be flexible enough to withstand the differential settlements without damage to the joints. If necessary, the culvert may be designed with an approximately 75 to 100 mm camber, sloping down from inlet to outlet to prevent ponding of water or damage to the joints.

Chemical tests on soil or water samples from the founding soil were not reported in all of the Foundation Investigation Reports to evaluate the soil corrosivity on steel elements in contact with soil or potential exposure of concrete to sulphate attack. In case CSP culvert is adopted, chemical tests on soil and water samples should be conducted at the detail design stage.

2.1.2 Bedding and Cover Materials

Precast reinforced concrete box culver bedding and cover materials shall be installed in accordance with OPSS 422.

In general, where unsuitable soils are excavated below the subgrade, the replacement fill geometry under the culvert should extend to a distance of at least 1.0 m from the external face of the culvert invert and sloped at 1H:1V outwards to the bottom of excavation. Granular B Type II meeting the standard requirements of OPSS 1010 may be used if the construction is carried out in dry conditions. The replacement fill should be placed in layers not exceeding 200 mm in thickness before compaction and compacted in accordance with OPSS 501.

If bedding or cover materials need to be placed below groundwater, a cofferdam or dam and pump system could be provided to carry out the construction in-the-dry. Alternatively, the bedding can be placed below the water level if the material is sufficiently self-compacting or by overbuilding above the water level by 1.0 m and then compacting and trimming the fill to the bedding level. If the construction is carried out under water, the replacement fill should consist of Granular B Type II containing no particle sizes finer than 75 µm for ease of construction in saturated conditions.

2.1.3 Culvert Backfill

Backfill materials should meet the requirements of OPSS 422, and shall be placed according to the requirements of OPSS 422.

Backfill on each side of the culvert shall be carried out while maintaining approximately the same fill height. The differential backfill levels on each side of the culvert should not exceed 400 mm.

Heavy vibratory compaction equipment adjacent to culvert structures should be restricted to limit the compaction pressure described in Clause 6.12.3 of the CHBDC (2019). Restrictions on compaction near the culvert structure shall be as specified in OPSS 902 and SP109S12. The type of compaction equipment and the compaction procedure that can be used for this purpose should be in accordance with OPSS 501 and SP105S22.

2.1.4 Culvert Cut-Off Walls

Cast-in-place concrete cut-off walls should be in accordance with OPSD 812.010 or made of precast concrete with similar dimensions. The design should be suitable to protect the granular backfill and bedding from washouts, piping, scour and undermining.

2.2 Wing Walls / Head Walls

Proposed culverts may require wing walls or head walls depending on site conditions, such as, proposed location, available space, surrounding ground elevations and preferred design. Feasible wing wall options may include:

- Cast-in-place or precast concrete wing walls supported on spread footings may be considered depending on the subsoil conditions as discussed in the SITE-SPECIFIC FIDR sheets. The design-build ready preliminary bearing resistances and related recommendations for wing walls can be the same as those provided for the design of the respective culvert.
- Retained Soil System (RSS) walls are a feasible alternative where the site is not expected to be inundated. Where utilized, the selected RSS systems should be listed on MTO's DSM list and approved by MTO for the intended use/application. Use of RSS walls where inundated conditions are likely to occur shall be reviewed and authorized by the MTO Foundations Office.

RSS walls are proprietary systems designed by the respective suppliers. The settlement performance of an RSS wall depends primarily on the settlement tolerance characteristics of its front facing provided by the proprietary system designer. In general, for some RSS walls, total settlements up to 75 mm can be tolerated and a typical precast concrete panel facing can tolerate differential settlement magnitude up to 1% of its height. Specialized slip joints can be incorporated between segments if differential settlements exceed 1%.

Where encountered under the plan limits of the RSS facing and reinforced soil mass, compressible ground should be subexcavated and replaced with compacted granular fill. During the detail design phase of the project, the factored bearing resistance at Ultimate Limit States (ULS) and the bearing resistance at Serviceability Limit States (SLS) for up to 75 mm displacement or the tolerable limit of the proprietary system should be provided.

The external stability of the proposed cast-in-place, precast or RSS walls should be valuated and confirmed during the detail design phase of the project.

In settlement sensitive sites, the performance of wing walls may be affected by the post-construction settlement of the wall and/or backfill zone, depending on their height and the characteristics of the fill and those of the foundation ground. The selections of the type of wall and of the foundation option will depend on the predicted settlement and should be assessed during the detail design phase of the project.

Mitigation measures to reduce settlement could be achieved by incorporating ground improvement or load reduction techniques such as using lightweight fill materials, such as water-cooled blast furnace slag, cellular concrete or expanded polystyrene, preloading and surcharging with or without staged construction where applicable. The options for preliminary design of culverts are provided in the SITE-SPECIFIC FIDR Sheets. The preferred settlement mitigation option is site-specific and should be determined during the detail design phase of the project.

2.2.1 Lateral Earth Pressures

The lateral earth pressures acting on the culvert, head walls and/or wing walls will depend on the type and method of placement of the backfill materials, on the nature of the soils behind the backfill, on the magnitude of surcharge including construction loadings, on the freedom of lateral movement of the structure and on the drainage conditions behind the culvert or walls.

The following preliminary design recommendations assume level ground surface behind the wall. Where there is sloping ground behind the walls, the coefficient of lateral earth pressure should be adjusted to account for the slope in accordance with Section C6.12 of the CHBDC (2019).

The earth pressure for concrete structures should be computed as per Clause 6.12.2 of the CHBDC (2019). The lateral earth pressure, p (kPa), may be computed using the diagrams for equivalent fluid pressure given in CHBDC (2019) or by employing the following equation, assuming a triangular pressure distribution:

$$P = K(\gamma h_1 + \gamma' h_2 + q) + \gamma_w h_2 + C_p$$

Where; K = Coefficient of lateral earth pressure (dimensionless)

γ = Unit weight of backfill material above assumed water level (kN/m^3)

γ' = Unit weight of submerged backfill (γ - γw) material below assumed water level (kN/m^3)

γ_w = Unit weight of water (9.8 kN/m^3)

h_1 = Depth below final grade above assumed water level (m)

h_2 = Depth below design water level (m)

q = Surcharge load (kPa)

C_p = Compaction pressure (kPa) (Clause 6.12.3 of CHBDC, 2019)

The effect of seismic earth pressures should be evaluated during detail design in accordance with Clause 6.14 of CHBDC, 2019.

Select free-draining granular material meeting the specifications of OPSS.PROV 1010 Material Specifications for Aggregates, Granular 'A' or Granular 'B' Type II should be used as backfill behind culvert and wing walls. This material should be compacted in accordance with OPSS.PROV 501, Compaction, as amended by SP 105S22.

A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the walls, in accordance with Section 6.12.3 and Figure 6.8 of the CHBDC (2019). Compaction equipment should be used in accordance with MTO's Special Provision 105S10, Compaction. Surcharge loadings should be accounted for in the design, as required.

Where the earth pressures are based on granular fill behind the wall, the following parameters may be assumed:

Table 2.2.1: Earth Pressure Coefficients for Granular Fill

PARAMETERS	OPSS GRANULAR 'A' OR GRANULAR 'B' TYPE II	OPSS GRANULAR 'B' TYPE I
Internal Friction Angle, (degrees)	35	30
Unit weight, γ (kN/m^3)	22.5 ± 0.3	21.5 ± 0.3
Coefficient of Active Earth Pressure, K_a	0.27	0.33
Coefficient of Earth Pressure at Rest, K_o	0.43	0.50
Coefficient of Passive Earth Pressure, K_p	3.69	3.00

Where the earth pressures are based on existing materials behind the wall, the required parameters for design should be assessed on a site-specific basis during detail design.

In general, if the wall support or structure allows lateral yielding of the culvert and walls, active earth pressures may be used in the design of the structure. If the wall support or structure does not allow lateral yielding, at-rest earth pressures should be assumed for foundation design. The movement to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure, may be taken as presented in Section C6.12, Figure C6.27 and Table C12 of the Commentary to the CHBDC (2019).

2.3 Embankment Design

The configuration of the structure approaches may vary from site to site and may include approach embankment construction with fills or cuts depending on the design grades and existing ground elevations. It is inferred that the new or replacement culverts will be constructed in stable embankments as designed and constructed for the project. Design-build ready level recommendations associated with embankment stability and settlement are provided on the SITE-SPECIFIC FIDR sheets where considered appropriate.

FIDRs have been completed by Golder for the swamp crossings and high fill areas identified within the new alignment of Highway 69. PML also prepared FIDR Reference 11 around the proposed south transition and connection embankments across swamps. The GEOCRES identification numbers for the relevant reports and corresponding sites are provided in Table 1.1.2. We refer to the reports by Golder for design recommendations, construction and monitoring of the applicable main line embankments.

Design provisions to manage differential settlements of immediate embankment approaches to the culverts and embankment widenings, if any, should be addressed during the detail design phase of the project. Consideration should be given to surcharging/preloading to mitigate settlements before paving or to the use of lightweight fills or ground improvement techniques.

Widened portions of embankments should be benched into the slope of existing embankment in accordance with OPSD 208.010, Benching of Earth Slopes.

Measures to reduce erosion of the embankment slopes due to surface runoff should be considered during the detail design phase of the project and may include placement of topsoil and sod as soon as practical after construction of the embankments. Erosion protection measures should be in accordance with OPSS PROV 804 - Construction Specification for Seed and Cover.

Since the design of the proposed routes for the south transition sections are different from the alignment previously investigated by PML, the following subsections provide additional general recommendations associated with the design and construction of redesign embankments within the transition and connection routes at the south end of the subject four-laning section.

2.3.1 South Transition Embankment Stability

We refer to the SITE-SPECIFIC FIDR sheets for the South Transition for details of the site conditions and recommendations for each of the swamp crossing areas to be completed pending fieldwork. It is anticipated, however that the embankments in the Transition and Connection routes will be only up to 2.0 m high over the existing ground or may require shallow rock cuts subject to final design of the road grades.

The assessment of stability of the approaches or embankments where required will be assessed based on limit equilibrium analyses using the commercially available slope stability program SLOPE/W developed by Geo-Slope International Ltd. (Bishop’s modified method of slices). The analyses will assume earth embankment slopes will be no steeper than 2H:1V and rockfill embankments sloped at maximum 1.25H:1V slopes, as inferred from information available at the time of this report. These embankments would be generally considered to be stable or adequate against deep-seated slope instability for a target Factor of Safety of 1.3 under undrained static conditions, assuming appropriate subgrade preparation and proper placement and compaction of embankment fill materials as generally recommended in this report

In general, earth fill embankments exceeding 8.0 m high or rock fill embankments exceeding 10 m should incorporate a 2.0 m wide mid-height berm as required by OPSD 202.010.

This preliminary assessment of stability of the approach slopes should be reviewed and confirmed during the detail design phase of the project, based on the actual subsoil conditions encountered within the footprint of the proposed approach/embankment. In general, mitigation measures to improve slope stability include utilising lightweight fill materials, wick drains construction, staged construction or a combination of these options, which will also control magnitude and time rate of settlements.

Assessment of the overall stability of the embankment side slopes under seismic conditions is discussed in Section 2.7.

2.3.2 South Transition Embankment Settlements

The magnitude and rate of total settlements including compression of the South Transition embankment and consolidation of the underlying foundation soils should be determined during the detail design phase of the project on a site-specific basis.

Settlement of embankments may occur due to compression of the embankment fill as well as consolidation of the foundation soils. Most of the compression of the earth or rock fill for the anticipated low embankments up to 2.0 m high would likely occur during and shortly after completion of construction of embankments depending on the type of materials used and the method of placement. The magnitude of fill compression generally ranges from 0.5% to 1% of the height of embankment. Design-build ready level estimates of the amount of consolidation settlements of founding soils will be indicated on SITE-SPECIFIC FIDR sheets where considered appropriate.

Where estimated post-construction (i.e. consolidation) settlement within the foundation soils exceeds acceptable limits, design-build ready level measures to reduce such settlement to acceptable values have been proposed on the SITE-SPECIFIC FIDR sheets. Reference is made to the MTO Foundation Office Guideline entitled ‘Embankment Settlement Criteria for Design’ date July 2, 2010, which specifies maximum allowable post-construction settlement for longitudinal and transverse settlements for foundation design of highway embankments.

2.3.3 South Transition Subgrade Preparation and Embankment Construction

For all the proposed embankments, it is recommended that all soft and compressible material be stripped from the proposed embankment footprint. The depth and extent of stripped material should be determined during the detail design phase of the project. Particular attention will be required in low lying areas where thick layers of organic/alluvial soils are likely present.

After stripping of soft and compressible materials to a specified depth to be determined during detail design, the exposed subgrade should be proof rolled to identify any soft and compressible materials requiring sub-excavation and backfilling with compacted acceptable fill.

Embankment fill should be placed in accordance with OPSS.PROV 206 and compacted in accordance with OPSS.PROV 501. Topsoil and sod application should be in conformance with OPSS 802 and OPSS.PROV 803, respectively. Fill material should be in accordance with OPSS.PROV 1010 and SSP 110S06.

In the case of earth cuts in the areas where groundwater levels are at shallow depths, it is anticipated that measures will be needed to prevent instability of embankment slopes due to groundwater seepage. These measures should be addressed during the detail design phase and may include an observational engineering approach in which specific areas requiring treatment are identified based on their performance after they have been constructed.

2.4 Scour and Erosion Protection

Conceptual recommendations for minimum requirements from a foundation engineering perspective for erosion/scour protection of approach embankments to culverts, stream channels, and for foundation elements of structure foundations, including those for culverts and wing walls should be presented in the detail design level Foundation Reports. These conceptual recommendations should include the following aspects:

- Plan extent in both the longitudinal and transverse directions
- Cross-sectional extent from the base of embankments to design high water level.

The detail design level Foundation Report should include statements that address the following requirements:

- Scour design should be considered as a multi-disciplinary exercise that involves the structural and hydrology designer as well as the foundation/geotechnical designer working as a team.
- Ground conditions should be documented, and relevant ground characterization parameters related to scour design such as erodibility should be provided.
- The geotechnical engineering designer should review and endorse the resulting scour design by the Hydrology Engineer including the extent, thickness, gradation and placement of erosion/scour countermeasures as meeting the minimum erosion/scour protection requirements from a foundation engineering perspective, with reference made to the documentation reviewed.
- The geotechnical report should reference appropriate guidelines including Hydraulic Engineering Circulars from U.S. Department of Transportation.
    - HEC-18 (evaluating scour at bridges)
    - HEC-23 (bridge scour and stream instability countermeasures)

Pertinent geotechnical parameters to support the hydrology design of scour countermeasures including, SPT N-value, in-situ moisture content, percent passing the No. 200 sieve (%200), mean grain size diameter (D50), liquid limit (LL), plastic limit (PL), and plasticity index (PI) should be documented in the detail design level Foundation Report. The Foundation Engineering designer should assess the erodibility of the soil depending on the properties and behaviour of the soil and the flow velocity.

The Foundation Engineer should include conceptual recommendations for erosion/scour mitigation strategies in the detail design level Foundation Report, but the design of mitigation measures should be delivered by the drainage/hydraulics engineer subject to review by the Foundation Engineer.

At the minimum design level, Rip-Rap should be provided on both, the upstream and downstream sides of the drainage channel to protect the toe of the embankments depending on the fill material used, and to prevent erosion of the drainage channel bed in the proximity of the culvert. Rip-Rap shall be in accordance with OPSD 810.010 and provided to a minimum height of 1.0 m above the high flood level expected in the creek.

Culvert cut-off walls should be incorporated as outlined in a previous section of this report.

The Foundation Engineer should include confirmation that the interpretation of the ground conditions by the hydrologist is in a good agreement with the borehole information presented in the detail design level Foundation Report.

2.5 Foundation Frost Depth

Refer to OPSD 3090.101, Foundation Frost Depths for Southern Ontario, for confirmation of foundation frost penetration depths. In accordance with OPSD 3090.101, the minimum foundation frost penetration is a minimum of 1.8 m for earth cover. The frost penetration depth, f, is measured from the top of the final grade to the bottom of the footing. Commentary Figure C6.31 of the CHBDC 2019

All open-footing type culverts, headwalls or wings walls with independent foundations should be provided with a minimum 1.8 m of soil cover or equivalent thickness of insulation for foundation frost protection unless the footings are place on bedrock. Generally, footings placed directly on bedrock don't require foundation frost protection.

Foundation frost protection is also not required for adequately designed precast concrete box culverts or associated cantilevered wing walls or headwalls.

Where required, frost tapers within the granular backfill should be constructed in accordance with Clause 6.10.1.5, OPSD 803.030 and OPSD 803.031.

2.6 Seismic Considerations

Seismic design requirements must be confirmed by the Design-Builder during the detail design phase of the project. The following are preliminary design-build ready level recommendations.

Seismic loading can result in increased lateral earth pressures acting on culverts and associated wing or retaining walls.

The Spectral (Sa(T)) values, where T is the period in seconds and Peak Ground Acceleration (PGA) values, given in units of g (9.81 m/s^2) for the project sites are provided in Table 2.6.

Table 2.6 - Peak Ground Acceleration (PGA) Values

2% probability of exceedance in 50 years (2475-year return Period)						
PGA	**Sa(0.2)**	**Sa(0.5)**	**Sa(1.0)**	**Sa(2.0)**	**Sa(5.0)**	**Sa(10.0)**
0.066	0.113	0.079	0.048	0.025	0.0062	0.0027
5% probability of exceedance in 50 years (975-year return Period)						
PGA	**Sa(0.2)**	**Sa(0.5)**	**Sa(1.0)**	**Sa(2.0)**	**Sa(5.0)**	**Sa(10.0)**
0.041	0.073	0.052	0.031	0.015	0.0037	0.0016
10% probability of exceedance in 50 years (475-year return Period)						
PGA	**Sa(0.2)**	**Sa(0.5)**	**Sa(1.0)**	**Sa(2.0)**	**Sa(5.0)**	**Sa(10.0)**
0.027	0.049	0.035	0.02	0.0098	0.0022	0.001

Table 2.6 is based on the National Building Code of Canada (NBCC), 2015.

The Site Class for seismic design at each site shall be based on the site properties in the top 30 m of the ground profile in accordance with Clause 4.4.3.2 of the CHBDC (2019) and Table 4.1.

For retaining/wing wall design, seismic loading should be considered in the design of the foundations in accordance with Section 6.14 of CHBDC (2019) as significant seismic loading will result, for example, in increased lateral earth pressures acting on the wing walls and retaining walls. The static and seismic active earth pressure coefficients can be determined in accordance with Sections 6.12 and 6.14 of the CHBDC (2019) and related Commentary.

Liquefaction susceptibility of the soil deposits underlying the proposed embankments and culverts and their stability under seismic loading conditions should be assessed in accordance with Clauses 6.14.8 and 6.14.9, respectively, of the CHBDC (2019) and related Commentary during the detail design phase of the project.

2.7 Construction Considerations

2.7.1 Excavation and Backfilling

Design-build ready preliminary recommendations for open-cut excavations are provided on a site-specific basis on the respective SITE-SPECIFIC FIDR sheets and include the Occupational Health and Safety Act (OHSA) anticipated Soil Types within the foundation excavations.

In accordance with OHSA, bedrock and hard or very dense soils are considered as Type 1 soils. Very stiff or dense soils are considered as Type 2 soils. The fill and firm to stiff or compact to loose soils are considered as Type 3 soils. Soft soils, soils that run or flow easily unless completely supported, and soils under groundwater are considered as Type 4 soils. The slope of excavation walls should conform to as described in Ont. Reg. 213/92, S. 234. Workers should not enter an unprotected excavation if there is evidence of ongoing groundwater seepage in the pits. Temporary shoring will be required if slopes as described in Ont. Reg. 213/92, S. 234 cannot be provided. Temporary shoring should be in accordance with OPSS.PROV 539, as amended.

The replacement fill geometry under the culvert should extend to a distance of at least 1.0 m from the external face of the culvert and sloped at 1H:1V to the bottom of excavation. Granular B Type II meeting the standard requirements of OPSS 1010 may be used if the construction is carried out in dry conditions.

The replacement fill should be placed in layers not exceeding 200 mm in thickness before compaction and compacted in accordance with OPSS 501. If the construction is carried out under water, the replacement fill should consist of Granular B Type II containing no particle sizes finer than 75 µm. Granular bedding can be placed below the water level if the material is sufficiently self-compacting or by overbuilding above the water level by 1.0 m and then compacting and trimming to the bedding level.

The placement of compacted granular materials should be as specified in OPSS 422. The granular material for the precast concrete box culvert should be placed in accordance with OPSS 422. Granular material should be as specified in accordance with OPSS 422., and may consist of either Granular ‘B’ Type II or Granular ‘A’, including a 75- mm levelling course for bedding purposes and partial frost protection as required by OPSS 422.

2.7.2 Traffic Protection Systems and Shoring

Excavation support systems may be required at the proposed culvert sites for temporary roadway protection and for shoring, namely at culvert replacement sites. Where required, the detail design of the temporary excavation support systems should be carried out and constructed by the Design-Builder.

The design should be in accordance with OPSS.PROV 539 – Construction Specification for Temporary Protection Systems as amended by SP105S09. Generally, the MTO requires that the design may allow for a maximum deflection or lateral movement of the traffic protection system to meet the Performance Level 2 specified in OPSS.PROV 539. Performance Level 1 may be required for excavation adjacent to railways. These requirements, along with other site-specific performance requirements for shoring should be confirmed in the plans prepared during the detail design phase of the project.

2.7.3 Groundwater and Surface Water Control

Design-build ready level estimates of groundwater levels within the culvert and wing wall foundation zones and preliminary anticipated requirements for groundwater and surface water control measures are reported in the SITE-SPECIFIC FIDR sheets in Part 2 of this report.

Typically, prevailing groundwater levels should be maintained a minimum of 0.5 m below the base of excavations during construction. Dewatering in excavations could be carried out by various methods such as, sump pumping, pumping from well points or deep wells and/or sheet pile cofferdams. The Design Builder should develop appropriate dewatering plans during detail design phase of the project

General site drainage of stormwater should also be planned by the Design Builder to efficiently occur by gravity or by pumping towards an appropriate outlet.

Where water taking is required, recommendations should be included during the detail design phase of the project to meet the applicable laws.

The following water takings are prescribed activities under the Water Taking EASR Regulation – O. Reg. 63/16:

- Surface water takings that are more than 50,000 L/day and are for road construction purposes that meet specified criteria about the purpose, rate or location of the water taking
- Construction site dewatering involving more than 50,000 L/day and less than 400,000 L/day

If a water taking does not meet the criteria of the prescribed activity set out in the regulation for EASR, a PTTW (Permission to Take Water) would be required. Requirements for applying for a PTTW are prescribed in the following documents:

- Ontario Water Resources Act, Section 34 – 34, 11
- Ontario Regulation 387/04 (Water Taking and Transfer)

In general, the NSSP FOUN0003, dated June 8, 2017, is not applicable to the culverts in this project and any exceptions should be provided during detail design.

2.7.4 Environmental Considerations for Construction Access

Since the proposed new of Highway 69 and Transition route alignments traverse through wetlands and swamps, environmental sensitive areas will likely be encountered. It is required that the foundation fieldwork for Design-Build detail design be carried out with adequate considerations and care for Species at Risk (SARs).

3.0 CLOSURE

This Final Design-Build ready Investigation and Design Report was prepared by Ms. Natasha Leong-Sem, EIT, and Mr. Nazibur Rahman, P.Eng. Mr. Geoffrey Uwimana, MEng., P.Eng., MTO Designated Principal Contact, conducted an independent quality review of the report.

Peto MacCallum Ltd.

LICENSED PROFESSIONAL ENGINEER
A. N. RAHMAN
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July 25, 2023
PROVINCE OF ONTARIO

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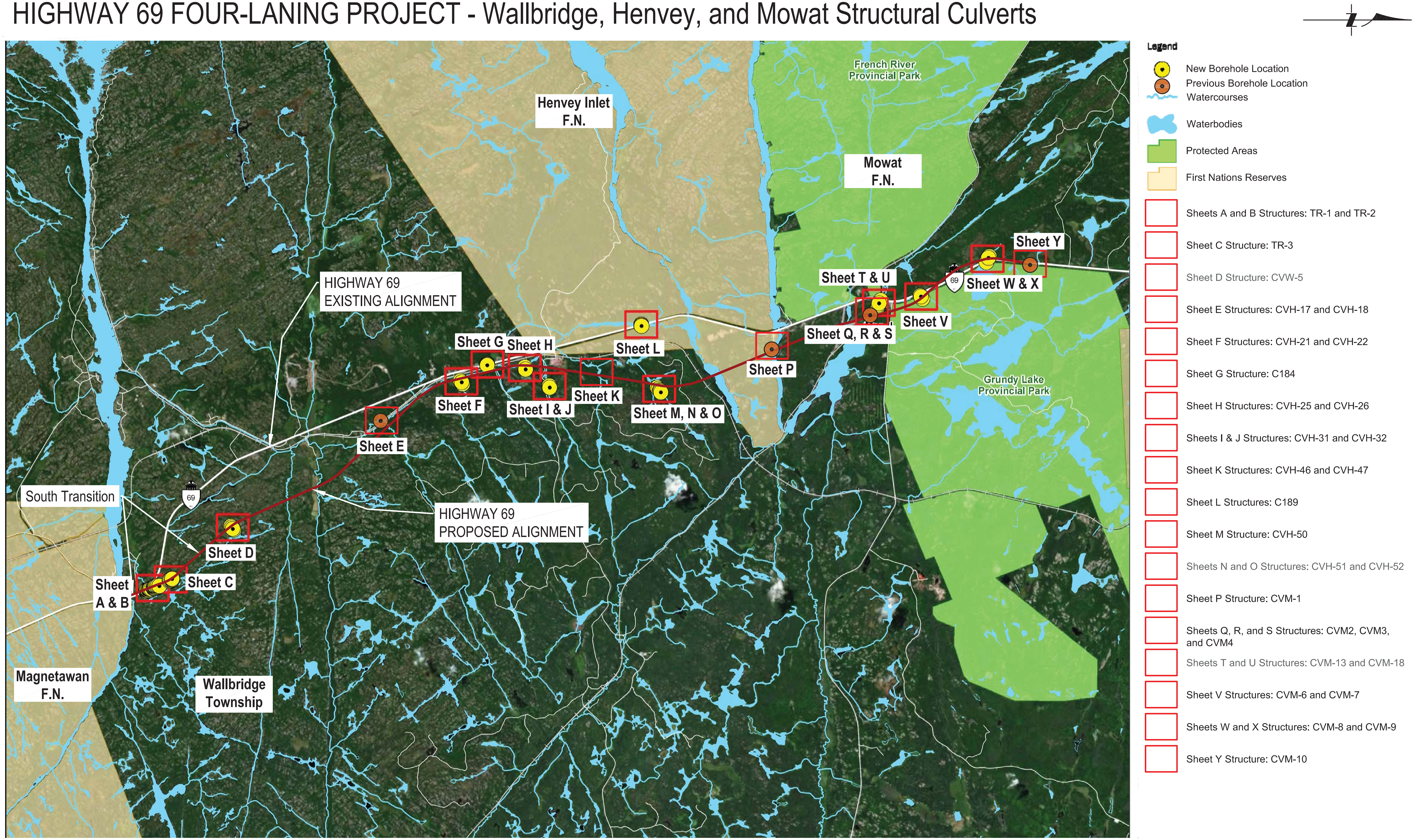
MTO Designated Principal Contact

NLS/NR/GU:nls-nr-nk

SITE LOCATION PLAN AND EXPLANATION OF TERMS

HIGHWAY 69 FOUR-LANING PROJECT - Wallbridge, Henvey, and Mowat Structural Culverts



ASSIGNMENT No.: 5013-E-0036

WORK ORDER No.: 23

SITE LOCATION PLAN

SCALE: 0 km 0.75 1.5 3 4.5 6 km

Peto MacCallum Ltd. CONSULTING ENGINEERS

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATOIN TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 31 MM O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3 m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 62.5 kg, FALLING FREELY A DISTANCE OF 0.76 m FOR PENETRATIONS OF LESS THAN 0.3 m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS $\bar{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51 mm O.D.. 60^{O} CONE ANGLE) DRIVEN BY 475 JOULES IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3 m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION, CONSISTENCY OR COMPACTNESS.

COMPOSISTION: SECONDARY SOIL COMPONENTS ARE DESCRIBED ON THE BASIS OF PERCENTAGE BY MASS OF THE WHOLE SAMPLE AS FOLLOWS:

PERCENTAGE BY MASS	0 - 10	10 - 20	20 -35	>35	>35 and main fraction
	'trace'	'some'	Adjective (silty, sandy, clayey etc.)	'and'	Noun (gravel, sand, silt, clay)

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (C_u) AS FOLLOWS:

C_U (kPa)	0 - 12	12 - 25	25 -50	50 - 100	100 – 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

COMPACTNESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3 m PENETRATION)	0 - 4	4 - 10	10 -30	30 - 50	>50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURES FEATURES AND/OR STRENGTH.

TOTAL CORE RECOVERY (TCR): CORE RECOVERED AS A PERCENTAGE OF TOTAL CORE RUN LENGTH.

ROCK QUALITY DESIGNATION (RQD): TOTAL LENGTH OF SOUND ROCK RECEOVED IN PIECES 10 cm OR LARGER AS A PERCENTAGE OF TOTAL CORE RUN LENGTH. CLASSIFICATION OF ROCK WITH RESPECT TO RQD VALUE AS FOLLOWS:

RQD VALUE (%)	<25	25 - 50	50 -75	75 - 90	90 - 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

UNIAXIAL COMPRESSIVE STRENGTH (UCS): AXIAL STRESS REQUIRED TO BREAK THE ROCK CORE SPECIMEN. CLASSIFICATION OF ROCK WITH RESPECT TO STRENGTH IS AS FOLLOWS:

GRADE	R0	R1	R2	R3	R4	R5	R6
UCS (MPa)	0.25 - 1	1 - 5	5 - 25	25 - 50	50 - 100	100 – 250	>250
	EXTREMELY WEAK	*VERY WEAK*	*WEAK*	*MEDIUM STRONG*	*STRONG*	*VERY STRONG*	*EXTREMELY STRONG*

DISCONTINUITY SPACING: DISTANCE BETWEEN A PAIR OF DISCONTINUITIES MEASURED ALONG A LINE OF SPECIFIED LOCATION AND ORIENTATION. CLASSIFICATION OF ROCK WITH RESPECT TO DISCONTINUITY SPACING IS AS FOLLOWS:

SPACING WIDTH (m)	<0.02	0.02 – 0.06	0.06 – 0.20	0.20 – 0.6	0.6 – 2.0	2.0 – 6.0	<6.0
SPACING CLASSIFICATION	*EXTREMELY CLOSE*	*VERY CLOSE*	*CLOSE*	*MODERATELY CLOSE*	*WIDE*	*VERY WIDE*	*EXTREMELY WIDE*

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS – SPLIT SPOON
TP – THINWALL PISTON SAMPLE
WS – WASH SAMPLE
OS – OSTERBERG SAMPLE
AS – AUGER SAMPLE
RC – ROCK CORE
FV – FIELD VANE
BS – BLOCK SAMPLE
TW – THINWALL SHELBY TUBE SAMPLE
PH – TW ADVANCED HYDRULICALLY
PM – TW ADVANCED MANUALLY
CS – CHUNK SAMPLE
FS – FOIL SAMPLE

STRESS AND STRAIN

U_w	PORE WATER PRESSURE (kPa)
r_u	PORE PRESSURE RATIO
σ	TOTAL NORMAL STRESS (kPa)
σ'	EFFECTIVE NORMAL STRESS (kPa)
τ	SHEAR STRESS (kPa)
$\sigma_1, \sigma_2, \sigma_3$	PRINCIPAL STRESSES (kPa)
ϵ	LINEAR STRAIN (%)
$\epsilon_1, \epsilon_2, \epsilon_3$	PRINCIPAL STRAINS (%)
E	MODULUS OF LINEAR DEFORMATION (MPa)
G	MODULUS OF SHEAR DEFORMATION (GPa)
μ	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

C_c	COMPRESSION INDEX
C_s	RECOMPRESSION INDEX
c_v	COEFFICIENT OF CONSOLIDATION – VERTICAL (cm^2/s)
c_h	COEFFICIENT OF CONSOLIDATION – HORIZONTAL (cm^2/s)
σ'_p	PRECONSOLIDATION PRESSURE (kPa)
σ'_{vo}	EFFECTIVE OVERBURDEN PRESSURE (kPa)
C_α	COEFFICIENT OF SECONDARY CONSOLIDATION
M_v	COEFFICIENT OF VOLUME CHANGE (kPa^{-1})
H	DRAINAGE PATH (m)
U	DEGREE OF CONSOLIDATION (%)
T_v	TIME FACTOR; VERTICAL DRAINAGE
T_h	TIME FACTOR; horizontal DRAINAGE
S_u, C_u	UNDRAINED SHEAR STRENGTH (kPa)
S_R	RESIDUAL SHEAR STRENGTH (kPa)
S_r	REMOULDED SHEAR STRENGTH (kPa)
σ_C	UNIAXIAL COMPRESSIVE STRENGTH (kPa)
c'	EFFECTIVE COHESION INTERCEPT (kPa)
c	APPARENT COHESION INTERCEPT (kPa)
Θ'	EFFECTIVE ANGLE OF INTERNAL FRICTION (Degrees)
S_t	SENSITIVITY = C_u / S_r
I_s	POINT LOAD SETTLEMENT INDEX

PHYSICAL PROPERTIES

Wp – PLASTIC LIMIT (%)	W_L – LIQUID LIMIT (%)	W – MOISTURE CONTENT (%)
W_S – SHRINKAGE LIMIT (%)	I_P – PLASTIC LIMIT (%)	Υ_w – UNIT WEIGHT OF WATER (kg/m^3)
Υ – UNIT WEIGHT OF SOIL (kg/m^3)	Υ_{sat} – UNIT WEIGHT OF SATURATED SOIL (kg/m^3)	Υ_d – UNIT WEIGHT OF DRY SOIL (kg/m^3)
ρ_w – DENSITY OF WATER (kN/m^3)	ρ – DENSITY OF SOIL (kN/m^3)	ρ_{sat} – DENSITY OF SATURATED SOIL (kN/m^3)
ρ_d – DENSITY OF DRY SOIL (kN/m^3)	S_r – DEGREE OF SATURATION	D_r , SG – RELATIVE DENSITY (FORMERLY SPECIFIC GRAVITY)
C_u – UNIFORMITY COEFFICIENT	C_c – CURVATURE COEFFICIENT	

OTHER SYMBOLS

>> - GREATER THAN OR ABOVE	= SAME OR EQUAL	<< - LESS THAN OR BELOW

PART 2
SITE-SPECIFIC FOUNDATION INVESTIGATION AND DESIGN SHEETS

INTERIM NOTE: Sheets T and U will be provided separately following investigation.

SHEET A – TR-1 (Station: ± 9+150 to ± 9+260 – South Transition – Wallbridge)

- Borehole Location Plan (PML)
- Record of Borehole Logs (PML)

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field work for the South Transition Area TR-1 from Station 9+150 to Station 9+260, in the Township of Wallbridge was carried out on July 29, 2021.

2. BOREHOLE INFORMATION

A total of 12 boreholes were advanced along the alignment of the proposed south transition of Highway 69.

Refer to:
- Drawing A-1 for the borehole location plan
- Table A-1 for details of borehole origin, borehole location coordinates and borehole elevations/depths
- Record of Borehole sheets and lab results showing details of the subsurface conditions at the borehole locations from current investigation

Table A-1 Structural Culvert Borehole Information

BOREHOLE ID	MTM ON10 NAD 83 COORDINATES		GROUND SURFACE ELEVATION (m)	BOREHOLE DEPTH (m)
	NORTHING (m)	EASTING (m)		
TR1-1	5 071 353.6	227 124.1	195.7	0.03
TR1-2	5 071 369.5	227 129.4	195.3	0
TR1-3	5 071 361.6	227 109.4	195.3	0
TR1-4	5 071 377.2	227 115.0	195.4	0
TR1-5	Borehole could not be accessed due to approximately 1.8 m of water at Borehole Location			
TR1-6	5 071 384.8	227 100.3	196.1	0
TR1-7	5 071 416.2	227 111.6	194.3	0.13
TR1-8	5 071 408.1	227 091.1	195.2	0
TR1-9	5 071 423.8	227 099.7	194.3	0.05
TR1-10	5 071 439.5	227 102.4	196.0	0.08
TR1-11	5 071 431.4	227 081.9	195.1	0.08
TR1-12	5 071 456.4	227 083.9	194.6	0.08

2.1. Subsurface Conditions

The stratigraphy generally consists of approximately 30 mm to 130 mm of organics over bedrock. Refer to the Record of Boreholes for details.

The subsurface conditions at this site can be categorized into two (2) general layers as presented below from surface downwards.

2.1.1. Organics

A 30 mm to 130 mm thick layer of organics was encountered at the existing road surface in Boreholes TR1-1, TR1-7, and TR1-9 to TR1-12. The SPT N value recorded near the bedrock surface in Borehole TR1-1 was over 100 blows per 0.3 m penetration.

2.1.2. Probable Bedrock

Probable bedrock was encountered immediately below the organics in in Boreholes TR1-1, TR1-7, and TR1-9 to TR1-12. In Boreholes TR1-2, TR1-3, TR1-4, TR1-6, and TR1-8, the bedrock was exposed at the ground surface.

2.2. Groundwater Conditions

Groundwater was observed at the ground surface at all borehole locations.

Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) are based on the information provided by Parsons on March 2, 2018 and the relevant geotechnical data provided in the FIR Reference 1 for the South Transition Area TR-1 in the Township of Wallbridge.

3. PROJECT DESCRIPTION

3.1. General

A 925 m long Transition and a 250 m long Connection are proposed at the south end of the new four-lane Highway 69 to allow traffic to and from the existing 2-lane Highway 69. The site conditions for the new embankments carrying the south Transition and Connection sections of the new Highway 69 were previously investigated by Golder Associates Ltd. (Golder). Test holes within the South Transition Area TR-1 were investigated to 1.0 m depth, where bedrock was encountered.

3.2. Proposed Embankment

The maximum height of the embankment over South Transition Area TR-1 is anticipated to be up to 2.0 m between Station 9+150 and Station 9+260. The side slopes of the embankment are anticipated to be sloped at a minimum 2H:1V.

3.3. Embankment Construction

Refer to the General Report for preliminary recommendations for South Transition Embankment.

In general, construction of embankments shall be in accordance with OPSS.PROV 206. Where construction of embankments over swamps is anticipated, the construction shall be in accordance with OPSS.PROV 209.

All organic materials and cohesive soils shall be removed from the proposed footprint of the embankment. Backfill should be placed in accordance with OPSS.PROV 206. Where water bodies are within the footprint of the embankment, backfill material other than rock may be placed up to 600 mm above water level without compaction in accordance with OPSS.PROV 209 (209.07.03.01). It should also be noted that vibratory compaction equipment should not be used within 1.0 m of the original surface of the swamp (OPSS.PROV 209 – 209.07.04.2).

The proposed embankment can be construct with granular materials, earth borrow or rockfill. The side slopes of the proposed embankment are to be sloped at a minimum 2H:1V if granular material or earth borrow is used to construct the embankment. The side slopes of the embankment should be a minimum 1.25H:1V if rockfill is used to construct the embankment.

Granular materials shall be in accordance with OPSS.PROV 1010, amended by SSP 110S06. If earth borrow is utilized to construct the embankment, the earth borrow should be in accordance with OPSS.PROV 212, amended by SSP 112S07 and SSP 212F01. If rockfill is utilized to construct the new embankment, the material should be in accordance with OPSS.PROV 1004, amended by SS 110S16. Compaction shall be carried out in accordance with OPSS.PROV 501, amended by SSP 105S22. It should be noted that frost susceptible material shall not be placed within the zone between the frost penetration depth and the final grade of the roadway.

No stability and settlement issues are anticipated following construction of the embankments as discussed above. It is anticipated that 10 mm to 20 mm of settlement of the embankment fill due to self weight will be completed following construction of the embankment.

4. CONSTRUCTION CONSIDERATIONS

4.1. Excavation

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

Proper equipment

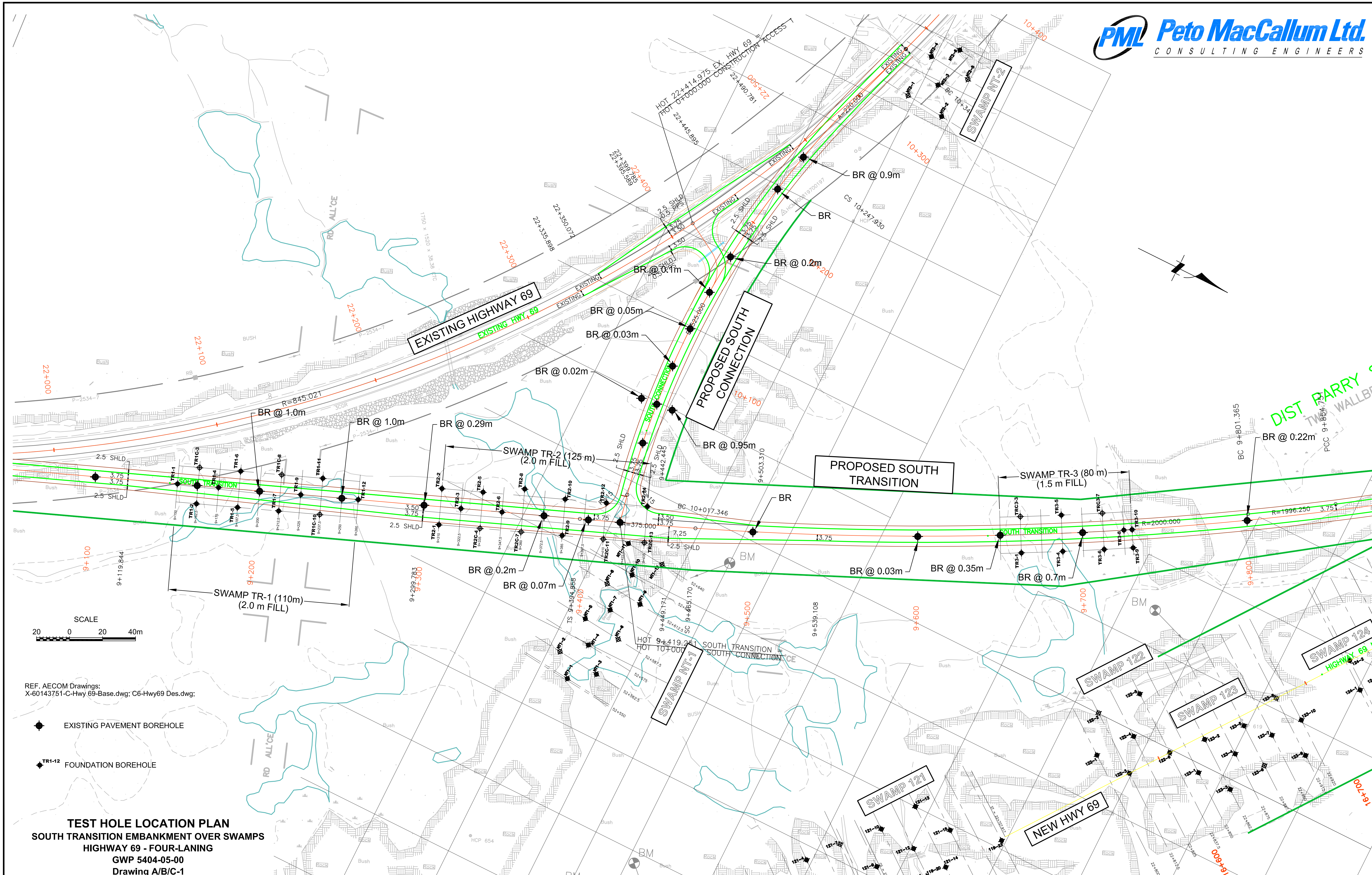
4.2. Groundwater and Surface Water Control

Surface water flow should be directed away from the excavation areas. It is recommended to carry out the construction during the drier time of the season.

Refer to the General Report for further groundwater control recommendations.

4.3. Additional Investigation

It is suggested that additional investigation should be carried out within the footprint of the proposed embankment where bedrock is not at shallow depths to determine the depth of overburden soils over bedrock. This would allow determining where excavation of the organic/cohesive soils would be required prior to construction of the embankment to mitigate any settlement issues.



TEST HOLE LOCATION PLAN

SOUTH TRANSITION EMBANKMENT OVER SWAMPS

HIGHWAY 69 - FOUR-LANING

GWP 5404-05-00

Drawing A/B/C-1

Ministry of Transportation Ontario

RECORD OF BOREHOLE No TR1-1

METRIC

PROJECT Hwy 69 Structural Culvert	COORDINATES Coords: 5 071 353.6 N; 227 124.1 E	ORIGINATED BY M.M.
DIST ___ HWY 69	BOREHOLE TYPE 1/2 Weight Hammer Tripod & SPT	COMPILED BY N.L.
DATUM Geodetic	DATE 2021.07.29 LATITUDE 45.777682 LONGITUDE -80.498855	CHECKED BY N.R.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
195.7	Ground Surface										
195.7 / 0.0	Organics, rock fragments Refusal on probable bedrock		1	SS	50/3cm						

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No TR1-2

METRIC

PROJECT Hwy 69 Structural Culvert	COORDINATES Coords: 5 071 369.5 N; 227 129.4 E	ORIGINATED BY M.M.
DIST ___ HWY 69	BOREHOLE TYPE 1/2 Weight Hammer Tripod & SPT	COMPILED BY N.L.
DATUM Geodetic	DATE 2021.07.29 LATITUDE 45.777826 LONGITUDE -80.498789	CHECKED BY N.R.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
195.3	Ground Surface										
0.0	Exposed bedrock at surface										

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

RECORD OF BOREHOLE No TR1-3

1 OF 1 **METRIC**

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 071 361.6 N; 227 109.4 E | ORIGINATED BY M.M.

DIST | HWY 69 | BOREHOLE TYPE 1/2 Weight Hammer Tripod & SPT | COMPILED BY N.L.

DATUM Geodetic | DATE 2021.07.29 | LATITUDE 45.777752 | LONGITUDE -80.499044 | CHECKED BY N.R.

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
195.4	Ground Surface										
0.0	Exposed bedrock at surface										

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

RECORD OF BOREHOLE No TR1-4

1 OF 1 **METRIC**

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 071 377.2 N; 227 115.0 E | ORIGINATED BY M.M.

DIST | HWY 69 | BOREHOLE TYPE 1/2 Weight Hammer Tripod & SPT | COMPILED BY N.L.

DATUM Geodetic | DATE 2021.07.29 | LATITUDE 45.777894 | LONGITUDE -80.498974 | CHECKED BY N.R.

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
195.4	Ground Surface										
0.0	Exposed bedrock at surface										

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

RECORD OF BOREHOLE No TR1-6

METRIC

PROJECT Hwy 69 Structural Culvert
COORDINATES Coords: 5 071 384.8 N; 227 100.3 E
ORIGINATED BY M.M.
DIST
HWY 69
BOREHOLE TYPE 1/2 Weight Hammer Tripod & SPT
COMPILED BY N.L.
DATUM Geodetic
DATE 2021.07.29
LATITUDE 45.77796
LONGITUDE -80.499166
CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
196.1	Ground Surface										
0.0	Exposed bedrock at surface										

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

RECORD OF BOREHOLE No TR1-7

METRIC

PROJECT Hwy 69 Structural Culvert
COORDINATES Coords: 5 071 416.2 N; 227 111.6 E
ORIGINATED BY M.M.
DIST
HWY 69
BOREHOLE TYPE 1/2 Weight Hammer Tripod & SPT
COMPILED BY N.L.
DATUM Geodetic
DATE 2021.07.29
LATITUDE 45.778244
LONGITUDE -80.499025
CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.3	Ground Surface										
194.1	Organics										
0.1	Refusal on probable bedrock										

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

RECORD OF BOREHOLE No TR1-8

METRIC

PROJECT Hwy 69 Structural Culvert
COORDINATES Coords: 5 071 408.1 N; 227 091.1 E
ORIGINATED BY M.M.
DIST
HWY 69
BOREHOLE TYPE 1/2 Weight Hammer Tripod & SPT
COMPILED BY N.L.
DATUM Geodetic
DATE 2021.07.29
LATITUDE 45.778169
LONGITUDE -80.499286
CHECKED BY N.R.

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
195.2	Ground Surface										
0.0	Exposed bedrock at surface										

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

RECORD OF BOREHOLE No TR1-9

METRIC

PROJECT Hwy 69 Structural Culvert
COORDINATES Coords: 5 071 423.8 N; 227 099.7 E
ORIGINATED BY M.M.
DIST
HWY 69
BOREHOLE TYPE 1/2 Weight Hammer Tripod & SPT
COMPILED BY N.L.
DATUM Geodetic
DATE 2021.07.29
LATITUDE 45.77831
LONGITUDE -80.499178
CHECKED BY N.R.

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.3	Ground Surface										
194.2	Organics										
0.1	Refusal on probable bedrock										

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

RECORD OF BOREHOLE No TR1-10

METRIC

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 071 439.5 N; 227 102.4 E | ORIGINATED BY M.M.
DIST | HWY 69 | BOREHOLE TYPE 1/2 Weight Hammer Tripod & SPT | COMPILED BY N.L.
DATUM Geodetic | DATE 2021.07.29 | LATITUDE 45.778452 | LONGITUDE -80.499146 | CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
196.0	Ground Surface										
196.0 / 0.1	Organics Refusal on probable bedrock										

$+^3, \times^3$: Numbers refer to Sensitivity $\bigcirc^{3\%}$ STRAIN AT FAILURE

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RECORD OF BOREHOLE No TR1-11

METRIC

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 071 431.4 N; 227 081.9 E | ORIGINATED BY M.M.
DIST | HWY 69 | BOREHOLE TYPE 1/2 Weight Hammer Tripod & SPT | COMPILED BY N.L.
DATUM Geodetic | DATE 2021.07.29 | LATITUDE 45.778377 | LONGITUDE -80.499408 | CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
195.1	Ground Surface										
195.1 / 0.1	Organics Refusal on probable bedrock										

$+^3, \times^3$: Numbers refer to Sensitivity $\bigcirc^{3\%}$ STRAIN AT FAILURE

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 22-10-26

RECORD OF BOREHOLE No TR1-12

METRIC

PROJECT Hwy 69 Structural Culvert
COORDINATES Coords: 5 071 456.4 N; 227 083.9 E
ORIGINATED BY M.M.
DIST
HWY 69
BOREHOLE TYPE 1/2 Weight Hammer Tripod & SPT
COMPILED BY N.L.
DATUM Geodetic
DATE 2021.07.29
LATITUDE 45.778602
LONGITUDE -80.499387
CHECKED BY N.R.

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	STRAT PLOT	SAMPLES – NUMBER	SAMPLES – TYPE	SAMPLES – "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L – WATER CONTENT (%) (20 40 60)	UNIT WEIGHT/ GAS READING γ kN/m^3 / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.6	Ground Surface										
194.5 / 0.1	Organics Refusal on probable bedrock										

$+^3, \times^3$: Numbers refer to Sensitivity
○ 3% STRAIN AT FAILURE

SHEET B – TR-2 (Station: ± 9+310 to ± 9+435 – South Transition – Wallbridge)

- Borehole Location Plan (PML)
- Record of Borehole Logs (PML)
- Laboratory Test Results (PML)

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field work for the South Transition Area TR-2 from Station 9+310 to Station 9+435, in the Township of Wallbridge was carried between July 29 and August 30, 2021.

2. BOREHOLE INFORMATION

A total of 14 boreholes were advanced along the alignment of the proposed south transition of Highway 69.

Refer to
- Drawing B-1 for the borehole location plan
- Table B-1 for details of borehole origin, borehole location coordinates and borehole elevations/depths
- Record of Borehole sheets and lab results showing details of the subsurface conditions at the borehole locations from current investigation

Table B-1 Structural Culvert Borehole Information

BOREHOLE ID	MTM ON10 NAD 83 COORDINATES		GROUND SURFACE ELEVATION (m)	BOREHOLE DEPTH (m)
	NORTHING (m)	EASTING (m)		
TR2-1	5 071 507.0	227 074.8	196.6	0.05
TR2-2	5 071 498.8	227 055.4	193.7	0.08
TR2-3	5 071 514.5	227 061.0	193.4	0.03
TR2-4	5 071 530.0	227 066.4	194.5	0.08
TR2-5	5 071 522.1	227 046.1	195.5	0
TR2-6	5 071 537.8	227 052.0	194.0	5.4
TR2-7	5 071 553.2	227 057.5	196.1	0
TR2-8	5 071 543.8	227 033.2	193.7	0.03
TR2-9	5 071 577.0	227 048.3	194.8	0
TR2-10	5 071 568.5	227 027.8	193.5	1.2
TR2-11	5 071 599.9	227 039.4	194.6	1.8
TR2-12	5 071 592.0	227 018.7	193.5	0.15
TR2-13	5 071 623.2	227 030.2	195.7	0
TR2-14	5 071 615.1	227 009.5	194.6	0

2.1. Subsurface Conditions

The stratigraphy generally consists of approximately 30 mm to 200 mm of organics, followed by 1.0 m to 5.2 m of stiff to hard clayey silt, over bedrock. Refer to the Record of Boreholes for details.

The subsurface conditions at this site can be categorized into four (4) general layers as presented below from surface downwards.

2.1.1. Organics

A 30 mm to 200 mm thick layer of organics was encountered at the existing road surface in Boreholes TR2-1 to TR2-4, TR2-6, and TR2-8 to TR1-12. The SPT N value recorded near the bedrock surface in Borehole TR1-1 was over 100 blows per 0.3 m penetration.

2.1.2. Clayey Silt/Silty Clay

A 5.4 m, 1.2 m, 1.8 m thick layer of clayey silt/silty clay was encountered below the organics in Boreholes TR2-6, TR2-10, and TR2-11 respectively. The SPT N values recorded from this layer generally ranged from 4 blows to 18 blows per 0.3 m penetration, indicating firm to very stiff consistency. One SPT N value of 2 was obtained in Borehole TR2-6 at the surface, indicating very soft consistency, and another SPT N value of 42 blows for 25 cm penetration was recorded in Borehole TR2-11, where the hammer was bouncing on probable bedrock. Moisture contents of the samples ranged between 16.1% and 23.9%.

The grain size distribution test results of the selected samples are provided in Figure GS-B-1 and the Atterberg limits are presented in Figure PC-B-1.

2.1.3. Bedrock

Bedrock was encountered immediately below the organics in in Boreholes TR2-1 to TR2-4, TR2-8, and TR2-12. In Boreholes TR2-5, TR2-7, TR2-9, TR1-13, and TR1-14, the bedrock was exposed at the ground surface. Boreholes TR2-6, TR2-10, and TR2-11 were terminated on probable bedrock below 1.2 m to 5.4 m overburden.

2.2. Groundwater Conditions

Groundwater was observed at the ground surface at all borehole locations.

Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) are based on the information provided by Parsons on March 2, 2018 and the relevant geotechnical data provided in the FIR Reference 1 for the South Transition Area TR-2 in the Township of Wallbridge.

3. PROJECT DESCRIPTION

3.1. General

A 925 m long Transition and a 250 m long Connection are proposed at the south end of the new four-lane Highway 69 to allow traffic to and from the existing 2-lane Highway 69. The site conditions for the new embankments carrying the south Transition and Connection sections of the new Highway 69 were previously investigated by Golder Associates Ltd. (Golder). Test holes within the South Transition Area TR-2 were investigated to 0.07 m and 0.29 m depth, where bedrock was encountered.

3.2. Proposed Embankment

The maximum height of the embankment over South Transition Area TR-2 is anticipated to be up to 2.0 m between Station 9+310 and Station 9+435. The side slopes of the embankment are anticipated to be sloped at a minimum 2H:1V.

3.3. Embankment Construction

Refer to the General Report for preliminary recommendations for South Transition Embankment.

In general, construction of embankments shall be in accordance with OPSS.PROV 206. Where construction of embankments over swamps is anticipated, the construction shall be in accordance with OPSS.PROV 209.

All organic materials and cohesive soil shall be removed from the proposed footprint of the embankment. It is anticipated that excavation up to 3.0 m will be required in the vicinities of boreholes TR2-6, TR2-10 and TR2-11 to remove the cohesive soils. Backfill should be placed in accordance with OPSS.PROV 206. Where water bodies are within the footprint of the embankment, backfill material other than rock may be placed up to 600 mm above water level without compaction in accordance with OPSS.PROV 209 (209.07.03.01). It should also be noted that vibratory compaction equipment should not be used within 1.0 m of the original surface of the swamp (OPSS.PROV 209 – 209.07.04.2).

The proposed embankment can be construct with granular materials, earth borrow or rockfill. The side slopes of the proposed embankment are to be sloped at a minimum 2H:1V if granular material or earth borrow is used to construct the embankment. The side slopes of the embankment should be a minimum 1.25H:1V if rockfill is used to construct the embankment.

Granular materials shall be in accordance with OPSS.PROV 1010, amended by SSP 110S06. If earth borrow is utilized to construct the embankment, the earth borrow should be in accordance with OPSS.PROV 212, amended by SSP 112S07 and SSP 212F01. If rockfill is utilized to construct the new embankment, the material should be in accordance with OPSS.PROV 1004, amended by SSP 110S16. Compaction shall be carried out in accordance with OPSS.PROV 501, amended by SSP 105S22. It should be noted that frost susceptible material shall not be placed within the zone between the frost penetration depth and the final grade of the roadway.

No stability and settlement issues are anticipated following construction of the embankments as discussed above. It is anticipated that 10 mm to 20 mm of settlement of the embankment fill due to self weight will be completed following construction of the embankment.

4. CONSTRUCTION CONSIDERATIONS

4.1. Excavation

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

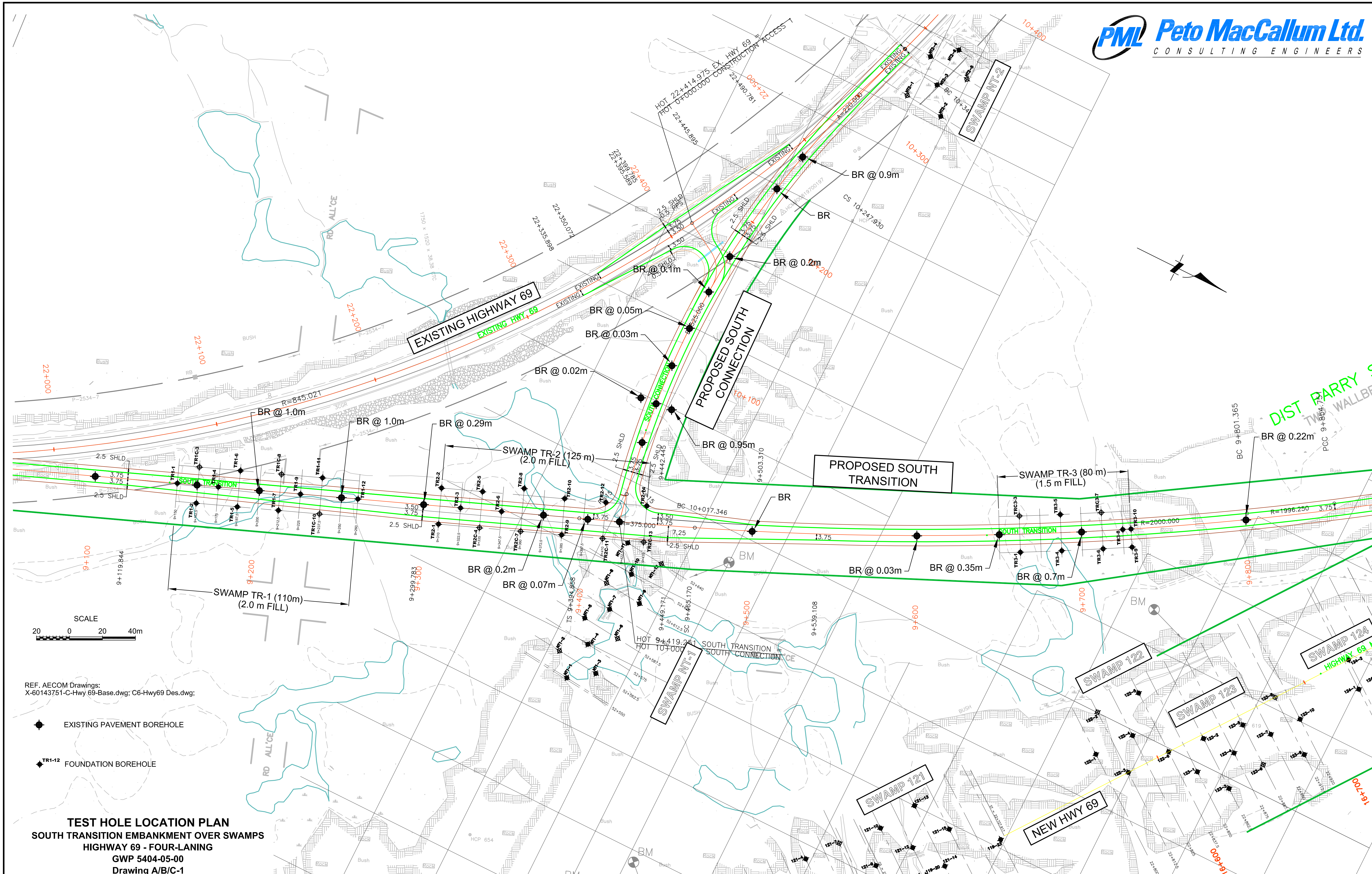
4.2. Groundwater and Surface Water Control

Surface water flow should be directed away from the excavation areas. It is recommended to carry out the construction during the drier time of the season.

Refer to the General Report for further groundwater control recommendations.

4.3. Additional Investigation

It is suggested that additional investigation should be carried out within the footprint of the proposed embankment where bedrock is not at shallow depths to determine the depth of overburden soils over bedrock. This would allow determining where excavation of the organic/cohesive soils would be required prior to construction of the embankment to mitigate any settlement issues.



REF. AECOM Drawings:
X-60143751-C-Hwy 69-Base.dwg; C6-Hwy69 Des.dwg;

TEST HOLE LOCATION PLAN
SOUTH TRANSITION EMBANKMENT OVER SWAMPS
HIGHWAY 69 - FOUR-LANING
GWP 5404-05-00
Drawing A/B/C-1

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No TR2-1

METRIC

PROJECT: Hwy 69 Structural Culvert
COORDINATES: Coords: 5 071 507.0 N; 227 074.8 E
ORIGINATED BY: M.M.
DIST:
HWY: 69
BOREHOLE TYPE: 1/2 Weight Hammer Tripod & SPT
COMPILED BY: N.L.
DATUM: Geodetic
DATE: 2021.07.29
LATITUDE: 45.779057
LONGITUDE: -80.499512
CHECKED BY: N.R.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
196.6	Ground Surface										
196.5 / 0.1	Organics Refusal on probable bedrock										

$+^3, \times^3$: Numbers refer to Sensitivity　　$\bigcirc^{3\%}$ STRAIN AT FAILURE

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Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No TR2-2

METRIC

PROJECT: Hwy 69 Structural Culvert
COORDINATES: Coords: 5 071 498.8 N; 227 055.4 E
ORIGINATED BY: M.M.
DIST:
HWY: 69
BOREHOLE TYPE: 1/2 Weight Hammer Tripod & SPT
COMPILED BY: N.L.
DATUM: Geodetic
DATE: 2021.08.10
LATITUDE: 45.778981
LONGITUDE: -80.49976
CHECKED BY: N.R.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RE I TANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
193.7	Ground Surface										
193.6 / 0.1	Organics Refusal on probable bedrock										

$+^3, \times^3$: Numbers refer to Sensitivity　　$\bigcirc^{3\%}$ STRAIN AT FAILURE

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Ministry of Transportation Ontario

RECORD OF BOREHOLE No TR2-3

METRIC

PROJECT Hwy 69 Structural Culvert COORDINATES Coords: 5 071 514.5 N; 227 061.0 E ORIGINATED BY M.M.

DIST HWY 69 BOREHOLE TYPE 1/2 Weight Hammer Tripod & SPT COMPILED BY N.L.

DATUM Geodetic DATE 2021.07.29 LATITUDE 45.779122 LONGITUDE -80.49969 CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.4	Ground Surface										
193.4 / 0.0	Organics Refusal on probable bedrock										

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No TR2-4

METRIC

PROJECT Hwy 69 Structural Culvert COORDINATES Coords: 5 071 530.0 N; 227 066.4 E ORIGINATED BY M.M.

DIST HWY 69 BOREHOLE TYPE 1/2 Weight Hammer Tripod & SPT COMPILED BY N.L.

DATUM Geodetic DATE 2021.07.29 LATITUDE 45.779263 LONGITUDE -80.499625 CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.5	Ground Surface										
194.5 / 0.1	Organics Refusal on probable bedrock										

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

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

RECORD OF BOREHOLE No TR2-5

METRIC

PROJECT Hwy 69 Structural Culvert COORDINATES Coords: 5 071 522.1 N; 227 046.1 E ORIGINATED BY M.M.

DIST HWY 69 BOREHOLE TYPE 1/2 Weight Hammer Tripod & SPT COMPILED BY N.L.

DATUM Geodetic DATE 2021.07.29 LATITUDE 45.779189 LONGITUDE -80.499883 CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
195.5	Ground Surface										
0.0	Exposed bedrock at surface										

RECORD OF BOREHOLE No TR2-6

METRIC

PROJECT Hwy 69 Structural Culvert COORDINATES Coords: 5 071 537.8 N; 227 052.0 E ORIGINATED BY M.M.

DIST HWY 69 BOREHOLE TYPE 1/2 Weight Hammer Tripod & SPT COMPILED BY N.L.

DATUM Geodetic DATE 2021.07.30 LATITUDE 45.779331 LONGITUDE -80.49981 CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	GR	SA	SI	CL
194.0	Ground Surface									
0.0	Organics CLAYEY SILT/SILTY CLAY, some sand to sandy, trace gravel Firm to stiff, Brown to grey, Wet	1	SS	2						
		2	SS	7		193				
		3	SS	8	∇		1	7	69	23
		4	SS	5		192				
		5	SS	4						
		6	SS	7		191	0	73	23	4
		7	SS	12		190				
		8	SS	7						
		9	SS	12		189	25	27	27	21
188.6 / 5.4	Auger refusal at a depth of 5.4 m on probable bedrock									

∇ Groundwater level observed during drilling

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No TR2-7

1 OF 1 **METRIC**

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 071 553.2 N; 227 057.5 E | ORIGINATED BY M.M.

DIST | HWY 69 | BOREHOLE TYPE 1/2 Weight Hammer Tripod & SPT | COMPILED BY N.L.

DATUM Geodetic | DATE 2021.07.29 | LATITUDE 45.77947 | LONGITUDE -80.499742 | CHECKED BY N.R.

SOIL PROFILE: ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
196.1	Ground Surface										
0.0	Exposed bedrock at surface										

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

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Foundation Design

RECORD OF BOREHOLE No TR2-8

1 OF 1 **METRIC**

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 071 543.8 N; 227 033.2 E | ORIGINATED BY M.M.

DIST | HWY 69 | BOREHOLE TYPE 1/2 Weight Hammer Tripod & SPT | COMPILED BY N.L.

DATUM Geodetic | DATE 2021.07.30 | LATITUDE 45.779383 | LONGITUDE -80.500053 | CHECKED BY N.R.

SOIL PROFILE: ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.7	Ground Surface										
193.7	Organics										
0.0	Refusal on probable bedrock										

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

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 22-10-26

Ministry of Transportation Ontario

RECORD OF BOREHOLE No TR2-9

METRIC

PROJECT: Hwy 69 Structural Culvert	COORDINATES: Coords: 5 071 577.0 N; 227 048.3 E		ORIGINATED BY: M.M.
DIST: HWY: 69	BOREHOLE TYPE: 1/2 Weight Hammer Tripod & SPT		COMPILED BY: N.L.
DATUM: Geodetic	DATE: 2021.07.30	LATITUDE: 45.779684 LONGITUDE: -80.499864	CHECKED BY: N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT/GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.8	Ground Surface										
194.7 / 0.1	Organics Refusal on probable bedrock										

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

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 22-10-26

Ministry of Transportation Ontario

RECORD OF BOREHOLE No TR2-10

METRIC

PROJECT: Hwy 69 Structural Culvert	COORDINATES: Coords: 5 071 568.5 N; 227 027.8 E		ORIGINATED BY: M.M.
DIST: HWY: 69	BOREHOLE TYPE: 1/2 Weight Hammer Tripod & SPT		COMPILED BY: N.L.
DATUM: Geodetic	DATE: 2021.08.10	LATITUDE: 45.779605 LONGITUDE: -80.500127	CHECKED BY: N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT/GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.5	Ground Surface										
0.0	Organics CLAYEY SILT/SILTY CLAY Firm to very stiff, Brown, Wet		1	SS	6		193				0 40 39 21
			2	SS	18						
192.3 / 1.2	Auger refusal at a depth of 1.2 m on probable bedrock										

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

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 22-10-26

RECORD OF BOREHOLE No TR2-11

METRIC

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 071 599.9 N; 227 039.4 E | ORIGINATED BY M.M.

DIST | HWY 69 | BOREHOLE TYPE 1/2 Weight Hammer Tripod & SPT | COMPILED BY N.L.

DATUM Geodetic | DATE 2021.08.10 | LATITUDE 45.779888 | LONGITUDE -80.499983 | CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³ / GAS READING ppm/%	GR	SA	SI	CL
194.6	Ground Surface												
0.0	Organics												
	CLAYEY SILT/SILTY CLAY Soft to stiff, Brown, Wet		1	SS	3		194						
			2	SS	8					0	10	64	26
			3	SS	42/25cm		193			19	65	11	5
192.8 1.8	Refusal on probable bedrock Hammer bouncing at 1.8 m depth												

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; REMARKS & GRAIN SIZE DISTRIBUTION (%)

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

RECORD OF BOREHOLE No TR2-12

METRIC

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 071 592.0 N; 227 018.7 E | ORIGINATED BY M.M.

DIST | HWY 69 | BOREHOLE TYPE 1/2 Weight Hammer Tripod & SPT | COMPILED BY N.L.

DATUM Geodetic | DATE 2021.08.10 | LATITUDE 45.779815 | LONGITUDE -80.500247 | CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³ / GAS READING ppm/%	GR	SA	SI	CL
193.5	Ground Surface												
193.3 0.2	Organics Refusal on probable bedrock												

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; REMARKS & GRAIN SIZE DISTRIBUTION (%)

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

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No TR2-13

1 OF 1 **METRIC**

PROJECT Hwy 69 Structural Culvert COORDINATES Coords: 5 071 623.2 N; 227 030.2 E ORIGINATED BY M.M.

DIST HWY 69 BOREHOLE TYPE 1/2 Weight Hammer Tripod & SPT COMPILED BY N.L.

DATUM Geodetic DATE 2021.07.30 LATITUDE 45.780097 LONGITUDE -80.500105 CHECKED BY N.R.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
195.7	Ground Surface										
0.0	Exposed bedrock at surface										

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

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 22-10-26

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No TR2-14

1 OF 1 **METRIC**

PROJECT Hwy 69 Structural Culvert COORDINATES Coords: 5 071 615.1 N; 227 009.5 E ORIGINATED BY M.M.

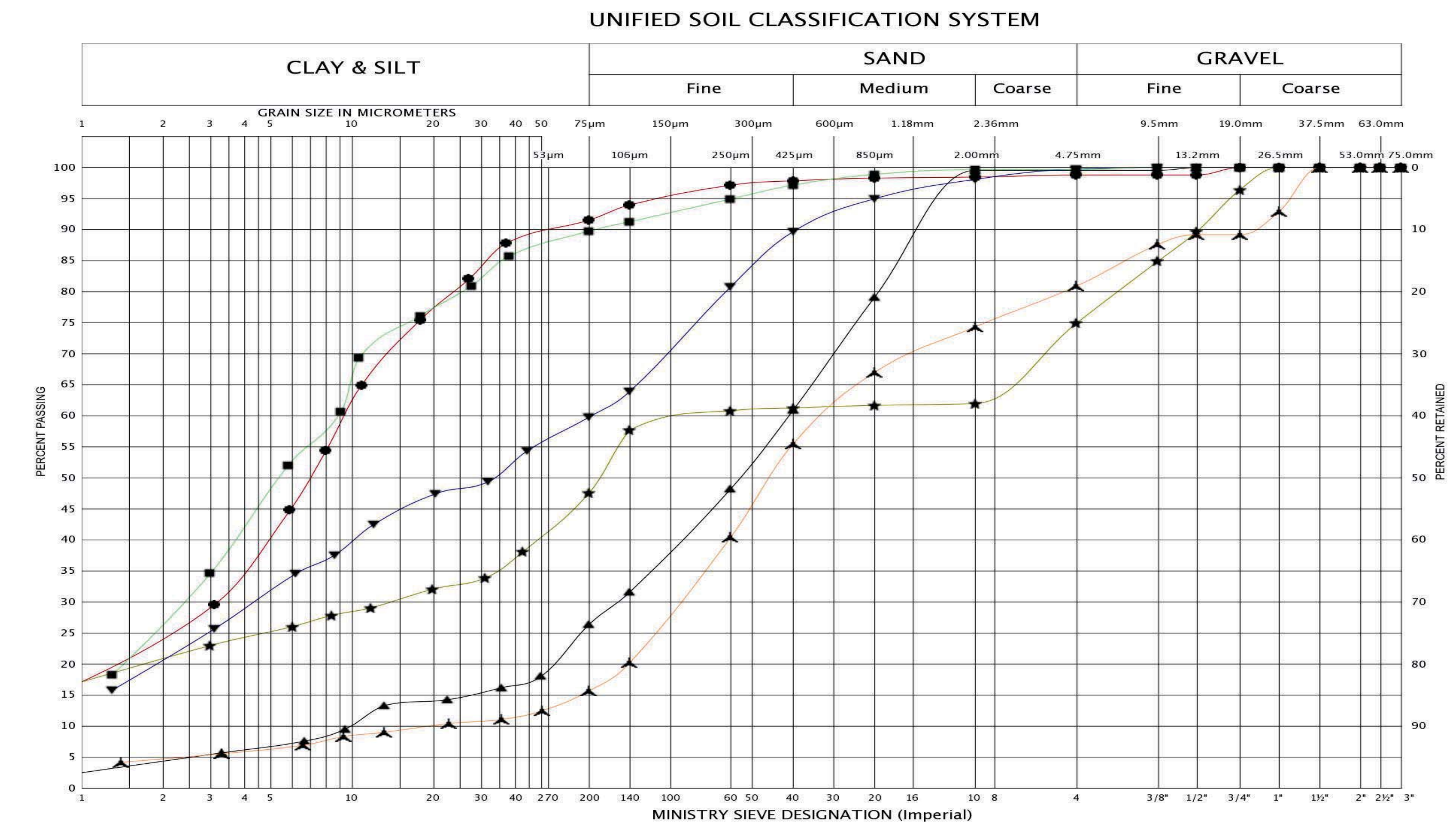
DIST HWY 69 BOREHOLE TYPE 1/2 Weight Hammer Tripod & SPT COMPILED BY N.L.

DATUM Geodetic DATE 2021.08.09 LATITUDE 45.78002 LONGITUDE 80.50037 CHECKED BY N.R.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
194.0	Ground Surface										
0.0	Exposed bedrock at surface										

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

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 22-10-26



LEGEND	BH	TR2-6	TR2-6	TR2-6	TR2-10	TR2-11	TR2-11
	SAMPLE	3	6	9	1	2	3
	SYMBOL	●	▲	★	▼	■	⅄

GRAIN SIZE DISTRIBUTION

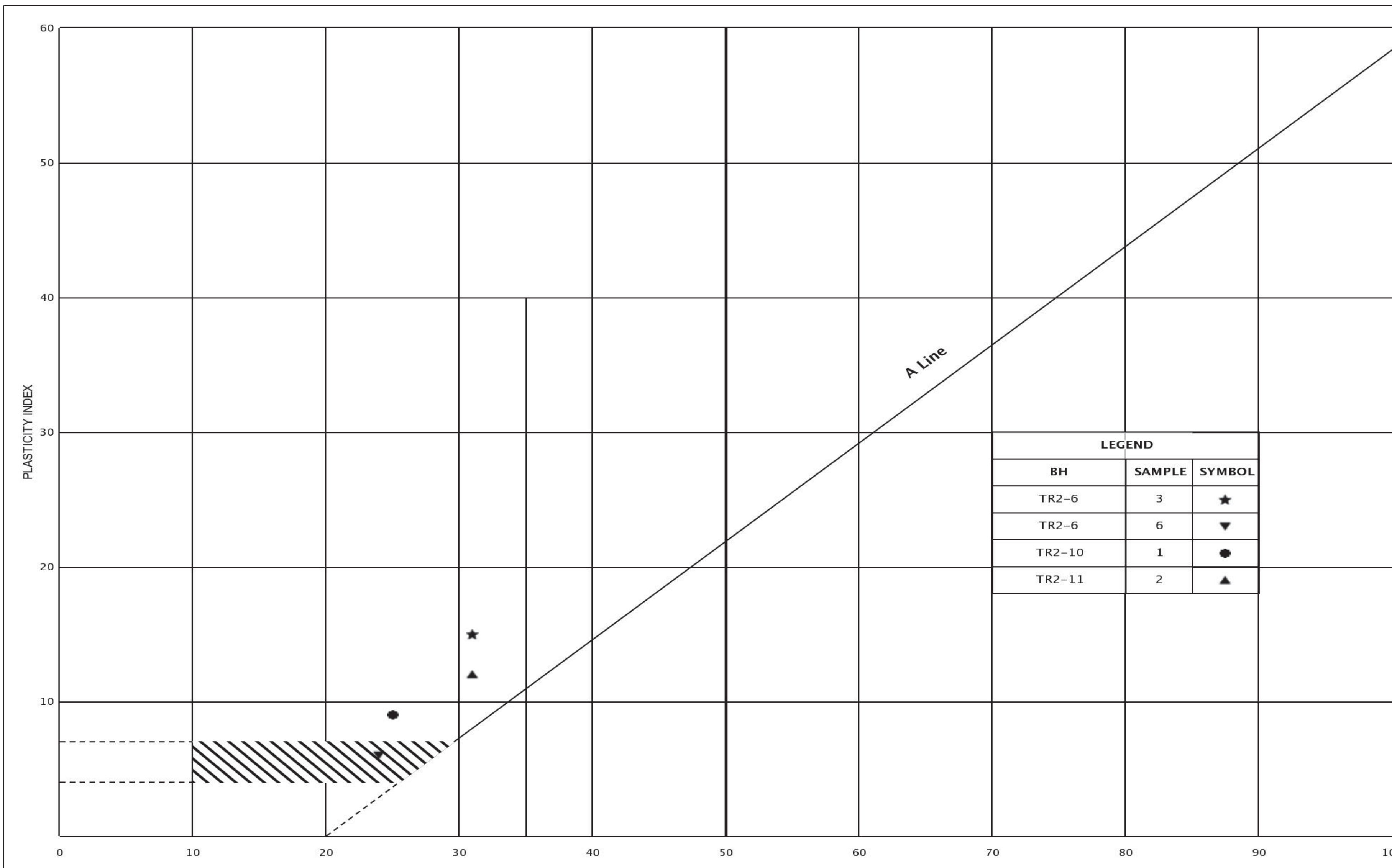
CLAYEY SILT/SILTY CLAY

Ontario

FIG No.: GS-B-1

HWY : 69

Project No.: 14TF034G



LEGEND		
BH	SAMPLE	SYMBOL
TR2-6	3	★
TR2-6	6	▼
TR2-10	1	●
TR2-11	2	▲

PLASTICITY CHART

CLAYEY SILT

Ontario

FIG No.: PC-B-1

HWY.: 69

Proj No. 14TF034G

SHEET C – TR-3 (Station: ± 9+650 to ± 9+730 – South Transition – Wallbridge)

- Borehole Location Plan (PML)
- Record of Borehole Logs (PML)

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field work for the South Transition Area TR-3 from Station 9+650 to Station 9+750, in the Township of Wallbridge was carried out on August 10 & 11, 2021, and July 10,2023.

2. BOREHOLE INFORMATION

A total of 10 boreholes were proposed along the alignment of the proposed south transition of Highway 69.

Refer to
- Drawing C-1 for the borehole location plan
- Table C-1 for details of borehole origin, borehole location coordinates and borehole elevations/depths
- Record of Borehole sheets and lab results showing details of the subsurface conditions at the borehole locations from current investigation

Table C-1 Structural Culvert Borehole Information

BOREHOLE ID	UTM17 NAD 83 COORDINATES		GROUND SURFACE ELEVATION (m)	BOREHOLE DEPTH (m)
	NORTHING (m)	EASTING (m)		
TR3-1	5 071 884.4	226 891.2	199.3	0.025
TR3-2	5 071 836.7	226 917.0	198.1	0.20
TR3-3	5 071 819.7	226 913.7	198.7	0.20
TR3-4	5 071 852.6	226 921.8	198.1	0.20
TR3-5	5 071 842.0	226 902.5	198.1	0.15
TR3-6	5 071 874.6	226 909.5	198.7	0.15
TR3-7	5 071 863.8	226 890.4	198.6	0.00
TR3-8	5 071 880.0	226 893.8	198.8	0.33
TR3-9	5 071 889.9	226 900.8	199.0	0.08
TR3-10	5 071 830.6	226 933.8	199.8	0.00

2.1. Subsurface Conditions

The stratigraphy generally consists of approximately 30 mm to 200 mm of organics, followed by 1.0 m to 5.2 m of stiff to hard clayey silt, over bedrock. Refer to the Record of Boreholes for details.

The subsurface conditions at this site can be categorized into three (3) general layers as presented below from surface downwards.

2.1.1. Water

Boreholes TR3-2 to TR3-6 were located within the deep swam waters and thus could not be accessed/investigated at the time of fieldwork.

2.1.2. Organics

A 50 mm and 330 mm thick layer of organics was encountered at the existing road surface in Boreholes TR3-1 to TR3-6, and TR2-8. The SPT N value recorded near the bedrock surface in Borehole TR3-1 was over 100 blows per 0.3 m penetration.

2.1.3. Bedrock

Bedrock was encountered immediately below the organics in in Boreholes TR3-1 to TR3-6, and TR3-8. In Boreholes TR3-7, TR3-9, and TR3-10, the bedrock was exposed at the ground surface. Boreholes TR3-1 to TR3-6, and TR3-8 were terminated on probable bedrock.

2.2. Groundwater Conditions

Groundwater was observed at the ground surface at all borehole locations.

Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) are based on the information provided by Parsons on March 2, 2018 and the relevant geotechnical data provided in the FIR Reference 1 for the South Transition Area TR-3 in the Township of Wallbridge.

3. PROJECT DESCRIPTION

3.1. General

A 925 m long Transition and a 250 m long Connection are proposed at the south end of the new four-lane Highway 69 to allow traffic to and from the existing 2-lane Highway 69. The site conditions for the new embankments carrying the south Transition and Connection sections of the new Highway 69 were previously investigated by Golder Associates Ltd. (Golder). Test holes within the South Transition Area TR-3 were investigated to 0.35 m and 0.7 m depth, where bedrock was encountered.

3.2. Proposed Embankment

The maximum height of the embankment over South Transition Area TR-3 is anticipated to be up to 2.0 m between Station 9+650 and Station 9+750. The side slopes of the embankment are anticipated to be sloped at a minimum 2H:1V.

3.3. Embankment Construction

Refer to the General Report for preliminary recommendations for South Transition Embankment.

In general, construction of embankments shall be in accordance with OPSS.PROV 206. Where construction of embankments over swamps is anticipated, the construction shall be in accordance with OPSS.PROV 209.

All organic materials and clayey silts shall be removed from the proposed footprint of the embankment. Backfill should be placed in accordance with OPSS.PROV 206. Where water bodies are within the footprint of the embankment, backfill material other than rock may be placed up to 600 mm above water level without compaction in accordance with OPSS.PROV 209 (209.07.03.01). Rock excavation is anticipated approximately between Station 9+738 and Station 9+750. It should be noted that vibratory compaction equipment should not be used within 1.0 m of the original surface of the swamp (OPSS.PROV 209 – 209.07.04.2).

The proposed embankment can be construct with granular materials, earth borrow or rockfill. The side slopes of the proposed embankment are to be sloped at a minimum 2H:1V if granular material or earth borrow is used to construct the embankment. The side slopes of the embankment should be a minimum 1.25H:1V if rockfill is used to construct the embankment.

Granular materials shall be in accordance with OPSS.PROV 1010, amended by SSP 110S06. If earth borrow is utilized to construct the embankment, the earth borrow should be in accordance with OPSS.PROV 212, amended by SSP 112S07 and SSP 212F01. If rockfill is utilized to construct the new embankment, the material should be in accordance with OPSS.PROV 1004, amended by SS 110S16. Compaction shall be carried out in accordance with OPSS.PROV 501, amended by SSP 105S22. It should be noted that frost susceptible material shall not be placed within the zone between the frost penetration depth and the final grade of the roadway.

No stability and settlement issues are anticipated following construction of the embankments as discussed above. It is anticipated that 10 mm to 20 mm of settlement of the embankment fill due to self weight will be completed following construction of the embankment.

4. CONSTRUCTION CONSIDERATIONS

4.1. Excavation

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

Rock excavation up to 0.5 m is anticipated approximately between Station 9+738 and 9+750. Proper rock excavation equipment will be required to excavate the rock to the proposed subgrade alignment of the new Highway 69 alignments.

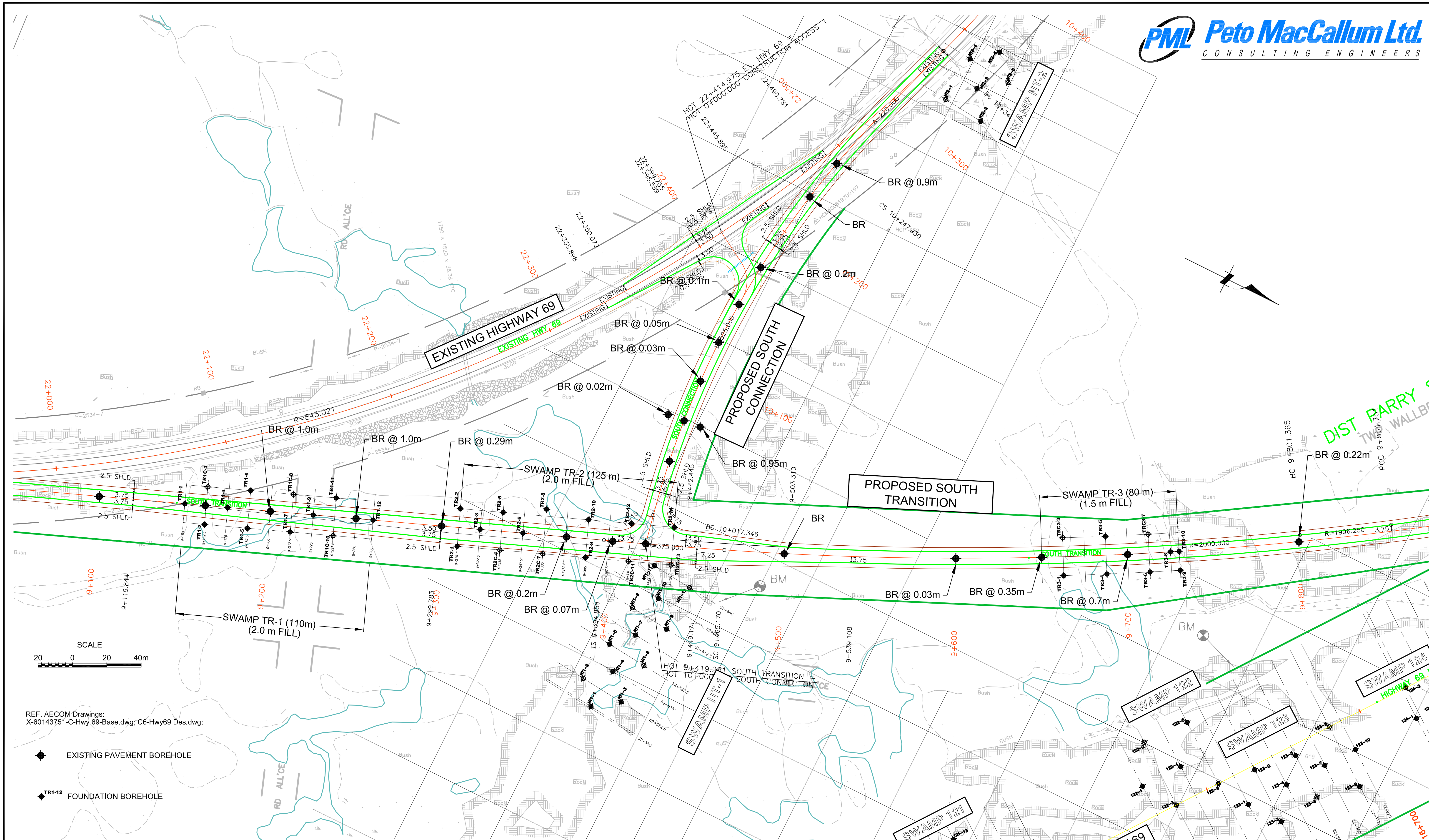
4.2. Groundwater and Surface Water Control

Surface water flow should be directed away from the excavation areas. It is recommended to carry out the construction during the drier time of the season.

Refer to the General Report for further groundwater control recommendations.

4.3. Additional Investigation

It is suggested that additional investigation should be carried out within the footprint of the proposed embankment where bedrock is not at shallow depths to determine the depth of overburden soils over bedrock. This would allow determining where excavation of the organic/cohesive soils would be required prior to construction of the embankment to mitigate any settlement issues.



TEST HOLE LOCATION PLAN

SOUTH TRANSITION EMBANKMENT OVER SWAMPS

HIGHWAY 69 - FOUR-LANING

GWP 5404-05-00

Drawing A/B/C-1

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No TR3-1

1 OF 1 **METRIC**

PROJECT Hwy 69 Structural Culvert
COORDINATES Coords: 5 071 884.4 N; 226 891.2 E
ORIGINATED BY M.M.

DIST ______ HWY 69
BOREHOLE TYPE Mankiller
COMPILED BY N.L.

DATUM Geodetic
DATE 2021.08.21
LATITUDE 45.782431
LONGITUDE -80.501933
CHECKED BY N.R.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
199.3	Ground Surface										
199.3 / 0.1	Organics Refusal on probable bedrock										

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

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 23-7-31

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No TR3-2

1 OF 1 **METRIC**

PROJECT Hwy 69 Structural Culvert
COORDINATES Coords: 5 071 836.7 N; 226 917.0 E
ORIGINATED BY D.C.

DIST ______ HWY 69
BOREHOLE TYPE Manual Probe
COMPILED BY N.L.

DATUM Geodetic
DATE 2023.07.10
LATITUDE 45.782005
LONGITUDE -80.501594
CHECKED BY N.R.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
198.1	Ground Surface										
197.9 / 0.2	Organics Refusal on probable bedrock						198				

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

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 23-7-31

RECORD OF BOREHOLE No TR3-3

METRIC

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 071 819.8 N; 226 913.7 E | ORIGINATED BY D.C.
DIST | HWY 69 | BOREHOLE TYPE Manual Probe | COMPILED BY N.L.
DATUM Geodetic | DATE 2023.07.10 | LATITUDE 45.781853 | LONGITUDE -80.501634 | CHECKED BY N.R.

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT (WATER CONTENT %)	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
198.7	Ground Surface										
198.5	Organics										
0.2	Refusal on probable bedrock										

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

Ministry of Transportation Ontario
Foundation Design

RECORD OF BOREHOLE No TR3-4

METRIC

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 071 852.6 N; 226 921.8 E | ORIGINATED BY D.C.
DIST | HWY 69 | BOREHOLE TYPE Manual Probe | COMPILED BY N.L.
DATUM Geodetic | DATE 2023.07.10 | LATITUDE 45.782149 | LONGITUDE -80.501535 | CHECKED BY N.R.

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT (WATER CONTENT %)	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
198.1	Ground Surface										
197.9	Organics						198				
0.2	Refusal on probable bedrock										

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

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No TR3-5

METRIC

PROJECT Hwy 69 Structural Culvert
COORDINATES Coords: 5 071 842.1 N; 226 902.5 E
ORIGINATED BY D.C.

DIST
HWY 69
BOREHOLE TYPE Manual Probe
COMPILED BY N.L.

DATUM Geodetic
DATE 2023.07.10
LATITUDE 45.782052
LONGITUDE -80.501781
CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
198.1	Ground Surface										
197.9 / 0.2	Organics						198				
	Refusal on probable bedrock										

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

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Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No TR3-6

METRIC

PROJECT Hwy 69 Structural Culvert
COORDINATES Coords: 5 071 874.6 N; 226 909.5 E
ORIGINATED BY D.C.

DIST
HWY 69
BOREHOLE TYPE Manual Probe
COMPILED BY N.L.

DATUM Geodetic
DATE 2023.07.10
LATITUDE 45.782345
LONGITUDE -80.501696
CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
198.7	Ground Surface										
198.5 / 0.2	Organics										
	Refusal on probable bedrock										

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

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 23-7-31

RECORD OF BOREHOLE No TR3-7

1 OF 1 **METRIC**

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 071 863.8 N; 226 890.4 E | ORIGINATED BY M.M.
DIST | HWY 69 | BOREHOLE TYPE Mankiller | COMPILED BY N.L.
DATUM Geodetic | DATE 2021.08.21 | LATITUDE 45.782246 | LONGITUDE -80.50194 | CHECKED BY N.R.

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
198.6	Ground Surface										
0.0	Exposed bedrock at surface										

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

RECORD OF BOREHOLE No TR3-8

1 OF 1 **METRIC**

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 071 880.0 N; 226 893.8 E | ORIGINATED BY M.M.
DIST | HWY 69 | BOREHOLE TYPE Mankiller | COMPILED BY N.L.
DATUM Geodetic | DATE 2021.08.21 | LATITUDE 45.782392 | LONGITUDE -80.5019 | CHECKED BY N.R.

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
198.8	Ground Surface										
0.0	Organics, rock fragments		1	SS	54/18cm						
198.5 0.3	Refusal on probable bedrock										

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

RECORD OF BOREHOLE No TR3-9

METRIC

PROJECT Hwy 69 Structural Culvert
COORDINATES Coords: 5 071 889.9 N; 226 900.8 E
ORIGINATED BY M.M.
DIST
HWY 69
BOREHOLE TYPE Mankiller
COMPILED BY N.L.
DATUM Geodetic
DATE 2021.08.21
LATITUDE 45.782482
LONGITUDE -80.501811
CHECKED BY N.R.

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m^3 / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
199.0	Ground Surface										
0.0	Exposed bedrock at surface										

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

RECORD OF BOREHOLE No TR3-10

METRIC

PROJECT Hwy 69 Structural Culvert
COORDINATES Coords: 5 071 830.6 N; 226 933.8 E
ORIGINATED BY M.M.
DIST
HWY 69
BOREHOLE TYPE Mankiller
COMPILED BY N.L.
DATUM Geodetic
DATE 2021.08.21
LATITUDE 45.781952
LONGITUDE -80.501378
CHECKED BY N.R.

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m^3 / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
199.8	Ground Surface										
0.0	Exposed bedrock at surface										

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

SHEET E – CVH-17 - Fisheries Culvert (Station: ± 13+810 Hwy 69 NBL – Henvey)

SHEET E – CVH-18 - Fisheries Culvert (Station: ± 13+810 Hwy 69 SBL – Henvey)

- Borehole Locations and Soil Strata (Geocres 41H-128)
- Record of Borehole Logs (Geocres 41H-128)
- Laboratory Test Results (Geocres 41H-128)
- Rock Core Photograph (Geocres 41H-128

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field work for Culverts CVH-17 and CVH-18 at Station 13+810 Henvey Township (Site Nos. 44-626/C1 under the NBL and C2 under the SBL) was carried out by Golder Associates (Golder) between February 8 and March 10, 2012, and a foundation investigation report (FIR) (Reference 1 below) was completed and submitted to MTO.

Seven (7) boreholes were advanced by Golder at the proposed culverts locations across the northbound lanes (NBL) and southbound lanes (SBL) of the new alignment of Highway 69. Refer to the report Reference 1 for details of the borehole locations and subsurface conditions encountered at each culvert location.

The following Reference Reports were referenced:

1. Foundation Investigation Report (FIR) - Culverts: Site No. 44 - 626/C1 and C2, Contract 3, Highway 69 Four-Laning from 1.7 km North of Highway 529 Northerly to 3.9 km North of Highway 522, MTO, GWP 5404-05-00; WP 5404-05-01, (GEOCRES No. 41H-128), submitted to URS Canada Inc. (URS) by Golder, October 1, 2013 (Report Number: 09-1111-6014-3521)

2. Foundation Investigation and Design Report (FIDR), Swamp Crossings and High Fill Areas - Contract 3, Highway 69 Four-Laning from 1.7 km North of Highway 529 Northerly to 3.9 km North of Highway 522, MTO, GWP 5404-05-00; WP 5404-05-01, (GEOCRES No. 41H-134, submitted to URS by Golder, February 11, 2014 (Report Number: 09-1111-6014-3520).

The proposed culverts are located within Swamp 301 in the report Reference 2. Refer to this report for the design recommendations, including construction and monitoring of the embankments across the swamp.

Relevant geotechnical data from the reference reports are included in Appendix A-2 of this report, including records of borehole logs and preliminary foundation drawings

PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) are based on the information provided by Parsons on March 2, 2018 and the relevant geotechnical data provided in the FIR Reference 1.

2. PROJECT DESCRIPTION

2.1. General

The proposed Fisheries/Wildlife (SAR) Culverts) and (Site No. 44-626/C2) are new structures across the new alignment of Highway 69. The culverts are located 6.5 km north of the intersection of Highway 529, Township of Henvey, District of Parry Sound.

2.2. Proposed Structures

Based on the Drawing No. A2 dated March, 2013, included in report Reference 1, both culverts will have an opening size of 3.0 m in span, 2.4 m in height, will be approximately 32.0 m long and will be on a skew of approximately 15 degrees to the new alignment of the new Highway 69.

The existing ground surface in the vicinity of the culvert alignments varies from approximately EL. 182.0 to EL. 181.0 m and is gently sloping downward in the direction from northeast to southwest towards Georgian Bay.

Based on the reference drawing, the proposed invert levels of the proposed NBL and SBL culverts and inferred founding levels are summarized in Table E-1 and Table E-2 below.

Table E-1: Box Culvert Founding Elevations at Station 13+810 NBL CVH-17 Culvert (Site No. 44-626/C1)

FOUNDATION LOCATION	PROPOSED CULVERT INVERT ELEVATION	BOTTOM OF BOX CULVERT ELEVATION	SUBGRADE ELEVATION FOR GRANULAR BEDDING	FOUNDING STRATUM
West End (Inlet)	180.62 m	180.32 m	180.02 m	Firm clayey silt, trace sand
East End (Outlet)	180.60 m	180.30 m	180.00 m	Firm silty clay, trace sand

Note(s): 1: The bottom thickness of the precast concrete box culvert is assumed 0.25 m (minimum).

Table E-2: Box Culvert Founding Elevations at Station 13+810 SBL CVH-18 Culvert (Site No. 44-626/C2)

FOUNDATION LOCATION	PROPOSED CULVERT INVERT ELEVATION	BOTTOM OF BOX CULVERT ELEVATION	SUBGRADE ELEVATION FOR GRANULAR BEDDING	FOUNDING STRATUM
West End (Inlet)	180.60 m	180.30 m	180.10 m	Very soft to soft silty clay, trace sand
East End (Outlet)	180.59 m	180.29 m	180.00 m	Soft to stiff sandy clayey silt, containing organics

Note(s): 1: The bottom thickness of the precast concrete box culvert is assumed 0.25 m (minimum).

The height of embankment fill required above the culverts to the proposed grades of re-aligned highway at Station 13+810 is not expected to exceed 2.5 m, including the pavement structure. Report Reference 2 indicates that the maximum height of embankment across Swamp 301 will be 4.0 m.

In the absence of any structural details of the culverts, it is assumed that concrete culverts and fill would impose a dead load of 70 kPa on the founding subgrade.

3. STRUCTURE FOUNDATION SUBSURFACE CONDITIONS

Refer to the report Reference 1 for the subsurface information that is summarized in the following paragraph:

The subsurface soils along the culvert alignments consist of topsoil or near surface deposit of sandy silt to silty sand, underlain by a thick deposit of cohesive soil comprised of clayey silt to clay, which is generally separated into an upper deposit and a lower deposit by an interlayer of silt to sandy silt to silty sand. The cohesive deposit is in turn underlain by deposits of silt to sandy silt, and sand and silt to silty sand, which extend to refusal or underlying granite gneiss bedrock.

The soil stratigraphy encountered at both NBL and SBL culverts, is similar and generally consists of alternating layers of cohesive and cohesionless soils. However, the encountered thickness of overburden varies significantly from the location of culvert CVH-17 on NBL at approximately 19.7 m to some 30.5 m at the location of the SBL culvert CVH-18. The relevant subsoil conditions encountered at the culvert locations on NBL and SBL are summarized in the following sections.

3.1.1. Culvert CVH-17 on NBL (Boreholes 301-N1, -N2, -N3)

In summary, the soil stratigraphy below surficial topsoil at the Culvert CVH-17 location includes alternating layers of cohesive soils with a total thickness of 12.1 to 13.4 m and cohesionless deposits with a total thickness of 6.4 to 14.1 m. Granitic bedrock was confirmed by coring to 22.7 m depth (EL. 158.9) in borehole C301-N3.

The in-situ vane shear strength (C_u) of clayey soil below the proposed invert level of Culvert CVH-17 to a depth of about 9.8 m (EL. 171.8) ranged from 22 to 38 kPa, with an average value of 28 kPa. Below this depth, the in-situ vane shear strength ranged from 34 to 78 kPa, with an average value of 58 kPa.

Groundwater levels recorded upon completion of drilling ranged from 0.2 m (El. 181.4 m) to 1.7 m (EL. 179.9 m) below the existing ground surface. An artesian condition was observed in borehole C301-N1 with a stabilized artesian head 0.7 m above existing ground surface, approximate EL. 181.9 m, that is approximately 1.0 m above the proposed culvert invert level.

3.1.2. Culvert CVH-18 on SBL (Boreholes C301-S1, -S2, - S3 and S301-03)

In summary, the soil stratigraphy below the surficial topsoil at the Culvert CVH-18 location includes alternating layers of cohesive soils with a total thickness of approximately 14.4 to 18.6 m and cohesionless soils with a total thickness of 6.3 to 11.8 m. Boreholes C301-S1 to C301-S3 were advanced by Dynamic Cone Penetration Test (DCPT) to depths ranging from 27.9 m (EL. 153.6) to 30.7 m (EL. 150.7) where refusal to DCPT was encountered.

The in-situ vane shear strength (C_u) tests conducted in the vicinity of sampling depths ranged from 12 to 23 kPa, with an average value of 16.5 kPa. Below this depth, the in-situ vane shear test results ranged from 20 to 75 kPa, with an average value of 41.0 kPa.

The groundwater level measured upon completion of drilling in these boreholes ranged from EL. 179.8 m to EL. 180.9 m. Artesian conditions were observed in borehole Boreholes C301-S1, CS301-S2 and C301-S3. The stabilized artesian heads observed in these boreholes were 0.8 to 1.1 m above the existing ground surface, which corresponds to approximate EL. 182.3 to 182.6 m, which are approximately 2.3 to 2.6 m above the culvert invert level.

The results of a one-dimensional consolidation test performed by Golder on a thin-walled tube (Shelby tube) sample obtained from Borehole C301-S2 at a depth of 2.8 m (EL. 178.7) below the ground surface was reported on Figure A of their report. The interpreted geotechnical values are included in the Section 4.3.3 of the same report.

For this preliminary FDR, the compression index (C_c) value was estimated using the empirical formulae suggested by Koppula (1981)[1] and Rendon-Herrero (1980)[2]. Based on the estimate, an average C_c value of 0.62 and the reported void ratio (e_o) of 1.80 were used to estimate the magnitude of total settlement expected under the imposed load of 70 kPa, assuming that the clayey deposit encountered at this site is normally consolidated.

4. EVALUATION OF FOUNDATION ALTERNATIVES

The foundation alternatives listed below were based on the available information in report Reference 1 and also considered the construction of the embankments across swamps in Reference 2, including the assumed embankment fill required above the culverts that is not expected to exceed 2.5 m, including the pavement structures and the fill height will be a maximum of 4.0 m.

1. Precast concrete box culverts placed without settlement mitigation
2. Precast concrete box culverts placed after preloading or surcharging
3. Corrugated Steel Plate (CSP) Arch or Circular Culverts

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[1] Koppula, S. (1981). "Statistical Estimation of Compression Index," Geotechnical Testing Journal, Vol. 4, No. 2, pp. 68-73.

[2] Rendon-Herrero, O. (1980). "Universal Compression Index Equation," Journal of the Geotechnical Engineering Division, ASCE, Vol. 106, No. GT11, pp.1179-1200.

4.1. Option 1: Precast Concrete Box Culverts Placed without Settlement Mitigation

Assuming that the culverts are placed at the proposed subgrade level of ±EL. 180.6 m, there will be about 3.4 m to 8.7 m (NBL) and 4.2 m to 6.3 m (SBL) thick soft to firm clayey silt to silty clay layer underneath the base of the culverts, which will result in significant total and differential settlements along the length of each of the culverts. The magnitude of differential settlements expected from the 5.3 m (NBL) and 2.1 m (SBL) variation in thickness of clayey layer under the imposed load of 70 kPa will be higher than the tolerable limit of 100 mm generally assumed for a precast concrete box culvert.

Specifically, the 3.4 m to 8.7 m thick soft to firm clayey silt to silty clay below the proposed NBL culvert under a load of 70 kPa is expected to undergo a total settlement ranging from 810 to 1050 mm and associated estimated differential settlement ranging from 65 mm to 210 mm. For the SBL culvert, the 4.2 m to 6.3 m thick soft to firm clay below its proposed founding level under the same loading is expected to undergo a total settlement ranging from 630 to 800 mm and associated differential settlement ranging from 40 to 170 mm.

Such relatively large total and differential settlements are not acceptable, considering that the magnitudes are in excess of the tolerable settlement limits for a precast concrete box culvert, and can cause damage to the joints, leading to deterioration of the culvert. Therefore, factored geotechnical resistances at ULS and at SLS for 100 mm of differential settlement are not applicable since the option of placing the proposed culverts for both NBL and SBL on native soils at ±EL. 180.6 m without settlement mitigation measures is not considered to be feasible.

4.2. Option 2: Precast Concrete Box Culverts after Preloading or Surcharging

The report Reference 2 recommends the use of preloading and adding a surcharge of 1.0 m to mitigate the post-construction settlement in the area of Swamp 301. The report indicates that under 4.0 m high rock fill embankment and no surcharge, 90 % of primary consolidation will be completed in 2.5 years and a minimum period of 1.2 years is required to mitigate high post-construction settlements at this location. If a 1.0 m high granular fill surcharge was placed, the primary consolidation period could be reduced to 9 months.

Since there is no existing road or proposed structure where the culverts are proposed, it is recommended that the construction of precast concrete box culverts be coordinated with the construction of the embankment fill across Swamp 301 and the footprint of the culverts preloaded and surcharged simultaneously with the embankments. The scheme may require the placement of temporary CSP pipes under the embankment fill to allow for the local drainage of the creek, if required. At the appropriate time, the fill used for the preload, the surcharge material and the temporary CSPs would be removed and the precast box culverts would be installed.

In this option 2, the estimated average height over the existing ground including the surcharge will include some 5.0 m of granular soils for ease of excavation after surcharging. These materials would impose an estimated preload and surcharge load of 105 kPa, assuming an average unit weight of 21.0 kN/m^3. For this material placed on the footprint of the culvert sites, it is estimated that the primary consolidation settlement of some 800 to 1300 mm will take approximately 6 months to 18 months to complete.

Unsuitable/organic materials at the culvert locations should be excavated from the areas under and within the zone of influence of the culverts (minimum of 2 m beyond the culvert walls) and care should be exercised when preparing the subgrade for the embankment construction to minimize excavation concerns including artesian conditions when installing the culverts. Following the preloading/surcharging period, the exposed subgrade should be inspected and approved before placement of compacted granular materials as specified in OPSS 422.07.06.

The granular material to backfill the precast concrete box culvert should be placed in accordance with OPSS 422.07.07. Granular material should be as specified in accordance with OPSS 422.05.13 and may consist of either Granular ‘A’ or Granular ‘B’ Type II, including a 75 mm levelling course for bedding purposes as required by OPSS 422.07.08.

The precast concrete box culverts after preloading or surcharging period may be designed assuming a factored geotechnical resistance of 105 kPa at ULS and 70 kPa at SLS. Following placement of the precast concrete box culvert as recommended and the estimated 2.5 m of fill above the culvert, it is estimated that the total settlements would be less than 100 mm and the differential settlement between 20 mm and 25 mm.

4.3. Option 3: Corrugated Steel Plate (CSP) Arch Culvert on NBL and SBL

Refer to the General Report for preliminary general recommendations for the use of Corrugated Steel Plate (CSP) arch culverts.

5. CULVERT BEDDING AND COVER MATERIALS

Refer to the General Report for preliminary recommendations for materials to be used for culvert bedding and cover purposes.

6. APPROACH EMBANKMENT

The details for design, construction, and mitigation procedures for the embankment through Swamp 301 were presented in the report Reference 2. This report may be consulted for placement of fill for the swamp crossing and no recommendation is provided in this report.

7. CONSTRUCTION CONSIDERATIONS

7.1. Excavation

Considering the existing ground level (EL. 181.2 to EL. 182.4 m) and the culvert invert levels (±EL. 180.6 m), 0.6 to 1.8 m deep excavations into native soils are needed for subgrade preparation and slope instability issues are not anticipated. For Option 2, some 5.0 m of cut into the embankment fill would be excavated and the stability of the temporary slope excavation should be assessed at the design-build stage.

The Contractor should consider the type of preloaded and/or surcharge material over the culvert area to facilitate excavation and disposal or reuse of the temporary fill materials.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

Preliminary recommendations for backfilling to the culvert are provided in the General Report.

7.2. Groundwater and Surface Water Control

To prevent basal heave from encountered artesian conditions, dewatering may have to be carried out from wells installed along the interior periphery of the excavation to maintain the groundwater level a minimum 0.5 m depth below the base of the excavations. Surface water flow should be directed away from the excavation areas to mitigate disturbance of the native subgrade. For construction in-the-dry, the watercourse will have to be temporarily diverted.

Refer to the General Report for further groundwater control recommendations and requirements for water taking.

MINISTRY OF TRANSPORTATION, ONTARIO

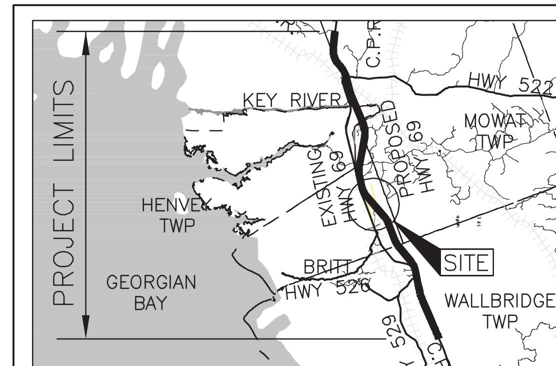
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 5404-05-01

SHEET

HIGHWAY 69
CULVERT 301 STA 13+810
BOREHOLE LOCATIONS

Golder Associates
Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN
SCALE
6 0 6 12 km

PLAN
SCALE
10 0 10 20 m

LEGEND

Borehole – Current Investigation

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
S301-03	182.4	5076355.4	223953.3
C301-S1	181.2	5076349.2	223937.5
C301-S2	181.5	5076373.2	223956.0
C301-S3	181.5	5076367.3	223942.8
C301-N1	181.2	5076376.5	223965.1
C301-N2	181.6	5076390.8	223972.2
C301-N3	181.6	5076396.4	223986.9

NOTES

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

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

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

REFERENCE

Base plans provided in digital format by URS, drawing file nos. Alignment and Contours from Hwy69_Contour-Plan_C3.dwg, received April 23, 2012.

LICENSED PROFESSIONAL ENGINEER J. M. A. COSTA Oct. 1, 2013 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER T.V. AYETAN 100130071 Oct. 1, 2013 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 41H-128

HWY. 69		PROJECT NO. 09-1111-6014	DIST.
SUBM'D. CC	CHKD. TVA	DATE: Oct. 2013	SITE: 44-626/C1&C2
DRAWN: DD/JFC	CHKD. CN	APPD. JPD/JMAC	DWG. A1

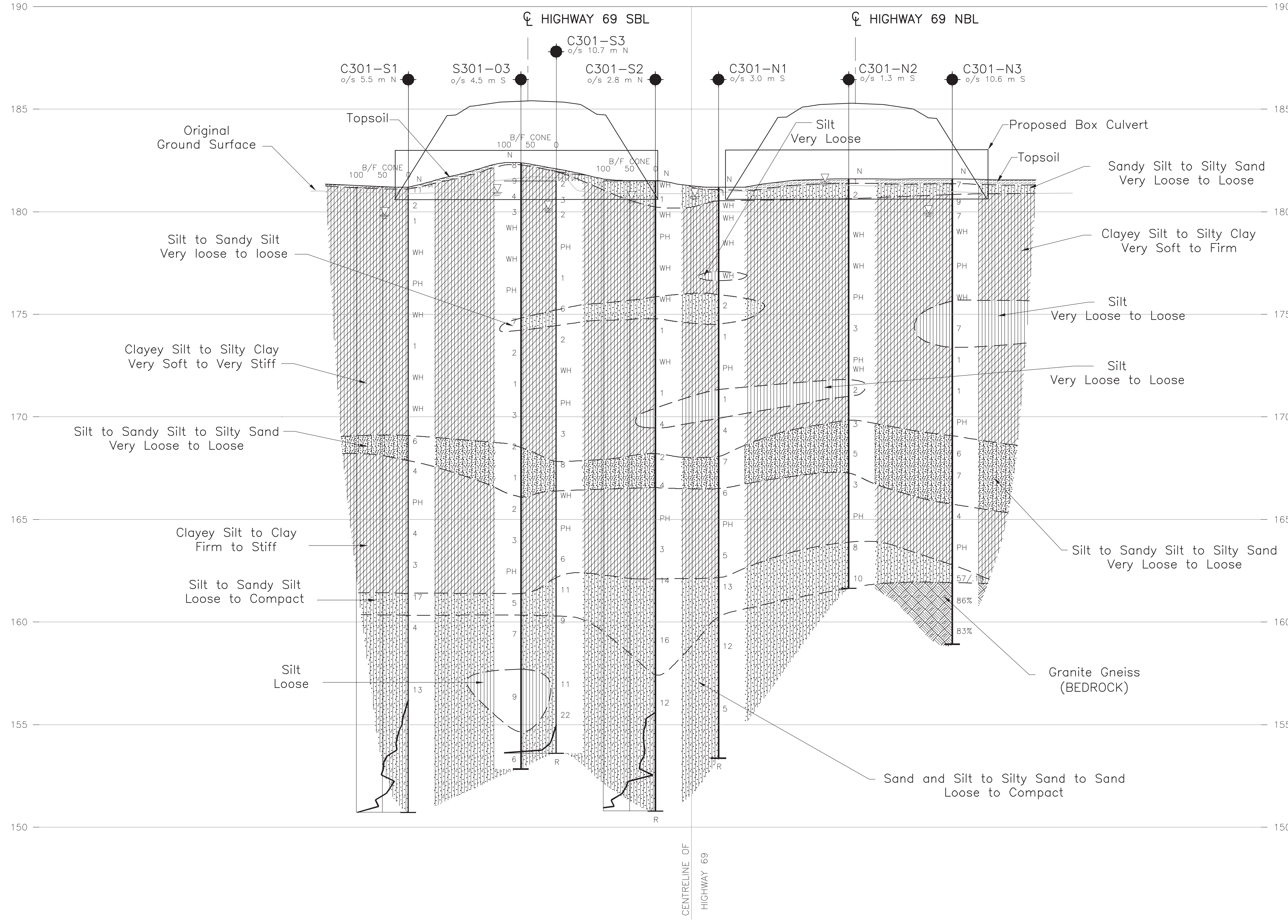
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 5404-05-01

HIGHWAY 69
CULVERT 301 13+810
SOIL STRATA

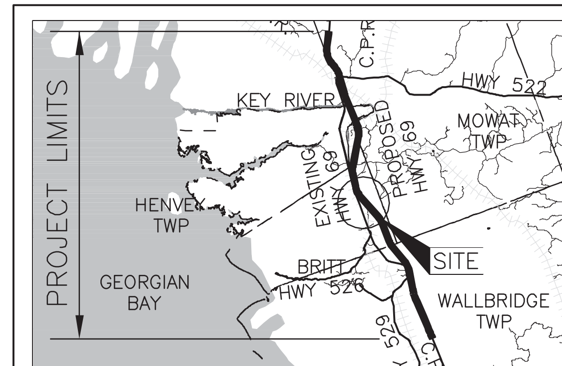
SHEET

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



(A-A' / A1) CULVERT 301 AT STA 13+810
HIGHWAY 69

HORIZONTAL SCALE 5 0 5 10 m
VERTICAL SCALE 2 0 2 4 m



KEY PLAN
SCALE 6 0 6 12 km

LEGEND

- Borehole – Current Investigation
- 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
S301-03	182.4	5076355.4	223953.3
C301-S1	181.2	5076349.2	223937.5
C301-S2	181.5	5076373.2	223956.0
C301-S3	181.5	5076367.3	223942.8
C301-N1	181.2	5076376.5	223965.1
C301-N2	181.6	5076390.8	223972.2
C301-N3	181.6	5076396.4	223986.9

NOTES

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

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

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

REFERENCE

Cross-Section drawing provided in digital format by URS for Culvert 13+810.dwg, received July 5, 2012.

LICENSED PROFESSIONAL ENGINEER J. M. A. COSTA Oct. 1, 2013 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER T.V. AYETAN 100130071 Oct. 1, 2013 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 41H-128

HWY. 69		PROJECT NO. 09-1111-6014	DIST.
SUBM'D. CC	CHKD. TVA	DATE: March 2013	SITE: 44-626/C1&C2
DRAWN: DD/JFC	CHKD. CN	APPD. JPD/JMAC	DWG. A2

PLOT DATE: October 4, 2013

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
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

Notes: 1 $\tau = c' + \sigma' \tan\phi'$
2 shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:
The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d:
The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60º 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 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive Soils

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

(b) Cohesive Soils
Consistency

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

IV. SOIL TESTS

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

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

V. MINOR SOIL CONSTITUENTS

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

October 1, 2013
Report No. 09-1111-6014-3521

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		

RECORD OF BOREHOLE No S301-03 SHEET 1 OF 3 METRIC

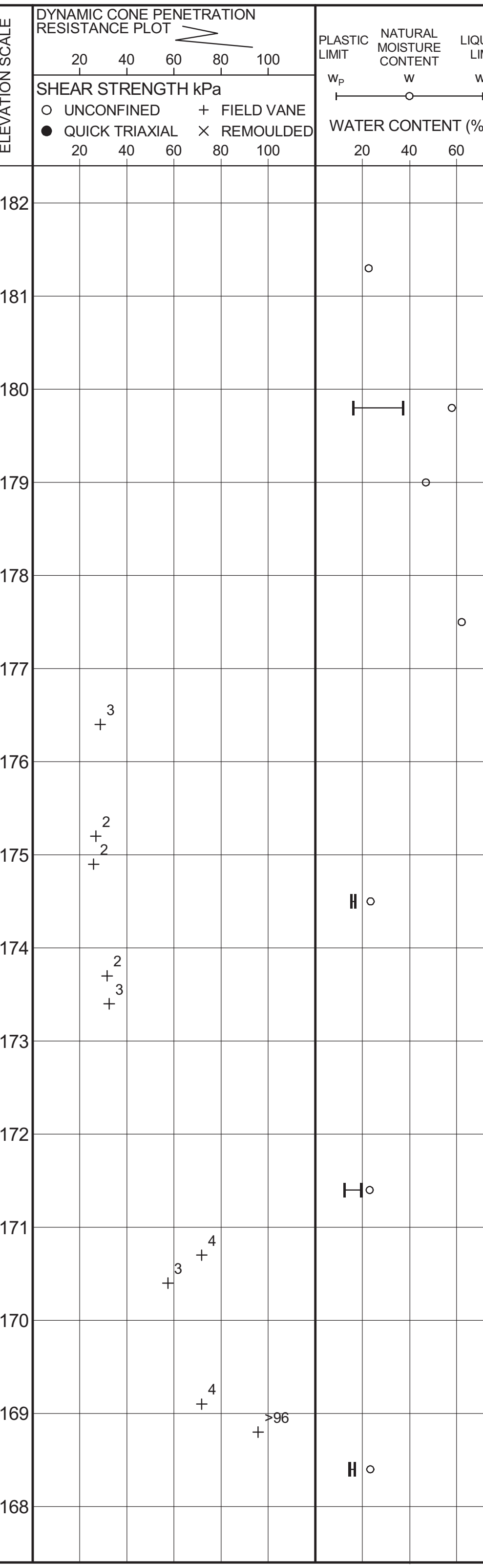
PROJECT 09-1111-6014
W.P. 5404-05-01 LOCATION N 5076355.4 ;E 223953.3 ORIGINATED BY ARM
DIST HWY 69 BOREHOLE TYPE NW Casing, Wash Boring COMPILED BY TT
DATUM Geodetic DATE February 26 and 27, 2012 CHECKED BY TZ

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
182.4	GROUND SURFACE
0.0	TOPSOIL
0.1	CLAYEY SILT, some sand, containing organics and rootlets, Firm to stiff, Brown, Moist
180.9 / 1.5	SILTY CLAY, trace sand, Soft to firm, Grey, Wet
174.8 / 7.6	SILT, some sand, trace to some clay, Loose, Grey, Wet
174.2 / 8.2	CLAYEY SILT, trace sand, Firm, Grey, Wet
170.8 / 11.6	SILTY CLAY, trace sand, Stiff, Grey, Wet
168.7 / 13.7	Sandy SILT, trace to some clay, Very loose, Grey, Wet

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	8	
2	SS	9	
3	SS	4	
4	SS	3	
5	SS	WH	
6	SS	WH	0 3 52 45
7	TO	PH	
8	SS	7	0 19 74 7
9	SS	2	
10	SS	1	
11	SS	3	
12	SS	2	0 21 73 6



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$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 03/28/13 JFC

Golder Associates

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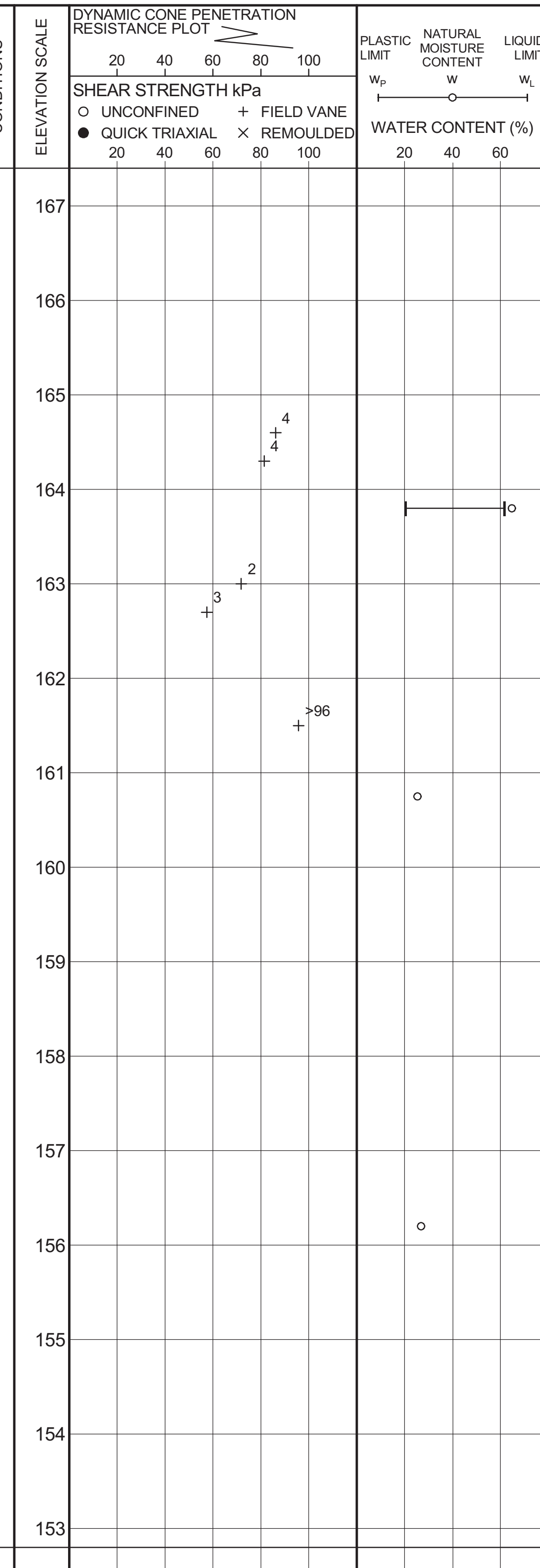
RECORD OF BOREHOLE No S301-03 SHEET 2 OF 3 METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01
LOCATION N 5076355.4 ;E 223953.3
ORIGINATED BY ARM
DIST HWY 69
BOREHOLE TYPE NW Casing, Wash Boring
COMPILED BY TT
DATUM Geodetic
DATE February 26 and 27, 2012
CHECKED BY TZ

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---				
	Sandy SILT, trace to some clay Very loose Grey Wet	13	SS	1	
166.1 16.3	CLAY Stiff Grey Wet	14	SS	2	
		15	SS	3	
		16	TO	PH	
161.4 21.0	SILT, some sand, trace clay Loose Grey Wet	17	SS	5	0 18 77 5
159.8 22.6	Silty SAND, trace gravel, trace clay Loose Grey Wet	18	SS	7	
157.7 24.7	SILT, some sand, trace clay Loose Grey Wet	19	SS	9	0 15 81 4
154.7 27.7	Silty SAND, trace gravel, trace clay Loose Grey wet	20	SS	6	
152.8 29.6	END OF BOREHOLE				



UNIT WEIGHT γ kN/m³

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

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 03/28/13 JFC

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RECORD OF BOREHOLE No S301-03 SHEET 3 OF 3 METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01
LOCATION N 5076355.4 ;E 223953.3
ORIGINATED BY ARM
DIST HWY 69
BOREHOLE TYPE NW Casing, Wash Boring
COMPILED BY TT
DATUM Geodetic
DATE February 26 and 27, 2012
CHECKED BY TZ

SOIL PROFILE — ELEV DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa | WATER CONTENT (%) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

--- CONTINUED FROM PREVIOUS PAGE ---

NOTE:

1. Water level in open borehole at a depth of 1.5 m below ground surface (Elev. 180.9 m) upon completion of drilling.

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

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 03/28/13 JFC

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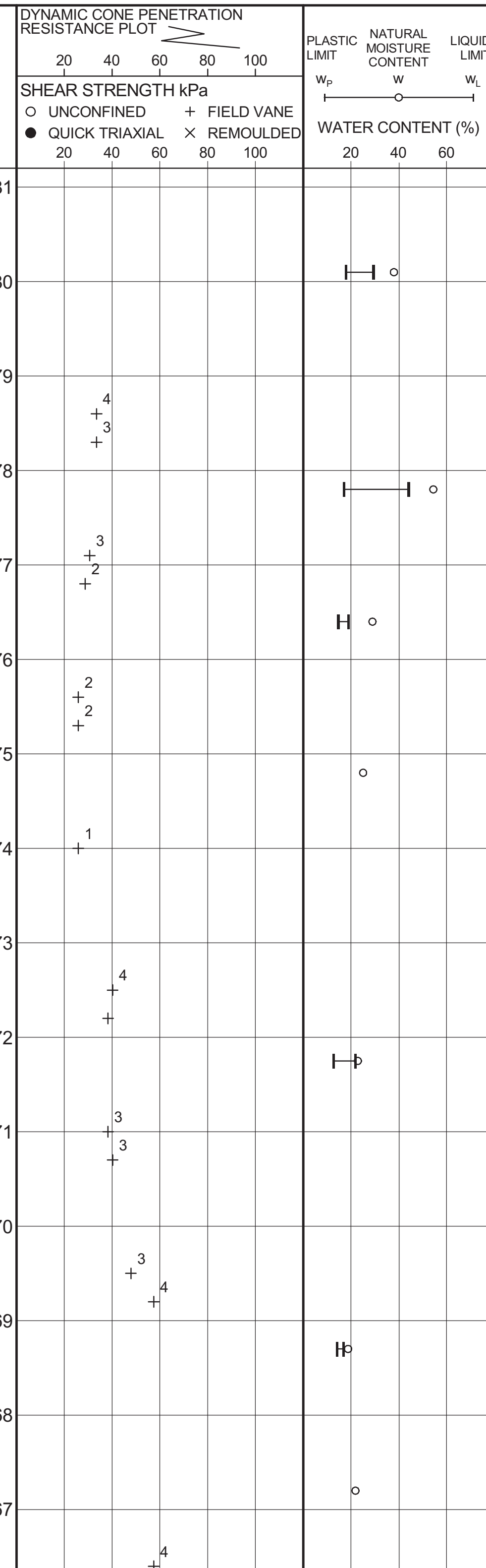
RECORD OF BOREHOLE No C301-S1 SHEET 1 OF 3 METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01 LOCATION N 5076349.2 ;E 223937.5 ORIGINATED BY ARM
DIST HWY 69 BOREHOLE TYPE NW Casing, Wash Boring COMPILED BY TT
DATUM Geodetic DATE February 10 and 14, 2012 CHECKED BY CN/TVA

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.2	GROUND SURFACE				
0.0	TOPSOIL				
0.1	Sandy CLAYEY SILT, containing organics Soft to stiff Brown to black Moist	1	SS	11	
		2	SS	2	0 26 58 16
179.7 1.5	SILTY CLAY, trace sand Firm Grey Wet	3	SS	1	
		4	SS	WH	
176.7 4.5	CLAYEY SILT, some sand Firm to stiff Grey Wet	5	TO	PH	0 15 69 16
	Silt seams at a depth of 6.4 m	6	SS	WH	
		7	SS	1	
		8	SS	WH	0 17 62 21
		9	SS	WH	
169.0 12.2	SILT, some sand, some clay Loose Grey Wet	10	SS	6	0 19 68 13
167.9 13.3	SILTY CLAY, trace sand Stiff Grey Wet	11	SS	4	



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

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 03/28/13 JFC

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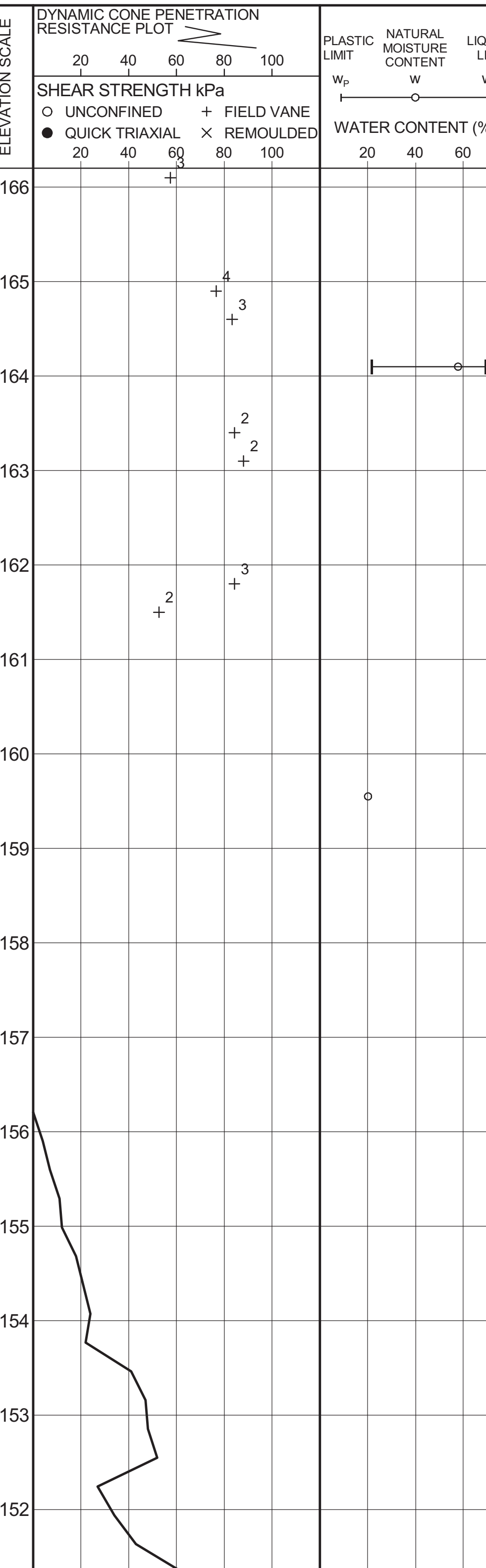
RECORD OF BOREHOLE No C301-S1 SHEET 2 OF 3 METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01 LOCATION N 5076349.2 ;E 223937.5 ORIGINATED BY ARM
DIST HWY 69 BOREHOLE TYPE NW Casing, Wash Boring COMPILED BY TT
DATUM Geodetic DATE February 10 and 14, 2012 CHECKED BY CN/TVA

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---				
	SILTY CLAY, trace sand Stiff Grey Wet	12	TO	PH	
164.9 16.3	CLAY Stiff Brown Wet	13	SS	4	
		14	SS	3	
161.4 19.8	SILT, some sand Compact Grey Wet	15	SS	17	
160.3 20.9	Silty SAND, trace clay Loose to compact Grey Wet	16	SS	4	0 67 29 4
		17	SS	13	
156.2 25.0	END OF BOREHOLE Dynamic Cone Penetration Test (DCPT)				



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

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RECORD OF BOREHOLE No C301-S1 SHEET 3 OF 3 METRIC

PROJECT 09-1111-6014 LOCATION N 5076349.2 ;E 223937.5 ORIGINATED BY ARM

W.P. 5404-05-01 BOREHOLE TYPE NW Casing, Wash Boring COMPILED BY TT

DIST HWY 69 DATE February 10 and 14, 2012 CHECKED BY CN/TVA

DATUM Geodetic

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT kN/m³	GR SA SI CL
						151		
150.7 30.5	END OF DCPT							

NOTES:

1. Artesian conditions encountered when casing advanced to a depth of 20.4 m below ground surface (Elev. 160.8 m), with the water level measured at about 0.9 m above ground surface (Elev. 182.1 m).

2. Water level in open borehole at a depth of 1.4 m below ground surface (Elev.179.8 m) upon completion of drilling.

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

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 03/28/13 JFC

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RECORD OF BOREHOLE No C301-S2 SHEET 1 OF 3 METRIC

PROJECT 09-1111-6014 LOCATION N 5076373.2 ;E 223956.0 ORIGINATED BY MR

W.P. 5404-05-01 BOREHOLE TYPE 165 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring COMPILED BY BM

DIST HWY 69 DATE March 7, 2012 CHECKED BY CN/TVA

DATUM Geodetic

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	UNIT WEIGHT kN/m³	GR SA SI CL
181.5	GROUND SURFACE					
0.0	Sandy SILT, containing organics, rootlets and wood fragments Very loose Dark brown to grey Wet	1	SS	WH		
		2	SS	1		
180.1 1.4	SILTY CLAY, trace sand Very soft to soft Grey Wet	3	SS	WH		0 2 50 48
		4	TO	PH	15.9	
177.9 3.6	CLAYEY SILT, trace sand Soft Grey Wet	5	SS	WH		
175.9 5.6	SILT, trace sand, trace clay Very loose Grey Wet	6	SS	WH		
174.8 6.7	CLAYEY SILT, trace sand Soft to firm Grey Wet	7	SS	1		
		8	SS	WH		
		9	SS	1		
170.4 11.1	SILT, some sand, some clay Loose Grey Wet	10A	SS	4		0 18 68 14
169.5 12.0	SILTY CLAY, trace to some sand Firm to stiff Grey Wet	10B				
168.2 13.3	SILT, trace sand, trace clay Very loose Grey Wet	11	SS	2		
167.5 14.0	Silty SAND, trace clay Grey Wet					
166.6		12A				

Continued Next Page

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

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 03/28/13 JFC

RECORD OF BOREHOLE No C301-S2 SHEET 2 OF 3 METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01 LOCATION N 5076373.2 ;E 223956.0 ORIGINATED BY MR
DIST HWY 69 BOREHOLE TYPE 165 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring COMPILED BY BM
DATUM Geodetic DATE March 7, 2012 CHECKED BY CN/TVA

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT / REMARKS	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
14.9	SILTY CLAY Stiff Grey Wet	12B	SS	4		
		13	TO	PH		
163.8 17.7	CLAYEY SILT, containing silt seams Stiff Brown to grey Wet	14	SS	3		
162.1 19.4	SILT, some sand, trace to some clay Compact Grey Wet	15	SS	14		1 17 71 11
		16	SS	16		
157.4 24.1	SAND, trace silt, trace gravel Compact Grey Wet	17	SS	12		1 96 3 0
155.6 25.9	END OF BOREHOLE Dynamic Cone Penetration Test (DCPT)					

Field vane readings (shear strength plot, sensitivity): 5, 3, 4, 4, 2, 2

Elevation scale: 166, 165, 164, 163, 162, 161, 160, 159, 158, 157, 156, 155, 154, 153, 152

Continued Next Page

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

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RECORD OF BOREHOLE No C301-S2 SHEET 3 OF 3 METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01 LOCATION N 5076373.2 ;E 223956.0 ORIGINATED BY MR
DIST HWY 69 BOREHOLE TYPE 165 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring COMPILED BY BM
DATUM Geodetic DATE March 7, 2012 CHECKED BY CN/TVA

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION
150.8 30.7	END OF DCPT Refusal to Further Penetration

Elevation scale: 151 (DCPT blow count 144)

NOTES:

1. Vane tests carried out on Sample No. 4 are laboratory shear vanes performed on shelby tube sample.

2. Artesian conditions encountered when advanced casing to a depth of 11.7 m below ground surface (Elev. 169.8 m), with the water level measured at about 0.8 m above ground surface (Elev. 182.3 m).

3. Water level in open borehole at a depth of 0.9 m below ground surface (Elev. 180.6 m) upon completion of drilling.

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

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RECORD OF BOREHOLE No C301-S3 SHEET 1 OF 3 METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01
LOCATION N 5076367.3 ;E 223942.8
ORIGINATED BY ARM
DIST HWY 69
BOREHOLE TYPE NW Casing, Wash Boring
COMPILED BY TT
DATUM Geodetic
DATE February 8 and 9, 2012
CHECKED BY CN/TVA

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.5	GROUND SURFACE				
0.0 / 0.1	TOPSOIL				
	CLAYEY SILT, some sand, trace gravel, containing organics, Soft, Brown, Moist	1	SS	2	
		2	SS	3	
180.0 / 1.5	SILTY CLAY, trace sand, Firm, Brown becoming grey at a depth of 3.4 m, Wet	3	SS	2	
		4	TO	PH	
177.4 / 4.1	CLAYEY SILT, trace sand, Firm, Grey, Wet	5	SS	1	
175.1 / 6.4	SILT, some sand, trace to some clay, Loose, Grey, Wet	6A / 6B	SS	6	0 20 71 9 Non-Plastic
174.3 / 7.2	CLAYEY SILT, trace sand, Firm to stiff, Grey, Wet	7	SS	2	
		8	SS	WH	
		9	TO	PH	
		10	SS	3	
167.8 / 13.7	SILT, trace to some clay, Loose, Grey, Wet	11	SS	8	

Continued Next Page

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

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 03/28/13 JFC

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RECORD OF BOREHOLE No C301-S3 SHEET 2 OF 3 METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01
LOCATION N 5076367.3 ;E 223942.8
ORIGINATED BY ARM
DIST HWY 69
BOREHOLE TYPE NW Casing, Wash Boring
COMPILED BY TT
DATUM Geodetic
DATE February 8 and 9, 2012
CHECKED BY CN/TVA

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
166.4 / 15.1	SILTY CLAY, trace sand, Stiff, Grey, Wet	12	SS	WH	
		13	TO	PH	
		14	SS	6	
162.1 / 19.4	Sandy SILT, trace to some clay, Compact, Grey, Wet	15	SS	11	0 28 66 6 Non-Plastic
160.6 / 20.9	SAND, trace silt, trace gravel, Loose, Grey, Wet	16	SS	9	
158.3 / 23.2	SAND and SILT, trace to some clay, Compact, Grey, Wet	17	SS	11	0 42 49 9
		18	SS	22	
155.0 / 26.5	END OF BOREHOLE Dynamic Cone Penetration Test (DCPT)				
153.6 / 27.9	END OF DCPT Refusal to Further Penetration (105 Blows / 0.15 m)				

Continued Next Page

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

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 03/28/13 JFC

RECORD OF BOREHOLE No C301-S3 SHEET 3 OF 3 METRIC

PROJECT 09-1111-6014

W.P. 5404-05-01 LOCATION N 5076367.3 ;E 223942.8 ORIGINATED BY ARM

DIST HWY 69 BOREHOLE TYPE NW Casing, Wash Boring COMPILED BY TT

DATUM Geodetic DATE February 8 and 9, 2012 CHECKED BY CN/TVA

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

--- CONTINUED FROM PREVIOUS PAGE ---

NOTES:

1. Artesian conditions encountered when casing advanced to a depth of 21.3 m below ground surface (Elev. 160.2 m), with the water level measured at about 1.1 m above ground surface (Elev. 182.6 m).

2. Water level in open borehole at a depth of 1.4 m below ground surface (Elev. 180.1 m) upon completion of drilling.

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

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 03/28/13 JFC

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RECORD OF BOREHOLE No C301-N1 SHEET 1 OF 3 METRIC

PROJECT 09-1111-6014

W.P. 5404-05-01 LOCATION N 5076376.5 ;E 223965.1 ORIGINATED BY MR

DIST HWY 69 BOREHOLE TYPE 165 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring COMPILED BY BM

DATUM Geodetic DATE March 5 and 6, 2012 CHECKED BY CN/TVA

ELEV / DEPTH	DESCRIPTION
181.2	GROUND SURFACE
0.0	TOPSOIL
0.1	Silty SAND, containing organics, wood fragments and roots; Very loose; Dark brown; Moist
180.5 / 0.7	SILTY CLAY, trace sand; Firm; Grey; Wet
177.1 / 4.1	SILT, trace to some sand, trace clay; Very loose; Grey; Wet
176.6 / 4.6	CLAYEY SILT, trace to some sand; Firm; Grey; Wet
176.0 / 5.2	Sandy SILT, trace to some clay; Very loose; Grey; Wet
174.5 / 6.7	CLAYEY SILT, trace to some sand; Firm; Grey; Wet
171.3 / 9.9	SILT, some sand, trace to some clay; Very loose; Grey; Wet
169.9 / 11.3	CLAYEY SILT, trace to some sand, containing sandy silt seams; Firm; Grey; Wet
168.1 / 13.1	Sandy SILT, some clay; Loose; Grey; Wet
166.3	

NUMBER	TYPE	"N" VALUES	GR SA SI CL
1	SS	1	
2	SS	WH	
3	SS	WH	
4	SS	WH	
5A / 5B	SS	WH	
6	SS	2	0 21 72 7
7	SS	1	
8	TO	PH	
9	SS	1	0 19 74 7
10	SS	4	
11	SS	7	0 20 66 14
12A			

Elevation scale: 181, 180, 179, 178, 177, 176, 175, 174, 173, 172, 171, 170, 169, 168, 167

Field vane sensitivities: 6; 7, 5; 4; 6, 5; 5, 5; 6, 5

Continued Next Page

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

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RECORD OF BOREHOLE No C301-N1 SHEET 2 OF 3 METRIC

PROJECT 09-1111-6014 | W.P. 5404-05-01 | LOCATION N 5076376.5 ;E 223965.1 | ORIGINATED BY MR
DIST | HWY 69 | BOREHOLE TYPE 165 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring | COMPILED BY BM
DATUM Geodetic | DATE March 5 and 6, 2012 | CHECKED BY CN/TVA

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
14.9	CLAY Stiff Brown to grey Moist	12B	SS	6	
		13	TO	PH	
163.8 17.4	CLAYEY SILT, containing silt seams stiff Brown to grey Wet	14	SS	5	
162.1 19.1	Sandy SILT Compact Grey Wet	15	SS	13	
160.0 21.2	SAND, trace silt Loose to compact Grey Wet	16	SS	12	
		17	SS	5	0 98 2 0
		18	SS	50/0.0	
153.4 27.8	END OF BOREHOLE SPOON AND CASING REFUSAL				

Elevation scale: 166, 165, 164, 163, 162, 161, 160, 159, 158, 157, 156, 155, 154

Field vane sensitivity labels: 5, 5, 5, 5, 3, 2

Continued Next Page

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

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 03/28/13 JFC

Foundation Design

Golder Associates

RECORD OF BOREHOLE No C301-N1 SHEET 3 OF 3 METRIC

PROJECT 09-1111-6014 | W.P. 5404-05-01 | LOCATION N 5076376.5 ;E 223965.1 | ORIGINATED BY MR
DIST | HWY 69 | BOREHOLE TYPE 165 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring | COMPILED BY BM
DATUM Geodetic | DATE March 5 and 6, 2012 | CHECKED BY CN/TVA

--- CONTINUED FROM PREVIOUS PAGE ---

NOTES:

1. Water level in casing at a depth of 1.5 m below ground surface (Elev. 179.7 m) at 5:30 pm on March 5, 2012, when casing advanced to a depth of 19.4 m (Elev. 161.8 m).

2. Artesian conditons observed in casing with water level at 0.7 m above ground surface (Elev. 181.9 m) at 7:30 am on March 6, 2012.

3. Sand blow back encountered when advanced casing to a depth of 23.8 m below ground surface (Elev. 157.4 m).

4. Water level in open borehole at a depth of 0.5 m below ground surface (Elev. 180.7 m) upon completion of drilling.

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

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 03/28/13 JFC

Golder Associates

Foundation Design

RECORD OF BOREHOLE No C301-N2 SHEET 1 OF 2 METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01
LOCATION N 5076390.8 ;E 223972.2
ORIGINATED BY MR
DIST HWY 69
BOREHOLE TYPE 165 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring
COMPILED BY MAS
DATUM Geodetic
DATE March 9, 2012
CHECKED BY CN/TVA

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.6	GROUND SURFACE					
0.0	TOPSOIL	1A	SS	1	∇	
	Sandy SILT, trace clay, containing organics and rootlets, Very loose, Grey	1B				
181.0 / 0.6	SAND and SILT, some clay, Very loose, Brown to grey, Wet	2A / 2B	SS	2		0 51 35 14
180.5 / 1.1	SILTY CLAY, containing silt seams, Soft, Grey, Wet					
179.3 / 2.3	CLAYEY SILT, trace sand, Soft to firm, Grey, Wet	3	SS	WH		
		4	SS	WH		0 5 70 25
		5	TO	PH		
		6	SS	3		
		7	TO	PH		
		8	SS	WH		
171.8 / 9.8	SILT, trace sand, trace clay, Very loose, Grey, Wet	9A	SS	2		
171.1 / 10.5	SILTY CLAY, containing silt and sand seams, Firm, Grey, Wet	9B				
169.8 / 11.8	SILT, some sand, some clay, Very loose to loose, Grey, Wet	10	SS	3		0 18 62 20
		11	SS	5		
167.3 / 14.3						

Continued Next Page

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

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

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 03/28/13 JFC

Golder Associates

Foundation Design

RECORD OF BOREHOLE No C301-N2 SHEET 2 OF 2 METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01
LOCATION N 5076390.8 ;E 223972.2
ORIGINATED BY MR
DIST HWY 69
BOREHOLE TYPE 165 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring
COMPILED BY MAS
DATUM Geodetic
DATE March 9, 2012
CHECKED BY CN/TVA

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILTY CLAY, containing silt seams, Stiff, Grey, Wet	12	SS	3	
		13	TO	PH	
163.9 / 17.7	Sandy SILT, trace to some clay, containing sand seams, Loose to compact, Grey, Wet	14	SS	8	
		15	SS	10	0 27 63 10
161.6 / 20.0	END OF BOREHOLE				

NOTE:

1. Water level in open borehole at a depth of 0.2 m below ground surface (Elev. 181.4 m) upon completion of drilling.

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

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 03/28/13 JFC

Golder Associates — Foundation Design

RECORD OF BOREHOLE No C301-N3 — SHEET 1 OF 2 — METRIC

PROJECT 09-1111-6014			
W.P. 5404-05-01	LOCATION N 5076396.4 ;E 223986.9		ORIGINATED BY MR
DIST	HWY 69	BOREHOLE TYPE 165 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring	COMPILED BY MAS
DATUM Geodetic	DATE March 10, 2012		CHECKED BY CN/TVA

SOIL PROFILE

ELEV DEPTH	DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.6	GROUND SURFACE					
0.0	TOPSOIL					
0.2	Silty SAND, containing organics and roots, Loose	1A				
180.8 / 0.8	Brown, Moist	1B	SS	7		
	CLAYEY SILT, trace sand, containing sand seams, Firm, Grey, Wet	2	SS	9		0 2 76 22
					∇ (Elev. 179.9)	
		3	SS	7		
		4	SS	WH		
		5	TO	PH		
175.8 / 5.8	SILT, trace to some sand, trace clay, Very loose to loose, Grey, Wet	6A / 6B	SS	WH		
		7	SS	7		
173.4 / 8.2	CLAYEY SILT, containing silt seams, Firm, Grey, Wet	8	SS	1		
		9	SS	1		
		10	TO	PH		
169.1 / 12.5	SILT, some sand, trace clay, Loose, Grey, Wet	11	SS	6		
167.3 / 14.3	Sandy SILT, trace clay, Loose, Grey, Wet	12	SS	7		

Continued Next Page

Column headings: STRAT PLOT; ELEVATION SCALE (181 to 167); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED, 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³.

Field vane sensitivity labels: 4, 5 (≈178 m); 5, 4 (≈176.5 m); 5, 5 (≈171.7 m); 4, 4 (≈170.2 m).

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

Golder Associates — Foundation Design

RECORD OF BOREHOLE No C301-N3 — SHEET 2 OF 2 — METRIC

PROJECT 09-1111-6014			
W.P. 5404-05-01	LOCATION N 5076396.4 ;E 223986.9		ORIGINATED BY MR
DIST	HWY 69	BOREHOLE TYPE 165 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring	COMPILED BY MAS
DATUM Geodetic	DATE March 10, 2012		CHECKED BY CN/TVA

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Sandy SILT, trace clay, Loose, Grey, Wet				
165.7 / 15.9	CLAY, Stiff, Grey, Wet	13	SS	4	
		14	TO	PH	
162.9 / 18.7	Sandy SILT, trace to some clay, Compact, Grey, Wet	15	SS	57/.18	0 23 67 10
161.9 / 19.7	Granite Gneiss (BEDROCK) Bedrock cored from depths of 19.7 m to 22.7 m. For bedrock coring details, refer to Record of Drillhole C301-N3	1	RC	REC 98%	RQD = 86%
		2	RC	REC 100%	RQD = 83%
158.9 / 22.7	END OF BOREHOLE				

NOTE:

1. Water level in open borehole at a depth of 1.7 m below ground surface (Elev. 179.9 m) upon completion of drilling.

Field vane sensitivity labels: 5, 5 (≈164 m).

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

PROJECT: 03-1112-001 T-6000

RECORD OF DRILLHOLE: C301-N3

SHEET 1 OF 1

LOCATION: N 5076396.4 ;E 223986.9

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D25 Track Mount

DRILLING CONTRACTOR: WALKER DRILLING

JN - Joint, FLT - Fault, SH - Shear, VN - Vein, CJ - Conjugate, BD - Bedding, FO - Foliation, CO - Contact, OR - Orthogonal, CL - Cleavage, PL - Planar, CU - Curved, UN - Undulating, ST - Stepped, IR - Irregular, PO - Polished, K - Slickensided, SM - Smooth, RO - Rough, VR - Very Rough, MB - Mechanical Break, BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	COLOUR / % RETURN / FLUSH	RECOVERY: TOTAL CORE % (80 60 40 20)	RECOVERY: SOLID CORE % (80 60 40 20)	R.Q.D. % (80 60 40 20)	FRACT. INDEX PER 0.3 m (5 10 15 20)	DISCONTINUITY DATA: B Angle (0 90 180 270)	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS (0 30 60 90)	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-6} 10^{-5} 10^{-4} 10^{-3})	Diametral Point Load Index (MPa) (2 4 6)	RMC -Q' AVG.	NOTES
		Continued from Record of Borehole C301-N3		161.91																
20, 21, 22	NW Casing; NQRC; March 10, 2012	GRANITE GNEISS Fresh, foliated, medium crystalline, slightly porous, strong, grey, pink and black		19.69	1											3				
					2											2				
		END OF DRILLHOLE		158.92 22.68																
23, 24, 25, 26, 27, 28, 29																				

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MR

CHECKED: MAS/TVA

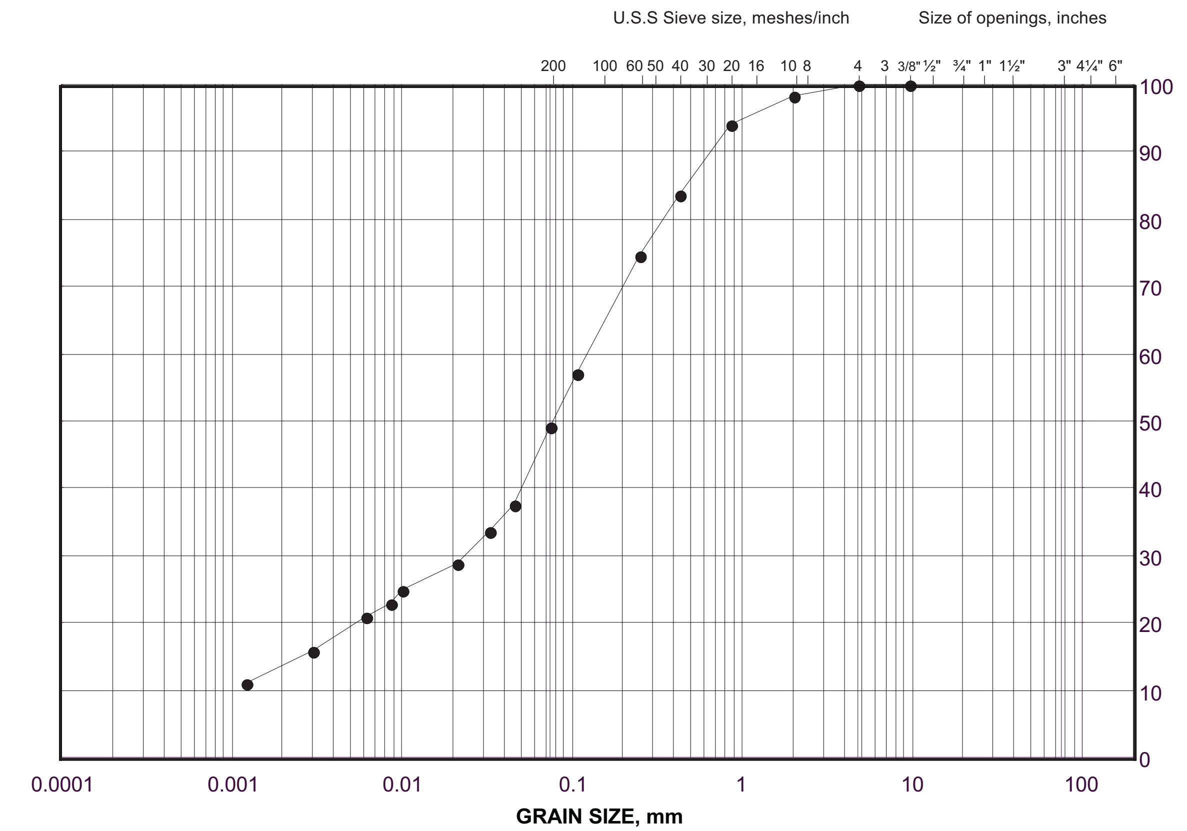
GTA-RCK 018 09-1111-6014.GPJ GAL-MISS.GDT 03/27/13 JFC

GRAIN SIZE DISTRIBUTION

Sand and Silt

Highway 69 (SBL and NBL) Culvert C301

FIGURE A.C301-01A



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

LEGEND

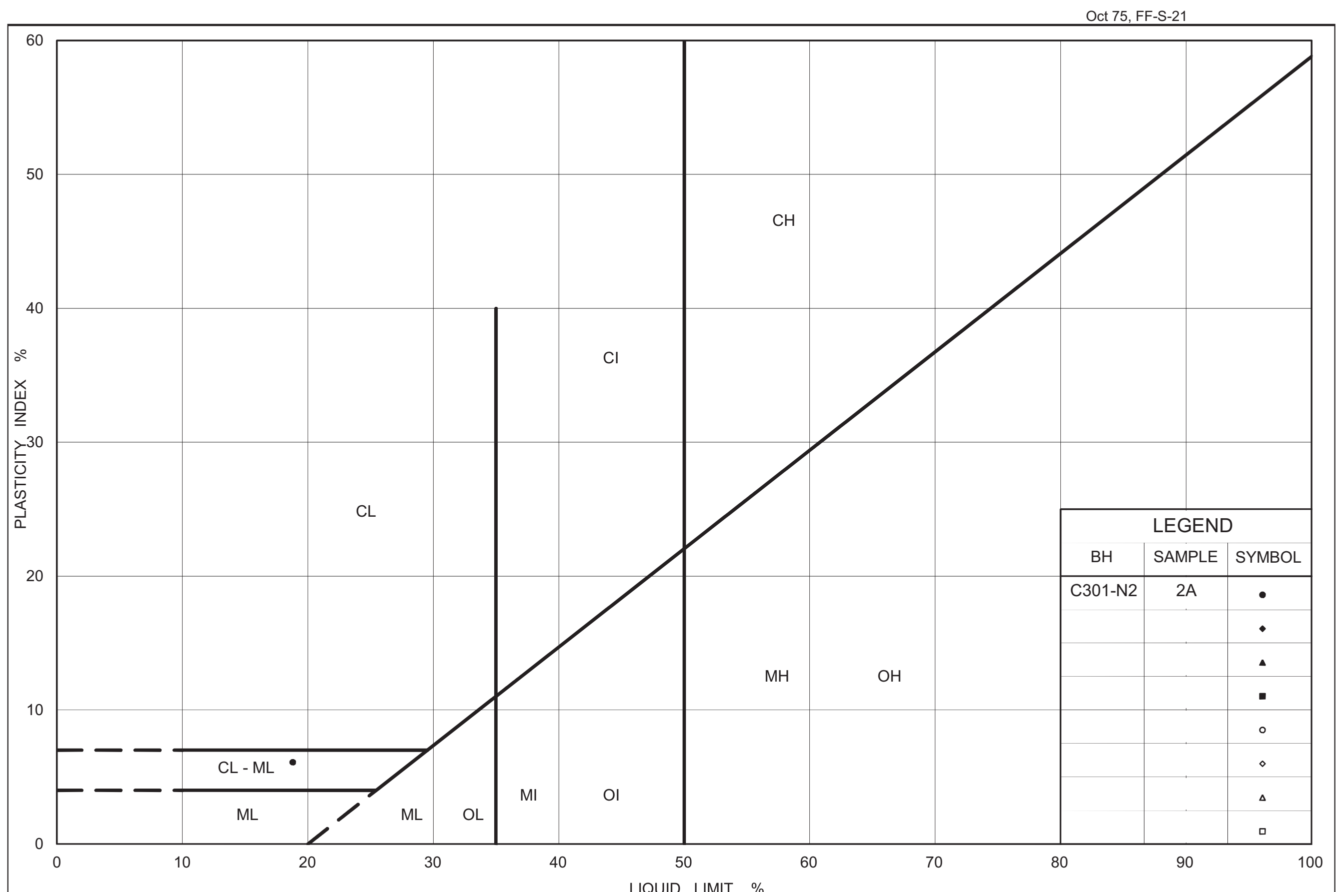
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C301-N2	2A	180.7

Project Number: 09-1111-6014

Checked By: TVA

Golder Associates

Date: 15-Feb-13



LEGEND

BH	SAMPLE	SYMBOL
C301-N2	2A	●

Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt to Silt of Slight Plasticity (Sand and Silt)
Highway 69 (SBL and NBL) Culvert C301

Figure No. A.C301-01B

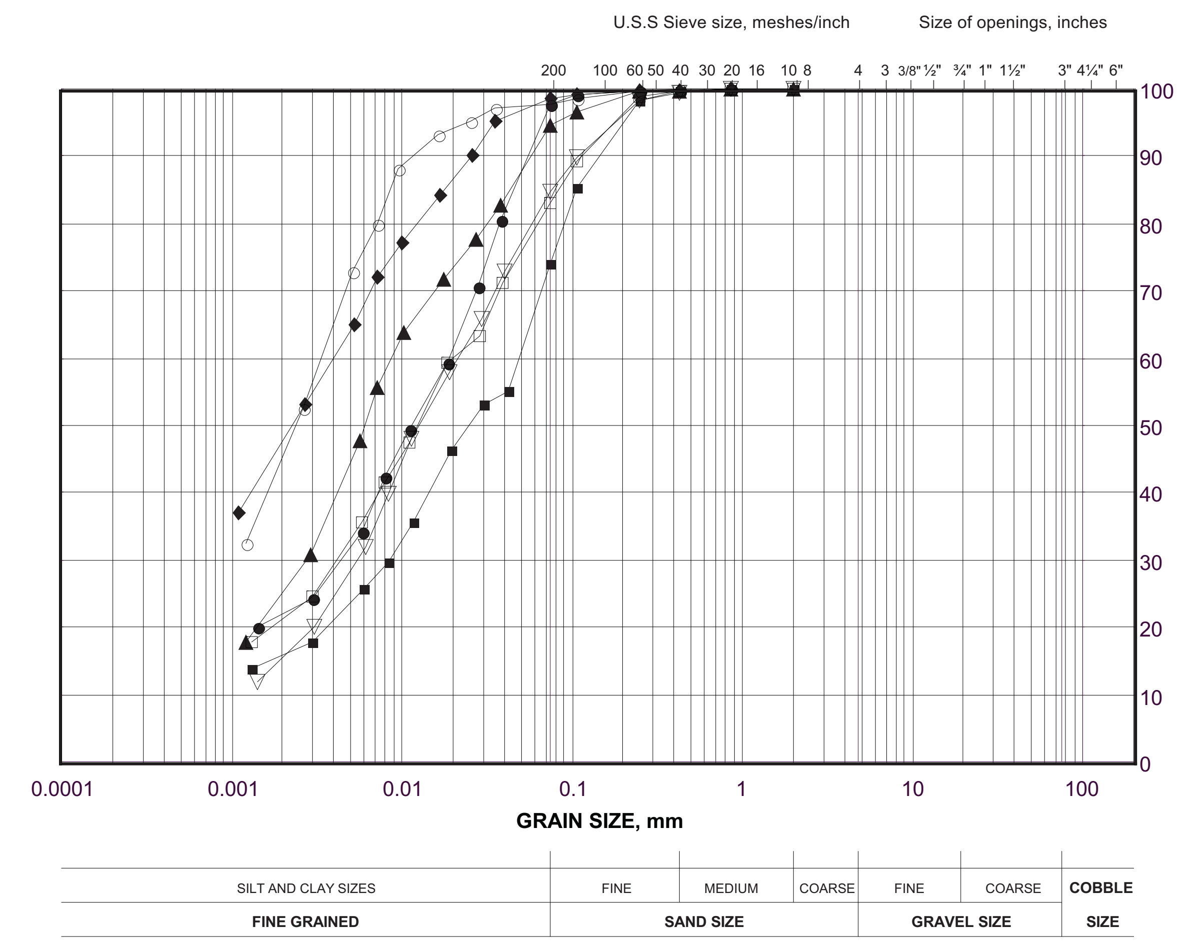
Project No. 09-1111-6014

Checked By: TVA

GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay (Upper Deposit)
Highway 69 (SBL and NBL) Culvert C301

FIGURE A.C301-02A



LEGEND

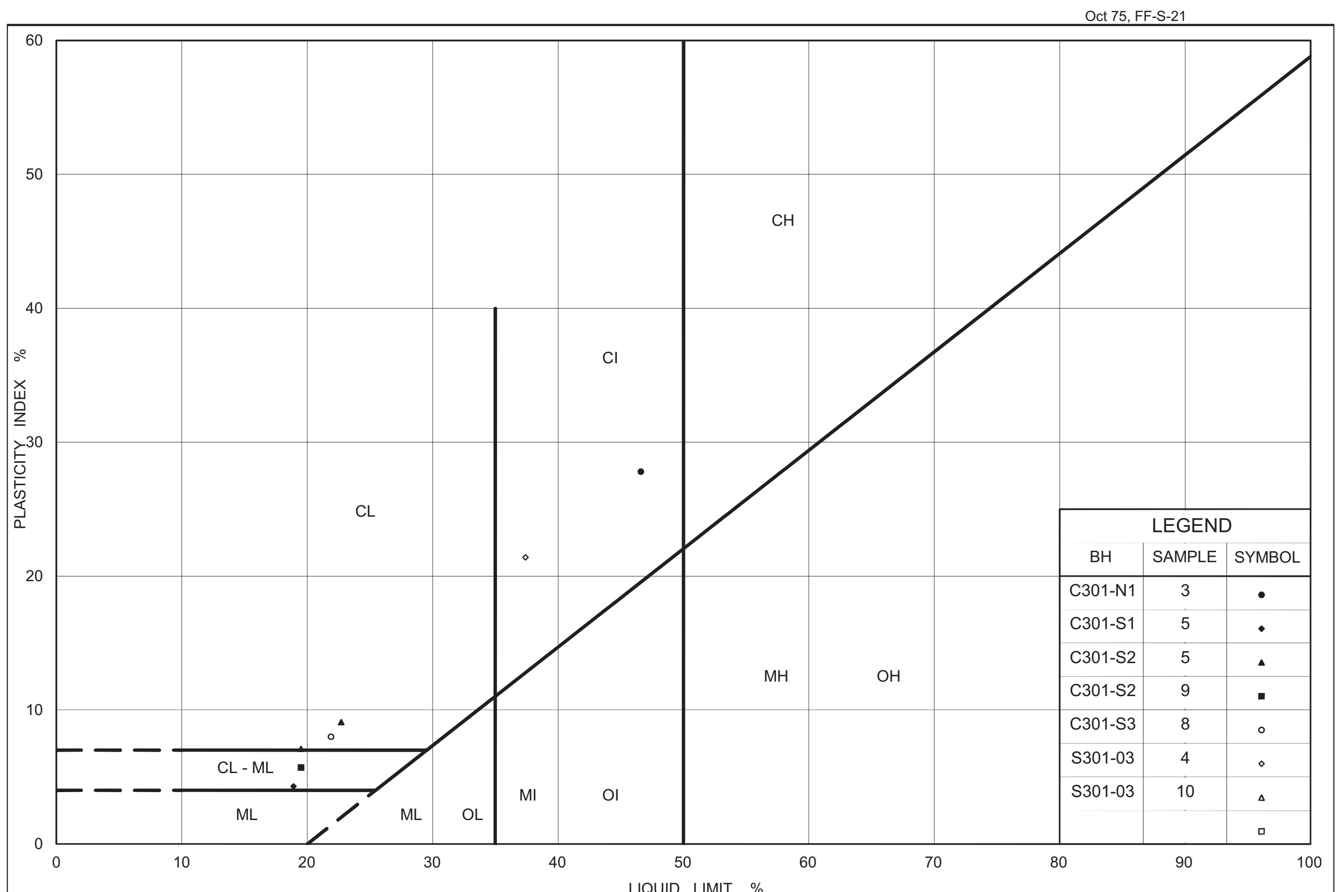
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C301-N3	2	180.4
■	C301-S1	2	180.1
◆	C301-S2	3	179.7
▲	C301-N2	4	177.2
▽	C301-S1	5	176.4
❍	S301-03	6	177.5
□	C301-S1	8	171.8

Project Number: 09-1111-6014

Checked By: TVA

Golder Associates

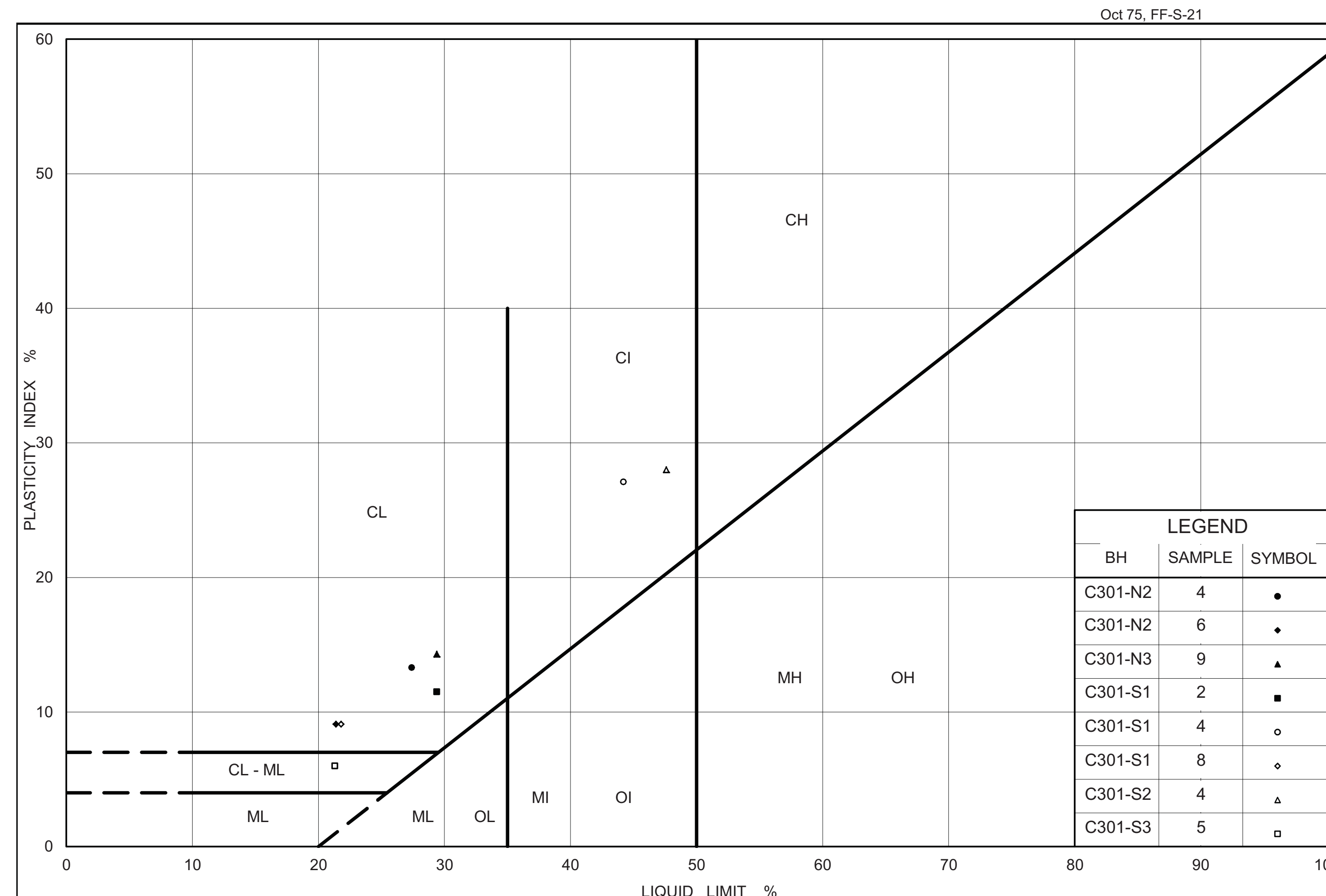
Date: 15-Feb-13



LEGEND

BH	SAMPLE	SYMBOL
C301-N1	3	●
C301-S1	5	◆
C301-S2	5	▲
C301-S2	9	■
C301-S3	8	○
S301-03	4	◇
S301-03	10	△
		□

Ministry of Transportation Ontario	PLASTICITY CHART Clayey Silt to Silty Clay (Upper Deposit) Highway 69 (SBL and NBL) Culvert C301	Figure No. A.C301-02B-1 Project No. 09-1111-6014 Checked By: TVA



LEGEND

BH	SAMPLE	SYMBOL
C301-N2	4	●
C301-N2	6	◆
C301-N3	9	▲
C301-S1	2	■
C301-S1	4	○
C301-S1	8	◇
C301-S2	4	△
C301-S3	5	□

Ministry of Transportation Ontario	PLASTICITY CHART Clayey Silt to Silty Clay (Upper Deposit) Highway 69 (SBL and NBL) Culvert C301	Figure No. A.C301-02B-2 Project No. 09-1111-6014 Checked By: TVA

CONSOLIDATION TEST SUMMARY Highway 69 (SBL and NBL) Culvert C301	**FIGURE A.C301-03** Sheet 1 of 4

SAMPLE IDENTIFICATION

Project Number	09-1111-6014	Sample Number	4
Borehole Number	C301-S2	Sample Depth, m	2.8

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	3		
Date Started	9/28/2012		
Date Completed	10/27/2012		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.54	Unit Weight, kN/m^3	15.92
Sample Diameter, cm	6.32	Dry Unit Weight, kN/m^3	9.70
Area, cm^2	31.40	Specific Gravity, measured	2.77
Volume, cm^3	79.76	Solids Height, cm	0.907
Water Content, %	64.22	Volume of Solids, cm^3	28.47
Wet Mass, g	129.50	Volume of Voids, cm^3	51.29
Dry Mass, g	78.86	Degree of Saturation, %	98.7

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	2.540	1.802	2.540				
5.92	2.535	1.796	2.538	7	1.95E-01	3.26E-04	6.23E-06
10.82	2.530	1.790	2.532	184	7.39E-03	4.26E-04	3.08E-07
20.63	2.523	1.782	2.526	487	2.78E-03	2.85E-04	7.76E-08
40.20	2.503	1.761	2.513	190	7.05E-03	3.88E-04	2.68E-07
20.84	2.508	1.766	2.506				
10.77	2.512	1.771	2.510				
20.61	2.508	1.766	2.510	90	1.48E-02	1.80E-04	2.62E-07
40.15	2.501	1.759	2.505	118	1.13E-02	1.27E-04	1.40E-07
79.27	2.470	1.724	2.485	240	5.46E-03	3.21E-04	1.72E-07
157.20	2.324	1.563	2.397	2940	4.14E-04	7.38E-04	2.99E-08
312.87	1.983	1.187	2.153	2160	4.55E-04	8.61E-04	3.84E-08
624.49	1.777	0.960	1.880	1033	7.25E-04	2.60E-04	1.85E-08
1248.90	1.625	0.792	1.701	595	1.03E-03	9.60E-05	9.70E-09
2494.56	1.501	0.655	1.563	454	1.14E-03	3.92E-05	4.38E-09
1248.90	1.507	0.662	1.504				
312.87	1.550	0.710	1.529				
79.27	1.606	0.771	1.578				
20.63	1.664	0.835	1.635				
5.92	1.693	0.868	1.679				

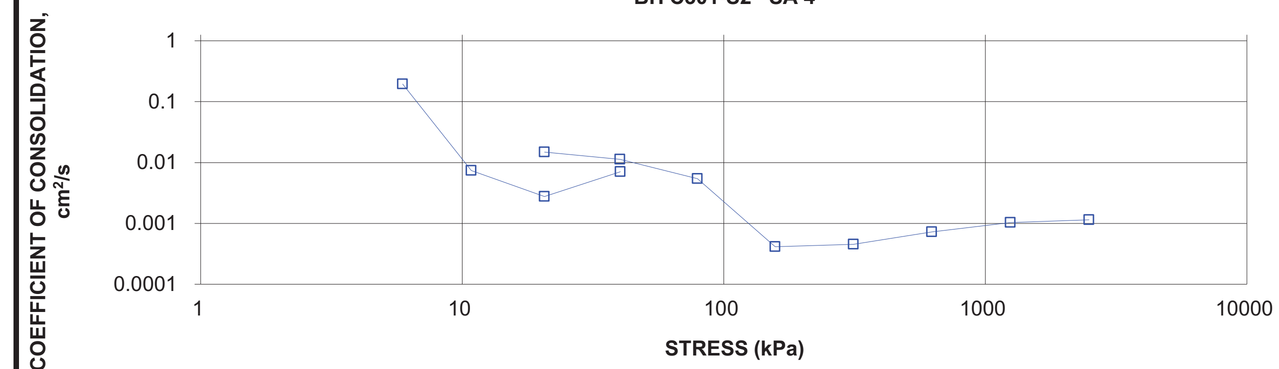
Note:
k calculated using cv based on t_{90} values.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

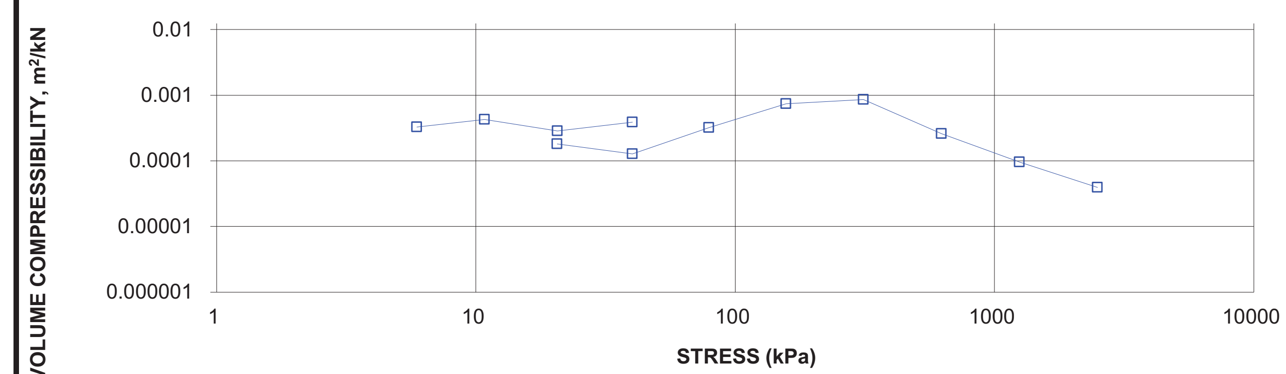
Sample Height, cm	1.69	Unit Weight, kN/m^3	19.43
Sample Diameter, cm	6.32	Dry Unit Weight, kN/m^3	14.54
Area, cm^2	31.40	Specific Gravity, measured	2.77
Volume, cm^3	53.17	Solids Height, cm	0.907
Water Content, %	33.60	Volume of Solids, cm ^{3}	28.47
Wet Mass, g	105.36	Volume of Voids, cm ^{3}	24.70
Dry Mass, g	78.86		

CONSOLIDATION TEST SUMMARY Highway 69 (SBL and NBL) Culvert C301	**FIGURE A.C301-03** Sheet 2 of 4

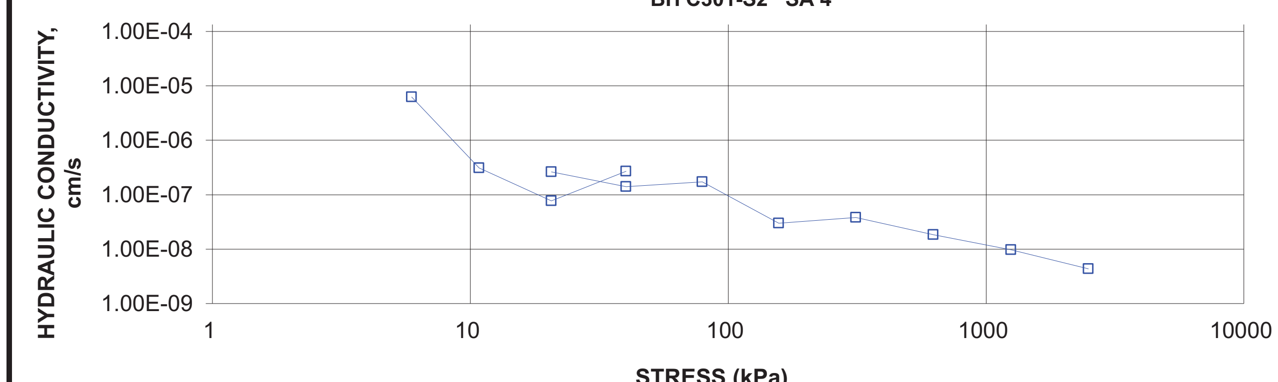
CONSOLIDATION TEST
CV cm²/s VS STRESS (kPa)
BH C301-S2 SA 4



CONSOLIDATION TEST
MV m²/kN vs STRESS (kPa)
BH C301-S2 SA 4



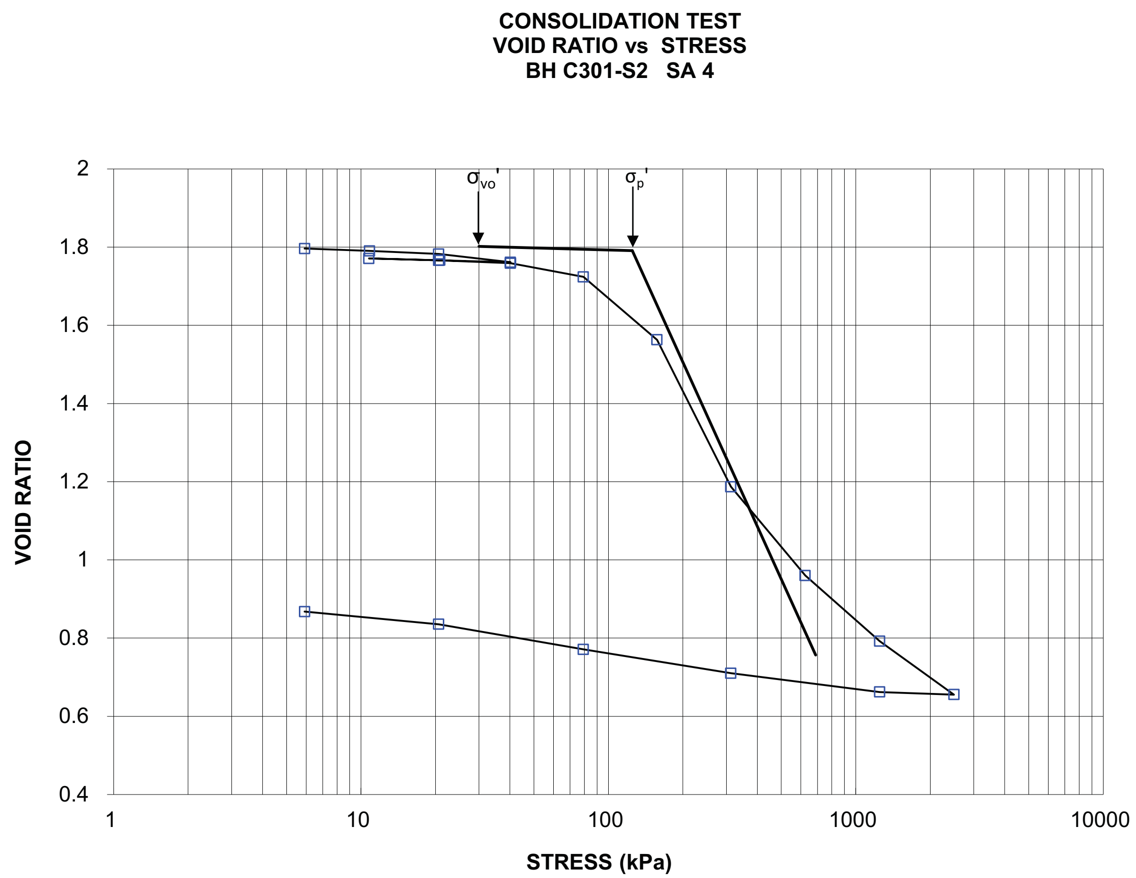
CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs STRESS
BH C301-S2 SA 4



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

Golder Associates

Checked By: TVA



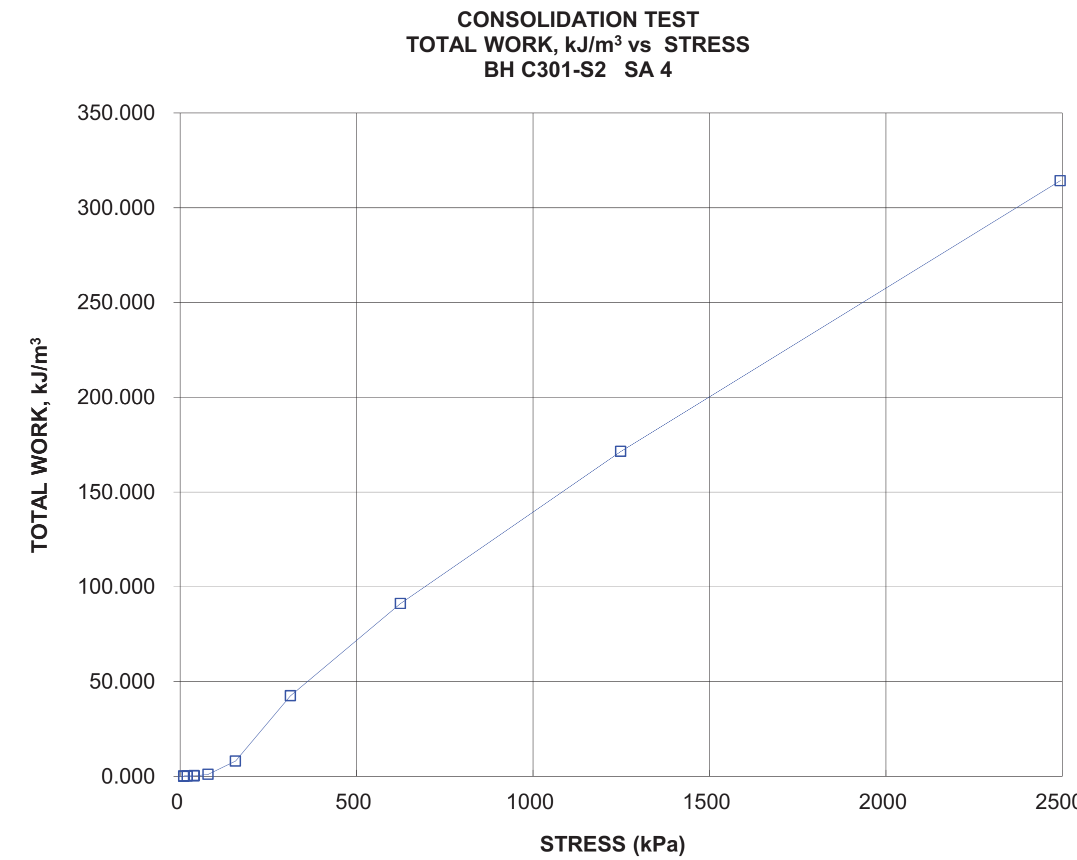
CONSOLIDATION TEST
VOID RATIO VS LOG STRESS

FIGURE A.C301-03
Sheet 3 of 4

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

Golder Associates

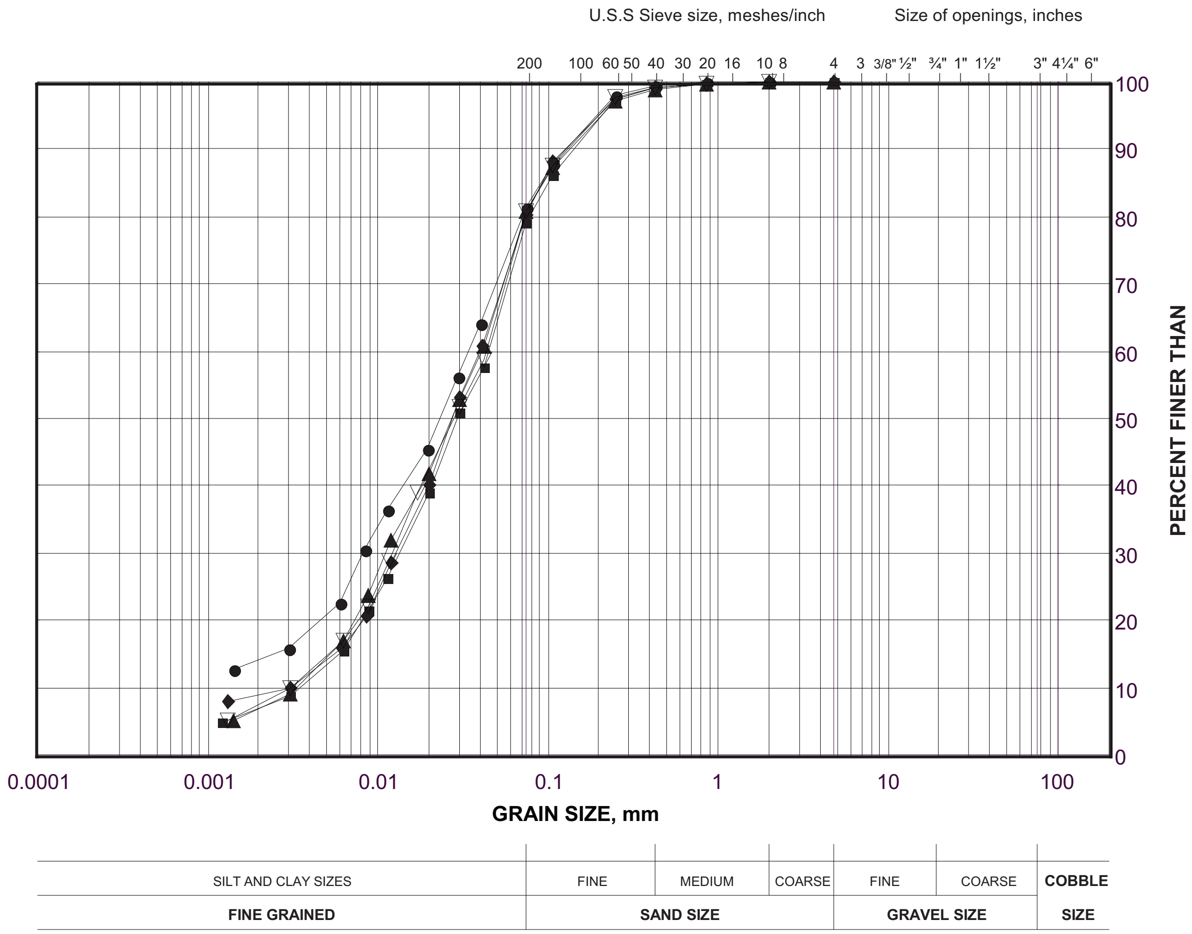
Checked By: TVA



CONSOLIDATION TEST
TOTAL WORK VS STRESS

FIGURE A.C301-03
Sheet 4 of 4

GRAIN SIZE DISTRIBUTION Silt to Sandy Silt (Pockets) Highway 69 (SBL and NBL) Culvert C301	FIGURE A.C301-04



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C301-S2	10A	169.7
■	C301-N1	6	175.3
◆	C301-S3	6B	175.0
▲	S301-03	8	174.5
▽	C301-N1	9	170.7

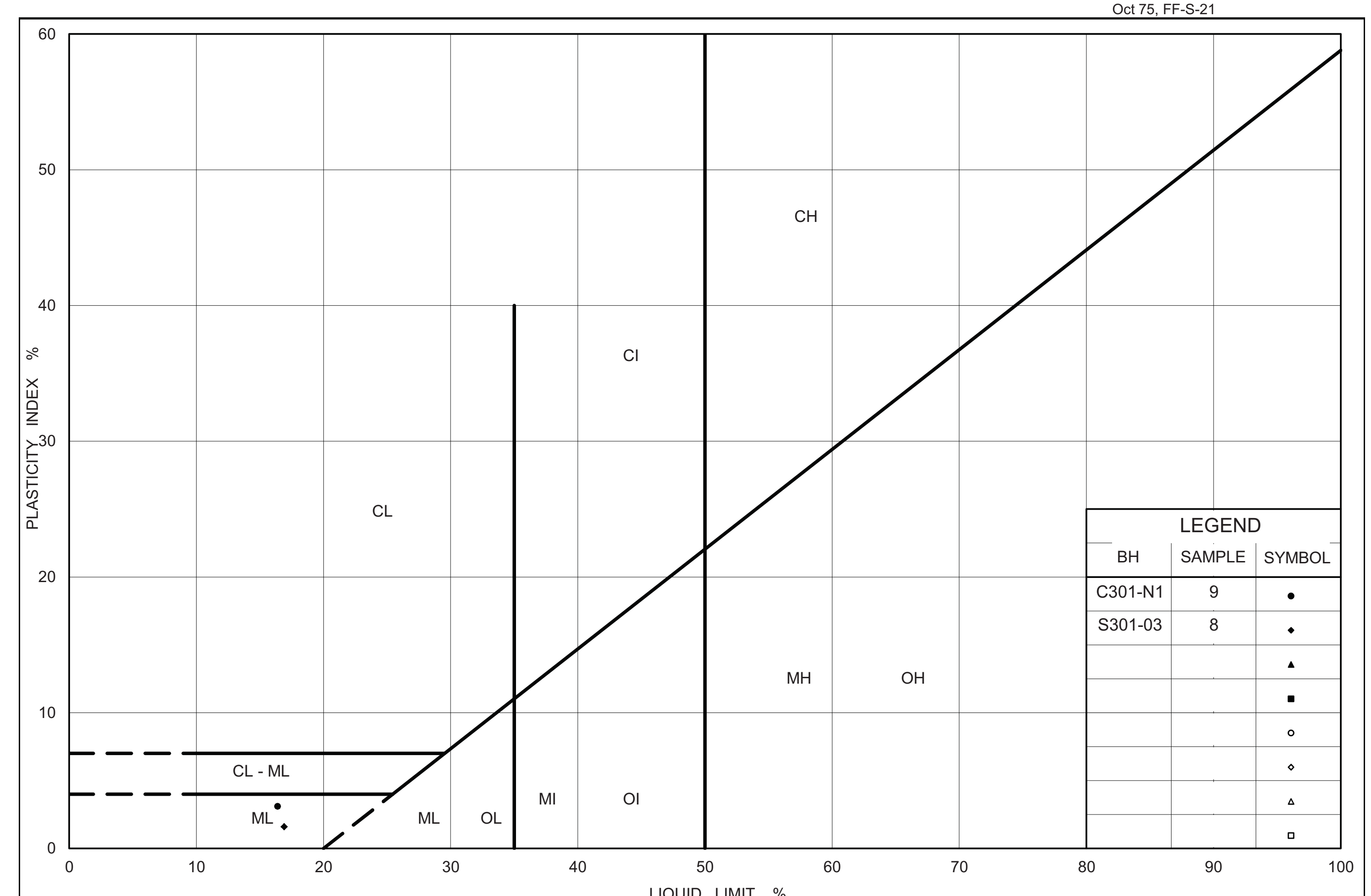
Project Number: 09-1111-6014

Checked By: TVA

Golder Associates

Date: 15-Feb-13

Oct 75, FF-S-21

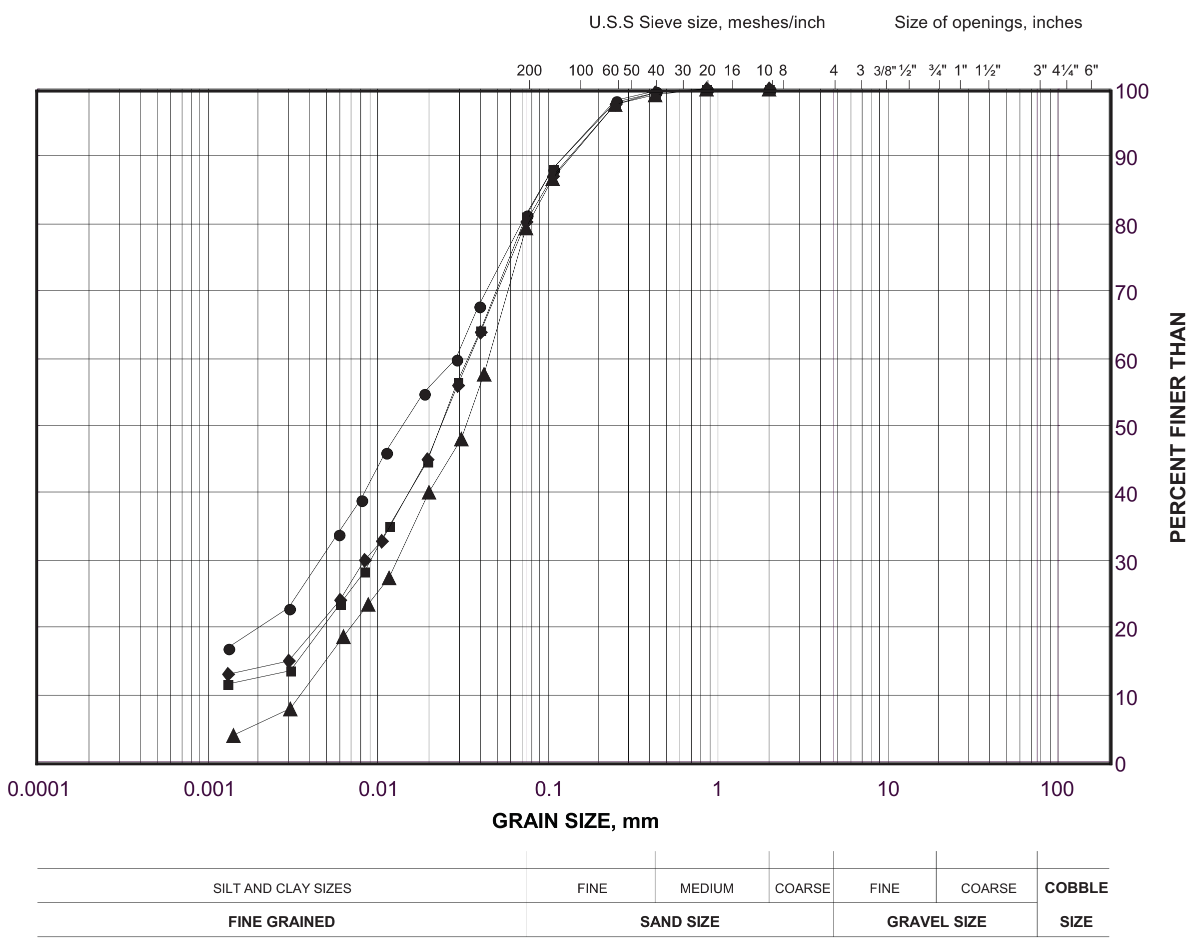


Ministry of Transportation Ontario	PLASTICITY CHART Silt of Slight Plasticity (Pockets) Highway 69 (SBL and NBL) Culvert C301	Figure No. A.C301-05 Project No. 09-1111-6014 Checked By: TVA

GRAIN SIZE DISTRIBUTION

Silt to Sandy Silt (Interlayer)
Highway 69 (SBL and NBL) Culvert C301

FIGURE A.C301-06



LEGEND

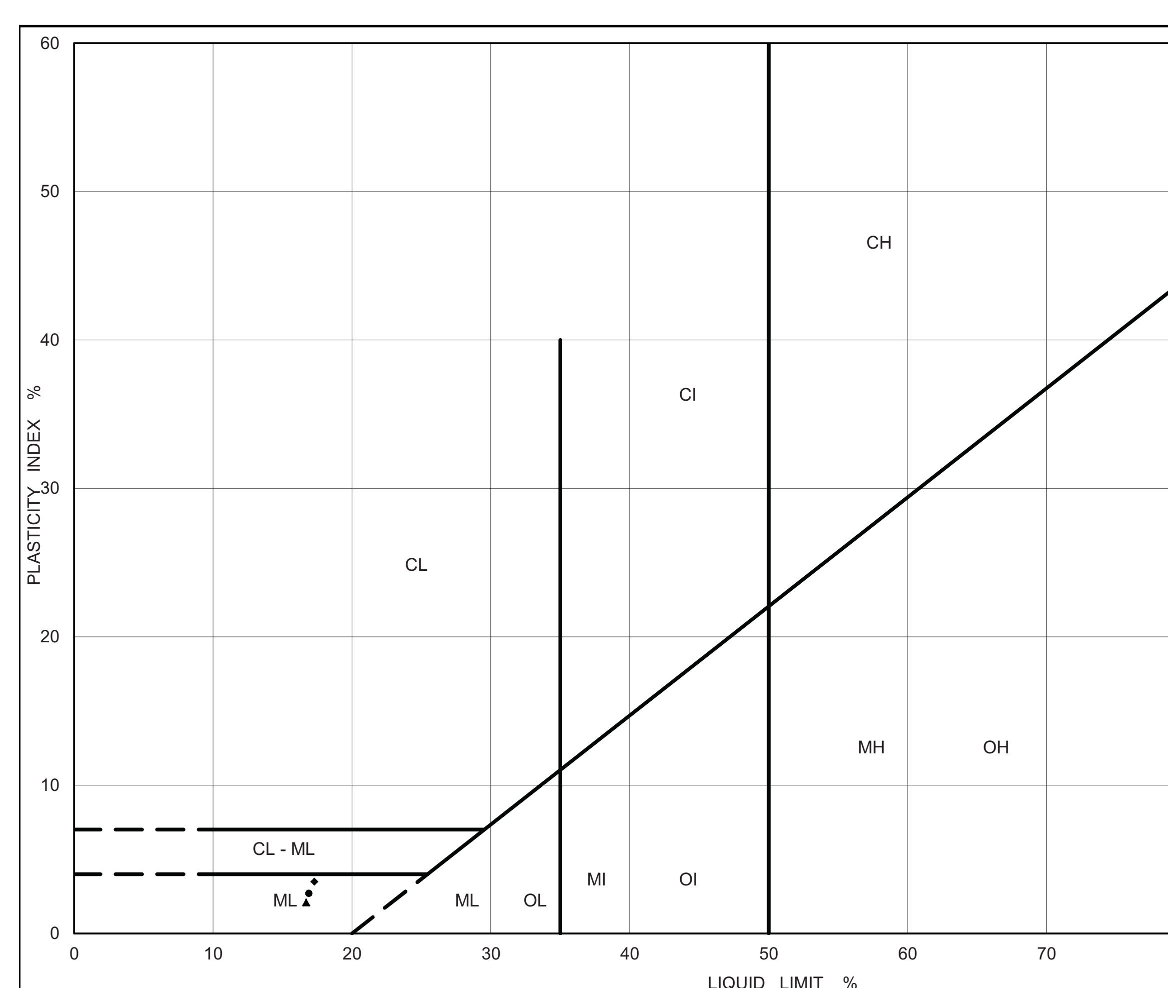
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C301-N2	10	169.6
■	C301-S1	10	168.7
◆	C301-N1	11	167.6
▲	S301-03	12	168.4

Project Number: 09-1111-6014

Checked By: TVA

Golder Associates

Date: 01-Feb-13



LEGEND

BH	SAMPLE	SYMBOL
C301-S1	10	●
C301-S2	11	◆
S301-03	12	▲
		■
		○
		◇
		△
		□

Ministry of Transportation

Ontario

PLASTICITY CHART

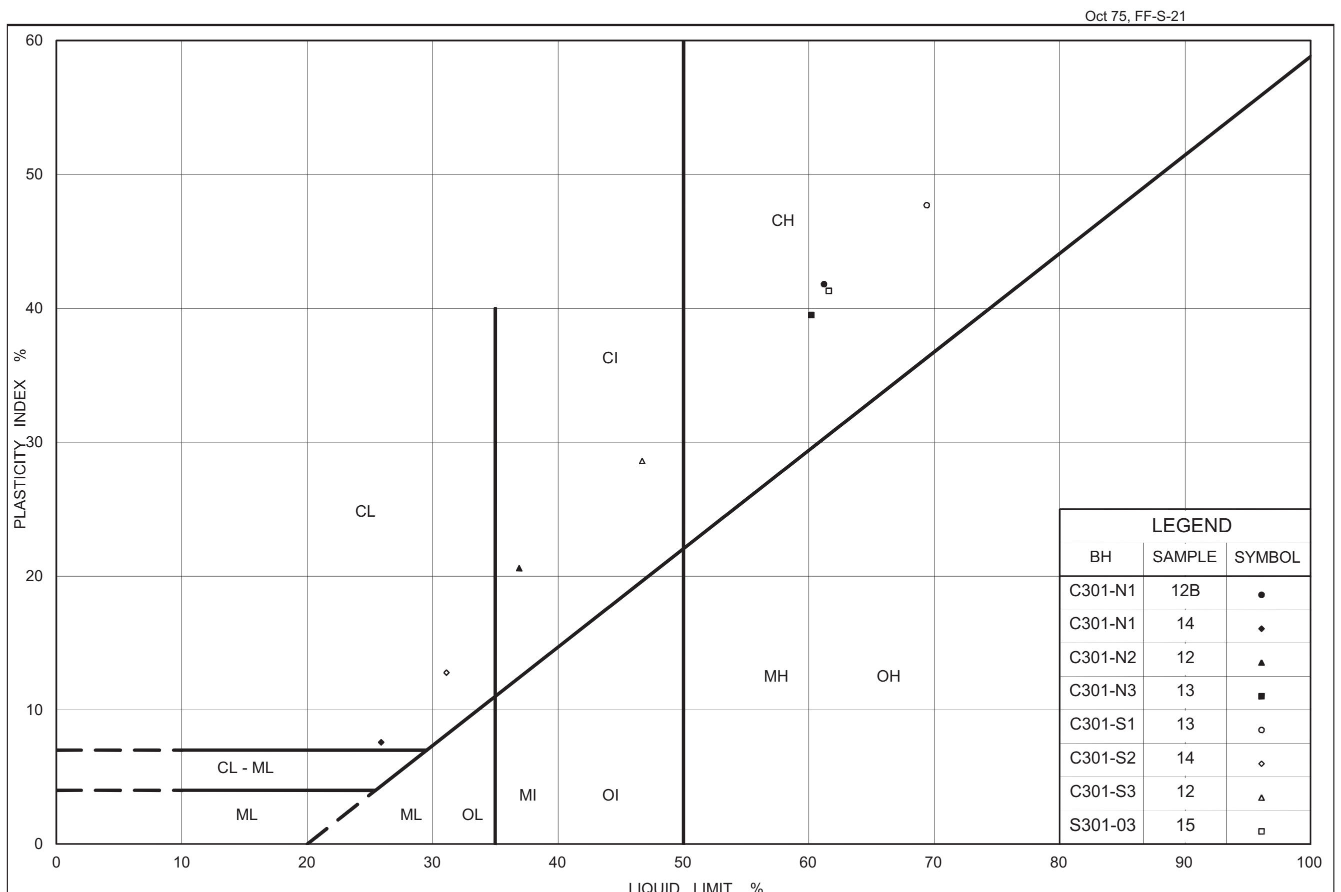
Silt to Sandy Silt of Slight Plasticity (Interlayer)

Highway 69 (SBL and NBL) Culvert C301

Figure No. A.C301-07

Project No. 09-1111-6014

Checked By: TVA



Ministry of Transportation

Ontario

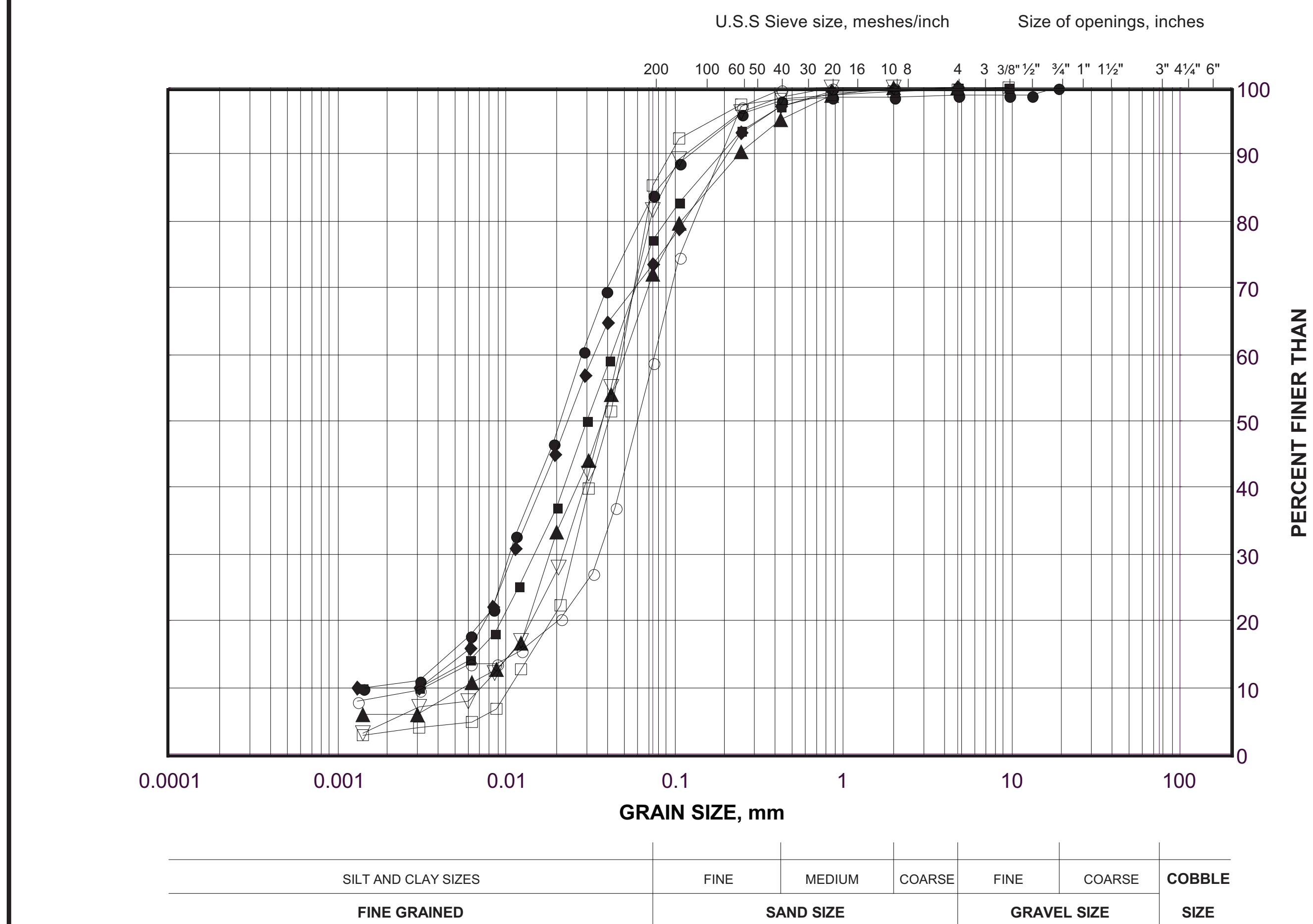
PLASTICITY CHART
Clayey Silt to Clay (Lower Deposit)
Highway 69 (SBL and NBL) Culvert C301

Figure No. A.C301-08
Project No. 09-1111-6014
Checked By: TVA

GRAIN SIZE DISTRIBUTION

Silt to Sandy Silt to Sand and Silt
Highway 69 (SBL and NBL) Culvert C301

FIGURE A.C301-09A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C301-S2	15	161.8
■	C301-N3	15	162.1
◆	C301-N2	15	161.9
▲	C301-S3	15	161.4
▽	S301-03	17	160.8
○	C301-S3	17	156.8
□	S301-03	19	156.2

Project Number: 09-1111-6014

Checked By: TVA

Golder Associates

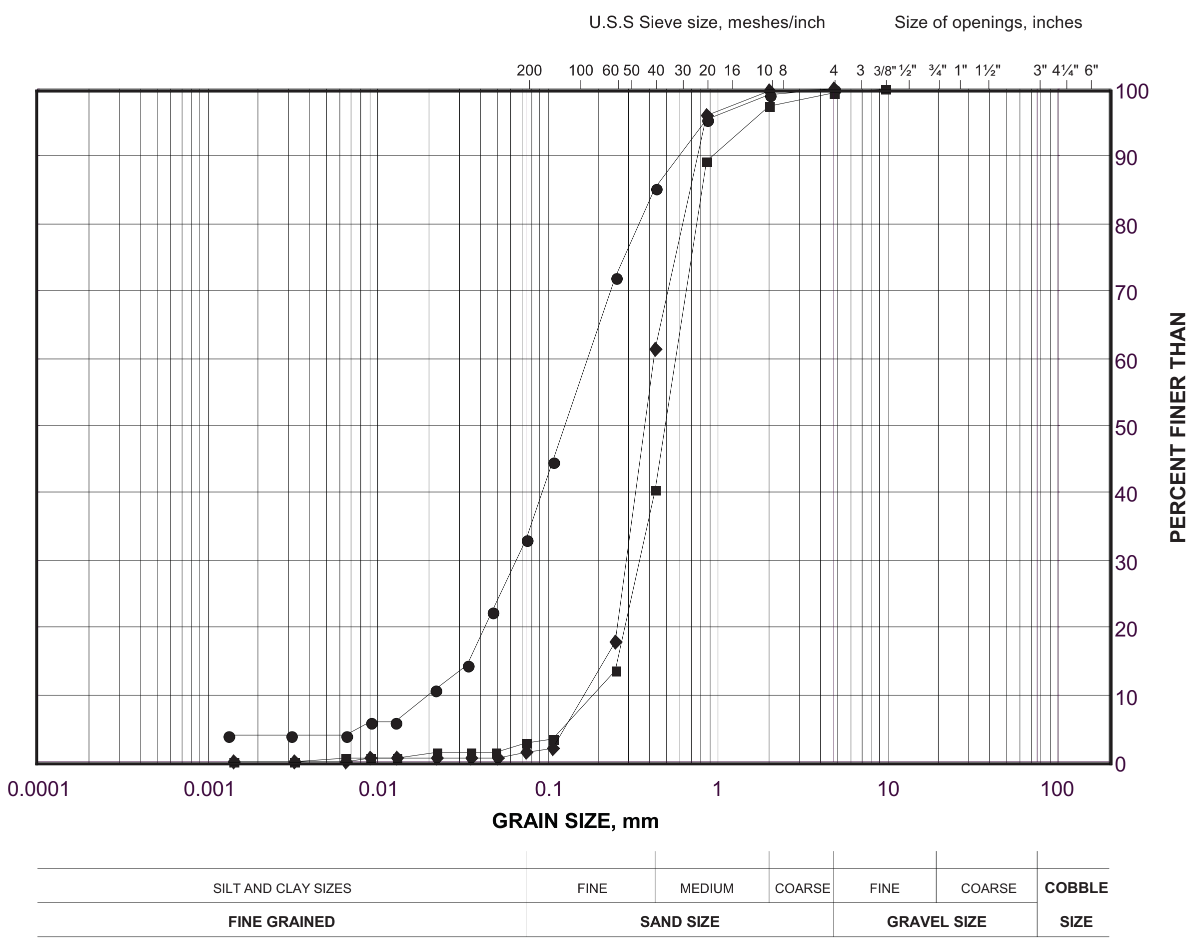
Date: 01-Feb-13

GRAIN SIZE DISTRIBUTION

Silty Sand to Sand

Highway 69 (SBL and NBL) Culvert C301

FIGURE A.C301-09B



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C301-S1	16	159.6
■	C301-S2	17	155.9
◆	C301-N1	17	155.6

Project Number: 09-1111-6014

Checked By: TVA

Golder Associates

Date: 01-Feb-13

Borehole C301-N3

Box 1: 19.69 m – 22.68 m

0 m 0.25 m 0.5 m 0.75 m 1.0 m 1.25 m 1.5 m

0 ft 1 ft 2 ft 3 ft 4 ft 5 ft

Scale

REVISION DATE: April 13, 2011 BY: TVA Project: 09-1111-6014

PROJECT

Culverts
Highway 69 Four-Laning
GWP 5404-05-00; WP 5404-05-01

TITLE

Bedrock Core Photograph – C301–N3
Highway 69 (SBL and NBL) STA 13+810

Golder Associates

PROJECT No.	09-1111-6014		FILE No.	----
DESIGN	MAS	FEB 13	SCALE NTS	REV.
CADD	-- --			
CHECK	TVA	FEB 13	FIGURE A.C301-10	
REVIEW	JPD/JMAC	FEB 13		

SHEET F – CVH-21 and CVH-22 - Fisheries Culverts (Station: ± 15+540 Hwy 69 NBL/SBL) – Henvey)

- Borehole Location Plan (PML)
- Record of Borehole Logs (PML)
- Laboratory Test Results (PML)

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field work and Dynamic Cone Penetration Testing (DCPT) for Culverts CVM-21 and CVM-22 at Station 15+540, in the Township of Mowat (Site Nos. 044-0648/01&02 under the NBL/SBL) was carried out on July 30, August 4, 2021, and May 25, 2022. Borehole CVH21-1 was advanced with drill rig equipped with continuous hollow stem augers and rotary drilling. Borehole CVH22-1 was advanced with portable tripod equipped with 31.7 kg (70 lbs) hammer and casings. The SPT N values obtained by utilizing tripod equipment were adjusted for 63.5 kg (140 lbs) hammer. The drop of the hammer was from standard height. Because drill rig and portable tripod was inaccessible at Borehole CVH21-2 location, manual DCPT was carried out to assess the subsurface conditions to a limited depth.

2. BOREHOLE INFORMATION

A total of three (3) boreholes were investigated along the alignment of the proposed culverts (Site No. 044-0648/01&02).

Refer to
- Drawing F-1 for the borehole location plan
- Table F-1 for details of borehole origin, borehole location coordinates and borehole elevations/depths
- Record of Borehole sheets and lab results showing details of the subsurface conditions at the borehole locations from current investigation

Table F-1 Borehole Information for Structural Culvert CVM-21

BOREHOLE ID	BOREHOLE LOCATION	MTM ON10 NAD 83 COORDINATES		GROUND SURFACE ELEVATION (m)	BOREHOLE DEPTH (m)	DCPT Depth (m)
		NORTHING (m)	EASTING (m)			
CVH21-1	West End (Outlet)	5 077 799. 5	223 035.56	186.5	12.4	-
CVH21-2	East End (Inlet)	5 077 822.4	223 063.3	184.5	-	2.1

Table F-2 Borehole Information for Structural Culvert CVM-22

BOREHOLE ID	BOREHOLE LOCATION	MTM ON10 NAD 83 COORDINATES		GROUND SURFACE ELEVATION (m)	BOREHOLE DEPTH (m)	DCPT Depth (m)
		NORTHING (m)	EASTING (m)			
CVH22-1	West End (Outlet)	5077783.8	222996.1	184.4	4.8	-
CVH22-2	East End (Inlet)	5077801.8	223027.3	184.7	-	1.0

2.1. Subsurface Conditions

The stratigraphy generally consists of surficial topsoil underlain by very loose to compact silty sand, followed by a deposit of stiff to hard clayey silt. Below the clayey silt deposit, dense to compact sandy silt to silty sand was encountered in Borehole CVH22-1 to the termination depth of drilling. In Borehole CVH21-1, the clayey silt deposit was underlain by loose to very dense sand, followed by bedrock which extended to the termination depth of drilling. Refer to the Record of Boreholes for details.

2.2. CVH-21 Subsurface Conditions

The stratigraphy generally consists of surficial topsoil underlain by compact silty sand, followed by a deposit of stiff clayey silt. The clayey silt deposit was underlain by loose to very dense sand, followed by bedrock which extended to the termination depth of drilling. Refer to the Record of Boreholes for details. The DCPT results for Borehole CVH21-2 are presented in Appendix A (A-1).

The subsurface conditions at this site can be categorized into four (4) general layers as presented below from surface downwards.

2.2.1. Organics

A 200 mm thick layer of organics was encountered at the existing ground surface in Borehole CVH21-1, which was drilled on the west end of the proposed culvert alignment.

2.2.2. Silty Sand

This 2.1 m thick layer of silty sand was encountered below the organics in Borehole CVH21-1, and extended to a depth 2.3 m (EL. 184.2) below the existing ground surface. The SPT N values ranged from 5 blows to 29 blows for 0.3 m penetration, indicating compactness ranging from loose to compact. Moisture content determination of one (1) sample from this layer was 20.1%.

2.2.3. Clayey Silt

The silty sand layer was underlain by this 800 mm thick clayey silt deposit, and extended to a depth of 3.1 m (EL. 183.4) below the existing ground surface. One SPT N value obtained was 13, indicating stiff consistency. The moisture content determination of one (1) sample tested from this layer was 14.1%.

The grain size distribution test results of one (1) representative sample selected from this layer are provided in Figure GS-F-1 and the Atterberg limits are presented in Figure PC-F-1.

2.2.4. Sand

The clayey silt was underlain by this 9.3 m thick sand deposit, and extended to a depth of 12.4 m (EL. 174.1) below the existing ground surface. From EL. 183.4 to 180.4, the SPT N values varied from 5 to 9, indicating loose compactness. Below EL. 180.4 to the termination depth of the borehole, the SPT N values ranged from 60 blows for 30 cm penetration to 70 blows for 23 cm penetration, indicating very dense compactness. Within the sand layer, boulder was encountered from EL. 175.9 to EL. 174.3. The presence of boulder was confirmed by coring the boulder. The moisture content determination of five (5) samples tested from this layer varied from 13.8% to 26.1%, with and average value of 20.7%.

The grain size distribution test results of two (2) representative sample selected from this layer are provided in Figure GS-F-2.

2.3. CVM-22 Subsurface Conditions

The stratigraphy generally consists of very loose silty sand, underlain by a deposit of hard clayey silt, followed by loose to dense sandy silt to silty to the termination depth of drilling. Refer to the Record of Boreholes for details. The DCPT results for Borehole CVH22-2 is presented in Appendix A (A-1).

The subsurface conditions at this site can be categorized into four (4) general layers as presented below from surface downwards.

2.3.1. Silty Sand

This layer of silty sand was encountered immediately below the existing ground surface in Borehole CVH22-1, and extended to a depth 1.5 m (EL. 182.9). Two N values recorded were 1 and 2, indicating very loose compactness. Moisture content determinations of two (2) samples from this layer were 22.3% and 37.3%.

2.3.2. Clayey Silt

The silty sand layer was underlain by this 900 mm thick clayey silt deposit, and extended to a depth of 2.4 m (EL. 182.0) below the existing ground surface. One N value recorded in this layer was 16, indicating very stiff consistency. The moisture content determination of two (2) sample tested from this layer were 17.8% and 23.9%.

The grain size distribution test results of one (1) representative sample selected from this layer are provided in Figure GS-F-1 and the Atterberg limits are presented in Figure PC-F-1.

2.3.3. Sandy Silt

The clayey silt was underlain by this 1.2 m thick sandy silt deposit, and extended to a depth of 3.6 m (EL. 180.8) below the existing ground surface. Two SPT N values recorded are 16 and 6, indicating the compactness ranging from compact to loose with depth. The moisture content determination of two (2) sample tested from this layer varied were 16.1% and 19.7%.

The grain size distribution test results of one (1) representative sample selected from this layer are provided in Figure GS-F-3.

2.3.4. Silty Sand

The sandy silt was underlain by this silty sand deposit, and extended to termination depth of investigation. Below this depth, the SPT spoon could not be advanced further. Two SPT N values obtained are 4 and 6, indicating loose in compactness. The moisture content determinations of two (2) samples tested from this layer varied were 13.4% and 21.2%.

The grain size distribution test results of one (1) representative sample selected from this layer are provided in Figure GS-F-2.

2.4. Groundwater Conditions

Groundwater was encountered during drilling in Boreholes CVH21-1 and CVH22-1 at depths of 1.5 m (EL. 185.0) and 1.2 m (EL. 183.2), below the existing ground surface, respectively. Upon completion of drilling, the groundwater was measured in Boreholes CVH21-1 and CVH22-1 at depths of 2.0 m (EL. 184.6) and 0.6 m (EL. 183.8) below the existing ground surface, respectively. The creek water level at the inlet of the existing culvert was measured at EL. 184.3 m, on May 25, 2022.

Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) are based on the following references:

1. Highway 69 Profile Drawings, provided by Parson via email dated November 25, 2020
2. Culvert Sections Drawings, provided by Parsons via email dated November 25, 2020

3. PROJECT DESCRIPTION

3.1. General

The proposed Fisheries Culverts (Site No. 044-0648/01&02) are new structures across the new alignment of Highway 69 NBL/SBL. The culverts will be located within the Township of Henvey.

3.2. Proposed Structure

It is proposed that the culverts will have an opening size of 3.0 m in span, 1.8 m in height, will be approximately 35.0 m to 36.0 m long and will be on a skew of approximately 17 degrees to the new alignments of the new Highway 69 NBL/SBL.

The existing ground surface in the vicinity of the culvert alignments varies from approximate EL. 184.4 m to EL. 186.5 m. The terrain at the culvert locations is undulating and an existing creek meanders through the general area of the culvert sties. The creek water is flowing east to west direction in general. A beaver dam is situated in the creek northeast of the proposed Culvert CVH-21 inlet location.

Based on Reference 1, the proposed invert levels of the Culverts CVH-21 and CVH-22 are approximately at EL. 183.6 and EL. 183.5, respectively.

Table F1: Box Culvert Founding Elevations at Station 15+538 NBL CVH-21 Culvert (Site No. 044-0648/01)

PROPOSED CULVERT INVERT ELEVATION	BOTTOM OF BOX CULVERT ELEVATION	SUBGRADE ELEVATION FOR GRANULAR BEDDING	FOUNDING STRATUM
183.6 m	183.3 m	183.0 m	Sand

Note(s): 1: The bottom thickness of the precast concrete box culvert is assumed 0.25 m (minimum).

Table F2: Box Culvert Founding Elevations at Station 15+538 SBL CVH-22 Culvert (Site No. 044-0648/02)

PROPOSED CULVERT INVERT ELEVATION	BOTTOM OF BOX CULVERT ELEVATION	SUBGRADE ELEVATION FOR GRANULAR BEDDING	FOUNDING STRATUM
183.5 m	183.2 m	182.9 m	Clayey Silt

Note(s): 1: The bottom thickness of the precast concrete box culvert is assumed 0.25 m (minimum).

Based on Reference 2, the height of embankment fill required above the culverts to the proposed grade of Highway 69 NBL/SBL at Station 15+538.49 is not expected to exceed 3.6 m and 3.8 m, respectively, including the pavement structure.

In the absence of any structural details of the culverts, at the time of writing this report, it is assumed that concrete culverts and fill would impose a dead load of approximately 100 kPa on the founding subgrade.

4. EVALUATION OF FOUNDATION ALTERNATIVES

The foundation alternatives listed below were based on the available information in References 1 and 2.

1. Precast concrete box culverts placed without settlement mitigation
2. Precast concrete box culverts placed after preloading or surcharging

For both options, assuming that the culvert is placed at the proposed subgrade levels of EL. 183 m and EL.182.9 as shown in Tables F1 and F2, sand is expected underneath the base of Culvert CVH-21 and clayey silt is expected underneath base of Culvert CVH-22. No major settlement issues are expected under the imposed load of 100 kPa at the culvert location as it is anticipated that all cohesive soil will be excavated to found the subgrade level for the culvert installation. Once excavated, the excavation should be filled with compacted granular material to the subgrade level.

Unsuitable/organic materials at the culvert location should be excavated from within the zone of influence of the culvert (minimum of 2.0 m beyond the culvert walls) and the area under the culvert when preparing the subgrade for the culvert. The exposed subgrade should be inspected and approved before placement of compacted granular materials as specified in OPSS 422.07.06.

The granular material to backfill the precast concrete box culvert should be placed in accordance with OPSS 422.07.07. Granular material should be as specified in accordance with OPSS 422.05.13 and may consist of either Granular ‘A’ or Granular ‘B’ Type II, including a 75 mm levelling course for bedding purposes as required by OPSS 422.07.08.

The precast concrete box culvert may be designed assuming a factored geotechnical resistance of 150 kPa at ULS and 100 kPa at SLS placed on sand. For culvert CVH-22 the clayey silt should be excavated to EL. 182.0. and replaced with compacted granular ‘A’ or ‘B’ material. Following placement of the precast concrete box culvert as recommended and the estimated fill of 3.6 to 3.8 m above the culverts, it is estimated that the total settlement would be less than 30 mm and the differential settlement between 15 mm and 20 mm. Generally, for precast concrete box culvert, a tolerable limit of 100 mm of differential settlement is assumed.

If Option 2 is considered, excavation up to 7.4 m of fill and subsurface soil would be required to install the culverts at the subgrade level. Furthermore, it would also require additional handling of the fill material. During preloading, granular soils, instead of rockfill, would need to be utilized for preloading over the proposed culvert area for ease of excavation for the installation of the culvert. Option 2 may also require temporary shoring during excavation and installation of the culvert. It is considered that Option 2 is feasible but not preferred.

5. CULVERT BEDDING AND COVER MATERIALS

Refer to the General Report for preliminary recommendations for materials to be used for culvert bedding and cover purposes.

6. APPROACH EMBANKEMNT

Based on References 1 and 2, the proposed embankment will be constructed approximately up to EL. ±189.0.

In general, construction of embankments shall be in accordance with OPSS.PROV 206. Where construction of embankments over swamps is anticipated, the construction shall be in accordance with OPSS.PROV 209.

All organic materials and cohesive soils shall be removed from the proposed footprint of the embankment and replaced with compacted granular material. Backfill should be placed in accordance with OPSS.PROV 206. Where water bodies are within the footprint of the embankment, backfill material other than rock may be placed up to 600 mm above water level without compaction in accordance with OPSS.PROV 209 (209.07.03.01). It should also be noted that vibratory compaction equipment should not be used within 1.0 m of the original surface of the swamp (OPSS.PROV 209 – 209.07.04.2).

The proposed embankment can be construct with granular materials, earth borrow or rockfill. The side slopes of the proposed embankment are to be sloped at a minimum 2H:1V if granular material or earth borrow is used to construct the embankment. The side slopes of the embankment should be a minimum 1.25H:1V if rockfill is used to construct the embankment.

Granular materials shall be in accordance with OPSS.PROV 1010, amended by SSP 110S06. If earth borrow is utilized to construct the embankment, the earth borrow should be in accordance with OPSS.PROV 212, amended by SSP 112S07 and SSP 212F01. If rockfill is utilized to construct the new embankment, the material should be in accordance with OPSS.PROV 1004, amended by SS 110S16. Compaction shall be carried out in accordance with OPSS.PROV 501, amended by SSP 105S22. It should be noted that frost susceptible material shall not be placed within the zone between the frost penetration depth and the final grade of the roadway.

No stability and settlement issues are anticipated following construction of the embankments as discussed above. It is anticipated that 20 mm to 40 mm of settlement of the embankment fill due to self-weight will be completed following construction of the embankment.

7. CONSTRUCTION CONSIDERATIONS

7.1. Excavation

Considering the existing ground level (EL. 184.4 EL. 186.5 m) and the culvert subgrade level (EL. ±183.0 m), 1.6 m to 3.5 m deep excavation into native soils is required for subgrade preparation. With proper slope cutback and/or temporary protection in place in accordance to OHSA, slope instability issues are not anticipated. The stability of the temporary slope excavation should be assessed at the design-build stage for culverts CVH-21 and CVH-22.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

Preliminary recommendations for backfilling to the culvert are provided in the General Report.

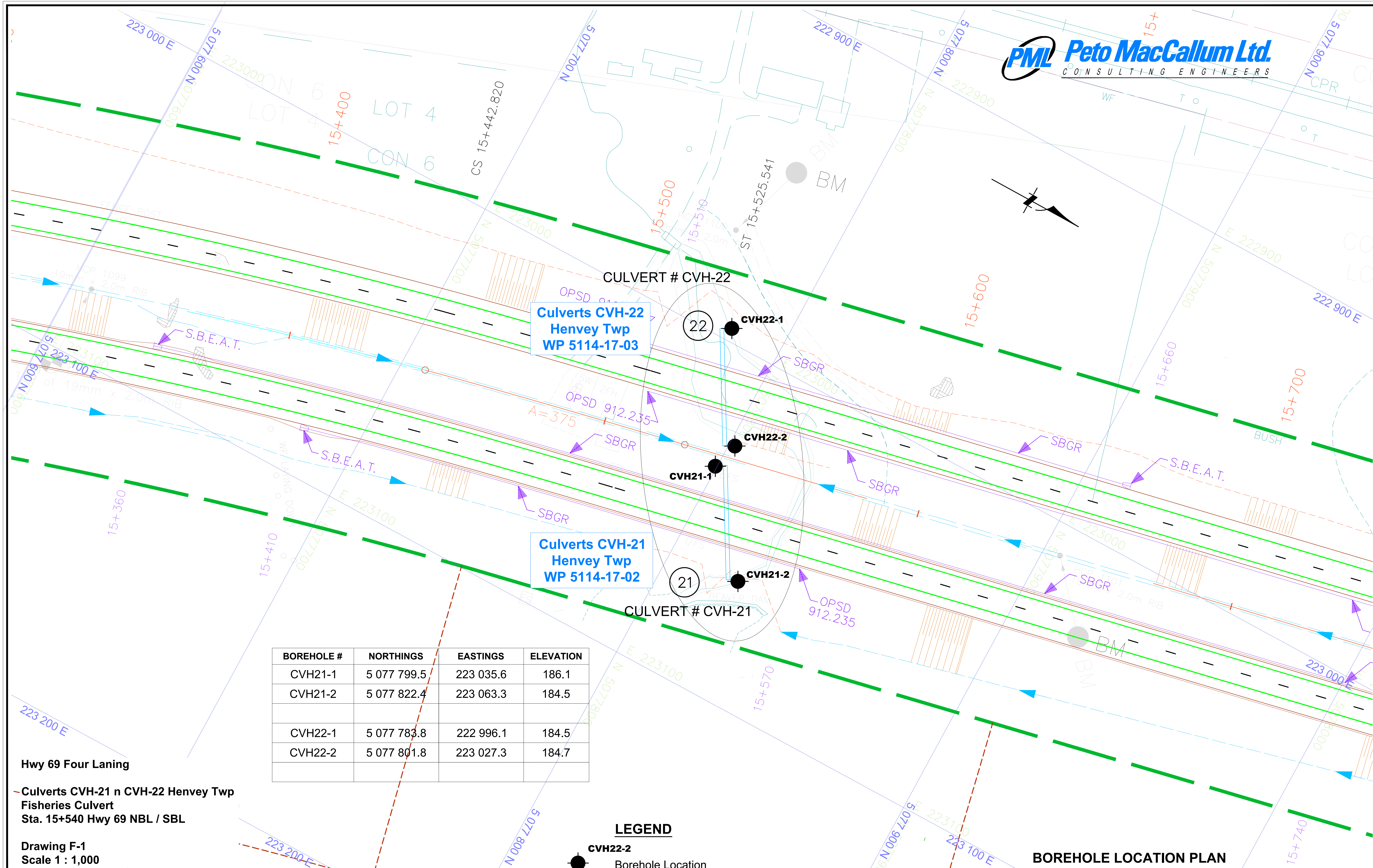
7.2. Groundwater and Surface Water Control

For construction in-the-dry, proper dewatering system, including temporary flow channel, would be required at the culvert locations. The existing beaver dam may need to be dismantled during the construction of the proposed Highway 69 NBL embankment and installation of culvert CVH-21.

Refer to the General Report for further groundwater control recommendations and requirements for water taking.

7.3. Additional Investigation

It is suggested that additional investigation to 3.0 m below the depth of the proposed subgrade level be carried out during the detail design at the inlets of the two proposed culverts to confirm the subsurface conditions. Based on the data, the recommendations provided in this report may have to be revised.



BOREHOLE #	NORTHINGS	EASTINGS	ELEVATION
CVH21-1	5 077 799.5	223 035.6	186.1
CVH21-2	5 077 822.4	223 063.3	184.5
CVH22-1	5 077 783.8	222 996.1	184.5
CVH22-2	5 077 801.8	223 027.3	184.7

Hwy 69 Four Laning

Culverts CVH-21 n CVH-22 Henvey Twp
Fisheries Culvert
Sta. 15+540 Hwy 69 NBL / SBL

Drawing F-1
Scale 1 : 1,000

LEGEND

CVH22-2
Borehole Location

BOREHOLE LOCATION PLAN

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No CVH21-1

1 OF 1 **METRIC**

PROJECT Hwy 69 Structural Culvert COORDINATES Coords: 5 077 797.8 N; 223 040.3 E ORIGINATED BY M.M.

DIST ____ HWY 69 BOREHOLE TYPE CFHSA COMPILED BY N.L.

DATUM Geodetic DATE 2021.07.30 LATITUDE 45.835201 LONGITUDE -80.552511 CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
186.5	Ground Surface					
0.0	organics SILTY SAND, trace gravel Compact, Brown, Moist	1	SS	5		
		2	SS	29	∇	
		3	SS	15	▼	
184.2 / 2.3	CLAYEY SILT, trace sand Stiff, Grey, Moist	4	SS	13		0 6 48 46
183.4 / 3.1	SAND, trace gravel Loose, Grey, Moist to wet	5	SS	5		
		6	SS	9		
		7	SS	7		
		8	SS	9		
	very dense	9	SS	60		5 92 (3)
		10	SS	64		
		11	SS	50/23cm		0 94 (6)
		12	SS	50/3cm		
	boulder	RUN 1	RC	RQD 0%		REC 0%
		13	SS	70/23cm		
174.1 / 12.4	End of borehole					

∇ Groundwater level observed during drilling

▼ Groundwater level measured upon completion of drilling

NOTE: Borehole caved-in at a depth of 3.2 m (EL. xxx) below the ground surface, upon extraction of hollow stem augers.

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 22-10-26

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

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No CVH22-1

1 OF 1 **METRIC**

PROJECT Hwy 69 Structural Culvert COORDINATES Coords: 5 077 781.8 N; 222 992.6 E ORIGINATED BY M.M.

DIST ____ HWY 69 BOREHOLE TYPE 1/2 Weight Hammer Tripod & SPT COMPILED BY N.L.

DATUM Geodetic DATE 2021.08.04 LATITUDE 45.835055 LONGITUDE -80.553017 CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
184.4	Ground Surface					
0.0	SILTY SAND, trace gravel Very loose, Brown, Wet	1	SS	2	▼	
		2	SS	1	∇	
182.9 / 1.5	CLAYEY SILT, sandy Very stiff, Grey, Wet	3	SS	2		0 47 38 15
		4	SS	16		
182.0 / 2.4	SANDY SILT Compact to loose, Grey, Wet	5	SS	16		0 23 70 7
		6	SS	6		
180.8 / 3.6	SILTY SAND, trace gravel Loose, Grey, Wet	7	SS	4		
		8	SS	6		3 80 (17)
179.6 / 4.8	End of borehole					

∇ Groundwater level observed during drilling

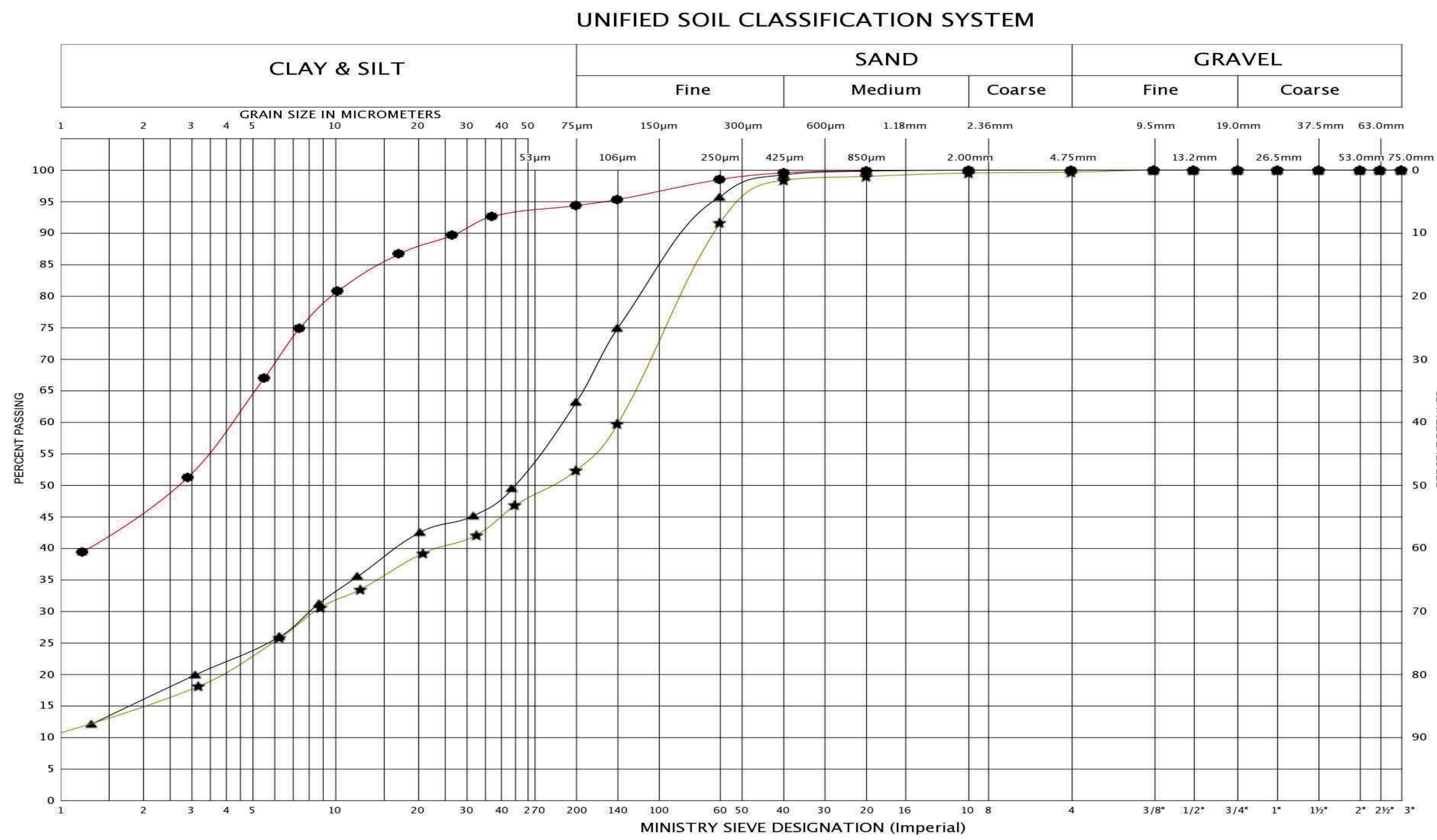
▼ Groundwater level measured upon completion of drilling

NOTES:

1. Borehole caved-in at a depth of 1.2 m (EL. 183.2) below the ground surface, upon extraction of hollow stem augers.
2. Casing was pushed down to 10-7 m (EL. 173.7) below the ground surface, where refusal was met on probable boulder/bedrock.

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 22-10-26

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



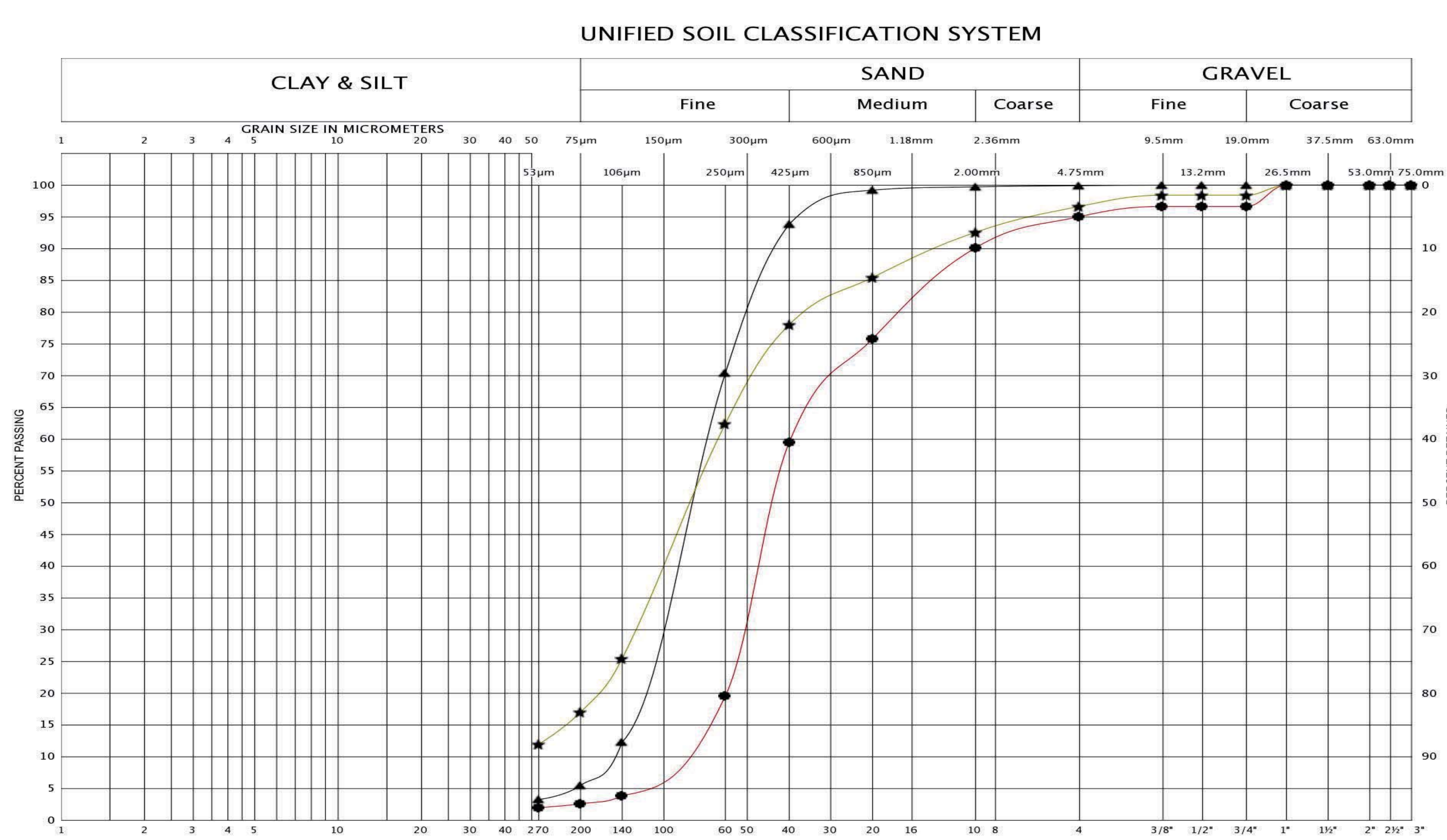
LEGEND	BH	CVH22-1	CVH21-1	CVH21-2
	SAMPLE	3	4	1
	SYMBOL	★	●	▲

Ontario

GRAIN SIZE DISTRIBUTION

CLAYEY SILT

FIG No.:	GS-F-1
HWY :	69
Project No.:	14TF034G



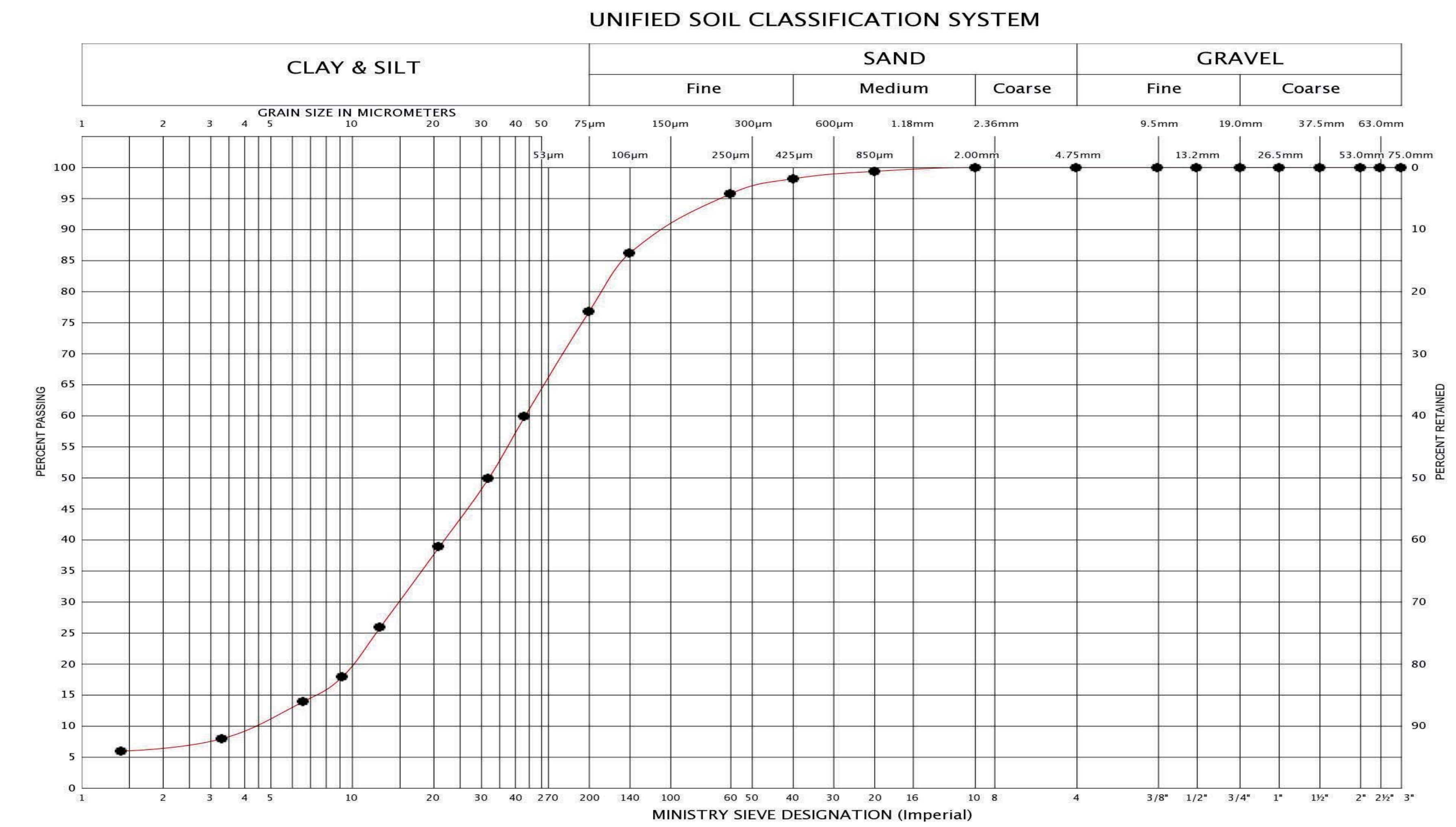
LEGEND	BH	CVH21-1	CVH21-1	CVH22-1
	SAMPLE	9	11	8
	SYMBOL	●	▲	★

Ontario

GRAIN SIZE DISTRIBUTION

SAND/SILTY SAND

FIG No.:	GS-F-2
HWY :	69
Project No.:	14TF034G

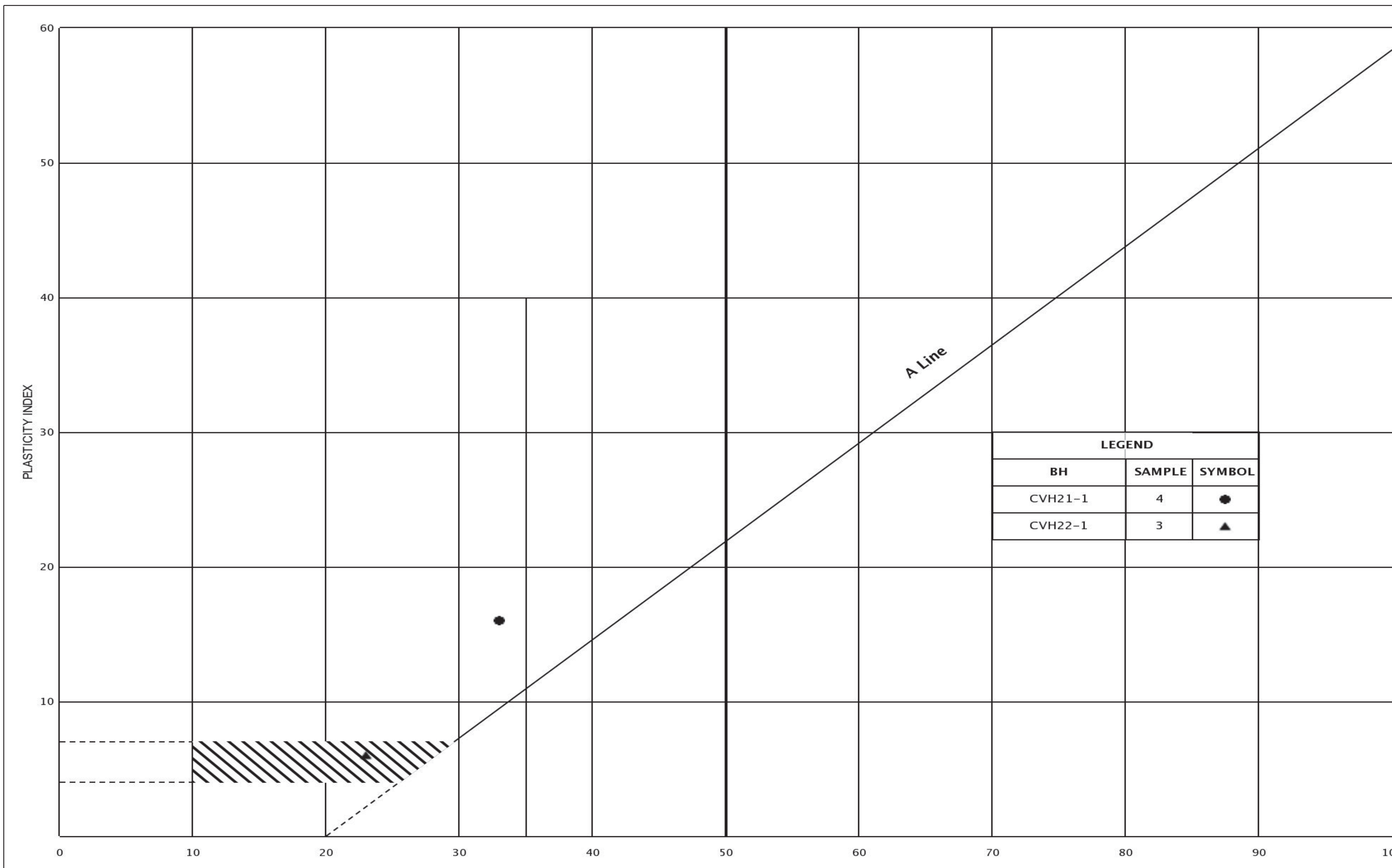


LEGEND	BH	CVH22-1
	SAMPLE	5
	SYMBOL	●

GRAIN SIZE DISTRIBUTION

SANDY SILT

FIG No.: GS-F-3
HWY : 69
Project No.: 14TF034G



LEGEND		
BH	SAMPLE	SYMBOL
CVH21-1	4	●
CVH22-1	3	▲

PLASTICITY CHART

CLAYEY SILT

FIG No.: PC-F-1
HWY.: 69
Proj No. 14TF034G

SHEET G – C184 - Fisheries Culvert (Station: ± 16+000 Existing Hwy 69 NBL/SBL – Henvey)

- Borehole Location Plan (PML)
- Record of Borehole Logs (PML)
- Laboratory Test Results (PML)

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field work for Culvert C184 at Station 16+000, in the Township of Henvey (Site Nos. 44X-0666/C0 under the NBL and SBL) was carried out between July 12 and 19, 2021.

2. BOREHOLE INFORMATION

A total of three (3) boreholes were advanced along the alignment of the proposed replacement of the existing culvert (Site No. 44X-0666/C0) along the same horizontal and vertical alignment.

Refer to
- Drawing G-1 for the borehole location plan
- Table G-1 for details of borehole origin, borehole location coordinates and borehole elevations/depths
- Record of Borehole sheets and lab results showing details of the subsurface conditions at the borehole locations from current investigation

Table G-1 Structural Culvert Borehole Information

BOREHOLE ID	BOREHOLE LOCATION	MTM ON10 NAD 83 COORDINATES		GROUND SURFACE ELEVATION (m)	BOREHOLE DEPTH (m)
		NORTHING (m)	EASTING (m)		
C184-1	East End (Inlet)	5 078 325.2	222 677.7	186.0	12.8
C184-2	Median	5 078 329.9	222 692.8	186.0	12.8
C184-3	West End (Outlet)	5 078 328.9	222 693.0	185.9	12.8

2.1. Subsurface Conditions

The stratigraphy generally consists of approximately 250 mm of roadway pavement and approximately 0.9 m to 2.4 m of general fill consisting of sand, sandy silt, and/or clayey silt, underlain by silty clay/clayey silt to the termination depth of drilling. Refer to the Record of Boreholes for details.

The subsurface conditions at this site can be categorized into four (4) general layers as presented below from surface downwards.

2.1.1. Asphalt

A 250 mm thick layer of asphalt was encountered at the existing road surface in Borehole C184-2, which was drilled on the southbound shoulder of Highway 69.

2.1.2. Fill

2.1.2.1. Sand, Some Gravel Fill

0.8 m to 1.8 m of sand, some gravel fill was encountered below the asphalt in Borehole C184-2, and immediately below the ground surface in Boreholes C184-1 and C184-3. The SPT N values of this layer varied from 9 blows to 60 blows per 0.3 m penetration, indicating a loose to very dense state of compaction. Moisture contents of the samples ranged between 14.8% and 27.0%.

The grain size distribution test results of the representative samples selected from this layer are provided in Figure GS-G-1.

2.1.2.2. Sandy Silt Fill

A 0.7 m thick layer of Sandy Silt fill was encountered below the sand fill in Borehole C184-3. The SPT N value recorded from this layer was 15 blows per 0.3 m penetration, indicating a compact state of compaction. The moisture content determination of one (1) sample from this layer was 29.5%.

2.1.2.3. Clayey Silt Fill

A 0.9 m thick layer of silty sand fill was encountered below the sandy silt fill in Borehole C184-3. The SPT N value recorded from this layer was 5 blows per 0.3 m penetration, indicating firm consistency. The moisture content determination of one (1) sample from this layer was 48.7%.

The grain size distribution test results of the representative samples selected from this layer are provided in Figure GS-G-2 and the Atterberg limits are presented in Figure PC-G-1.

2.1.3. Silty Clay/Clayey Silt, Trace Sand/Sandy

This silty clay/clayey silt, trace sand/sandy deposit was encountered immediately below the fill in Boreholes C184-1, C184-2, and C184-3, extending to the borehole termination depth of 12.8 m below the existing ground surface. The SPT N values of this layer ranged from as low as none (WH – penetration due to the weight of the hammer and rods) to 12 blows per 0.3 m penetration, indicating very soft to stiff consistency. Moisture content determinations of the samples tested from this layer ranged from 19.5% and 44.8%, with the exception of one (1) sample from the layer surface in Borehole C184-2, which was 85.3%.

The grain size distribution test results of the representative samples selected from this layer are provided in Figure GS-G-3 and the Atterberg limits are presented in Figure PC-G-2.

2.2. Groundwater Conditions

Groundwater was not encountered inside any of the boreholes during drilling. Upon completion of drilling, groundwater levels were measured at depths 1.5 m (EL. 184.5), 2.1 m (EL. 183.9), and 1.8 m (EL. 184.1) below the existing ground surface in Boreholes C184-1, C184-2, and C184-3, respectively. The creek water level at the inlet of the existing culvert was measured at Elevation 211.5 m, on July 12, 2021.

Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) are based on the information provided by Parsons on March 2, 2018 and the relevant geotechnical data provided in the FIR.

3. PROJECT DESCRIPTION

3.1. General

The existing fisheries culvert crossing existing Highway 69 at Station 16+000 in the Henvey Township is to be replaced. The existing culvert has a 3.1 m span and 2.1 m in height, and approximately 20.0 m in length.

3.2. Proposed Structure

In the absence of a General Arrangement (GA) drawing of the proposed structure, it is anticipated that the existing culvert will be replaced with a culvert of same size, 3.1 m in span and 2.1 m in height, along the same horizontal and vertical alignment. The inlet and outlet invert levels of the proposed culvert are anticipated to remain the same as the existing culvert. New embankment fill, of similar heights as existing Highway 69 embankment, will be placed following removal and replacement of the existing culvert.

4. EVALUATION OF FOUNDATION ALTERNATIVES

The foundation alternatives listed below are considered for the replacement culvert.

1. Precast concrete box culvert
2. Cast-in-place concrete culvert

Assuming that the size, length, and vertical and horizontal alignments of the proposed culvert will remain same as the existing culvert and that the existing grade of Highway 69 will be maintained, no associated differential and total settlement is anticipated along the length of the proposed culvert. Based on the subsurface conditions the culvert is proposed to be placed on a founding elevation of EL.183.0 or below, where firm to stiff clayey silt/silty clay at the founding level of the proposed culvert is anticipated. For design purposes, factored geotechnical resistances of 105 kPa and 70 kPa at ULS and SLS, respectively, may be considered.

There may be some disturbances to the subgrade due to the removal of the existing culvert. It is anticipated that the existing culvert, along with any existing bedding and leveling course, will be removed. To limit the degradation of the founding soil, it is recommended that 100 mm thick concrete working slab (lean concrete) be placed on subgrade within four hours after preparation, inspection and approval of the foundation subgrade for both options.

From a geotechnical perspective, both options are feasible. However, precast box culvert construction can be carried out faster than cast-in-place open footing culvert construction resulting in shorter durations for dewatering. Furthermore, the precast box culvert will be more tolerant to the total and differential settlement.

5. CULVERT BEDDING AND COVER MATERIALS

Refer to the General Report for preliminary recommendations for materials to be used for culvert bedding and cover purposes.

6. TEMPORARY FLOW DIVERSION AND TEMPORARY ROADWAY PROTECTION

For both options, temporary flow diversion or channel will be required to replace the existing culvert in accordance with OPSS.PROV 517, amended by SSP 517F07. It is anticipated the open-cut method will be utilized to replace the existing culvert. Temporary roadway protection will be required in accordance with OPSS.PROV 539, amended by SSP 105S09. The Contractor is responsible for the selection, design, construction and performances of temporary flow channel, cofferdams, if utilized, and temporary roadway protection. Parameters and recommendations for design of temporary flow channel, cofferdam and roadway protection should be determined during the detail design phase of the project. The geotechnical parameters provided in Table G-2 may be used for the preliminary evaluation of temporary protection system.

Table G-2 Preliminary Geotechnical Design Parameters

SOIL TYPE	DESIGN PARAMETERS		UNIT WEIGHT, kN/m^3
	EFFECTIVE FRICTION ANGLE (θ)	UNDRAINED SHEAR STRENGTH, kPa (c_u)	
Sand (Fill)	30	-	19
Soft cohesive	-	20	17.5
Firm cohesive	-	35	18
Stiff cohesive	-	55	18.5

7. APPROACH EMBANKMENT

It is anticipated that there will be no increase in the profile grade of the existing Highway 69. No instability problems are anticipated for the excavated section of the embankment to be reconstructed with similar side slope as the existing. Any soft or compressible zones observed should be removed prior to placing the fill.

8. CONSTRUCTION CONSIDERATIONS

8.1. Staged Construction

The removal of the existing culvert and construction of the new culvert is expected to be carried out in stages. The details of the staged construction should be finalized during the detail design phase of the project.

8.2. Excavation

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

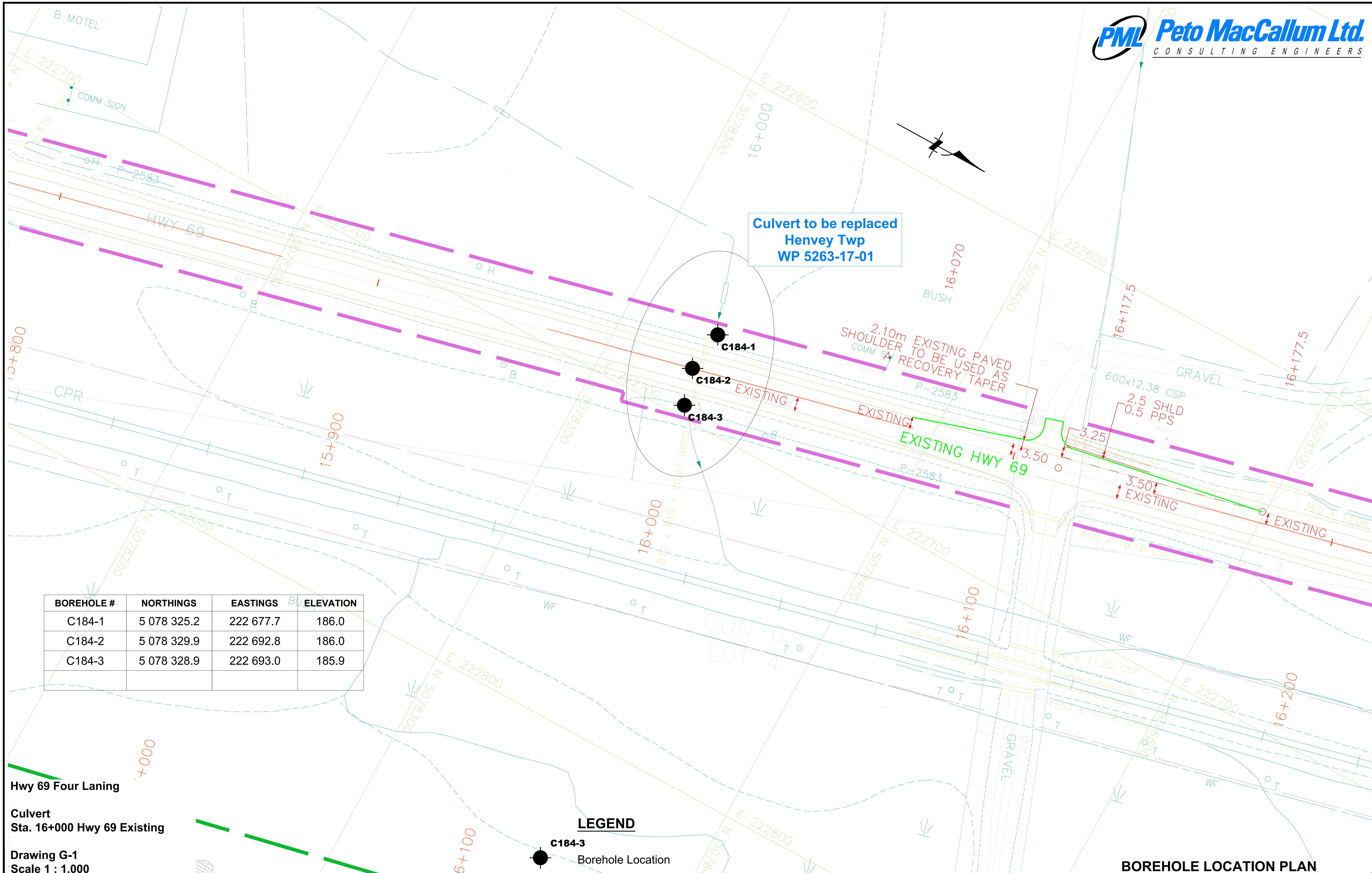
It is anticipated that the excavation will extend through the existing Highway 69 embankment fill into the soft to stiff cohesive soils. In accordance with OHSA, the fill and firm to stiff soils are considered as Type 3 soils. Soft soils, soils that run or flow easily unless completely supported, and soils under groundwater are considered as Type 4 soils. The slope of excavation walls should conform to as described in Ont. Reg. 213/92, S. 234. Workers should not enter an unprotected excavation if there is evidence of ongoing groundwater seepage in the pits. Temporary shoring will be required if slopes as described in Ont. Reg. 213/92, S. 234 cannot be provided. Temporary shoring should be in accordance with OPSS.PROV 539, as amended.

Preliminary recommendations for backfilling to the culvert are provided in the General Report.

8.3. Groundwater and Surface Water Control

To prevent basal heave, if any, dewatering may have to be carried out from wells installed along the interior periphery of the excavation to maintain the groundwater level a minimum 0.5 m depth below the base of the excavations. Surface water flow should be directed away from the excavation areas to mitigate disturbance of the native subgrade. For construction in-the-dry, the watercourse will have to be temporarily diverted.

Refer to the General Report for further groundwater control recommendations and requirements for water taking.



Peto MacCallum Ltd.
CONSULTING ENGINEERS

BOREHOLE #	NORTHINGS	EASTINGS	ELEVATION
C184-1	5 078 325.2	222 677.7	186.0
C184-2	5 078 329.9	222 692.8	186.0
C184-3	5 078 328.9	222 693.0	185.9

Hwy 69 Four Laning

Culvert
Sta. 16+000 Hwy 69 Existing

Drawing G-1
Scale 1 : 1,000

LEGEND

C184-3 Borehole Location

BOREHOLE LOCATION PLAN

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No C184-1

METRIC

PROJECT Hwy 69 Structural Culvert
COORDINATES Coords: 5 078 325.2 N; 222 677.7 E
ORIGINATED BY M.M.
DIST ____ HWY 69
BOREHOLE TYPE CFHSA
COMPILED BY N.L.
DATUM Geodetic
DATE 2021.07.19
LATITUDE 45.839914
LONGITUDE -80.557271
CHECKED BY N.R.

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION
186.0	Ground Surface
0.0	SAND, some gravel. Compact to loose, Brown, Moist (FILL)
185.1 / 0.9	SILTY CLAY/CLAYEY SILT, trace sand/sandy. Firm to very soft, Grey, Moist to wet
173.2 / 12.8	End of borehole

SAMPLE NUMBER	TYPE	"N" VALUES	FIELD VANE (sensitivity)	GR SA SI CL (%)
1	SS	16		18 75 (7)
2	SS	5		
	VANE		2	
3	SS	7		
	VANE		9	
4	SS	6		0 2 47 51
	VANE		4	
5	SS	3		
	VANE		3	
6	SS	WH		
	VANE		3	
7	SS	4		
	VANE		4	
8	SS	1		0 21 65 14
	VANE		3	
9	SS	WH		

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (185 to 174); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT W_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT/GAS READING γ kN/m³ / ppm/%; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

▼ Groundwater level measured upon completion of drilling

WH Penetration due to weight of hammer and rods

NOTE: Borehole caved-in at a depth of 6.1 m (EL. 179.9) below the ground surface, upon extraction of hollow stem augers.

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

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No C184-2

METRIC

PROJECT Hwy 69 Structural Culvert
COORDINATES Coords: 5 078 329.9 N; 222 692.8 E
ORIGINATED BY M.M.
DIST ____ HWY 69
BOREHOLE TYPE CFHSA
COMPILED BY N.L.
DATUM Geodetic
DATE 2021.07.12
LATITUDE 45.839897
LONGITUDE -80.557211
CHECKED BY N.R.

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION
186.0	Ground Surface
0.0	255 mm ASPHALT
185.8 / 0.3	SAND, some gravel. Very dense to loose, Brown, Moist to wet (FILL)
184.2 / 1.8	SILTY CLAY/CLAYEY SILT, sandy/some sand. Very soft to stiff, Grey, Moist to wet
173.2 / 12.8	End of borehole

SAMPLE NUMBER	TYPE	"N" VALUES	FIELD VANE (sensitivity)	GR SA SI CL (%)
1	SS	60		
2	SS	16		
3	SS	9		
4	SS	4	3	0 23 57 20
5	SS	7	3	
6	SS	6	3	
7	SS	4	7	
8	SS	WH	2	
9	SS	6	7	0 17 62 21
10	SS	6	4	
11	SS	12	3	
12	SS	6	2	
13	SS	4	4	

Water content plot annotation: 85

▼ Groundwater level measured upon completion of drilling

WH Penetration due to weight of hammer and rods

NOTES:
1. Borehole caved-in at a depth of 11.3 m (EL. 174.7) below the ground surface, upon extraction of hollow stem augers.

Continued Next Page

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

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 22-10-26

RECORD OF BOREHOLE No C184-2

 METRIC

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 078 329.9 N; 222 692.8 E | ORIGINATED BY M.M.

DIST | HWY 69 | BOREHOLE TYPE CFHSA | COMPILED BY N.L.

DATUM Geodetic | DATE 2021.07.12 | LATITUDE 45.839897 | LONGITUDE -80.557211 | CHECKED BY N.R.

SOIL PROFILE — ELEV/DEPTH; DESCRIPTION; STRAT PLOT | SAMPLES — NUMBER; TYPE; "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60) | UNIT WEIGHT/GAS READING γ kN/m³ / ppm/% | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

171.0

2. In-situ sheer vane tests were conducted in a seperate borehole located within 1.0 m of Borehole C184-2

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 22-10-26

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

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No C184-3

 METRIC

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 078 328.9 N; 222 693.0 E | ORIGINATED BY M.M.

DIST | HWY 69 | BOREHOLE TYPE CFHSA | COMPILED BY N.L.

DATUM Geodetic | DATE 2021.07.13 - 2021.07.14 | LATITUDE 45.839928 | LONGITUDE -80.556967 | CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION
185.9	Ground Surface
0.0	SAND, some gravel, trace silt, asphalt debris Loose, Grey, Moist SANDY SILT, trace gravel Compact, Grey, Moist CLAYEY SILT, sandy Firm to stiff, Brown, Wet (FILL)
183.5 / 2.4	SILTY CLAY/CLAYEY SILT, trace/some sand Very soft to soft, Grey, Wet
173.1 / 12.8	End of borehole

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	9				
2	SS	15				
3	SS	5	0	40	45	15
4	SS	9				
5	SS	4	0	9	48	43
	VANE					
6	SS	5				
	VANE					
7	SS	4				
	VANE					
8	SS	WH	0	18	62	20
	VANE					
9	SS	3				
	VANE					
10	SS	4				
	VANE					
11	SS	3				

Elevation scale: 185, 184, 183, 182, 181, 180, 179, 178, 177, 176, 175, 174

Field vane sensitivities: 4, 3, 3, 2, 4, 3

Ground water: ▼ at approx. El. 184.1

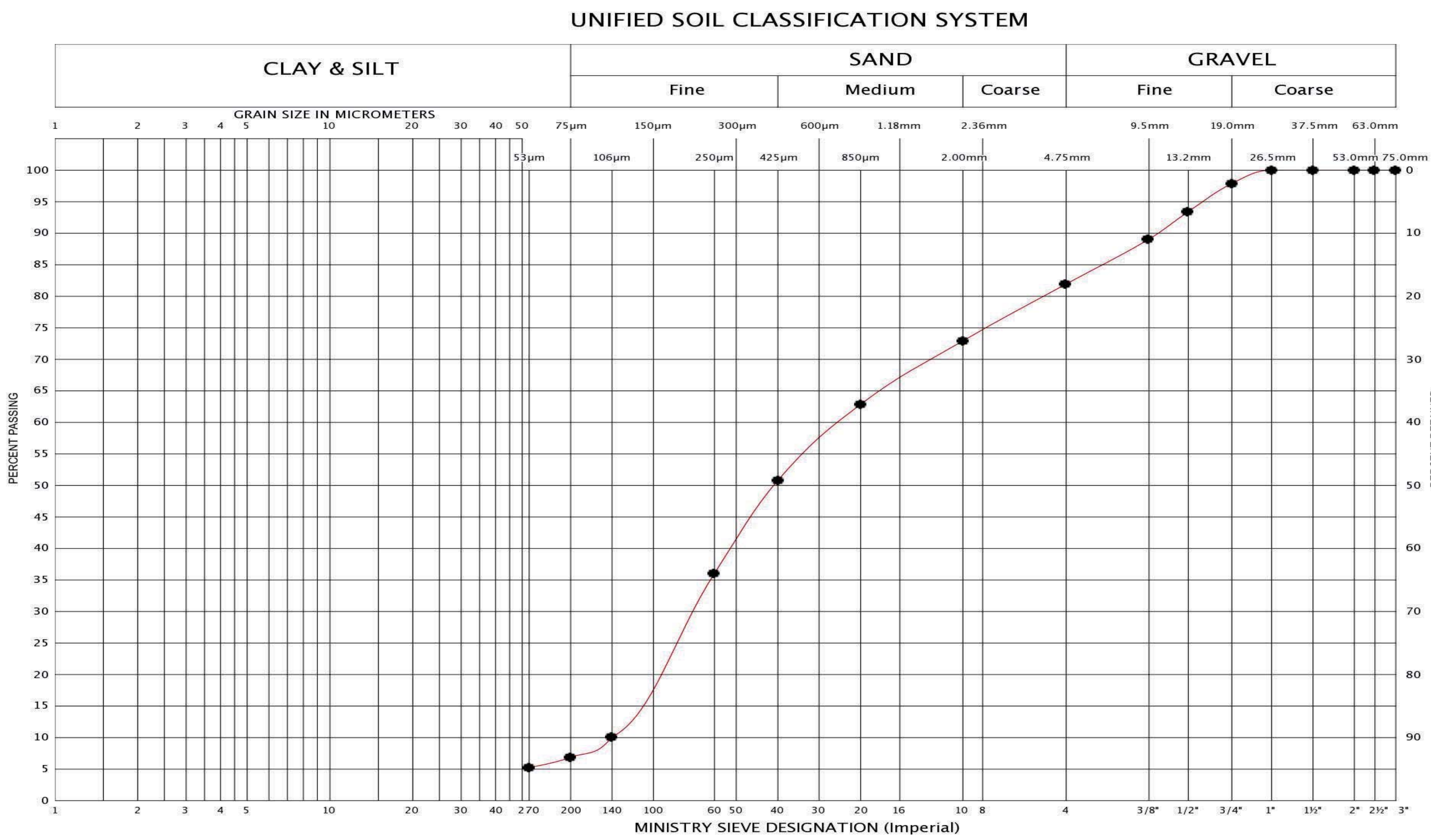
▼ Groundwater level measured upon completion of drilling

WH Penetration due to weight of hammer and rods

NOTE: Borehole caved-in at a depth of 11.6 m (EL. 174.3) below the ground surface, upon extraction of hollow stem augers.

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 22-10-26

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



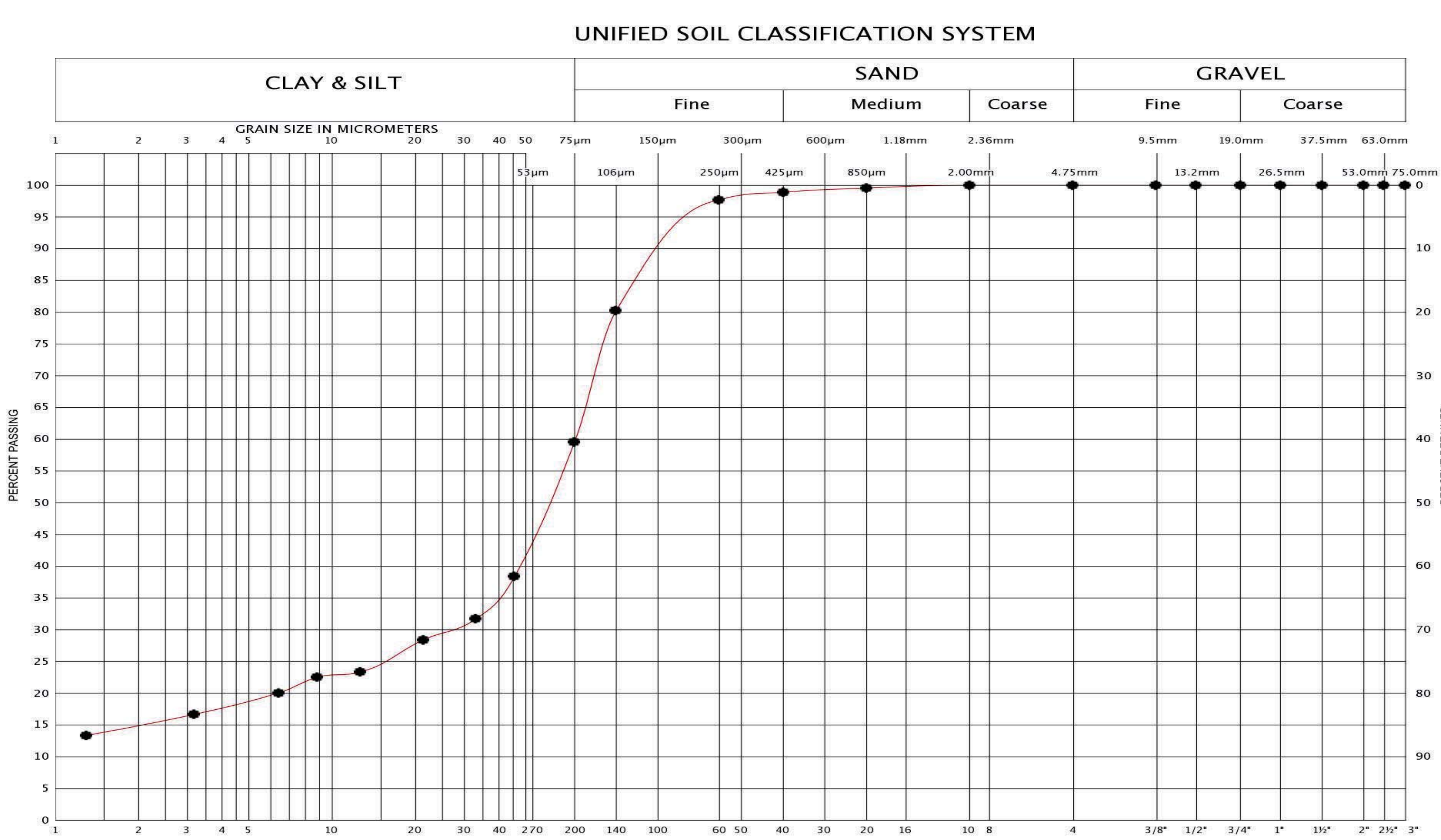
LEGEND		
	BH	C184-1
	SAMPLE	1
	SYMBOL	●

Ontario

GRAIN SIZE DISTRIBUTION

SAND FILL

FIG No.: GS-G-1
HWY : 69
Project No.: 14TF034G



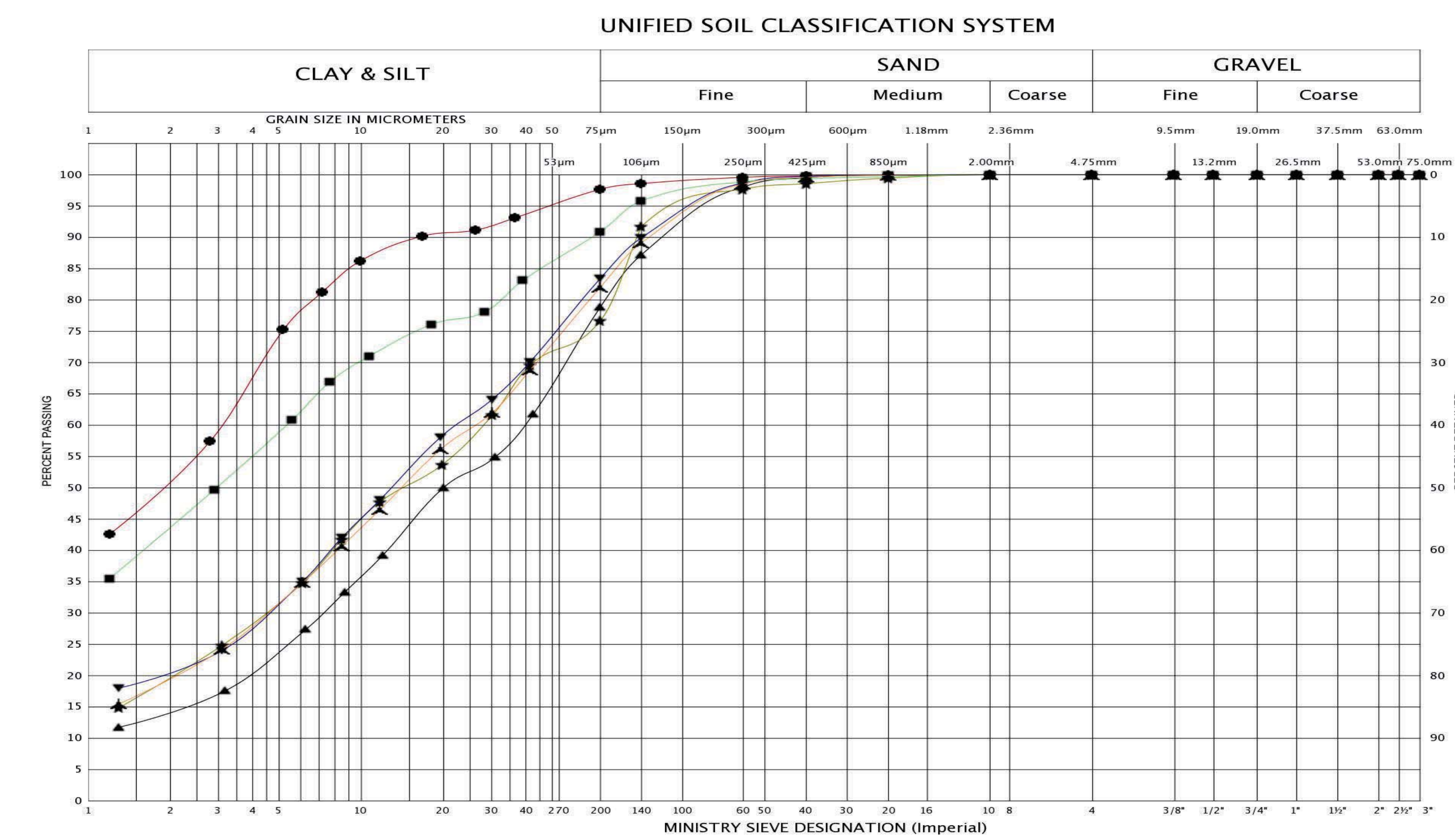
LEGEND		
	BH	C184-3
	SAMPLE	3
	SYMBOL	●

Ontario

GRAIN SIZE DISTRIBUTION

CLAYEY SILT FILL

FIG No.: GS-G-2
HWY : 69
Project No.: 14TF034G



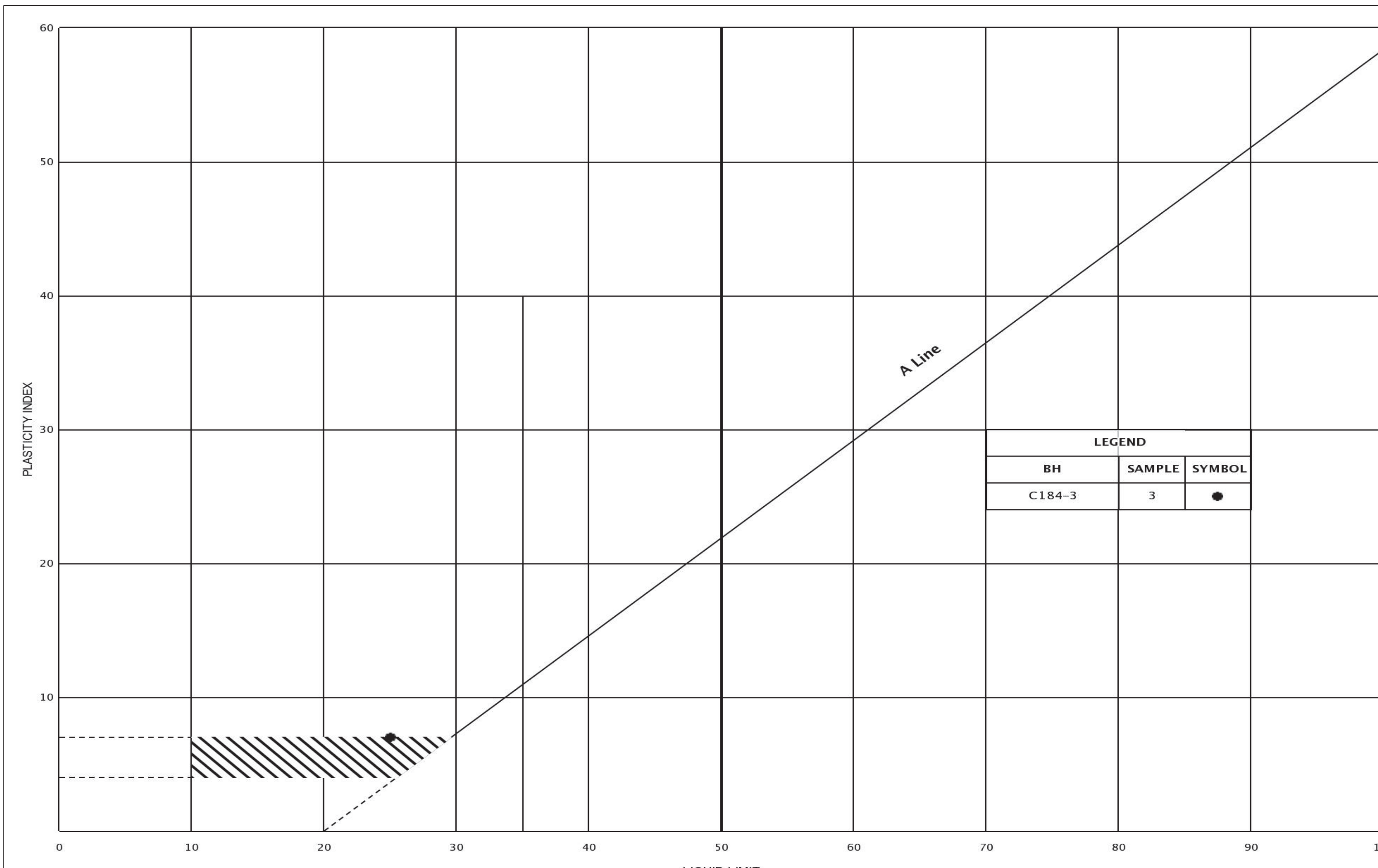
LEGEND	BH	C184-1	C184-1	C184-2	C184-2	C184-3	C184-3
	SAMPLE	4	8	4	9	5	8
	SYMBOL	●	▲	★	▼	■	⅄

Ontario

GRAIN SIZE DISTRIBUTION

SILTY CLAY/CLAYEY SILT FILL

FIG No.: GS-G-3
HWY : 69
Project No.: 14TF034G

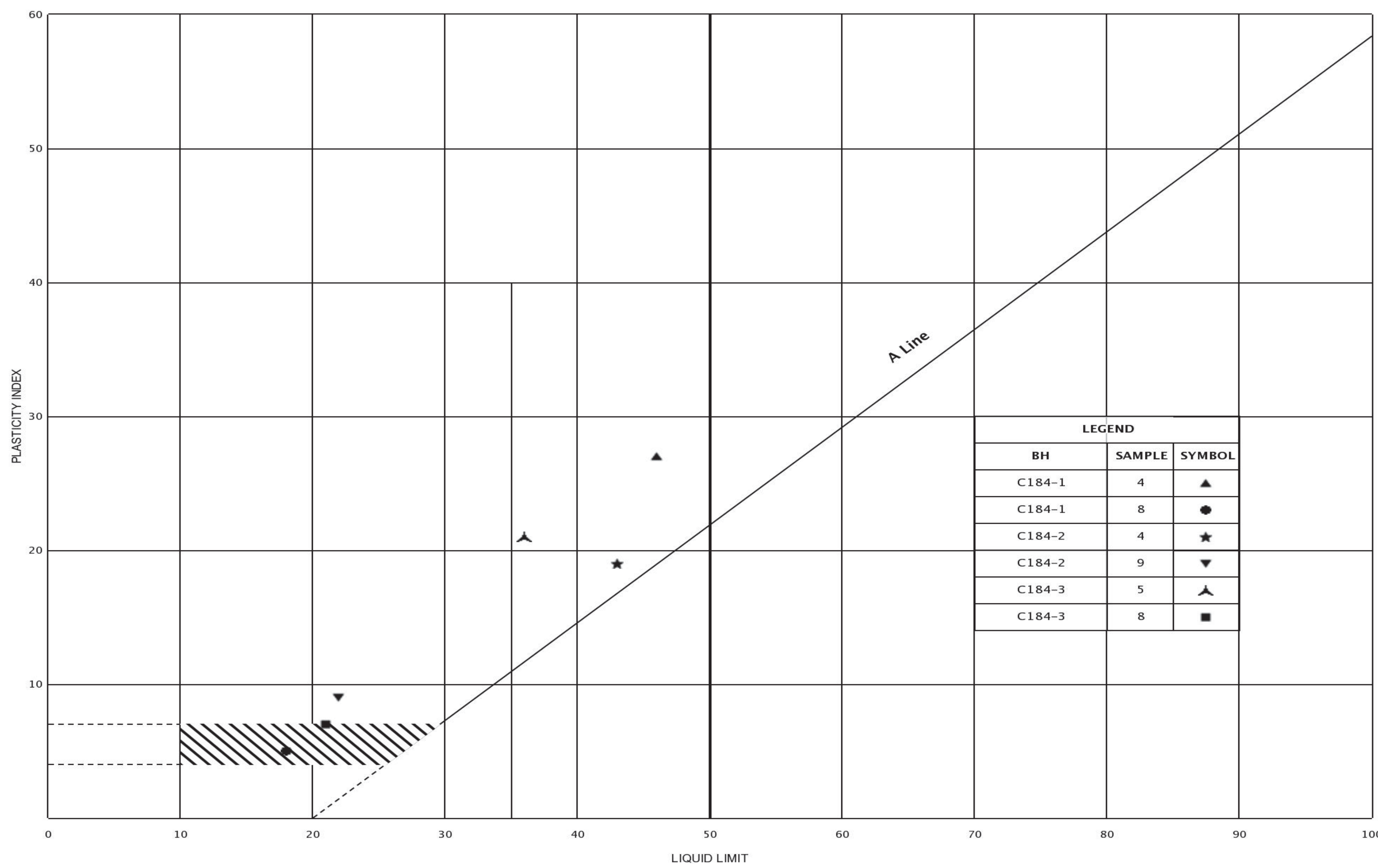


Ontario

PLASTICITY CHART

CLAYEY SILT FILL

FIG No.: PC-G-1
HWY.: 69
Proj No. 14TF034G



PLASTICITY CHART

SILTY CLAY/CLAYEY SILT

FIG No.:	PC-G-2
HWY.:	69
Proj No.	14TF034G

SHEET H1 – CVH-25 - Fisheries Culvert (Station: ± 16+850 Hwy 69 SBL – Henvey)

- Borehole Location Plan (PML)
- Record of Borehole Logs (PML)
- Laboratory Test Results (PML)

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field work for Culvert CVH-25 at Station 16+850, in the Township of Henvey (Site Nos. 044-0649/01under the SBL) was carried out on November 9, 2021.

2. BOREHOLE INFORMATION

A total of two (2) boreholes were advanced by manual methods, including hand auger, probe rod and Shelby (thin wall) sample tubes, along the proposed alignment of the proposed culvert (Site No. 044-0649/01). There were no accessible roadways/pathways for track/truck mounted drill rig or portable tripod equipment to the proposed culvert site.

Refer to
- Drawing H1-1 for the borehole location plan
- Table H-1 for details of borehole origin, borehole location coordinates and borehole elevations/depths
- Borehole sheets and lab results showing details of the subsurface conditions at the borehole locations from current investigation

Table H1-1 Structural Culvert Borehole Information

BOREHOLE ID	BOREHOLE LOCATION	MTM ON10 NAD 83 COORDINATES		GROUND SURFACE ELEVATION (m)	BOREHOLE DEPTH (m)
		NORTHING (m)	EASTING (m)		
CVH25-1	West End (Outlet)	5 079 087.6	222 749.5	185.8	1.0
CVH25-2	East End (Inlet)	5 079 101.7	222 792.6	186.6	0.3

2.1. Subsurface Conditions

During investigation, cobbles and boulders were observed on the ground surface in the vicinity of the culvert site. Typically, the topography was undulating and was generally sloping down from east to west. An open large rock outcrop area was observed some 25m to 50 m north of the culvert site. A lake is located at the west of the site.

The stratigraphy generally consists of approximately 200 mm of peat, underlain by silty sand to sandy silt to the termination depth of drilling, near the west end of the proposed culvert. At the east end of the culvert, sandy clayey silt was encountered immediately below the ground surface to the termination depth of drilling. The boreholes were terminated on probable boulder. Refer to the Record of Boreholes for details. Generally, boulders were observed on the ground along the creek banks.

The subsurface conditions at this site can be categorized into four (4) general layers as presented below from surface downwards.

2.1.1. Peat

A 200 mm thick layer of peat was encountered at the existing ground surface in Borehole CVH25-1, which was drilled on the west end of the proposed culvert alignment.

2.1.2. Silty Sand to Sandy Silt

This layer of silty sand to sandy silt was encountered below the peat in Borehole CVH25-1, and extended to the depth of termination. Moisture content determinations of two (2) samples from this layer were 25.1% and 50.5%.

The grain size distribution results of the selected samples are provided in Figure GS-H1-1.

2.1.3. Sandy Clayey Silt

This sandy clayey silt deposit was encountered immediately below the ground surface in Borehole CVH25-2 extending to the borehole termination depth of 0.3 m below the existing ground surface. The moisture content determination of one (1) sample tested from this layer was 49.6%.

The grain size distribution test results of one (1) representative sample selected from this layer are provided in Figure GS-H1-2 and the Atterberg limits are presented in Figure PC-H1-1.

2.1.4. Probable Bedrock/Boulder

Boreholes CVH25-1 and CVH-2 were terminated at depths of 1.0 m (EL. 184.8) and 0.3 m (EL. 186.3), respectively, below the existing ground surface due to refusal of hand auger/probe on probable bedrock/boulder.

2.2. Groundwater Conditions

Groundwater was not encountered inside any of the boreholes during drilling. Upon completion of drilling, groundwater levels were measured at a depth of 0.3 m (EL. 185.5) below the existing ground surface in Boreholes CVH25-1. Groundwater level was not encountered upon completion of drilling in Borehole CVH25-2. The creek water level at the inlet of the existing culvert was measured at Elevation 185.8 m, on November 9, 2021.

Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) are based on the following references:

1. Foundation Investigation and Design Report – Swamp 304 - Swamp Crossings and High Fill Areas – Contract 3, 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, (GEOCRES No. 41H-134), submitted to URS Canada Inc. by Golder Associates, February 11, 2014 (Report Number: 09-1111-6014-3520)
2. Highway 69 Profile Drawings, provided by Parson via email dated November 25, 2020
3. Culvert Sections Drawings, provided by Parsons via email dated November 25, 2020

3. PROJECT DESCRIPTION

3.1. General

The proposed Fisheries Culvert (Site No. 044-0649/01) is a new structure across the new alignment of Highway 69 SBL. The culvert is located within the Township of Henvey.

3.2. Proposed Structure

It is proposed that the culvert will have an opening size of 3.0 m in span, 2.4 m in height, will be approximately 44.0 m long and will be on a skew of approximately 26 degrees to the new alignment of the new Highway 69 NBL alignment.

The existing ground surface in the vicinity of the culvert alignments varies from approximate EL. 185.8 m to EL. 186.6 m. The terrain is undulating and slopes west towards the existing Highway 69, and a narrow creek traverses the area from east to west to a larger water body.

Based on Reference 2, the proposed invert level of the culvert is approximately at EL. 185.8 m. Silty sand/sandy silt/sandy clayey silt is anticipated at the invert level of the culvert.

Table H: Box Culvert Founding Elevations at Station 16+868 SBL CVH-26 Culvert (Site No. 044-0649/01)

PROPOSED CULVERT INVERT ELEVATION	BOTTOM OF BOX CULVERT ELEVATION	SUBGRADE ELEVATION FOR GRANULAR BEDDING	FOUNDING STRATUM
185.8 m	185.5 m	185.0 m	Probable bedrock / Silty sand/sandy silt

Note(s): 1: The bottom thickness of the precast concrete box culvert is assumed 0.25 m (minimum).

Based on Reference 3, the height of embankment fill required above the culvert to the proposed grade of Highway 69 NBL at Station 16+866.71 is not expected to exceed 4.7 m, including the pavement structure.

In the absence of any structural details of the culverts, at the time of writing this report, it is assumed that concrete culvert and fill would impose a dead load of 135 kPa on the founding subgrade.

4. EVALUATION OF FOUNDATION ALTERNATIVES

The foundation alternatives listed below were based on the available information in References 1, 2 and 3, and also considered the construction of the embankments across swamp 304 in Reference 1, including the assumed embankment fill required above the culvert that is not expected to exceed 4.7 m. Reference 1 indicates that 5.0 m high rock fill embankment to be used for preloading with no surcharge over Swamp 304 area. It is estimated that 90% of primary consolidation will be completed in 15 days.

1. Precast concrete box culverts placed without settlement mitigation
2. Precast concrete box culverts placed after preloading or surcharging

For both options, assuming that the culvert is placed at the proposed subgrade level of EL. ±185.0 m, silty sand/sandy silt/sandy clayey silt or probable boulder is expected underneath the base of the culvert. Any boulder/cohesive soils encountered at the subgrade level should be excavated, and replaced with approved granular material.

It is recommended to provide a minimum 500 mm of combined granular and levelling course with a 400 mm thick granular bedding below the culvert. The bedding material should be composed of Granular A or Granular B Type II, and be compacted in conformance with OPSS.PROV 501. Alternatively, 20 mm clear stone could be used provide that the stone is wrapped in a geotextile for separation from the native soil or rockfill to avoid loss of fines in the surrounding voids.

No major settlement issues are expected under the imposed load of 135 kPa at the culvert location as it is anticipated that all peat/cohesive soil will be excavated to found the subgrade level for the culvert installation. It is anticipated that probable bedrock/boulder may need to be excavated to found the subgrade elevation. The subsurface below 0.3 m could not be penetrated during investigation at borehole CVH25-2.

Since there is no existing road or proposed structure where the culvert is proposed, it is recommended that the construction of precast concrete box culvert be coordinated with the construction of the embankment fill across Swamp 304. It is suggested that Option 1 be considered for the installation of the culvert. Prior to construction of the embankment with rockfill over the culvert area, the culvert should be installed in accordance with OPSS.PROV 422.

Unsuitable/organic materials at the culvert location should be excavated from within the zone of influence of the culvert (minimum of 2.0 m beyond the culvert walls) and the area under the culvert when preparing the subgrade for the culvert. The exposed subgrade should be inspected and approved before placement of compacted granular materials as specified in OPSS 422.07.06.

The granular material to backfill the precast concrete box culvert should be placed in accordance with OPSS 422.07.07. Granular material should be as specified in accordance with OPSS 422.05.13 and may consist of either Granular 'A' or Granular 'B' Type II, including a 75 mm levelling course for bedding purposes as required by OPSS 422.07.08.

The precast concrete box culvert may be designed assuming a factored geotechnical resistance of 260 kPa at ULS and 140 kPa at SLS placed on silty sand/sandy silt soils. For bedrock surface, where encountered, SLS will not govern because the loads required to produce detrimental deformation is anticipated to be larger than the factored resistance at ULS. Following placement of the precast concrete box culvert as recommended and the estimated fill of 4.7 m above the culvert, it is estimated that the total settlement would be less than 25 mm and the differential settlement between 15 mm and 20 mm. Generally, for precast concrete box culvert, a tolerable limit of 100 mm of differential settlement is assumed.

If Option 2 is considered, excavation up to 7.9 m of fill and subsurface soil and/or probable boulders would be required to install the culvert at the subgrade level. Furthermore, it would also require additional handling of the fill material. Reference 1 recommends the use of preloading with rockfill to mitigate the post-construction settlement in the area of Swamp 304. During preloading, granular soils, instead of rockfill, would need to be utilized for preloading over the proposed culvert area for ease of excavation for the installation of the culvert. Option 2 may also require temporary shoring during excavation and installation of the culvert. Following the installation of the culvert, the rockfill may be placed as suggested in Reference 1. It is considered that Option 2 is feasible but not preferred.

5. CULVERT BEDDING AND COVER MATERIALS

Refer to the General Report for preliminary recommendations for materials to be used for culvert bedding and cover purposes.

6. APPROACH EMBANKMENT

The details for design, construction, and mitigation procedures for the embankment through Swamp 304 were presented in the report Reference 1. This report may be consulted for placement of fill for the swamp crossing and no recommendation is provided in this report.

7. CONSTRUCTION CONSIDERATIONS

7.1. Excavation

Considering the existing ground level (EL. 185.8 m to EL. 186.6 m) and the culvert subgrade level (EL. ±185.0 m), 0.8 m to 1.6 m deep excavation into existing soils and/or probable bedrock/boulders is needed for subgrade preparation. Slope instability issues are not anticipated.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

Preliminary recommendations for backfilling to the culvert are provided in the General Report.

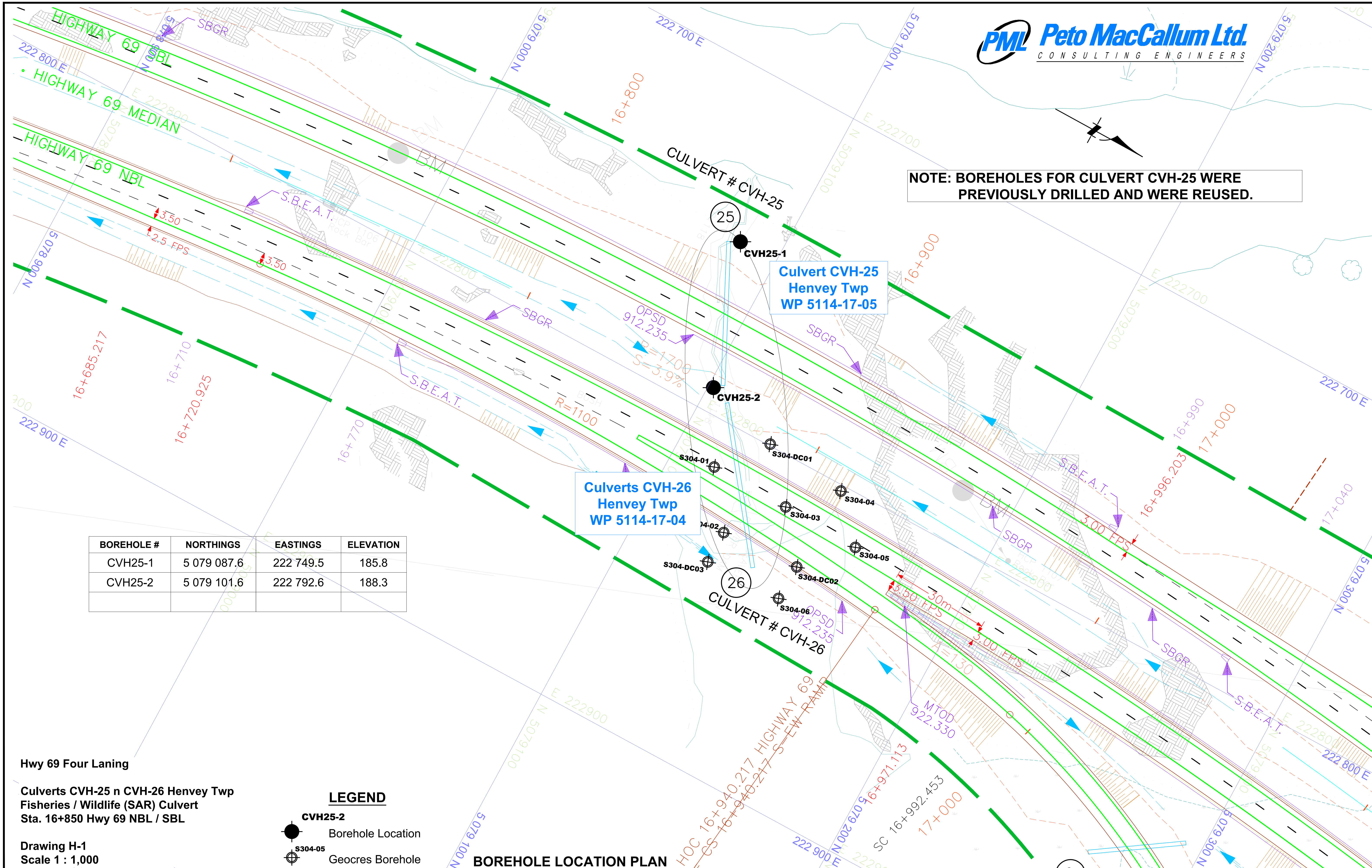
7.2. Groundwater and Surface Water Control

Surface water flow should be directed away from the excavation areas to mitigate disturbance of the native subgrade by means of temporary pipe. Dewatering may be carried out from sumps along the interior periphery of the excavation to maintain the groundwater level a minimum of depth of 0.5 m below the base of excavations. For construction in-the-dry, the flowing water will have to be temporary diverted.

Refer to the General Report for further groundwater control recommendations and requirements for water taking.

7.3. Additional Investigation

It is suggested that additional investigation below the depth of the proposed subgrade level be carried out during the detail design within 2.0 m north or south of the proposed culvert along the centreline of Highway 69 NBL and at the ends of the culvert to confirm the presence of bedrock, and groundwater conditions. Based on the data, the recommendations provided in this report may have to be revised.



NOTE: BOREHOLES FOR CULVERT CVH-25 WERE PREVIOUSLY DRILLED AND WERE REUSED.

BOREHOLE #	NORTHINGS	EASTINGS	ELEVATION
CVH25-1	5 079 087.6	222 749.5	185.8
CVH25-2	5 079 101.6	222 792.6	188.3

BOREHOLE LOCATION PLAN

Hwy 69 Four Laning

Culverts CVH-25 n CVH-26 Henvey Twp
Fisheries / Wildlife (SAR) Culvert
Sta. 16+850 Hwy 69 NBL / SBL

Drawing H-1
Scale 1 : 1,000

LEGEND

CVH25-2 Borehole Location

S304-05 Geocres Borehole

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No CVH25-1

METRIC

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 079 087.6 N; 222 749.5 E | ORIGINATED BY M.M.

DIST ______ HWY 69 | BOREHOLE TYPE Manual Probe | COMPILED BY N.L.

DATUM Geodetic | DATE 2021.11.09 | LATITUDE 45.846755 | LONGITUDE -80.556413 | CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	GR	SA	SI	CL
185.8	Ground Surface									
185.6 / 0.0	PEAT				▼					
0.2	SILTY SAND TO SANDY SILT Mottled grey/brown, Wet	1	TW				0	40	50	10
184.8		2	GRAB			185	0	36	53	11
1.0	End of borehole Hand auger refusal on probable bedrock									

Column headings: SOIL PROFILE; SAMPLES; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT/ GAS READING γ kN/m^3 / ppm/%; REMARKS & GRAIN SIZE DISTRIBUTION (%)

▼ Groundwater level measured upon completion of drilling

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

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 23-7-25

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No CVH25-2

METRIC

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 079 101.7 N; 222 792.6 E | ORIGINATED BY M.M.

DIST ______ HWY 69 | BOREHOLE TYPE Manual Probe | COMPILED BY N.L.

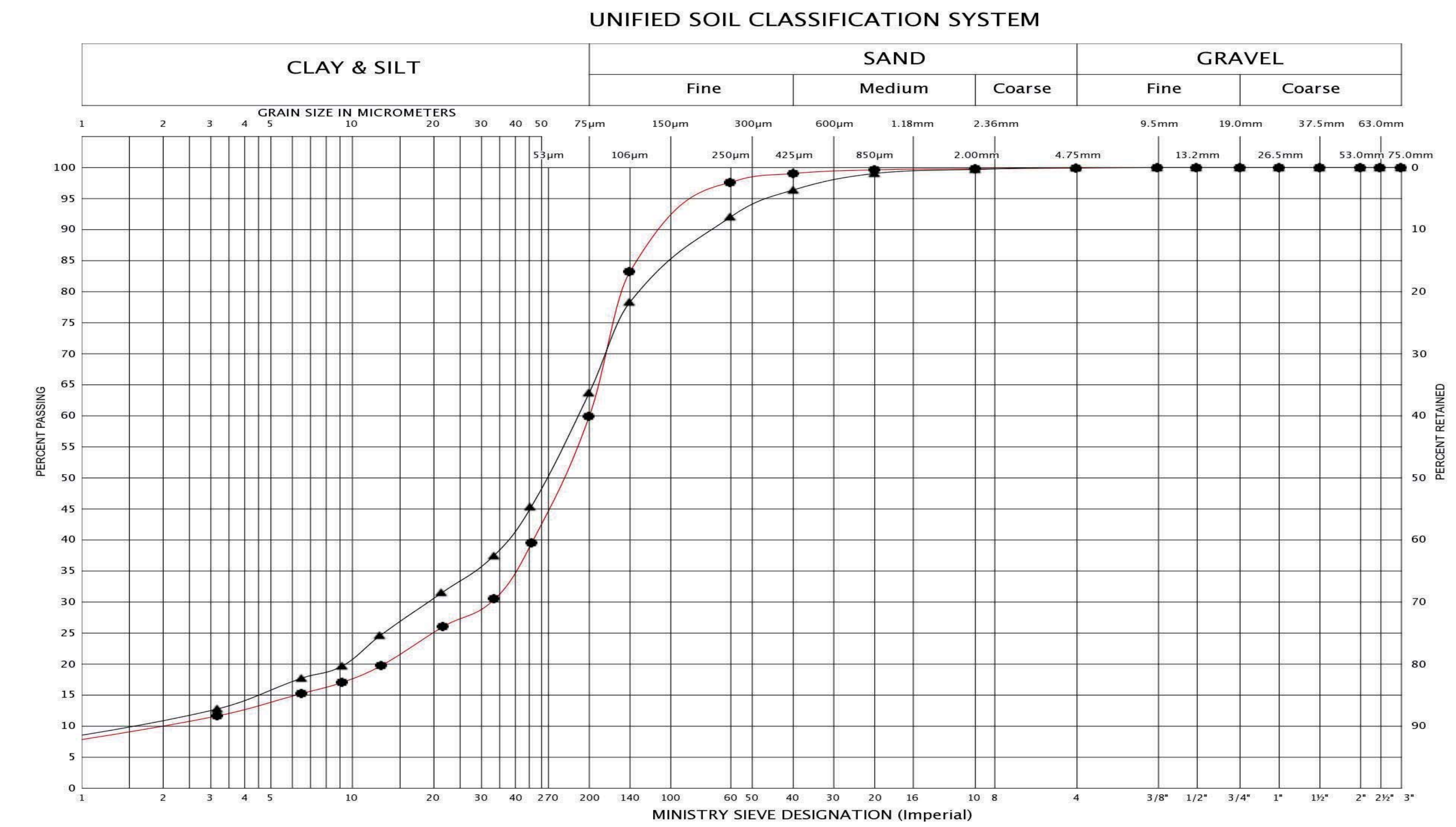
DATUM Geodetic | DATE 2021.11.09 | LATITUDE 45.846886 | LONGITUDE -80.55586 | CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	GR	SA	SI	CL
186.6	Ground Surface									
0.0	Sandy CLAYEY SILT, organics Mottled brown/grey, Wet	1	TW				0	27	56	17
186.3 / 0.3	Borehole terminated due to refusal on probable boulder									

Column headings: SOIL PROFILE; SAMPLES; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT/ GAS READING γ kN/m^3 / ppm/%; REMARKS & GRAIN SIZE DISTRIBUTION (%)

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

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 23-7-25



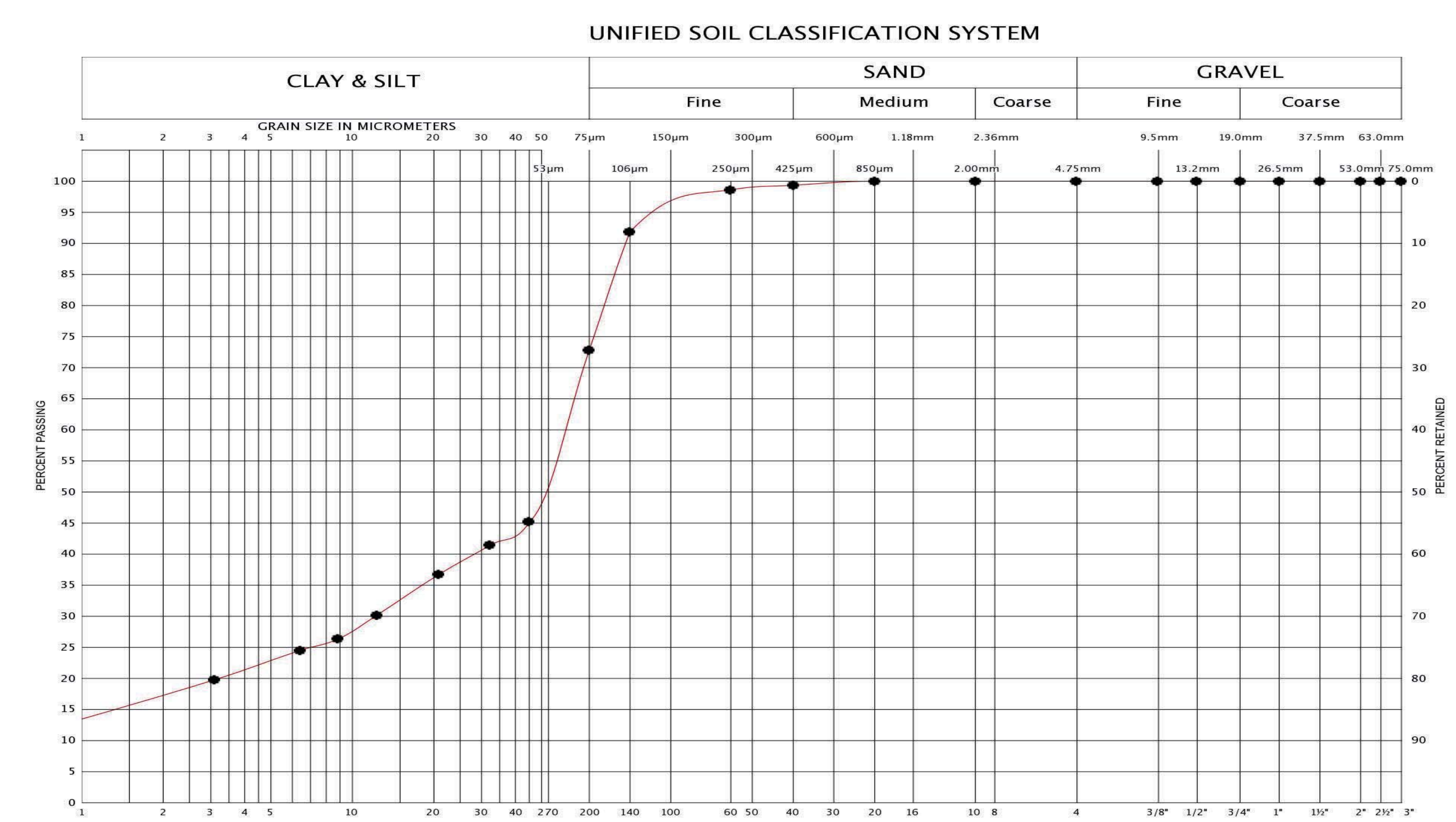
LEGEND	BH	CVH25-1	CVM25-1
	SAMPLE	1	2
	SYMBOL	●	▲

Ontario

GRAIN SIZE DISTRIBUTION

SANDY SILT

FIG No.: GS-H1-1
HWY : 69
Project No.: 14TF034G



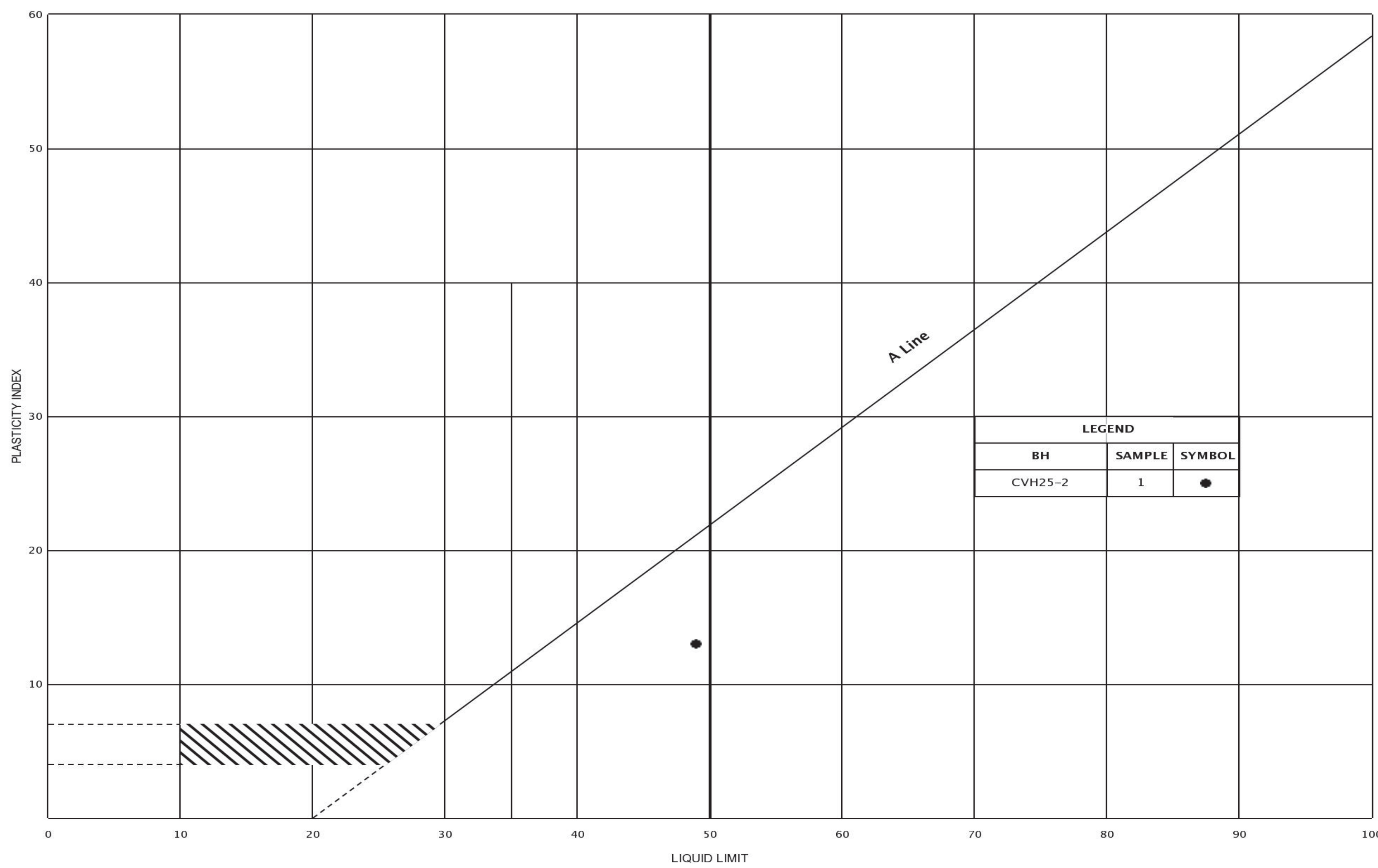
LEGEND	BH	CVH25-2
	SAMPLE	1
	SYMBOL	●

Ontario

GRAIN SIZE DISTRIBUTION

Sandy CLAYEY SILT

FIG No.: GS-H1-2
HWY : 69
Project No.: 14TF034G



Ontario

PLASTICITY CHART

Sandy CLAYEY SILT

FIG No.:	PC-H1-1
HWY.:	69
Proj No.	14TF034G

SHEET H2 – CVH-26 - Fisheries Culvert (Station: ± 16+850 Hwy 69 NBL – Henvey)

- Borehole Locations and Soil Strata (Geocres 41H-134)
- Record of Borehole Logs (Geocres 41H-134)
- Laboratory Test Results (Geocres 41H-134)

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field work for Culvert CVH-26 at Station 16+868 Henvey Township (Site No. 044-0649/02 under the NBL) was carried out by Golder Associates (Golder) between January 15 and 16, 2012, and a foundation investigation and design report (Reference 1 below) was completed and submitted to MTO.

The following Reference Report is referenced:

1. Foundation Investigation and Design Report – Swamp Crossings and High Fill Areas – Contract 3, 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, (GEOCRES No. 41H-134), submitted to URS Canada Inc. by Golder Associates, February 11, 2014 (Report Number: 09-1111-6014-3520)

2. BOREHOLE INFORMATION

A total of six (6) boreholes (S304-01 to S304-06) and three (3) DCPTs (S304-DC01 to S304-DC03) were advanced by Golder at the proposed swamp location across the northbound lanes (NBL) of the new alignment of Highway 69. For the purpose of this report, four (4) of the investigated boreholes (S304-01, S304-02, S304-03, and S304-06) have been considered relevant for the proposed culvert. The boreholes were advanced utilizing portable equipment equipped with NW casing and wash boring or 70 mm O.D. solid stem auger.

Refer to:
- Drawing H2-1 for the borehole location plan
- Table H2-1 for details of borehole origin, borehole location coordinates and borehole elevations/depths.
- Record of Borehole sheets and lab results showing details of the subsurface conditions at the borehole locations from current investigation.

Table H2-1 Structural Culvert Borehole Information

BOREHOLE ID	BOREHOLE LOCATION	MTM ON10 NAD 83 COORDINATES		GROUND SURFACE ELEVATION (m)	BOREHOLE DEPTH (m)
		NORTHING (m)	EASTING (m)		
S304-01	South of Culvert	5 079 113.4	222 813.8	191.3	3.1
S304-02		5 079 125.6	222 830.0	191.2	4.1
S304-03	North of Culvert	5 079 138.4	222 814.1	190.7	3.3
S304-06	Northeast of Culvert	5 079 149.8	222 839.7	191.4	1.7

2.1. Subsurface Conditions

In general, the stratigraphy consists of approximately 100 mm to 600 mm of surficial peat, ice, and/or water, over silt and sand/silty sand or clayey silt, which is underlain by sandy silt/ silt, followed by sand. Refer to the record of borehole sheets for subsoil conditions at each borehole location.

Based on the factual data presented in the Record of Borehole Sheets and Figures completed by Golder, the subsurface conditions encountered during the site investigation carried out by Golder can be categorized into five (5) general soil layers as presented below.

2.1.1. Peat/Ice/Water

200 mm and 600 mm thick layer of peat was encountered in Boreholes S304-01 and S304-03, respectively.

100 mm and 300 mm thick layer of ice was encountered in Boreholes S304-02 and S304-06, respectively. Below the ice layer in Borehole S304-06, a 600 mm depth of water was encountered, extending to a depth of 900 mm (EL. 198.5 m) below the ice surface.

The SPT ‘N’ values in this layer were 2 blows and 3 blows for 30 cm penetration, indicating very soft to soft consistency.

2.1.2. Silt and Sand/Silty Sand

This sandy layer was encountered immediately below the Peat/Ice/Water layer on Boreholes S304-02, S304-3, and S304-06. This layer is 0.6m to 1.1 m thick and extends to a depth of 1.2 m (EL. 190.6 to EL. 188.9 m) below the existing grade.

The SPT ‘N’ values in this layer ranged from as low as 1 blow to 10 blows for 30 cm penetration, indicating a very loose to loose state of compactness. The moisture contents of one (1) sample tested from this layer was approximately 29%.

The results of the grain size analysis test performed on one (1) representative sample from this layer are provided on Figure D.S304-03. The test results indicate that this deposit consists of 0% gravel, 32% sand, 55% silt and 13% clay sized particles.

2.1.3. Clayey Silt

This clayey silt layer was encountered below the Peat layer in Borehole S304-01 and below the Silt and Sand/Silty Sand layer in Boreholes S304-02, S304-03, and S304-06. This layer extends to depths ranging from 1.8 m to 3.1 m (EL. 188.9 m to EL. 188.1 m) below the existing grade, in Boreholes S304-01 to S304-03, where this layer was fully penetrated. This layer was not fully penetrated in Borehole S304-06, extending to the termination depth of 1.7 m (EL. 189.7 m), below the existing grade where spoon refusal was encountered.

The SPT ‘N’ values in this layer ranged from 9 blows to 17 blows for 30 cm penetration, indicating stiff to very stiff consistency. The moisture contents of samples tested from this deposit ranged from approximately 23% to 47%.

The results of the grain size analysis test performed on two (2) representative samples from this layer are provided on Figure D.S304-01. The test results indicate that this deposit consists of 0% gravel, 4% sand, 57% to 68% silt and 28% to 39% clay sized particles. Atterberg limit tests performed on four (4) representative samples are provided on Figure D.S304-02. The liquid limits of these samples range from 23 to 34, and the corresponding plastic limits range from 17 and 17, resulting in plasticity index values ranging from 9 to 16.

2.1.4. Sandy Silt/Silt

This silt deposit was encountered below the clayey silt in Boreholes S304-01 to S304-03. This layer extends to depths of 3.7 m (EL. 187.5 m) and 2.4 m (EL. 188.3 m) below the existing grade in Boreholes S304-02 and S304-03, respectfully, where this layer was fully penetrated. This layer was not fully penetrated in Borehole S304-01, extending to the termination depth of 3.1 m (EL. 188.2 m), below the existing grade where spoon refusal was encountered.

The SPT ‘N’ values in this layer ranged from 21 blows to over 100 blows for 30 cm penetration, indicating compact to very dense state of compactness. The moisture contents of two (2) samples tested from this layer were approximately 20% and 23%.

The results of the grain size analysis test performed on one (1) representative samples from this layer are provided on Figure D.S304-03. The test results indicate that this deposit consists of 0% gravel, 28% sand, 64 % silt and 8% clay sized particles.

2.1.5. Sand

This sand layer was encountered below the sandy silt/silt layer in Boreholes S304-02 and S304-03, extending to the borehole termination depths of 4.1 m and 3.3 m (EL. 187.1 m and EL. 187.4 m), respectively, where spoon refusal was encountered. This sand layer was not fully penetrated to determine the thickness of the deposit.

The SPT ‘N’ values in this layer ranged from 30 blows to over 100 blows for 30 cm penetration, indicating compact to very dense state of compactness. The moisture contents of one (1) sample tested from this layer was approximately 17%.

The results of the grain size analysis test performed on one (1) representative sample from this layer are provided on Figure D.S304-03. The test results indicate that this deposit consists of 14% gravel, 68% sand, 16% silt and 2% clay sized particles.

2.1.6. Inferred Bedrock Surface

The bedrock surface is inferred based on further split-spoon advancement refusal at the borehole locations approximately from EL. 189.7 to EL. 187.1 m.

2.2. Groundwater Conditions

The groundwater level observed upon completion of drilling was measured at depths 1.2 m (EL. 190.1 m) and 1.8m (EL. 188.9 m) below the existing ground surface in Boreholes S304-01 and S304-03, respectively. The groundwater level was encountered at the existing ground surface in Boreholes S304-02 and S304-06. Groundwater levels may fluctuate due to the influence of precipitation and seasonal changes.

PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) are based on the following references:

1. Foundation Investigation and Design Report – Swamp Crossings and High Fill Areas – Contract 3, 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, (GEOCRES No. 41H-134), submitted to URS Canada Inc. by Golder Associates, February 11, 2014 (Report Number: 09-1111-6014-3520)
2. Culvert Sections Drawings, provided by Parsons via email dated November 25, 2020
3. Highway 69 Profile Drawings, provided by Parson via email dated November 25, 2020.

3. PROJECT DESCRIPTION

3.1. General

The proposed Fisheries/Wildlife (SAR) Culvert (Site No. xx-xx) is a new structure across the new alignment of Highway 69 NBL. The culvert is located within the Swamp 304 area in the Township of Henvey.

3.2. Proposed Structure

It is proposed that the culvert will have an opening size of 3.0 m in span, 2.4 m in height, will be approximately 51.0 m long and will be on a skew of approximately 37 degrees to the new alignment of the new Highway 69 NBL alignment.

The existing ground surface in the vicinity of the culvert alignments varies from approximate EL. 190.7 m to EL. 191.4 m. The terrain is undulating and slopes west towards the existing Highway 69, and a narrow creek traverses the area from east to west.

Based on Reference 3, the proposed invert level of the culvert is approximately at EL. 187.8 m. Compact cohesionless sandy silt/silt/sand is anticipated at the invert level of the culvert.

Table H: Box Culvert Founding Elevations at Station 16+868 NBL CVH-26 Culvert (Site No. 044-0649/02)

PROPOSED CULVERT INVERT ELEVATION	BOTTOM OF BOX CULVERT ELEVATION	SUBGRADE ELEVATION FOR GRANULAR BEDDING	FOUNDING STRATUM
187.8 m	187.5 m	187.2 m	Probable bedrock / Compact sandy silt/silt/sand

Note(s): 1: The bottom thickness of the precast concrete box culvert is assumed 0.25 m (minimum).

Based on Reference 2, the height of embankment fill required above the culvert to the proposed grade of Highway 69 NBL at Station 16+868 is not expected to exceed 4.7 m, including the pavement structure. Reference Report 1 indicates that the maximum height of embankment across Swamp 304 will be 5.0 m.

In the absence of any structural details of the culverts, at the time of writing this report, it is assumed that concrete culverts and fill would impose a dead load of 70 kPa on the founding subgrade.

4. EVALUATION OF FOUNDATION ALTERNATIVES

The foundation alternatives listed below were based on the available information in References 1, 2 and 3 and also considered the construction of the embankments across swamp 304 in Reference 1, including the assumed embankment fill required above the culvert that is not expected to exceed 4.7 m. Reference 1 indicates that 5.0 m high rock fill embankment to be used for preloading with no surcharge over Swamp 304 area. It is estimated that 90% of primary consolidation will be completed in 15 days.

1. Precast concrete box culverts placed without settlement mitigation
2. Precast concrete box culverts placed after preloading or surcharging

For both options, assuming that the culvert is placed at the proposed subgrade level of EL. ±187.2 m, compact sandy silt/silt/sand or probable bedrock is expected underneath the base of the culvert. No major settlement issues are expected under the imposed load of 70 kPa at the culvert location as it is anticipated that all cohesive soil will be excavated to found the subgrade level for the culvert installation.

Since there is no existing road or proposed structure where the culvert is proposed, it is recommended that the construction of precast concrete box culvert be coordinated with the construction of the embankment fill across Swamp 304. It is suggested that Option 1 be considered for the installation of the culvert. Prior to construction of the embankment with rockfill over the culvert area, the culvert should be installed in accordance with OPSS.PROV 422.

Unsuitable/organic materials at the culvert location should be excavated from within the zone of influence of the culvert (minimum of 2 m beyond the culvert walls) and the area under the culvert when preparing the subgrade for the culvert. The exposed subgrade should be inspected and approved before placement of compacted granular materials as specified in OPSS 422.07.06.

The granular material to backfill the precast concrete box culvert should be placed in accordance with OPSS 422.07.07. Granular material should be as specified in accordance with OPSS 422.05.13 and may consist of either Granular ‘A’ or Granular ‘B’ Type II, including a 75 mm levelling course for bedding purposes as required by OPSS 422.07.08.

The precast concrete box culvert may be designed assuming a factored geotechnical resistance of 185 kPa at ULS and 100 kPa at SLS placed on compact sandy silt/silt/sand soils. For bedrock surface, SLS will not govern because the loads required to produce detrimental deformation is anticipated to be larger than the factored resistance at ULS. Following placement of the precast concrete box culvert as recommended and the estimated fill of 4.7 m above the culvert, it is estimated that the total settlement would be less than 25 mm and the differential settlement between 15 mm and 20 mm. Generally, for precast concrete box culvert, a tolerable limit of 100 mm of differential settlement is assumed.

If Option 2 is considered, excavation up to 8.0 m of fill and subsurface soil would be required to install the culvert at the subgrade level. Furthermore, it would also require additional handling of the fill material. Reference 1 recommends the use of preloading with rockfill to mitigate the post-construction settlement in the area of Swamp 304. During preloading, granular soils, instead of rockfill, would need to be utilized for preloading over the proposed culvert area for ease of excavation for the installation of the culvert. Option 2 may also require temporary shoring during excavation and installation of the culvert. Following the installation of the culvert, the rockfill may be placed as suggested in Reference 1. It is considered that Option 2 is feasible but not preferred.

5. CULVERT BEDDING AND COVER MATERIALS

Refer to the General Report for preliminary recommendations for materials to be used for culvert bedding and cover purposes.

6. APPROACH EMBANKMENT

The details for design, construction, and mitigation procedures for the embankment through Swamp 304 were presented in the report Reference 1. This report may be consulted for placement of fill for the swamp crossing and no recommendation is provided in this report.

7. CONSTRUCTION CONSIDERATIONS

7.1. Excavation

Considering the existing ground level (EL. 190.5 m to EL. 191.3 m) and the culvert subgrade level (EL. ±187.2 m), 3.3 m to 4.1 m deep excavation into native soils and probable bedrock is needed for subgrade preparation. Slope instability issues are not anticipated. Bedrock surface may be encountered along the culvert alignment and up to 2.5 m of bedrock excavation may be required to found the culvert subgrade level.

If Option 2 is selected, approximately 8.0 m of excavation into the embankment fill would be required and the stability of the temporary slope excavation should be assessed at the design-build stage. The Contractor should consider the type of preloaded and/or surcharge material over the culvert area to facilitate excavation and disposal or reuse of the temporary fill materials.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

Preliminary recommendations for backfilling to the culvert are provided in the General Report.

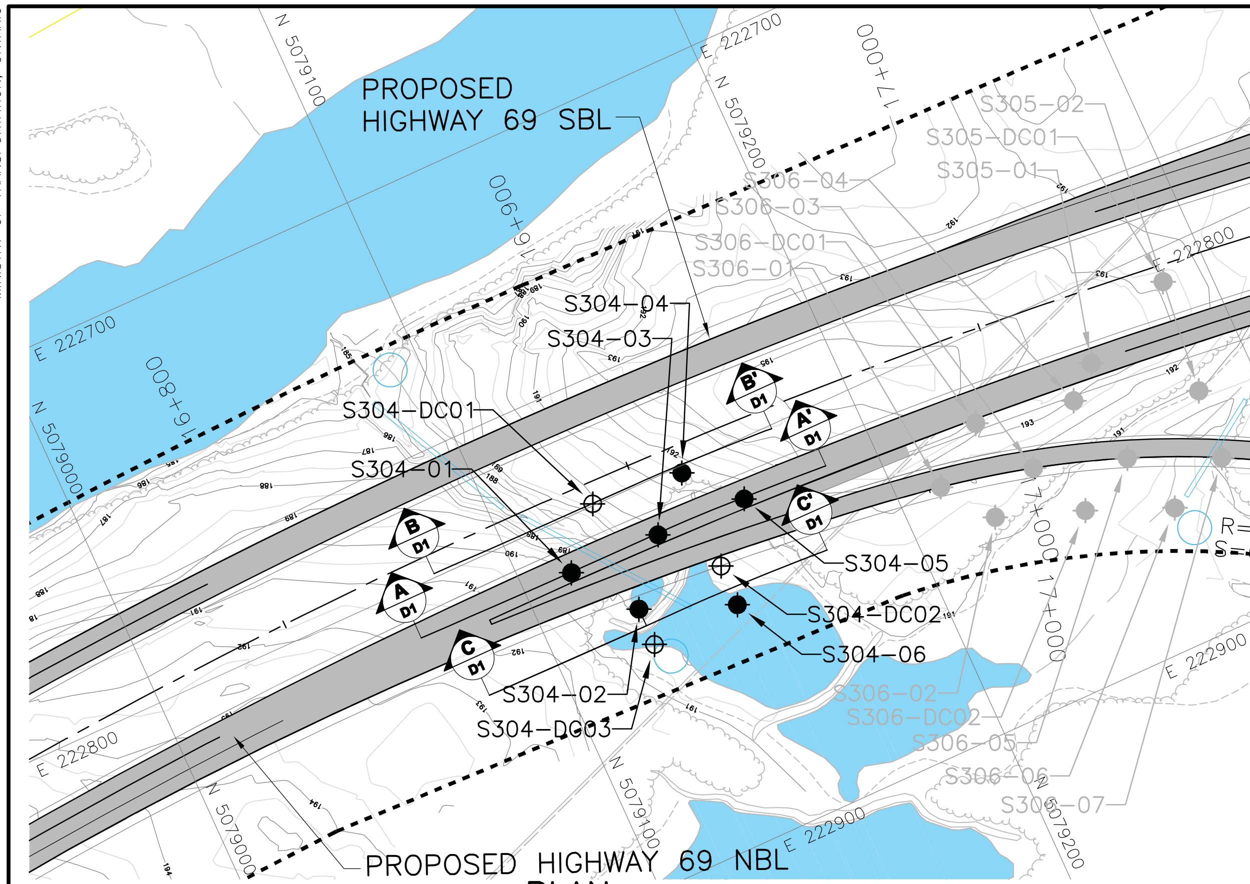
7.2. Groundwater and Surface Water Control

For construction in-the-dry, the existing beaver dams should be removed for the construction of the embankment and the culvert. Unwatering after beaver dam removal and groundwater dewatering may be carried out from sumps located along the interior periphery of the excavation.

Refer to the General Report for further groundwater control recommendations and requirements for water taking.

7.3. Additional Investigation

It is suggested that additional investigation to 3.0 m below the depth of the proposed subgrade level be carried out during the detail design within 2.0 m north or south of the proposed culvert along the centreline of Highway 69 NBL and at the ends of the culvert to confirm the presence of bedrock, and groundwater conditions. Based on the data, the recommendations provided in this report may have to be revised.

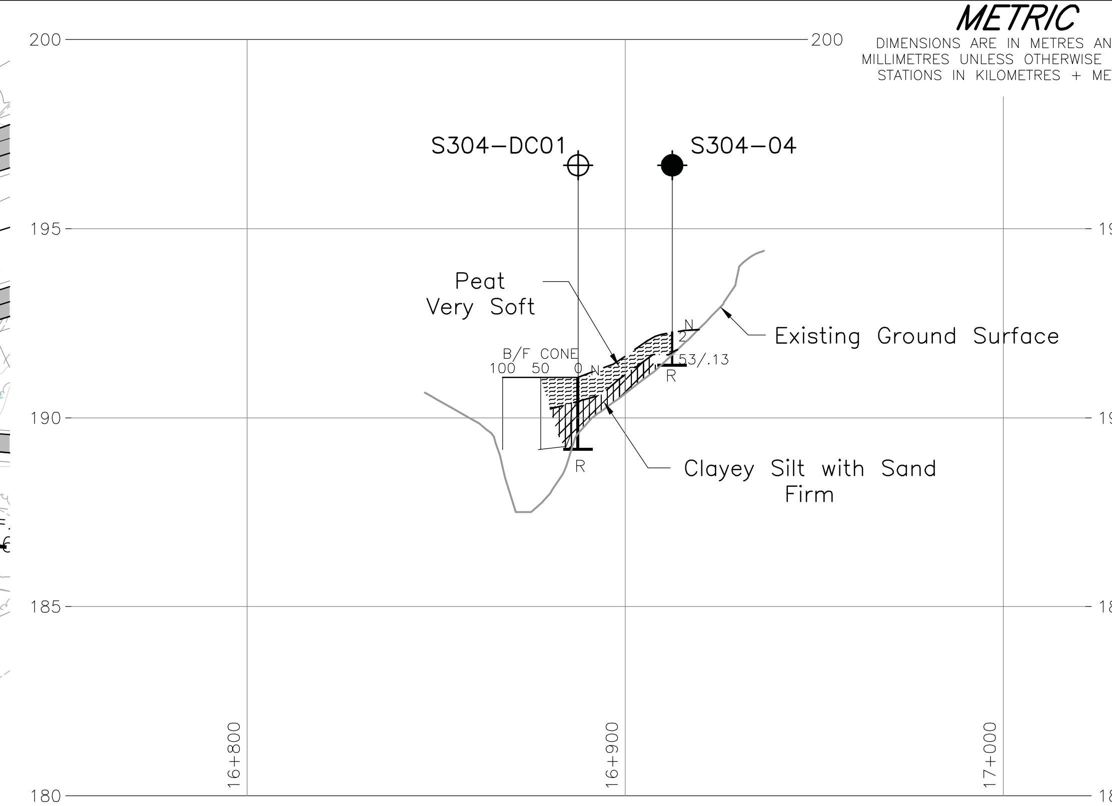


PLAN

SCALE 20 0 20 40 m

METRIC

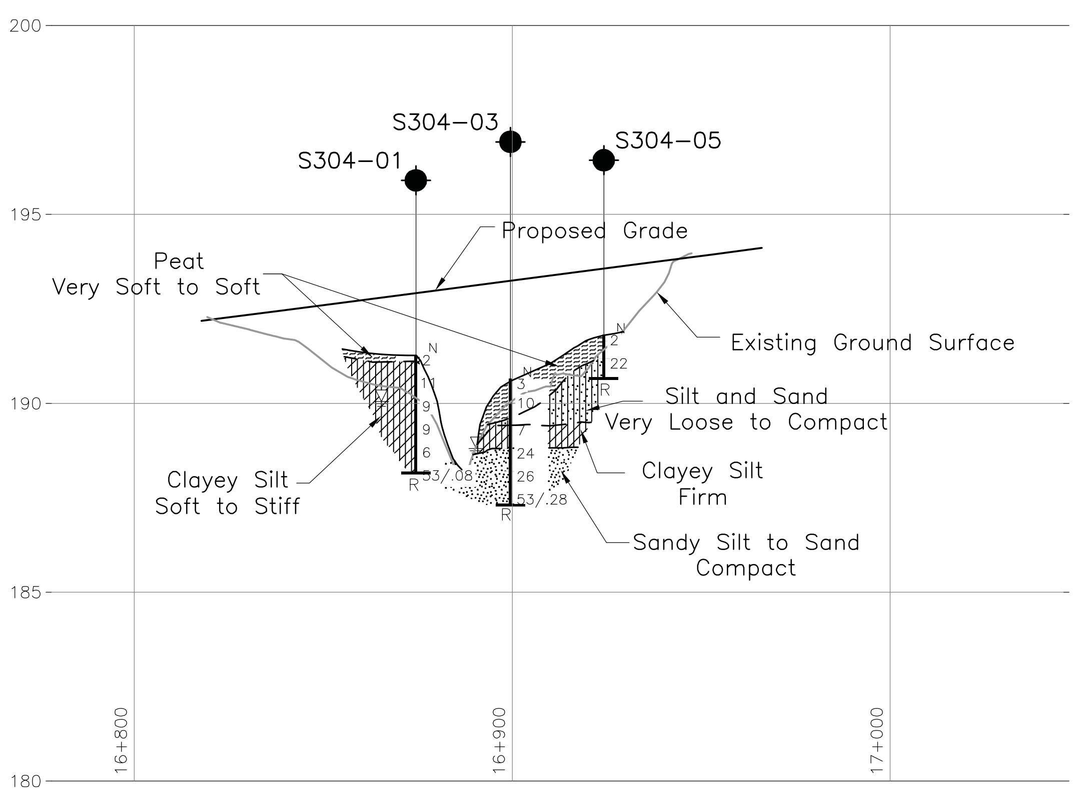
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.



B-B' D1 EMBANKMENT TOE PROFILE HIGHWAY 69 (NBL)

HORIZONTAL SCALE 20 0 20 40 m

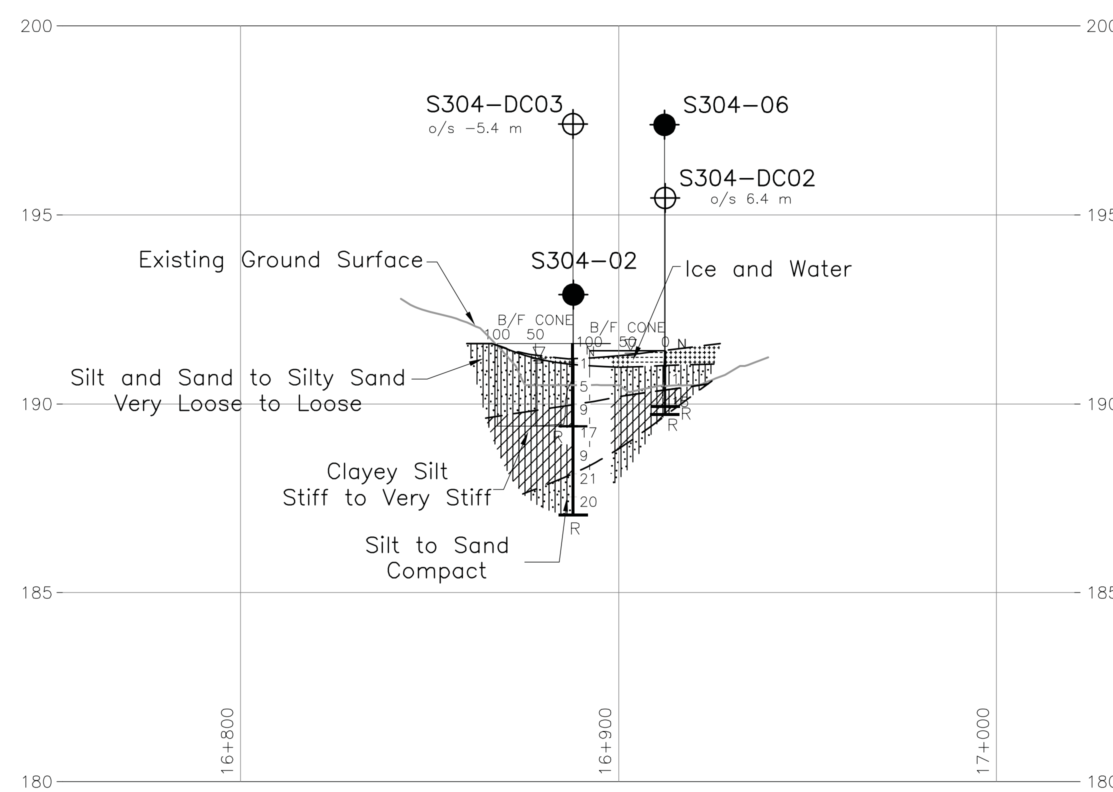
2 0 2 4 m VERTICAL SCALE



A-A' D1 CENTRELINE PROFILE HIGHWAY 69 (NBL)

HORIZONTAL SCALE 20 0 20 40 m

2 0 2 4 m VERTICAL SCALE



C-C' D1 EMBANKMENT TOE PROFILE HIGHWAY 69 (NBL)

HORIZONTAL SCALE 20 0 20 40 m

2 0 2 4 m VERTICAL SCALE

CONT No.
WP No. 5404-05-01

HIGHWAY 69

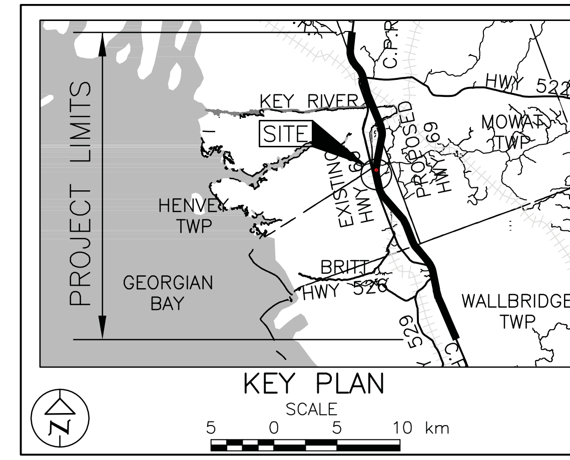
STA 16+875 TO 16+925 (NBL)

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Golder Associates

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN

SCALE 5 0 5 10 km

LEGEND

- Borehole – Current Investigation
- Dynamic Cone Penetration Test
- N 16 — Standard Penetration Test Value 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
S304-01	191.3	5079113.4	222813.8
S304-02	191.2	5079125.6	222830.0
S304-03	190.7	5079138.4	222814.1
S304-04	192.3	5079150.9	222801.8
S304-05	191.9	5079163.0	222814.8
S304-06	191.4	5079149.8	222839.7
S304-DC01	191.1	5079126.1	222799.5
S304-DC02	191.4	5079150.1	222828.6
S304-DC03	191.6	5079125.5	222840.2

NOTES

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

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

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

REFERENCE

Base plans provided in digital format by URS, drawing file nos. Alignment and Contours from Hwy69_Contour-Plan_C3.dwg, received April 23, 2012 and , Original Ground Surface cut from contour drawing file Hwy69_Contour-Plan_C3.dwg, received April 23, 2012 and the Proposed Grade obtained from drawing file Hwy69_profile March 2012.dwg, received March 14, 2012.

LICENSED PROFESSIONAL ENGINEER J. M. A. COSTA Jan. 2014 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER T. ZALUCKI 100128614 Jan. 2014 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 41H-134

HWY. 69		PROJECT NO. 09-1111-6014	DIST.
SUBM'D. CC	CHKD. TZ	DATE: Apr. 2013	SITE:
DRAWN: JFC/LL	CHKD. CN	APPD. JPD/JMAC	DWG. D1

PLOT DATE: January 22, 2014
FILENAME: T:\Projects\2009\09-1111-6014 (URS, Hwy 69, Henvey)\-DH- CONTRACT 3 (SWAMP)-FINAL-STAMPED\09111160140K001.dwg

Golder Associates

RECORD OF BOREHOLE No S304-01 SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01 LOCATION N 5079113.4 ;E 222813.8 ORIGINATED BY ARM
DIST HWY 69 BOREHOLE TYPE Portable Equipment, 70 mm O.D. Solid Stem Hand Auger COMPILED BY BM
DATUM Geodetic DATE January 15, 2012 CHECKED BY CN/TZ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	GR	SA	SI	CL
191.3	GROUND SURFACE									
0.0	PEAT (Fibrous)									
0.2	CLAYEY SILT, trace sand, trace organics to a depth of 1.2 m; Soft to stiff; Brown; Moist becoming wet below a depth of 1.2 m	1	SS	2		191				
		2	SS	11	▽					
		3	SS	9		190	0	4	68	28
		4	SS	9		189				
		5	SS	6						
188.3 / 3.1	Sandy SILT, trace clay; Brown; Wet	6	SS	53/0.08						
	END OF BOREHOLE; SPOON REFUSAL									

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m^3
REMARKS & GRAIN SIZE DISTRIBUTION (%)

NOTES:

1. Water level in open borehole at a depth of 1.2 m below ground surface (Elev. 190.1 m) upon completion of drilling.

2. 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

Golder Associates

RECORD OF BOREHOLE No S304-02 SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01 LOCATION N 5079125.6 ;E 222830.0 ORIGINATED BY ARM
DIST HWY 69 BOREHOLE TYPE Portable Equipment, 70 mm O.D. Solid Stem Hand Auger COMPILED BY BM
DATUM Geodetic DATE January 16, 2012 CHECKED BY CN/TZ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	GR	SA	SI	CL
191.2	ICE SURFACE				▽					
0.0	Ice									
0.1	Silty SAND, trace organics; Very loose; Brown and black; Wet	1	SS	1		191				
190.6 / 0.6	SILT and SAND, some clay; Loose; Grey; Wet	2	SS	5			0	32	55	13
190.0 / 1.2	CLAYEY SILT, trace sand; Stiff to very stiff; Brown; Wet	3	SS	9		190				
		4	SS	17		189	0	4	57	39
		5	SS	9						
188.1 / 3.1	SILT, some sand, trace gravel, trace clay; Compact; Brown; Wet	6	SS	21		188				
187.5 / 3.7	SAND, trace gravel, trace silt; Compact; Grey; Wet	7	SS	20						
187.1 / 4.1	END OF BOREHOLE; SPOON REFUSAL									

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m^3
REMARKS & GRAIN SIZE DISTRIBUTION (%)

NOTES:

1. Water level in open borehole at ground surface (Elev. 191.2 m) upon completion of drilling.

2. 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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No S304-03

SHEET 1 OF 1 **METRIC**

PROJECT 09-1111-6014
W.P. 5404-05-01 LOCATION N 5079138.4 ;E 222814.1 ORIGINATED BY ARM
DIST HWY 69 BOREHOLE TYPE Portable Equipment, 70 mm O.D. Solid Stem Hand Auger COMPILED BY BM
DATUM Geodetic DATE January 16, 2012 CHECKED BY CN/TZ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	GR	SA	SI	CL
190.7	GROUND SURFACE									
0.0	PEAT (Amorphous) Soft Black Moist	1	SS	3						
190.1 0.6	SILT and SAND, trace organics Loose Brown Moist	2	SS	10		190				
189.5 1.2	CLAYEY SILT, trace to some sand Firm Brown Moist	3	SS	7	▽	189				
188.9 1.8	SANDY SILT, trace to some clay, containing sand seams	4	SS	24			0	28	64	8
188.3 2.4	Compact Brown Wet	5	SS	26		188				
187.4 3.3	SAND, some gravel, some silt, trace clay Compact Brown Wet	6	SS	53/0.28			14	68	16	2
	END OF BOREHOLE SPOON REFUSAL									

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

NOTES:

1. Water level in open borehole at a depth of 1.8 m below ground surface (Elev. 188.9 m) upon completion of drilling.

2. 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.

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 01/22/14

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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No S304-06

SHEET 1 OF 1 **METRIC**

PROJECT 09-1111-6014
W.P. 5404-05-01 LOCATION N 5079149.8 ;E 222839.7 ORIGINATED BY ARM
DIST HWY 69 BOREHOLE TYPE Portable Equipment, NW Casing, Wash Boring COMPILED BY BM
DATUM Geodetic DATE January 16, 2012 CHECKED BY CN/TZ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	GR	SA	SI	CL
191.4	ICE SURFACE				▽					
0.0	Ice									
191.1 0.3	Water					191				
190.5	Silty SAND, trace organics Very loose	1	SS	2						
190.2 1.2	Brown Wet	2	SS	15		190				
189.7 1.7	CLAYEY SILT, trace to some sand Stiff Brown Wet									
	END OF BOREHOLE SPOON REFUSAL									

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

NOTES:

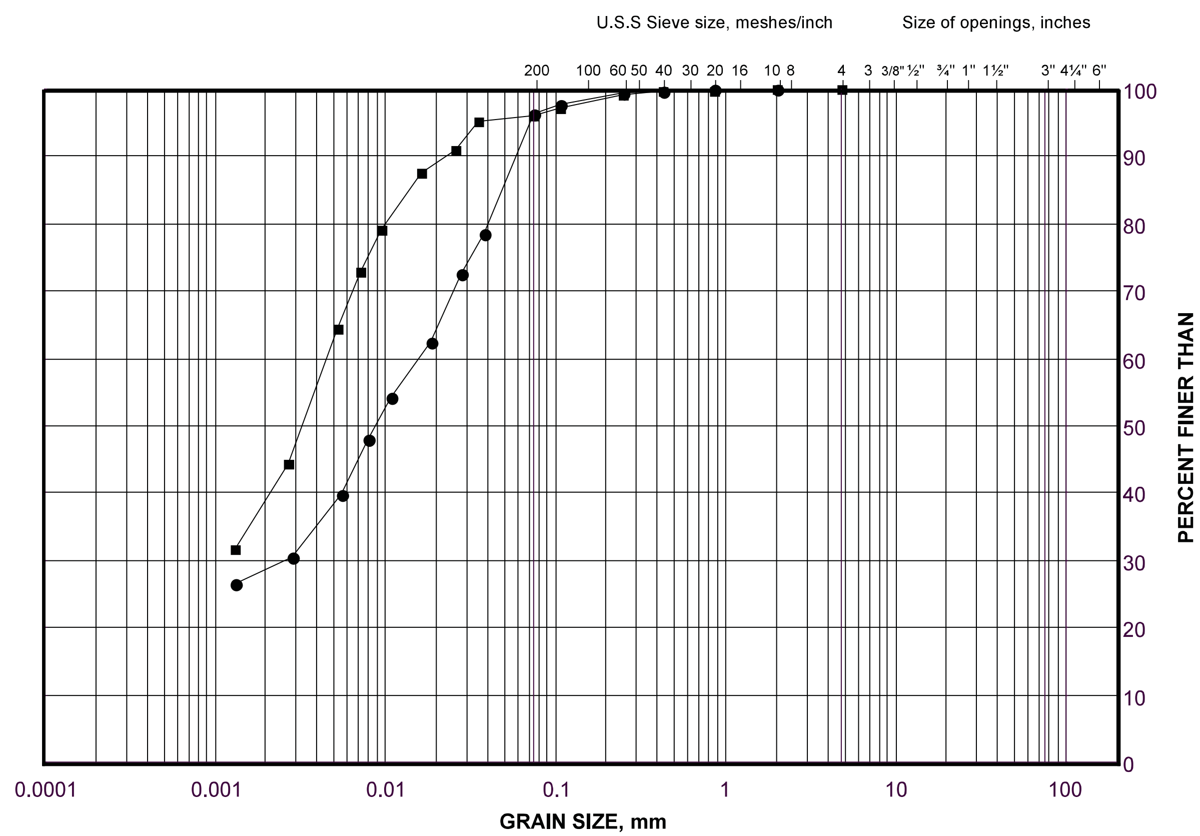
1. Water level in open borehole at ground surface (Elev. 191.4 m) upon completion of drilling.

2. 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.

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 01/22/14

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

GRAIN SIZE DISTRIBUTION Clayey Silt Highway 69 (NBL) STA 16+875 to 16+925 (Swamp 304)	FIGURE D.S304-01



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

LEGEND

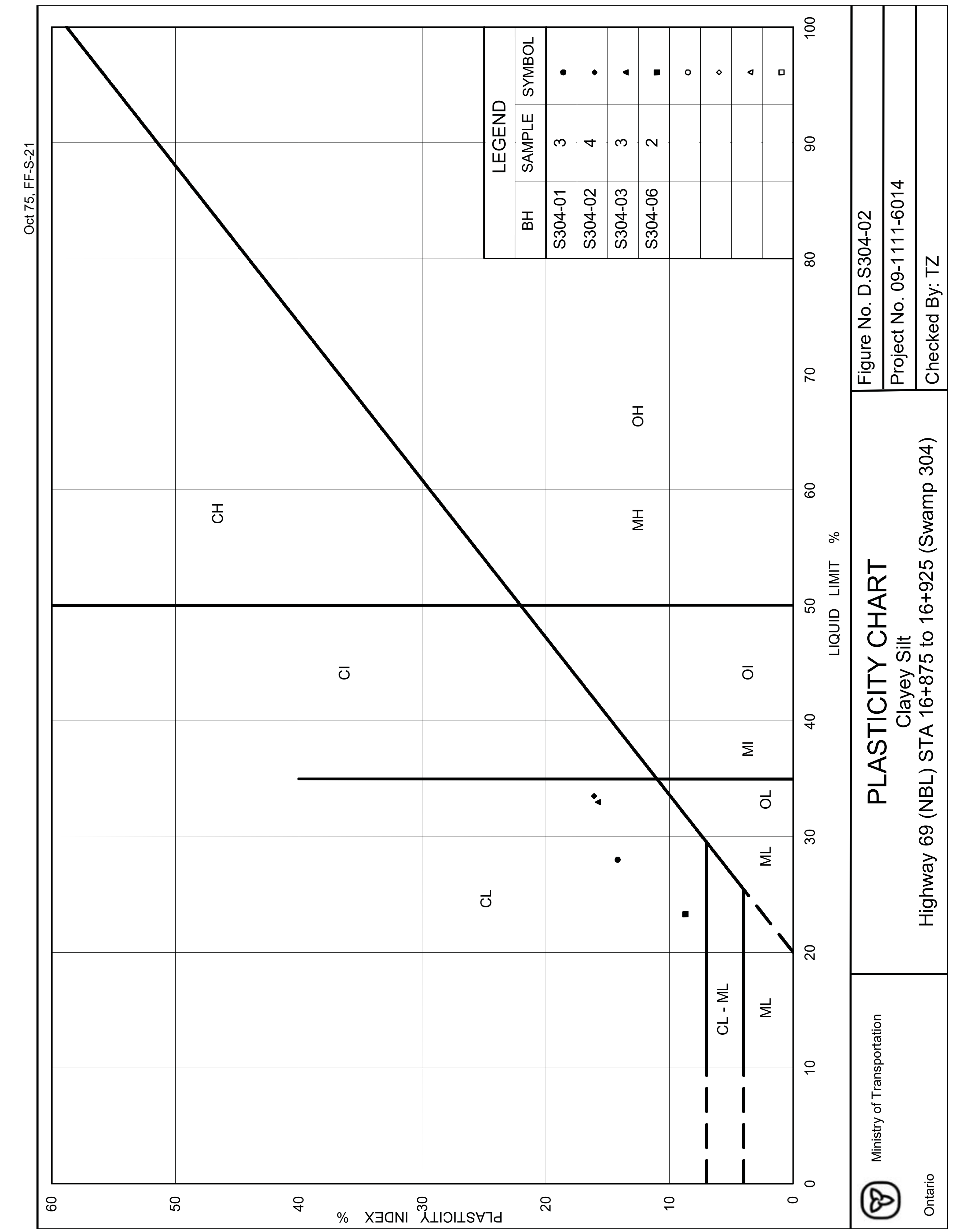
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S304-01	3	189.8
■	S304-02	4	189.1

Project Number: 09-1111-6014

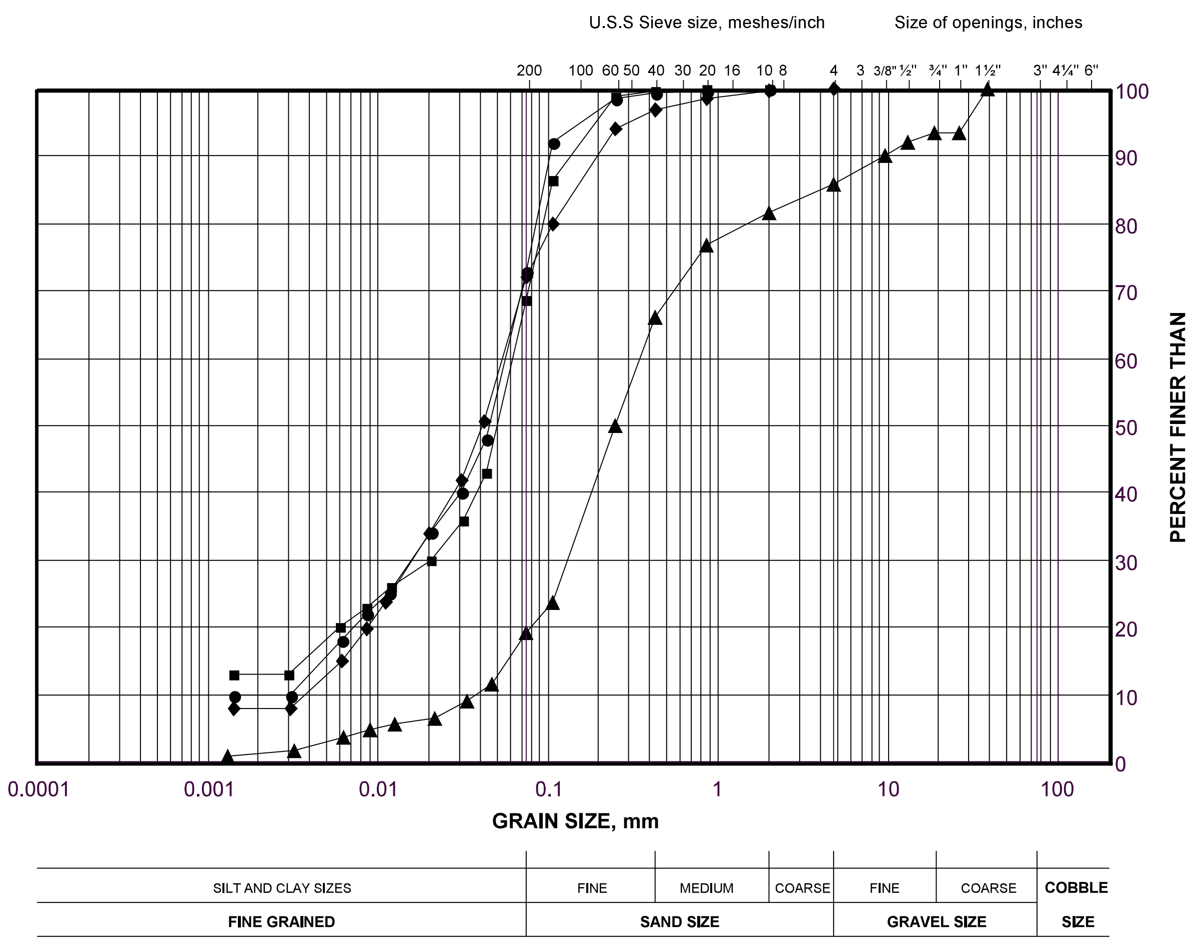
Checked By: TZ

Golder Associates

Date: 06-Nov-12



GRAIN SIZE DISTRIBUTION Sandy Silt to Sand Highway 69 (NBL) STA 16+875 to 16+925 (Swamp 304)	FIGURE D.S304-03



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S304-05	1	191.6
■	S304-02	2	190.3
◆	S304-03	4	188.6
▲	S304-03	6	187.6

Project Number: 09-1111-6014

Checked By: TZ

Golder Associates

Date: 06-Nov-12

SHEET I – CVH-31 - Fisheries Culvert (Station: ± 17+430 I/C-E/W BEKANON RAMP – Henvey)

- Borehole Locations and Soil Strata (Geocres 41H-134)
- Record of Borehole Logs (Geocres 41H-134)
- Laboratory Test Results (Geocres 41H-134)

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field work for Culvert CVH-31 at Station 17+430 Henvey Township (Site Nos. 044-0650/00 under the Bekanon Road S-E/W Ramp) was carried out by Golder Associates (Golder) between December 6 and 7, 2011, and a foundation investigation report (FIR) (Reference 1 below) was completed and submitted to MTO.

The following Reference Report is referenced:

1. Foundation Investigation and Design Report – Swamp Crossings and High Fill Areas – Contract 3, 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, (GEOCRES No. 41H-134), submitted to URS Canada Inc. by Golder Associates, February 11, 2014 (Report Number: 09-1111-6014-3520)

2. BOREHOLE INFORMATION

A total of five (5) boreholes (S307-01 to S304-05) and two (2) DCPTs (S307-DC01 and S307-DC02) were advanced by Golder at the proposed swamp location Bekanon Road. Four (4) of the investigated boreholes (S307-01 to S307-04) have been considered relevant for the proposed culvert design and purpose of this report.

Relevant geotechnical data from the reference report are provided in this report, including records of borehole logs and preliminary foundation drawings.

Table I-1 Structural Culvert Borehole Information

BOREHOLE ID	BOREHOLE LOCATION	MTM ON10 NAD 83 COORDINATES		GROUND SURFACE ELEVATION (m)	BOREHOLE DEPTH (m)
		NORTHING (m)	EASTING (m)		
S307-01	South of Culvert	5 079 553.2	223 104.3	189.2	2.4
S307-02	Outlet	5 079 551.4	223086.8	189.2	2.0
S307-03	North of Culvert	5 079 565.5	223 106.2	189.3	1.6
S307-04	Inlet	5 079 563.7	223 119.7	189.2	2.0

2.1. Subsurface Conditions

In general, the stratigraphy consists of approximately 100 mm to 200 mm of surficial peat, ice, over clayey silt, that is underlain by silty sand/silt and sand or gravelly sand/sand and gravel. Refer to the record of borehole sheets for subsoil conditions at each borehole location.

Based on the factual data presented in the Record of Borehole Sheets and Figures completed by Golder, the subsurface conditions encountered during the site investigation carried out by Golder can be categorized into four (4) general soil layers as presented below.

2.1.1. Peat

This 100 mm to 200 mm thick amorphous peat layer was encountered immediately below the existing ground surface in all four (4) boreholes.

The SPT ‘N’ values in this layer ranged from 1 blow and 4 blows for 30 cm penetration, indicating very soft to soft consistency.

2.1.2. Clayey Silt

This 0.4 m to 1.1 m thick clayey silt layer was encountered below the Peat layer in all four (4) boreholes. This layer extends to depths ranging from 0.6 m to 1.2 m (EL. 188.7 m to EL. 188.0 m) below the existing grade.

The SPT ‘N’ values in this layer ranged from 3 blows to 11 blows for 30 cm penetration, indicating soft to stiff consistency. The moisture contents of samples tested from this layer ranged from approximately 17% to 21%.

The results of the grain size analysis test performed on two (2) representative samples from this layer are provided on Figure D.S307-01. The test results indicate that this deposit consists of 0% gravel, 26% to 37% sand, 56% to 62% silt and 8% to 12% clay sized particles. Atterberg limit tests performed on four (4) representative samples are provided on Figure D.S307-02. The liquid limits of these samples range from 21 to 23, and the corresponding plastic limits range from 14 and 18, resulting in plasticity index values ranging from 5 to 7. Based on the results of Atterberg limit tests, these samples may be classified as clayey silt of slight plasticity (CL-ML) in the Unified Soil Classification System (USCS).

2.1.3. Silty Sand/Silt and Sand

This deposit was encountered below the clayey silt layer in Boreholes S304-01 and S304-03, extending to termination depths of 2.4 m (EL. 186.8 m) and 1.6 m (EL. 187.7 m) below the existing grade, respectively. This layer was not fully penetrated to determine the thickness of the deposit.

The SPT ‘N’ values in this layer ranged from 5 blows to 17 blows for 30 cm penetration, indicating loose to compact state of compactness. The moisture contents of two (2) samples tested from this layer were approximately 17% and 21%.

The results of the grain size analysis test performed on two (2) representative samples from this layer are provided on Figure D.S307-03. The test results indicate that this deposit consists of 0% to 6% gravel, 56% to 72% sand, 27% to 34% silt and 1% to 4% clay sized particles.

2.1.4. Gravelly Sand/Sand and Gravel

This deposit was encountered below the clayey silt layer in Boreholes S304-02 and S304-04, extending to termination depth of 2.0 m (EL. 187.2 m) below the existing grade. This layer was not fully penetrated to determine the thickness of the deposit.

The SPT ‘N’ values in this layer ranged from 12 blows to over 100 blows for 30 cm penetration, indicating compact to very dense state of compactness. The moisture contents of two (2) samples tested from this layer were approximately 13% and 20%.

The results of the grain size analysis test performed on two (2) representative samples from this layer are provided on Figure D.S307-04. The test results indicate that this deposit consists of 26% to 35% gravel, 60% to 67% sand, 5% silt and 0% to 2% clay sized particles.

2.1.5. Probable Bedrock

Probable bedrock surface was encountered in Borehole S307-02 to S307-04 at 1.6 m to 2.0 m (EL. 189.2 to EL. 189.3 m)

2.2. Groundwater Conditions

The groundwater level observed upon completion of drilling was measured at depths ranging from 0.1 m to 1.2 m (EL. 188.9 m to EL. 188.0 m) below the existing ground surface in the four (4) boreholes. Groundwater levels may fluctuate due to the influence of precipitation and seasonal changes.

PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) are based on the following references:

1. Foundation Investigation and Design Report – Swamp 307 - Swamp Crossings and High Fill Areas – Contract 3, 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, (GEOCRES No. 41H-134), submitted to URS Canada Inc. by Golder Associates, February 11, 2014 (Report Number: 09-1111-6014-3520)
2. Culvert Sections Drawings, provided by Parsons via email dated November 25, 2020
3. Highway 69 Profile Drawings, provided by Parson via email dated November 25, 2020

3. PROJECT DESCRIPTION

3.1. General

The proposed Fisheries Culverts (Site No. 044-0650/00) is a new structure under the proposed Bekanon Interchange S-EW ramp. The culvert is located within the Swamp 307 area in the Township of Henvey.

3.2. Proposed Structure

It is proposed that the culvert will have an opening size of 3.0 m in span, 2.4 m in height, will be approximately 38.0 m long and will be on a skew of approximately 33 degrees to the new S-EW ramp alignment.

The existing ground surface in the vicinity of the culvert alignments varies from approximate EL. 190.7 m to EL. 191.4 m. The terrain is undulating and slopes west towards the existing Highway 69, and a narrow creek traverses the area from east to west.

Based on the Reference 3, the proposed invert level of the culvert is approximately at EL. 187.8 m. Compact cohesionless sandy silt/silt/sand is anticipated at the invert level of the culvert.

Table E-1: Box Culvert Founding Elevations at Station 17+430 CVH-31 Culvert (Site No. 044-0650/00)

PROPOSED CULVERT INVERT ELEVATION	BOTTOM OF BOX CULVERT ELEVATION	SUBGRADE ELEVATION FOR GRANULAR BEDDING	FOUNDING STRATUM
187.9 m	187.6 m	187.3 m	Compact to very dense cohesionless soils / Probable Bedrock

Note(s): 1: The bottom thickness of the precast concrete box culvert is assumed 0.25 m (minimum).

Based on Reference 2, the height of embankment fill required above the culvert to the proposed grade of Highway 69 NBL at Station 17+430 is not expected to exceed 5.2 m, including the pavement structure. Reference Report 1 indicates that the maximum height of embankment across Swamp 307 will be 6.5 m.

In the absence of any structural details of the culverts, at the time of writing this report, it is assumed that concrete culverts and fill would impose a dead load of approximately 100 kPa on the founding subgrade.

4. EVALUATION OF FOUNDATION ALTERNATIVES

The foundation alternatives listed below were based on the available information in References 1, 2 and 3, and also considered the construction of the embankments across swamp 307 in Reference 1, including the assumed embankment fill required above the culvert that is not expected to exceed 5.2 m. Reference 1 indicates that 6.5 m high rock fill embankment to be used for preloading with no surcharge over Swamp 307 area. It is estimated that 90% of primary consolidation will be completed in 45 days.

1. Precast concrete box culverts placed without settlement mitigation
2. Precast concrete box culverts placed after preloading or surcharging

For both options, assuming that the culvert is placed at the proposed subgrade level of EL. ±187.3 m, compact to very dense cohesionless soils are expected underneath the base of the culvert, which underlies the clayey silt. No major settlement issue is expected under the imposed load of 115 kPa at the culvert location as it is anticipated that all cohesive soil will be excavated to found the subgrade level for the culvert installation.

Since there is no existing road or proposed structure where the culvert is proposed, it is recommended that the construction of precast concrete box culvert be coordinated with the construction of the embankment fill across Swamp 307. It is suggested that Option 1 be considered for the installation of the culvert. Prior to construction of the embankment with rockfill over the culvert area, the culvert should be installed in accordance with OPSS.PROV 422.

Unsuitable/organic materials at the culvert location should be excavated from within the zone of influence of the culvert (minimum of 2 m beyond the culvert walls) and the area under the culvert when preparing the subgrade for the culvert. The exposed subgrade should be inspected and approved before placement of compacted granular materials as specified in OPSS 422.07.06.

The granular material to backfill the precast concrete box culvert should be placed in accordance with OPSS 422.07.07. Granular material should be as specified in accordance with OPSS 422.05.13 and may consist of either Granular ‘A’ or Granular ‘B’ Type II, including a 75 mm levelling course for bedding purposes as required by OPSS 422.07.08.

The precast concrete box culvert may be designed assuming a factored geotechnical resistance of 330 kPa at ULS and 175 kPa at SLS placed on compact to very dense cohesionless soils. Following placement of the precast concrete box culvert as recommended and the estimated 5.2 m of fill above the culvert, it is estimated that the total settlement would be less than 25 mm and the differential settlement between 15 mm and 20 mm. Generally, for precast concrete box culvert, a tolerable limit of 100 mm of differential settlement is assumed.

If Option 2 is considered, excavation up to 8.5 m of fill and subsurface soil would be required to install the culvert at the subgrade level. Furthermore, it would also require additional handling of the fill material. Reference 1 recommends the use of preloading with rockfill to mitigate the post-construction settlement in the area of Swamp 307. During preloading, granular soils, instead of rockfill, would need to be utilized for preloading over the proposed culvert area for ease of excavation for the installation of the culvert. Option 2 may also require temporary shoring during excavation and installation of the culvert. Following the installation of the culvert, the rockfill may be placed as suggested in Reference 1. It is considered that Option 2 is feasible but not preferred.

5. CULVERT BEDDING AND COVER MATERIALS

Refer to the General Report for preliminary recommendations for materials to be used for culvert bedding and cover purposes.

6. APPROACH EMBANKMENT

The details for design, construction, and mitigation procedures for the embankment through Swamp 304 were presented in the report Reference 1. This report may be consulted for placement of fill for the swamp crossing and no recommendation is provided in this report.

7. CONSTRUCTION CONSIDERATIONS

7.1. Excavation

Considering the existing ground level (EL. 189.2 m to EL. 189.3 m) and the culvert subgrade level (EL. ±187.3 m), 1.9 m to 2.0 m deep excavations into native soils are needed for subgrade preparation and slope instability issues are not anticipated. Probable bedrock surface may be encountered in the vicinity of Borehole S307-03. Bedrock excavation may be required to found the culvert subgrade level.

For Option 2, some 8.5 m of cut into the embankment fill would be excavated and the stability of the temporary slope excavation should be assessed at the design-build stage. The Contractor should consider the type of preloaded and/or surcharge material over the culvert area to facilitate excavation and disposal or reuse of the temporary fill materials.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

Preliminary recommendations for backfilling to the culvert are provided in the General Report.

7.2. Groundwater and Surface Water Control

Dewatering may have to be carried out from sumps installed located along the interior periphery of the excavation to maintain the groundwater level a minimum 0.5 m depth below the base of the excavations. Surface water flow should be directed away from the excavation areas to mitigate disturbance of the native subgrade. For construction in-the-dry, the watercourse will have to be temporarily diverted.

Refer to the General Report for further groundwater control recommendations and requirements for water taking.

7.3. Additional Investigation

It is suggested that additional investigation be carried out during the detail design in the vicinity of Borehole S307-03 to confirm the presence of bedrock. Based on the data, the recommendations provided in this report may have to be revised

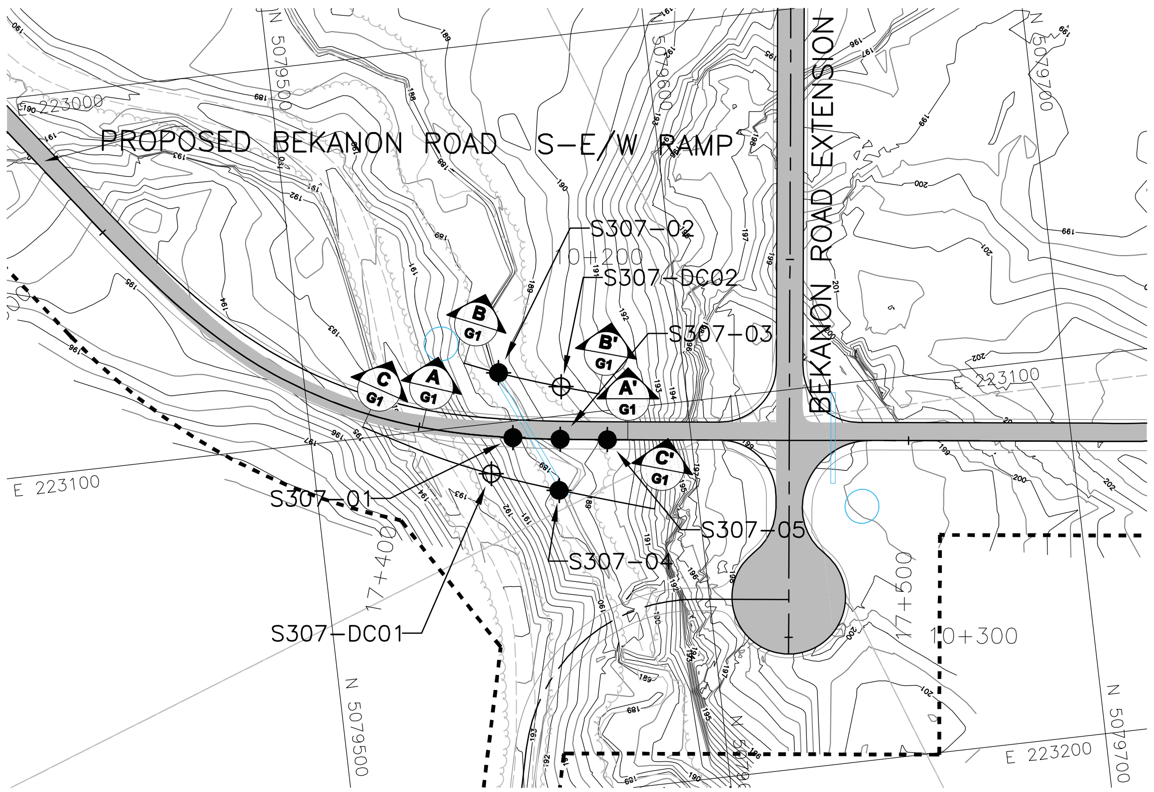
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 5404-05-01

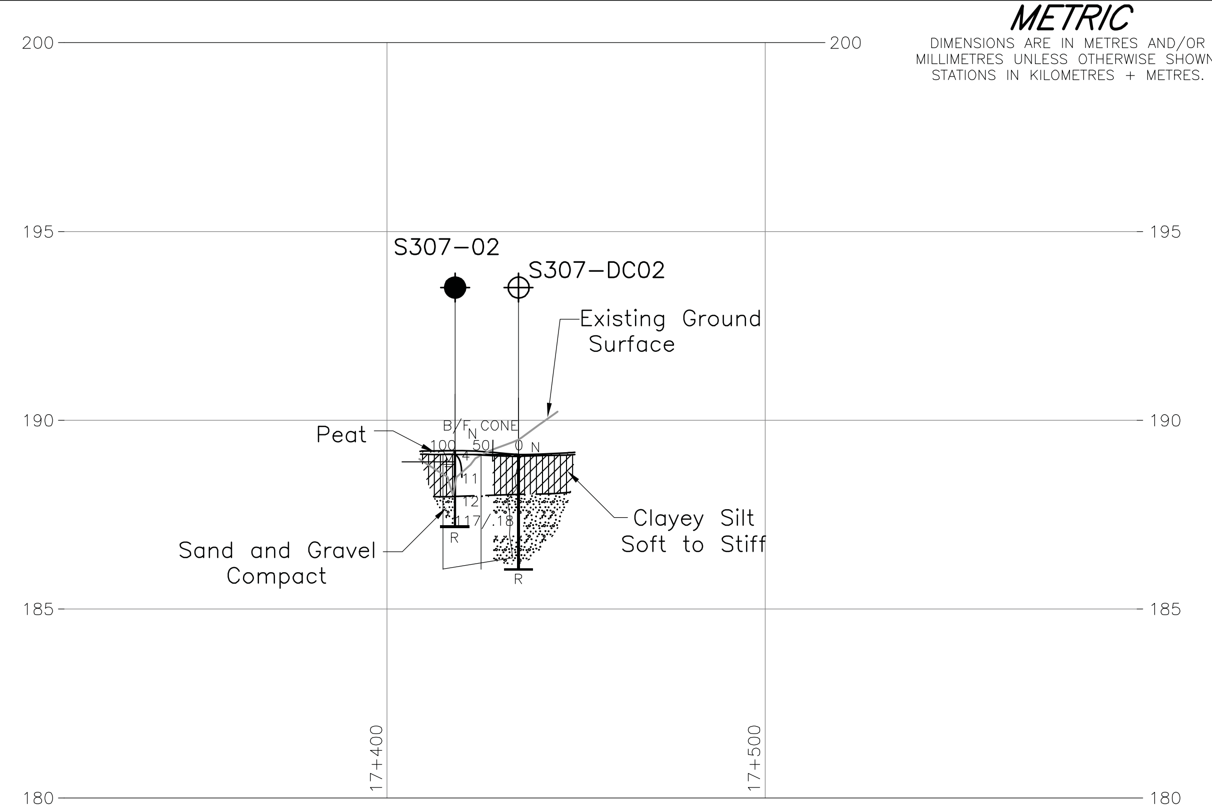
BEKANON ROAD S-E/W RAMP
STA 17+415 TO 17+450 (RAMP)
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

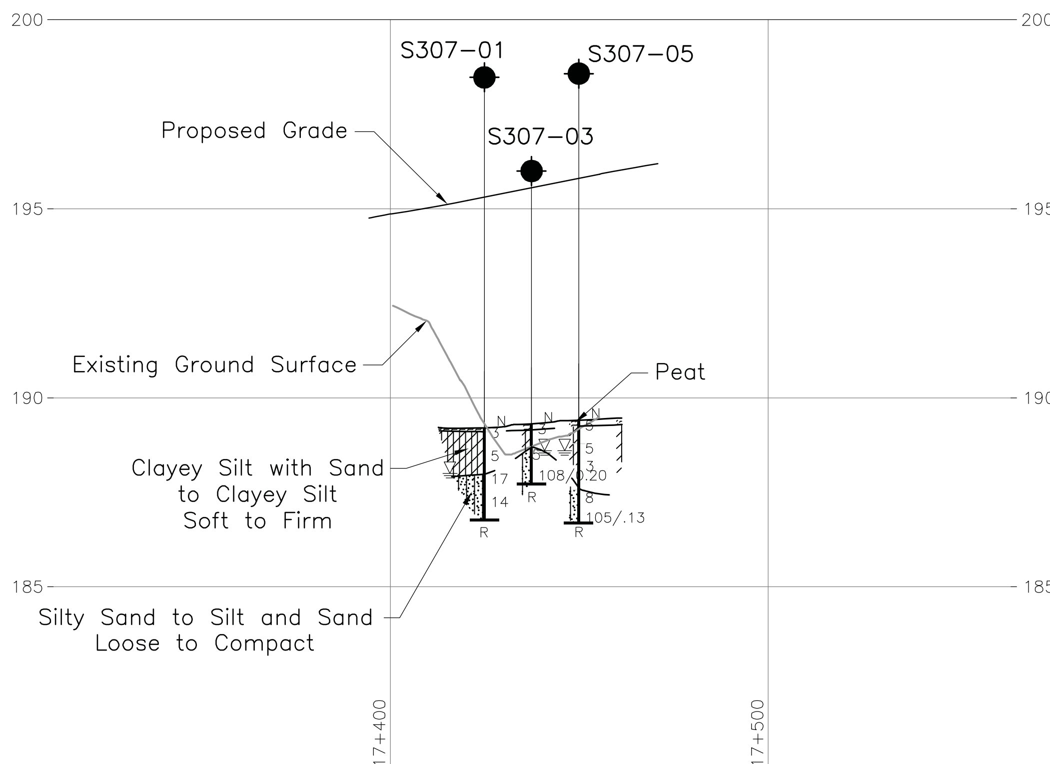
Golder Associates
Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



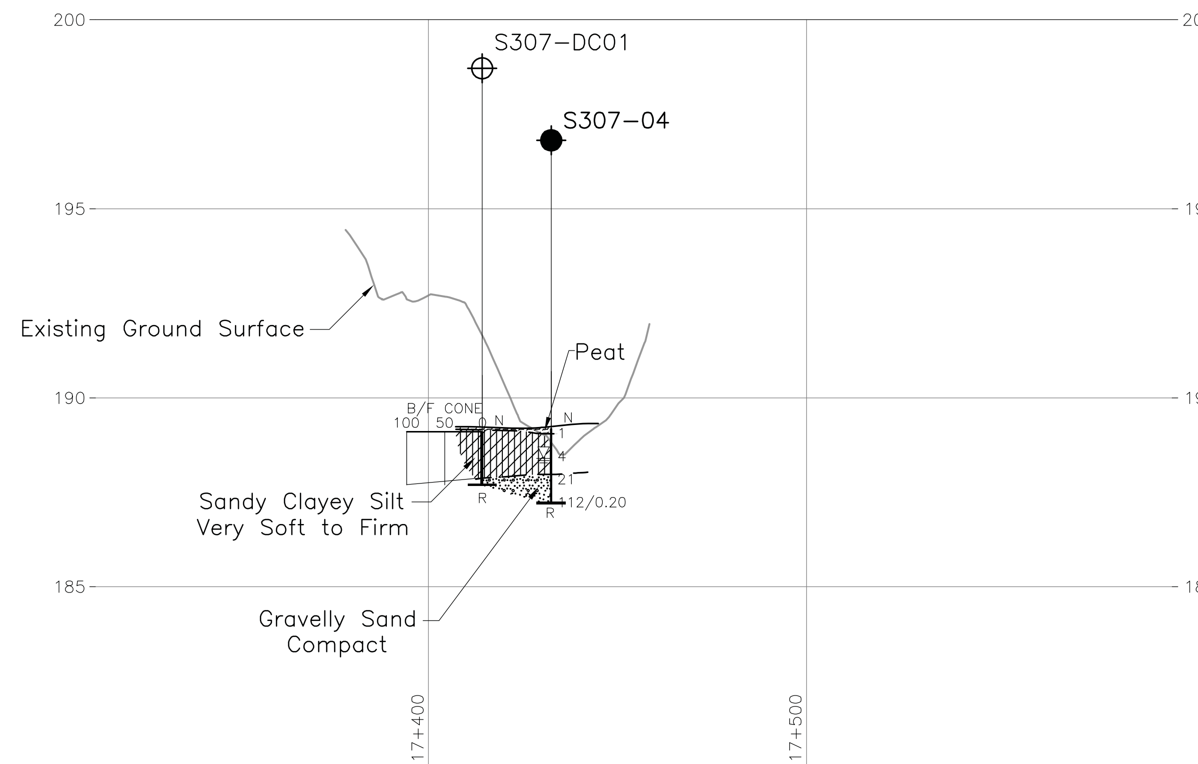
PLAN
SCALE
20 0 20 40 m



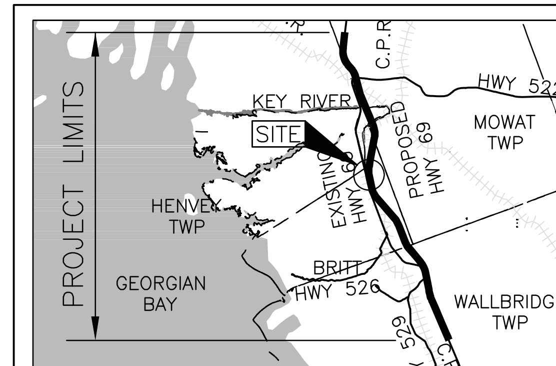
B-B' G1 EMBANKMENT TOE PROFILE
BEKANON ROAD S-E/W RAMP
HORIZONTAL SCALE
20 0 20 40 m
2 0 2 4 m
VERTICAL SCALE



A-A' G1 CENTRELINE PROFILE
BEKANON ROAD S-E/W RAMP
HORIZONTAL SCALE
20 0 20 40 m
2 0 2 4 m
VERTICAL SCALE



C-C' G1 EMBANKMENT TOE PROFILE
BEKANON ROAD S-E/W RAMP
HORIZONTAL SCALE
20 0 20 40 m
2 0 2 4 m
VERTICAL SCALE



KEY PLAN
SCALE
5 0 5 10km

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
S307-01	189.2	5079553.2	223104.3
S307-02	189.2	5079551.4	223086.8
S307-03	189.3	5079565.5	223106.2
S307-04	189.2	5079563.7	223119.7
S307-05	189.4	5079577.9	223107.7
S307-DC01	189.1	5079546.4	223113.2
S307-DC02	189.1	5079567.4	223092.4

NOTES

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

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

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

REFERENCE

Base plans provided in digital format by URS, drawing file nos. Alignment and Contours from Hwy69_Contour-Plan_C3.dwg, received April 23, 2012 and , Original Ground Surface cut from contour drawing file Hwy69_Contour-Plan_C3.dwg, received April 23, 2012 and the Proposed Grade obtained from drawing file Hwy69_profile March 2012.dwg, received March 14, 2012.

LICENSED PROFESSIONAL ENGINEER J. M. A. COSTA Jan. 2014 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER T. ZALUCKI 100128614 Jan. 2014 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 41H-134

HWY. 69		PROJECT NO. 09-1111-6014	DIST.
SUBM'D. CC	CHKD. TZ	DATE: May 2013	SITE:
DRAWN: JFC/LL	CHKD. CN	APPD. JPD/JMAC	DWG. G1

PLOT DATE: January 22, 2014

Golder Associates

RECORD OF BOREHOLE No S307-01 SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01 LOCATION N 5079553.2 ;E 223104.3 ORIGINATED BY ARM
DIST HWY 69 BOREHOLE TYPE Portable Equipment, 70 mm O.D. Solid Stem Hand Auger COMPILED BY MAS
DATUM Geodetic DATE December 7, 2011 CHECKED BY CN/TZ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	GR	SA	SI	CL
189.2	GROUND SURFACE									
0.0	PEAT (Amorphous)									
0.1	CLAYEY SILT with sand, trace organics Soft to firm Brown Moist	1	SS	3		189				
		2	SS	5	∇		0	37	56	7
188.0 1.2	Silty SAND, trace clay Compact Brown Wet	3	SS	17		188				
		4	SS	14		187	0	72	27	1
186.8 2.4	END OF BOREHOLE AUGER REFUSAL NOTE: 1. Water level in open borehole at a depth of 1.2 m below ground surface (Elev. 188.0 m) upon completion of drilling.									

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%)

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

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 01/22/14

Golder Associates

RECORD OF BOREHOLE No S307-02 SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01 LOCATION N 5079551.4 ;E 223086.8 ORIGINATED BY ARM
DIST HWY 69 BOREHOLE TYPE Portable Equipment, 70 mm O.D. Solid Stem Hand Auger COMPILED BY MAS
DATUM Geodetic DATE December 7, 2011 CHECKED BY CN/TZ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	GR	SA	SI	CL
189.2	GROUND SURFACE									
0.0	PEAT (Amorphous)									
0.1	CLAYEY SILT, some sand, trace organics Soft to stiff Brown Moist to wet	1	SS	4	∇	189				
		2	SS	11						
188.0 1.2	SAND and GRAVEL, trace silt Compact Grey Wet	3	SS	12		188				
		4	SS	117/0.18			35	60	5	0
187.2 2.0	END OF BOREHOLE SPOON AND AUGER REFUSAL NOTE: 1. Water level in open borehole at a depth of 0.3 m below ground surface (Elev. 188.9 m) upon completion of drilling.									

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%)

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

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 01/22/14

Golder Associates

RECORD OF BOREHOLE No S307-03 SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01 LOCATION N 5079565.5 ;E 223106.2 ORIGINATED BY ARM
DIST HWY 69 BOREHOLE TYPE Portable Equipment, 70 mm O.D. Solid Stem Hand Auger COMPILED BY MAS
DATUM Geodetic DATE December 6, 2011 CHECKED BY CN/TZ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
189.3	GROUND SURFACE								
0.0	PEAT (Amorphous)								
188.7 / 0.2	CLAYEY SILT, some sand, trace organics Soft Brown Moist to wet	1	SS	3	189				
187.7 / 0.6	SILT and SAND, trace to some gravel, trace clay Loose Brown to grey Moist	2	SS	5					
		3	SS	108/0.20	188	6	56	34	4
1.6	END OF BOREHOLE SPOON AND AUGER REFUSAL								

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

NOTE:

1. Water level in open borehole at a depth of 0.1 m below ground surface (Elev. 189.2 m) upon completion of drilling.

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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No S307-04 SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01 LOCATION N 5079563.7 ;E 223119.7 ORIGINATED BY ARM
DIST HWY 69 BOREHOLE TYPE Portable Equipment, 70 mm O.D. Solid Stem Hand Auger COMPILED BY MAS
DATUM Geodetic DATE December 7, 2011 CHECKED BY CN/TZ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
189.2	GROUND SURFACE								
0.0	PEAT (Amorphous)				189				
0.2	Sandy CLAYEY SILT, trace organics Very soft to firm Brown Moist	1	SS	1		0	26	62	12
		2	SS	4	188				
188.0 / 1.2	Gravelly SAND, trace silt, trace clay Compact Grey Wet	3	SS	21					
187.2		4	SS	112/0.20		26	67	5	2
2.0	END OF BOREHOLE SPOON AND AUGER REFUSAL								

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

NOTE:

1. Water level at a depth of 0.8 m below ground surface (Elev. 188.4 m) upon completion of drilling.

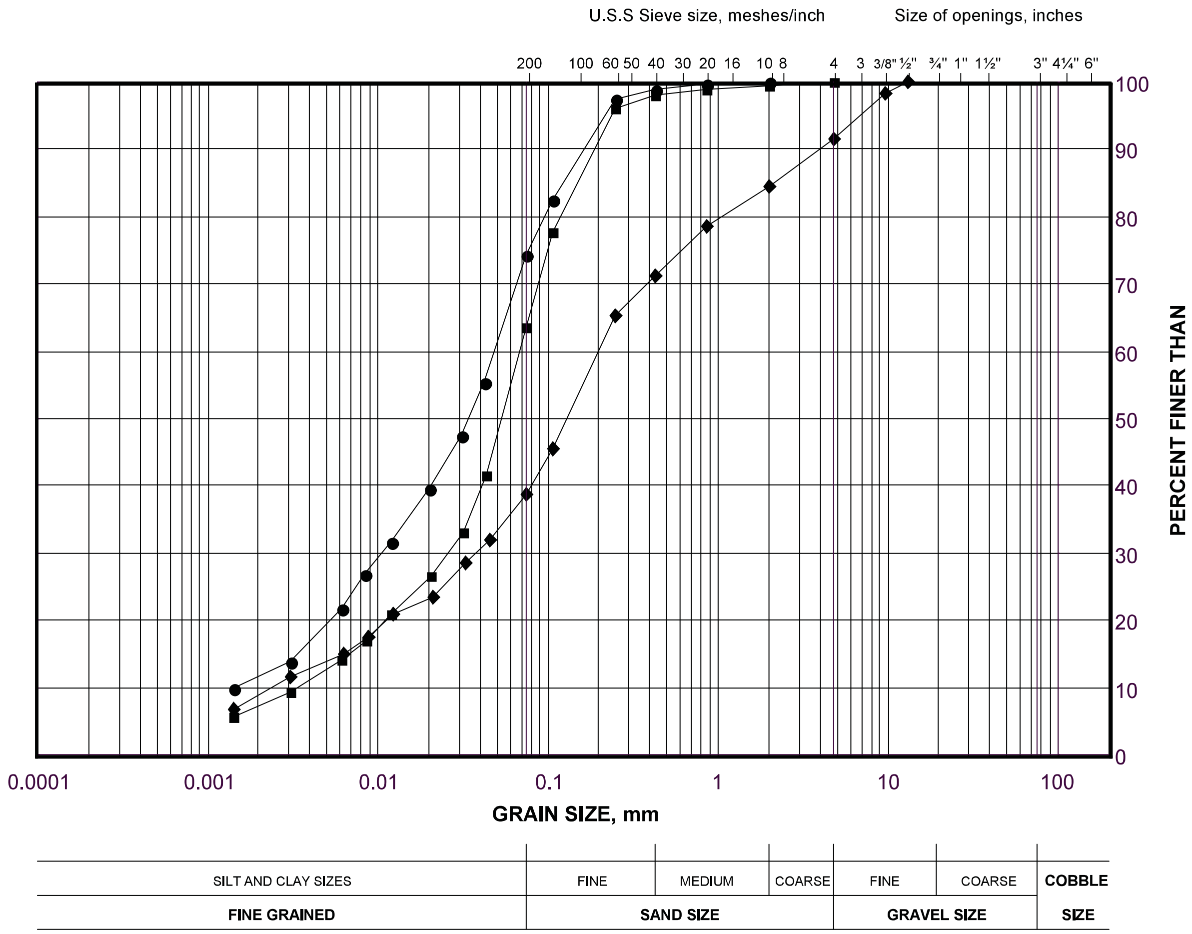
+ ^{3}, × ^{3}: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand

Bekanon Road S-E/W Ramp STA 17+415 to 17+450 (Swamp 307)

FIGURE G.S307-01



LEGEND

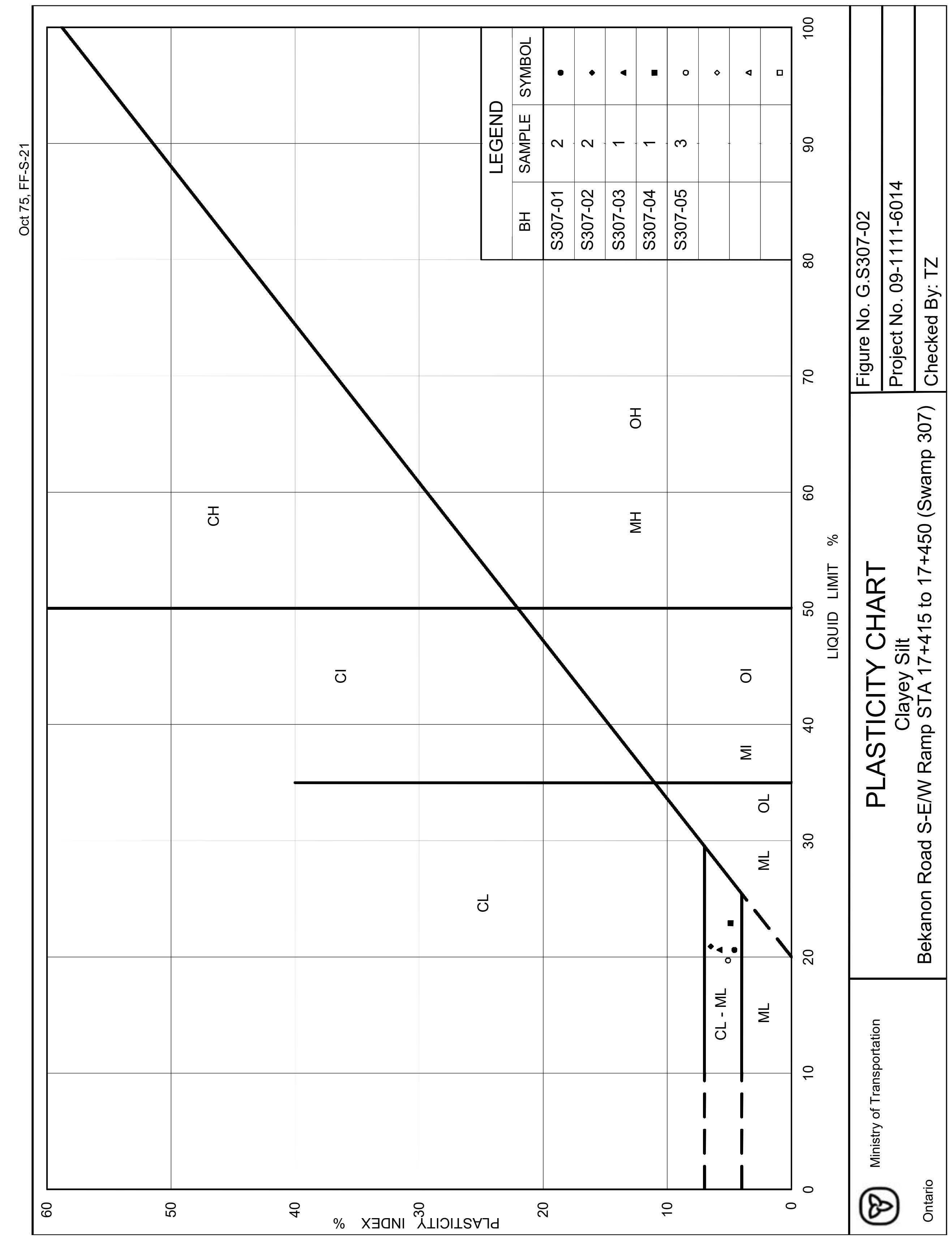
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S307-04	1	188.9
■	S307-01	2	188.3
◆	S307-05	3	187.9

Project Number: 09-1111-6014

Checked By: TZ

Golder Associates

Date: 19-Nov-12

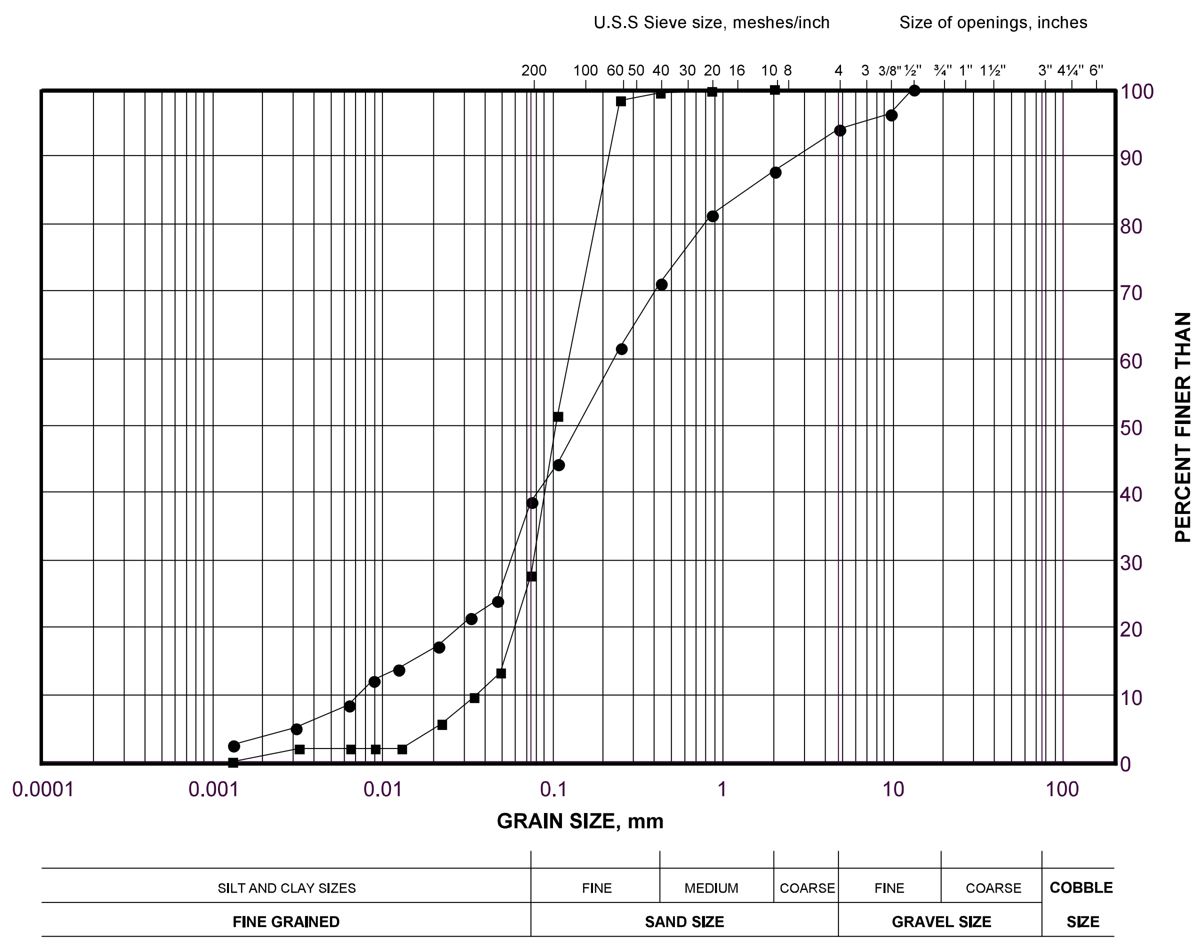


GRAIN SIZE DISTRIBUTION

Silt and Sand to Silty Sand

Bekanon Road S-E/W Ramp STA 17+415 to 17+450 (Swamp 307)

FIGURE G.S307-03



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S307-03	3	187.9
■	S307-01	4	187.1

Project Number: 09-1111-6014

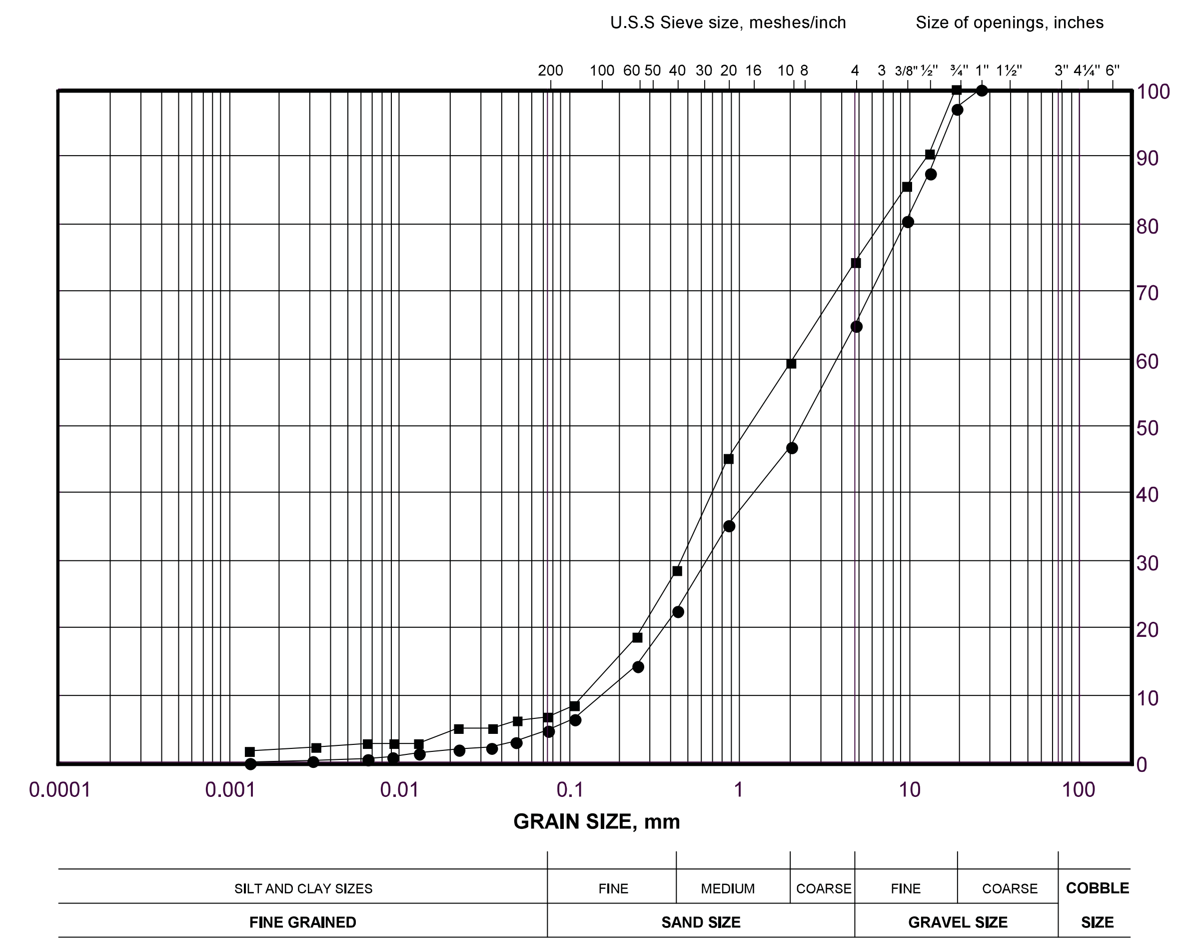
Checked By: TZ **Golder Associates** Date: 19-Nov-12

GRAIN SIZE DISTRIBUTION

Gravelly Sand to Sand and Gravel

Bekanon Road S-E/W Ramp STA 17+415 to 17+450 (Swamp 307)

FIGURE G.S307-04



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S307-02	4	187.3
■	S307-04	4	187.3

Project Number: 09-1111-6014

Checked By: TZ **Golder Associates** Date: 04-Apr-13

SHEET J – CVH-32 - Fisheries Culvert (Station: ± 10+042 Bekanon Forest Access – Henvey)

- Borehole Location Plan (PML)
- Record of Borehole Logs (PML)
- Laboratory Test Results (PML)

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field work for Culvert CVH-32 at Station 10+042, in the Township of Henvey (Site No. 044-0651/00 under the Bekanon Forest Access) was carried out on November 9, 2021. The proposed culvert site is located within a valley. Rock outcrop was observed at the north of the proposed culver site.

2. BOREHOLE INFORMATION

A total of two (2) boreholes were advanced by manual method, including hand auger, probe rod and Shelby (thin wall) sample tubes, along the proposed alignment of the culvert (Site No. 044-0651/00). There were no accessible roadway/pathway for track/truck mounted drill rig or portable tripod equipment to the proposed culvert site.

Refer to
- Drawing J-1 for the borehole location plan
- Table J-1 for details of borehole origin, borehole location coordinates and borehole elevations/depths
- Record of Borehole sheets and lab results showing details of the subsurface conditions at the borehole locations from current investigation

Table J-1 Structural Culvert Borehole Information

BOREHOLE ID	BOREHOLE LOCATION	UTM17 NAD 83 COORDINATES		GROUND SURFACE ELEVATION (m)	BOREHOLE DEPTH (m)
		NORTHING (m)	EASTING (m)		
CVH32-1	West End (Outlet)	5 079 574.9	223 136.9	189.3	1.3
CVH32-2	East End (Inlet)	5 079 578.1	223 171.2	189.1	1.5

2.1. Subsurface Conditions

The stratigraphy conceptually consists of clayey silt, trace/some sand, below the existing water surface, to the termination depth of drilling. Refer to the Record of Boreholes for details.

The subsurface conditions at this site can be categorized into two (2) general layers as presented below from surface downwards.

2.1.1. Sandy Silty Clay

This sandy silty clay deposit was encountered immediately below the water surface in Borehole CVH32-1 and below the ground surface in Borehole CVH32-2, extending to the borehole termination depths of 1.3 m and 1.5 m below the existing ground surface, respectively. Moisture content determinations of the samples tested from this layer ranged from 45.1% to 97.3%.

The grain size distribution test results of the representative samples selected from this layer are provided in Figure GS-J-2 and the Atterberg limits are presented in Figure PC-J-2.

2.1.2. Probable Bedrock

It is inferred that probable bedrock was encountered at 1.3 m and 1.5 m below existing ground surface at Borehole CVH32-1 and CVH32-2, where refusal to hand auger/probable was met.

2.2. Groundwater Conditions

Groundwater level was encountered at ground surface in Borehole CVH32-1. Borehole CVH32-2 was located in water, within the creek bed. The creek water level at the inlet of the proposed culvert was measured at Elevation 189.2 m, on November 9, 2021.

Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

3. PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) are based on the following references:

1. Foundation Investigation and Design Report – Swamp 307 - Swamp Crossings and High Fill Areas – Contract 3, 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, (GEOCRES No. 41H-134), submitted to URS Canada Inc. by Golder Associates, February 11, 2014 (Report Number: 09-1111-6014-3520)
2. Highway 69 Profile Drawings, provided by Parson via email dated November 25, 2020
3. Culvert Sections Drawings, provided by Parsons via email dated November 25, 2020

4. PROJECT DESCRIPTION

4.1. General

The proposed Fisheries Culverts (Site No. 044-0651/00) is a new structure under the proposed Bekanon Forest Access. The culvert is located within the Swamp 307 area in the Township of Henvey.

4.2. Proposed Structure

It is proposed that the culvert will have an opening size of 3.0 m in span, 2.4 m in height, will be approximately 31.0 m long and will be on a skew of approximately 8.4 degrees to the new Bekanon Forest Access alignment.

The existing ground surface in the vicinity of the culvert alignment varies from approximate EL. 189.1 m to EL. 189.3 m. The terrain is undulating and slopes west towards the existing Highway 69, and a narrow creek traverses the area from east to west.

Based on the Reference 2, the proposed invert level of the culvert is approximately at EL. 188.7 m. sandy silty clay is anticipated at the invert level of the culvert.

Table J-1: Box Culvert Founding Elevations at Station 10+042 CVH-32 Culvert (Site No. 044-0651/00)

PROPOSED CULVERT INVERT ELEVATION	BOTTOM OF BOX CULVERT ELEVATION	SUBGRADE ELEVATION FOR GRANULAR BEDDING	FOUNDING STRATUM
188.7 m	188.4 m	187.9 m	Probable Bedrock/Granular Material

Note(s): 1: The bottom thickness of the precast concrete box culvert is assumed 0.25 m (minimum).

Based on Reference 3, the height of embankment fill required above the culvert to the proposed grade of Highway 69 NBL at Station 10+042 is not expected to exceed 5.2 m, including the pavement structure. Reference Report 1 indicates that the maximum height of embankment across Swamp 307 will be 6.5 m.

In the absence of any structural details of the culverts, at the time of writing this report, it is assumed that concrete culverts and embankment fill would impose a dead load of approximately 165 kPa on the founding subgrade.

5. EVALUATION OF FOUNDATION ALTERNATIVES

The foundation alternatives listed below were based on the available information in References 1, 2 and 3, and also considered the construction of the embankments across swamp 307 in Reference 1, including the assumed embankment fill required above the culvert that is not expected to exceed 5.2 m. Reference 1 indicates that 6.5 m high rock fill embankment to be used for preloading with no surcharge over Swamp 307 area. It is estimated that 90% of primary consolidation will be completed in 45 days.

1. Precast concrete box culverts placed without settlement mitigation
2. Precast concrete box culverts placed after preloading or surcharging

For both options, assuming that the culvert is placed at the proposed subgrade level of EL. ±187.9 m, probable bedrock is anticipated at the inlet and sandy clayey silt is anticipated at the outlet. No major settlement issue is expected under the imposed load of 165 kPa at the culvert location as it is anticipated that all cohesive soil will be excavated to found the subgrade level for the culvert installation.

Since there is no existing road or proposed structure where the culvert is proposed, it is recommended that the construction of precast concrete box culvert be coordinated with the construction of the embankment fill across Swamp 307. It is suggested that Option 1 be considered for the installation of the culvert. Prior to construction of the embankment with rockfill over the culvert area, the culvert should be installed in accordance with OPSS.PROV 422.

Unsuitable/organic materials at the culvert location should be excavated from within the zone of influence of the culvert (minimum of 2 m beyond the culvert walls) and the area under the culvert when preparing the subgrade for the culvert. The exposed subgrade should be inspected and approved before placement of compacted granular materials as specified in OPSS 422.07.06.

The granular material to backfill the precast concrete box culvert should be placed in accordance with OPSS 422.07.07. Granular material should be as specified in accordance with OPSS 422.05.13 and may consist of either Granular ‘A’ or Granular ‘B’ Type II, including a 75 mm levelling course for bedding purposes as required by OPSS 422.07.08.

The precast concrete box culvert may be designed assuming a factored geotechnical resistance of 255 kPa at ULS and 170 kPa at SLS placed on compacted granular material. For bedrock surface, where encountered, SLS will not govern because the loads required to produce detrimental deformation is anticipated to be larger than the factored resistance at ULS. Following placement of the precast concrete box culvert as recommended and the estimated fill of 5.2 m above the culvert, it is estimated that the total settlement would be less than 25 mm and the differential settlement between 15 mm and 20 mm. Generally, for precast concrete box culvert, a tolerable limit of 100 mm of differential settlement is assumed.

Reference 1 recommends the use of preloading with rockfill to mitigate the post-construction settlement in the area of Swamp 307. During preloading, granular soils instead of rockfill, would need to be utilized for preloading over the proposed culvert area for ease of excavation for the installation of the culvert. Option 2 may require temporary shoring during excavation and installation of the culvert. Following the installation of the culvert, the rockfill may be placed as suggested in Reference 1. It is considered that Option 2 is feasible but not preferred.

6. <u>SUBGRADE PREPARATION, CULVERT BEDDING AND COVER MATERIALS</u>

Refer to the General Report for preliminary recommendations for materials to be used for culvert bedding and cover purposes.

7. <u>APPROACH EMBANKMENT</u>

The details for design, construction, and mitigation procedures for the embankment through Swamp 307 were presented in the report Reference 1. This report may be consulted for placement of fill for the swamp crossing and no recommendation is provided in this report.

8. <u>CONSTRUCTION CONSIDERATIONS</u>

8.1. Excavation

Considering the existing ground level (EL. 189.1 m to EL. 189.3 m) and the culvert subgrade level (EL. ±187.9 m), 1.2 m to 1.4 m deep excavations into native soils are needed for subgrade preparation and slope instability issues are not anticipated. Probable bedrock surface may be encountered in the vicinity of boreholes. Bedrock excavation may be required to found the culvert subgrade level.

For Option 2, some 8.4 m of cut into the embankment fill would be excavated and the stability of the temporary slope excavation should be assessed at the design-build stage. The Contractor should consider the type of preloaded and/or surcharge material over the culvert area to facilitate excavation and disposal or reuse of the temporary fill materials.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

Preliminary recommendations for backfilling to the culvert are provided in the General Report.

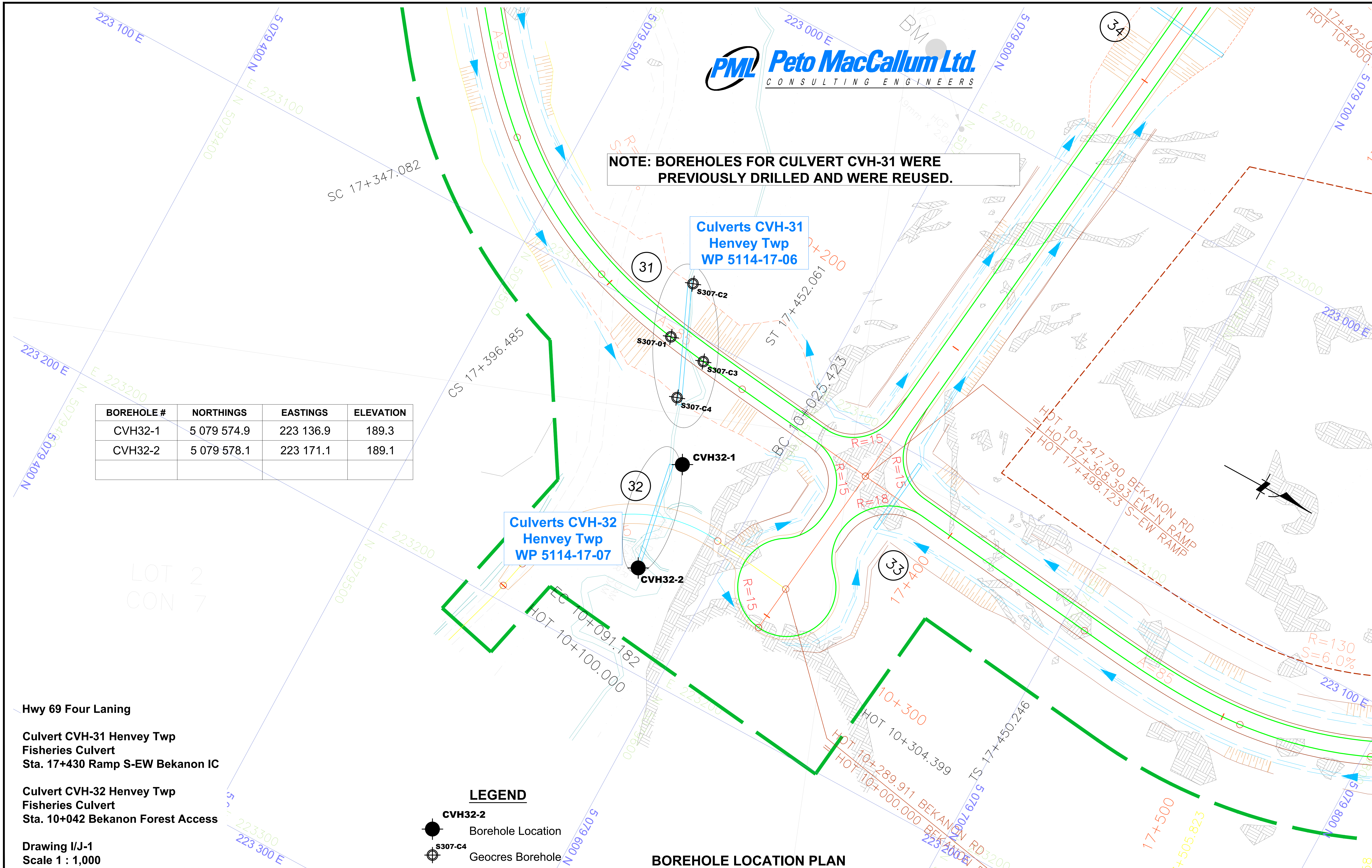
8.2. Groundwater and Surface Water Control

Surface water flow should be directed away from the excavation areas to mitigate disturbance of the native subgrade by means of temporary pipe. Dewatering may be carried out from sumps along the interior periphery of the excavation to maintain the groundwater level a minimum of depth of 0.5 m below the base of excavations. For construction in-the-dry, the flowing water will have to be temporary diverted.

Refer to the General Report for further groundwater control recommendations and requirements for water taking.

8.3. Additional Investigation

It is suggested that additional investigation be carried out during the detail design in the vicinity of the proposed culvert to confirm the presence of bedrock. Based on the data, the recommendations provided in this report may have to be revised.



NOTE: BOREHOLES FOR CULVERT CVH-31 WERE PREVIOUSLY DRILLED AND WERE REUSED.

BOREHOLE #	NORTHINGS	EASTINGS	ELEVATION
CVH32-1	5 079 574.9	223 136.9	189.3
CVH32-2	5 079 578.1	223 171.1	189.1

Hwy 69 Four Laning

Culvert CVH-31 Henvey Twp
Fisheries Culvert
Sta. 17+430 Ramp S-EW Bekanon IC

Culvert CVH-32 Henvey Twp
Fisheries Culvert
Sta. 10+042 Bekanon Forest Access

Drawing I/J-1
Scale 1 : 1,000

LEGEND

CVH32-2 Borehole Location

S307-C4 Geocres Borehole

BOREHOLE LOCATION PLAN

RECORD OF BOREHOLE No CVH32-1

METRIC

PROJECT: Hwy 69 Structural Culvert	COORDINATES: Coords: 5 079 574.9 N; 223 136.9 E		ORIGINATED BY: M.M.
DIST:	HWY: 69	BOREHOLE TYPE: Manual Probe	COMPILED BY: N.L.
DATUM: Geodetic	DATE: 2021.11.09	LATITUDE: 45.851185 LONGITUDE: -80.551508	CHECKED BY: N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P – NATURAL MOISTURE CONTENT w – LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	GR	SA	SI	CL
189.3	Ground Surface Below Water													
0.0	organics Sandy SILTY CLAY Mottled brown/grey, Wet to moist		1	TW			189				0	27	58	15
			2	GRAB							0	8	72	20
188.2 1.1	Borehole terminated due to auger refusal on probable bedrock													

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

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No CVH32-2

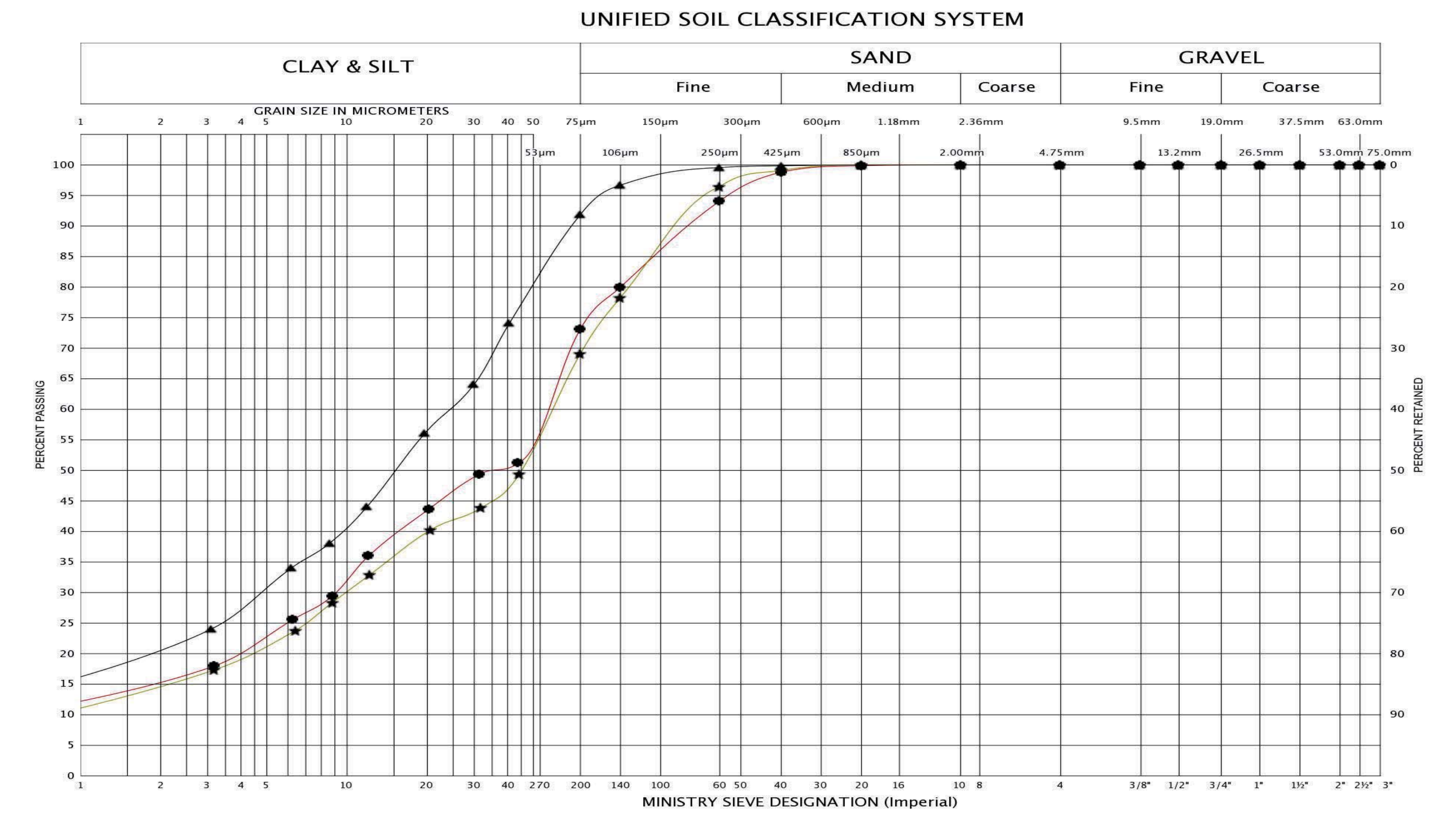
METRIC

PROJECT: Hwy 69 Structural Culvert	COORDINATES: Coords: 5 079 578.1 N; 223 171.2 E		ORIGINATED BY: M.M.
DIST:	HWY: 69	BOREHOLE TYPE: Manual Probe	COMPILED BY: N.L.
DATUM: Geodetic	DATE: 2021.11.09	LATITUDE: 45.851218 LONGITUDE: -80.551069	CHECKED BY: N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P – NATURAL MOISTURE CONTENT w – LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	GR	SA	SI	CL
189.1	Ground Surface													
0.0	organics Sandy SILTY CLAY Brown/grey, Wet to moist		1	TW			189		97		0	31	54	15
							188							
			2	GRAB										
187.6 1.5	Borehole terminated due to auger refusal on probable bedrock													

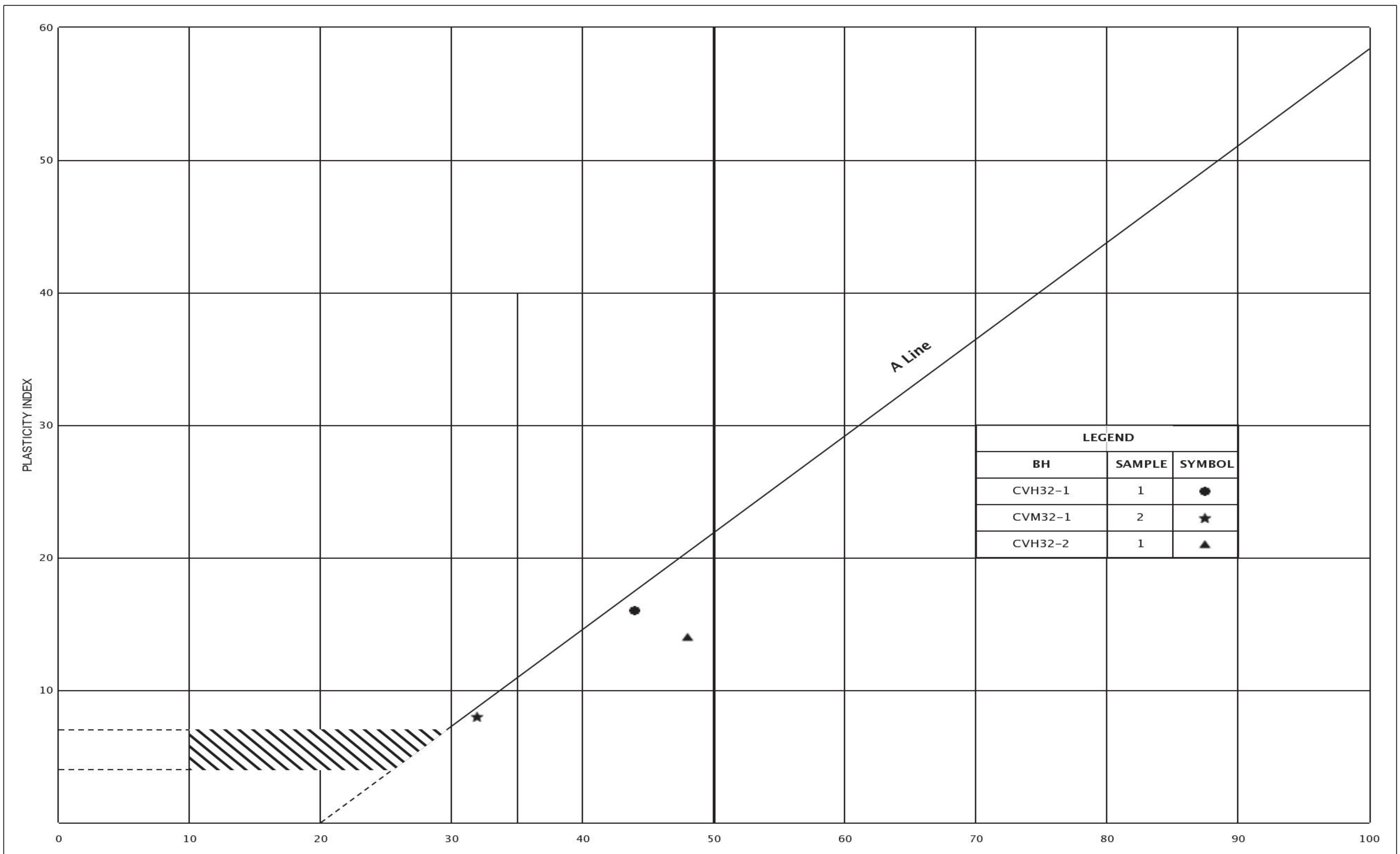
$+^3, \times^3$: Numbers refer to Sensitivity   ○ $^{3\%}$ STRAIN AT FAILURE

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 22-10-26



LEGEND			
BH	CVH32-1	CVM32-1	CVH32-2
SAMPLE	1	2	1
SYMBOL	●	▲	★

Ontario	**GRAIN SIZE DISTRIBUTION** SILTY CLAY/CLAYEY SILT	FIG No.: GS-J-1 HWY : 69 Project No.: 14TF034G



LEGEND		
BH	SAMPLE	SYMBOL
CVH32-1	1	●
CVM32-1	2	★
CVH32-2	1	▲

Ontario	**PLASTICITY CHART** Sandy SILTY CLAY/CLAYEY SILT	FIG No.: PC-J-1 HWY.: 69 Proj No. 14TF034G

SHEET K – CVH-46 AND 47 – Fisheries/Wildlife Culverts (Station: ± 18+400 Hwy 69 NBL/SBL – Henvey)

- Borehole Locations and Soil Strata (Geocres 41H-134)
- Record of Borehole Logs (Geocres 41H-134)
- Laboratory Test Results (Geocres 41H-134)

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field work for Culverts CVH-46 and CVH-47 at Station 18+400 Henvey Township (Site Nos. xxx and xxx under the Highway 69 NBL and SBL, respectively) was carried out by Golder Associates (Golder) between January 25 and 29, 2012, and a foundation investigation report (FIR) (Reference 1 below) was completed and submitted to MTO.

A total of 25 borehole (S308-01 to S308-25) and 11 DCPT (S308-DC01 to S308-DC11) investigations were conducted by Golder within the Swamp 308 area, along the northbound lanes (NBL) and southbound lanes (SBL) of the proposed Highway 69 alignment. For the purposes of this report, three (3) of the investigated boreholes (S308-03, S308-04, and S308-18) are deemed relevant for the proposed culverts. The boreholes were advanced using either portable equipment equipped with NW casing and wash boring, or 70 mm O.D. solid stem auger.

The following Reference Report were referenced:

1. Foundation Investigation and Design Report – Swamp Crossings and High Fill Areas – Contract 3, 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, (GEOCRES No. 41H-134), submitted to URS Canada Inc. by Golder Associates, February 11, 2014 (Report Number: 09-1111-6014-3520)

Relevant geotechnical data from the reference report are provided in Appendix A-2 of this report, including records of borehole logs and preliminary foundation drawings.

Table K-1 - Borehole Information for Culvert CVH-46

BOREHOLE ID	BOREHOLE LOCATION	MTM ON10 NAD 83 COORDINATES		GROUND SURFACE ELEVATION (m)	BOREHOLE DEPTH (m)
		NORTHING (m)	EASTING (m)		
S308-18	Centreline of Highway 69 NBL, south of proposed culvert	5 080 613.1	223 064.1	193.0	2.0

Table K-2 - Borehole Information for Culvert CVH-47

BOREHOLE ID	BOREHOLE LOCATION	MTM ON10 NAD 83 COORDINATES		GROUND SURFACE ELEVATION (m)	BOREHOLE DEPTH (m)
		NORTHING (m)	EASTING (m)		
S308-03	Centreline of Highway 69 SBL, north of proposed culvert	5 080 619.9	223 027.1	192.8	2.1
S308-04	West of embankment, south of proposed culvert	5 080 609.7	223 013.4	193.1	4.4

1.1. Culvert CVH-46 Subsurface Conditions

Based on the factual data presented in the Record of Borehole Sheets and Figures completed by Golder, the subsurface conditions encountered during the site investigation carried out by Golder can be categorized into three (3) general soil layers as presented below as presented below from surface downwards.

1.1.1. Peat

A 600 mm thick amorphous peat layer was encountered immediately below the existing ground surface. The SPT 'N' value in this layer was 1 blow for 30 cm penetration, indicating very soft consistency.

1.1.2. Gravelly Sand/Silty Sand

This sand deposit, with varying proportions of silt and gravel, was encountered below the peat. This layer extends to the termination depth of 2.0 m (EL. 191.0 m) below the existing grade.

The SPT 'N' values recorded in this layer ranged from 12 blows to over 100 blows for 30 cm penetration, indicating compact to very dense state of compaction.

The moisture content test results of two (2) samples from this layer were approximately 19% and 30%. The results of sieve analysis conducted on one (1) representative sample from this layer are provided in Figure H.S308-07. The test results indicate that this deposit consists of 27% gravel, 60% sand, 10% silt and 3% clay sized particles.

1.1.3. Inferred Bedrock

Probable bedrock surface was inferred by refusal to further split-spoon advancement in Boreholes S308-18 at 2.0 m (EL. 191.0 m) below ground surface.

1.1.4. Groundwater Conditions

The groundwater level observed upon completion of drilling was measured at a depth of 0.6 m (EL. 192.4 m) below the existing ground surface. Groundwater levels may fluctuate due to the influence of precipitation and seasonal changes.

1.2. Culvert CVH-47 Subsurface Conditions

Based on the factual data presented in the Record of Borehole Sheets and Figures completed by Golder, the subsurface conditions encountered during the site investigation carried out by Golder can be categorized into five (5) general soil layers as presented below as presented below from surface downwards.

1.2.1. Peat

A layer of amorphous peat, 100 mm to 600 mm thick, was encountered immediately below the existing ground surface in both boreholes.

The SPT ‘N’ values in this layer were 2 blows and 3 blows for 30 cm penetration, indicating soft consistency.

1.2.2. Clayey Silt

A layer of clayey silt, 1.0 m thick, was encountered below the peat layer in Borehole S308-04, extending to a depth of 1.1 m (EL. 192.0 m) below the existing grade.

The SPT ‘N’ value in this layer was 7 blows for 30 cm penetration, indicating firm consistency. The moisture content of one (1) sample tested from this layer was approximately 33%.

1.2.3. Silt and Sand/Silty Sand

A silt and sand deposit was encountered below the peat layer in Borehole S308-03, extending to the termination depth of 2.1 m (EL. 190.7 m). The deposit was not fully penetrated. The SPT ‘N’ values recorded in this deposit up to an approximate elevation of EL. 191.0 m were 0 ~~blows~~ (penetration due to the weight of the hammer and rods) and 1 blow for 30 cm penetration, indicating a very loose state of compactness. Below elevation EL. 191.0 m, the ‘N’ value increased to over 100 blows for 30 cm penetration, where spoon and casing refusal were encountered, indicating a very dense soil condition. Moisture contents of the samples recovered from this borehole were approximately 41% and 45%.

A 2.0 m thick sandy silt deposit was encountered below the clayey silt layer in Borehole S308-04, extending to a depth of 3.1 m (EL. 190.0 m) below the existing grade. The SPT ‘N’ values in this deposit ranged from 10 blows to 32 blows for 30 cm penetration, indicating compact to dense state of compactness.

A 0.7 m thick silt and sand deposit was encountered below the sandy silt in Borehole S308-04, extending to 3.8 m (EL. 189.3 m). The SPT ‘N’ value recorded within this silt and sand deposit was 12 blows for 30 cm penetration, indicating a compact state of compaction. The moisture content value determined on one sample from this deposit was approximately 16%.

The results of the sieve analysis test performed on three (3) representative samples from silt and sand/silty sand layers are provided on Figure H.S308-03. The test results indicate that these deposits consist of 0% to 11% gravel, 20% to 54% sand, 33% to 76% silt and 2% to 13% clay sized particles.

1.2.4. Gravelly Sand/Sand and Gravel

This deposit was encountered below the silt and sand deposit in Borehole S308-04, extending to termination depth of 4.4 m (EL. 188.7 m) below the existing grade. This layer was not fully penetrated to determine the thickness of the deposit.

The SPT ‘N’ value in this layer was 7 blows for 30 cm penetration, indicating a loose state of compactness. Casing refusal was encountered below 4.4 m depth (EL. 188.7 m).

1.2.5. Inferred Bedrock Surface

Probable bedrock surface was inferred by refusal to further split-spoon and/or casing advancement refusal at borehole S308-03 and S308-04 locations at 2.1 m and 4.4 m depth below ground surface (EL. 190.7 m and El. 188.7 m), respectively.

1.2.6. Groundwater Conditions

The groundwater level observed upon completion of drilling was measured at 0.6 m (EL. 192.2 m) and 1.1 m (EL. 192.0 m) below the existing ground surface in Boreholes S308-03 and S308-04, respectively. Groundwater levels may fluctuate due to the influence of precipitation and seasonal changes.

PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) were based on the following references:

1. Foundation Investigation and Design Report – Swamp Crossings and High Fill Areas – Contract 3, 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, (GEOCRES No. 41H-134), submitted to URS Canada Inc. by Golder Associates, February 11, 2014 (Report Number: 09-1111-6014-3520)
2. Culvert Sections Drawings, provided by Parsons via email dated November 25, 2020
3. Highway 69 Profile Drawings, provided by Parson via email dated November 25, 2020.

2. PROJECT DESCRIPTION

2.1. General

The proposed Fisheries/Wildlife (SAR) Culverts are new structures across the new alignment of Highway 69 NBL and SBL. The culverts are located within Swamp 308 area in the Township of Henvey.

2.2. Proposed Structures

It is understood that each of the proposed culverts will have a span of 3.0 m and a height of 2.4 m. They will be approximately 32.0 m long. Culverts CVH-46 and CVH-47 will be on skews of approximately 7.4 degrees and 12.3 degrees, respectively, to the new Highway 69 alignment.

The existing ground surface in the vicinities of the proposed culvert alignments varies from approximately EL. 192.8 m to EL. 193.0 m. A small creek runs across the proposed Highway 69 alignment from east to west.

Based on Reference 3, the proposed invert levels of the proposed NBL and SBL culverts and inferred founding levels are summarized in Table K-1 and Table K-2 below.

Table K-1: Box Culvert Founding Elevations at Station 18+400 NBL CVH-46 Culvert

PROPOSED CULVERT INVERT ELEVATION	BOTTOM OF BOX CULVERT ELEVATION	SUBGRADE ELEVATION FOR GRANULAR BEDDING	FOUNDING STRATUM
192.3 m	192.0 m	191.7 m	Compact gravelly sand

Note(s): 1: The thickness of the bottom slab of the precast concrete box culvert is assumed to be 0.25 m (minimum).

Table K-2: Box Culvert Founding Elevations at Station 18+400 SBL CVH-47 Culvert

PROPOSED CULVERT INVERT ELEVATION	BOTTOM OF BOX CULVERT ELEVATION	SUBGRADE ELEVATION FOR GRANULAR BEDDING	FOUNDING STRATUM
191.9 m	191.6 m	191.3 m	Compact sandy silt/silt and sand

Note(s): 1: The thickness of the bottom slab of the precast concrete box culvert is assumed to be 0.25 m (minimum).

Based on Reference 2, the height of the embankment fill required above the culverts to the proposed grades of re-aligned highway at Station 18+400 is not expected to exceed 2.5 m, including the pavement structure. The report Reference 2 indicates that the maximum height of embankment across Swamp 308 will be 5.0 m.

In the absence of any structural details of the culverts, it is assumed that concrete culverts and fill would impose a dead load of 60 kPa on the founding subgrade.

3. EVALUATION OF FOUNDATION ALTERNATIVES

The foundation alternatives listed below were based on the available information in References 1, 2 and 3 and also considered the construction of the embankments across Swamp 308 in Reference 1, including the assumed embankment fill required above the culvert that is not expected to exceed 2.5 m. Reference 1 indicates that embankment to be used for preloading the proposed Highway 69 SBL alignment with no surcharge over Swamp 308 area. No preloading will be carried out for the proposed Highway 69 NBL alignment.

1. Precast concrete box culverts placed without settlement mitigation
2. Precast concrete box culverts placed after preloading or surcharging

For both options, assuming that the culverts CVH-46 and CVH-47 are placed at the proposed subgrade levels of EL. ±191.7 m and EL. ±191.3 m, respectively, compact cohesionless soils are expected underneath the base of the culverts, which underlies the clayey silt. No major settlement issues are expected under the imposed load of 60 kPa at the culvert locations as it is anticipated that all cohesive soil will be excavated to found the subgrade levels for installation of the culverts.

Since there is no existing road or proposed structure where the culverts are proposed, it is recommended that construction of precast concrete box culverts be coordinated with the construction of the embankment fill across Swamp 308. Prior to construction of the embankments with rockfill over the culvert areas, the culverts should be installed in accordance with OPSS.PROV 422. It is suggested that Option 1 be considered for the installation of the culverts.

Unsuitable/organic materials at the culvert locations should be excavated from within the zone of influence of the culverts (minimum of 2 m beyond the culvert walls) and the area under the culverts when preparing the subgrade for the culverts. The exposed subgrade should be inspected and approved before placement of compacted granular materials as specified in OPSS 422.07.06.

The granular material to backfill the precast concrete box culverts should be placed in accordance with OPSS 422.07.07. Granular material should be as specified in accordance with OPSS 422.05.13 and may consist of either Granular 'A' or Granular 'B' Type II, including a 75 mm levelling course for bedding purposes as required by OPSS 422.07.08.

The culvert subgrade in the vicinity of Borehole S308-03 location under the Highway 69 SBL may need to be compacted to a minimum 95% of the standard Proctor maximum dry density (SPMDD) prior to placement of the precast concrete box culvert.

The precast concrete box culvert under the proposed Highway 69 NBL may be designed assuming a factored geotechnical resistance of 185 kPa at ULS and 100 kPa at SLS placed on compact cohesionless soils. Culvert CVH-47 may be designed assuming similar factored geotechnical resistances as Culvert CVH-46.

Following placement of the precast concrete box culvert as recommended and the estimated fill of up to 2.5 m above the culverts, it is estimated that the total settlement would be less than 25 mm and the differential settlement between 15 mm and 20 mm. Generally, for precast concrete box culvert, a tolerable limit of 100 mm of differential settlement is assumed.

If Option 2 is considered, excavation up to 6.0 m of fill and subsurface soil would be required to install the culvert under the proposed Highway 69 SBL at the subgrade levels. Furthermore, it would also require additional handling of the fill material. Reference Report 1 recommends use of preloading with 5.0 m high rockfill to mitigate the post-construction settlement under the Highway 69 SBL area of Swamp 308. It is estimated that 90% of primary consolidation will be completed in 30 days. During preloading, granular soils, instead of rockfill, would need to be utilized for preloading over the proposed culvert area under Highway 69 SBL for ease of excavation for the installation of the culverts. Option 2 may also require temporary shoring during excavation and installation of the culverts. Following the installation of the culvert, the rockfill may be placed as suggested in Reference Report 1. It is considered that Option 2 is feasible but not preferred.

4. CULVERT BEDDING AND COVER MATERIALS

Refer to the General Report for preliminary recommendations for materials to be used for culvert bedding and cover purposes.

5. APPROACH EMBANKMENT

The details for design, construction, and mitigation procedures for the embankment through Swamp 308 were presented in the Reference Report 1. This report may be consulted for placement of fill for the swamp crossing and no recommendation is provided in this report.

6. CONSTRUCTION CONSIDERATIONS

6.1. Excavation

Considering the existing ground level (EL. 192.8 m to EL. 193.1 m) and the culvert subgrade levels (EL. ±191.7 and EL. ±191.3 m), 1.3 m to 1.8 m deep excavations into native soils are required for subgrade preparation. Slope instability issues are not anticipated.

If Option 2 is selected, approximately 6.0 m of excavation into the embankment fill and subsurface soils would be required and the stability of the temporary slope excavation should be assessed during the design-build stage. The Contractor should consider the type of preloaded material over the culvert area under the proposed Highway 69 SBL to facilitate excavation and disposal or reuse of the temporary fill materials.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

Preliminary recommendations for backfilling to the culvert are provided in the General Report.

6.2. Groundwater and Surface Water Control

The existing beaver dam east of Culvert CVH-46 should be removed for the construction of the culvert. Dewatering may have to be carried out from sumps installed along the interior periphery of the excavation to maintain the groundwater level a minimum 0.5 m depth below the base of the excavations. Surface water flow should be directed away from the excavation areas to mitigate disturbance of the native subgrade. For construction in-the-dry, the creek watercourse will have to be temporarily diverted.

Refer to the General Report for further groundwater control recommendations and requirements for water taking.

6.3. Additional Investigation

It is suggested that additional investigation to 3.0 m below the depth of the proposed subgrade level at the inlet and outlet ends for both Culverts CVH-46 and CVH-47 be carried out during the detail design to determine the subsoil and groundwater conditions. Based on the data, the recommendations provided in this report may have to be revised.

MINISTRY OF TRANSPORTATION, ONTARIO

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

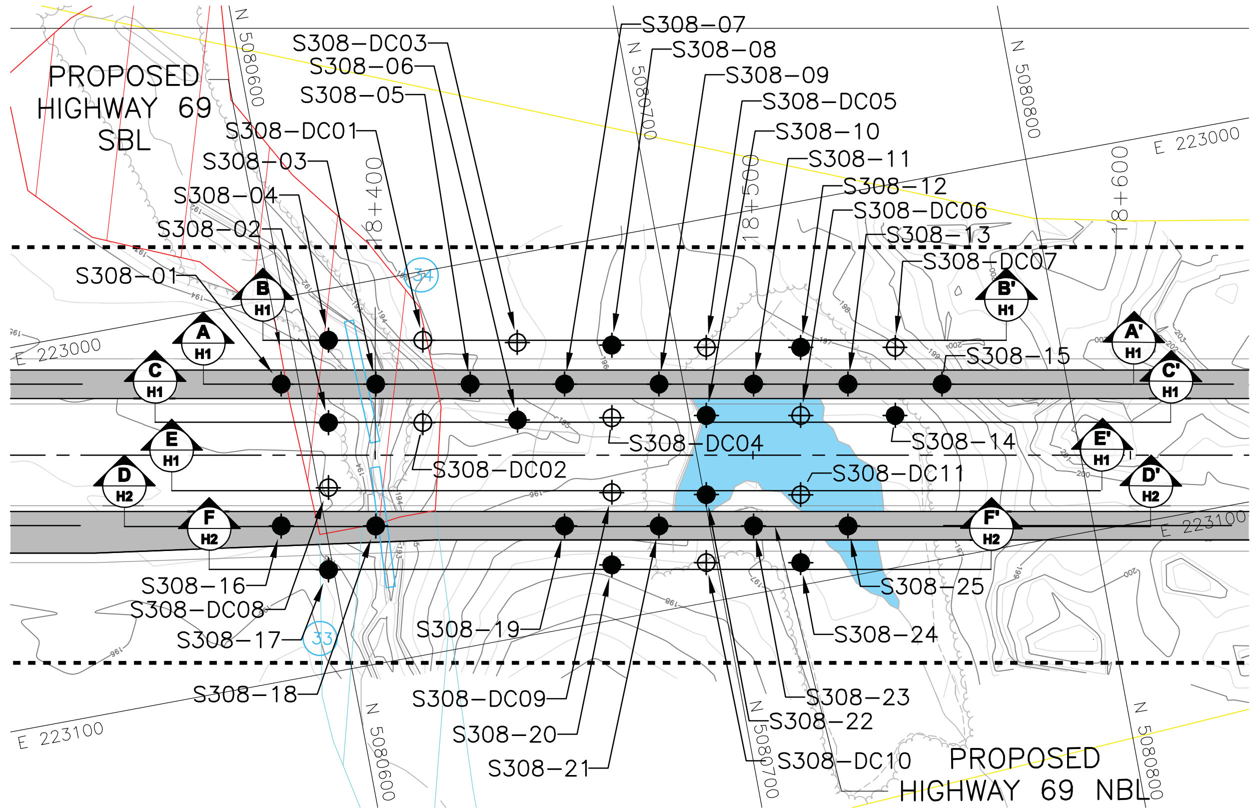
CONT No.
WP No. 5404-05-01

SHEET

HIGHWAY 69
STA 18+375 TO 18+550 (SBL)
STA 18+375 TO 18+535 (NBL)

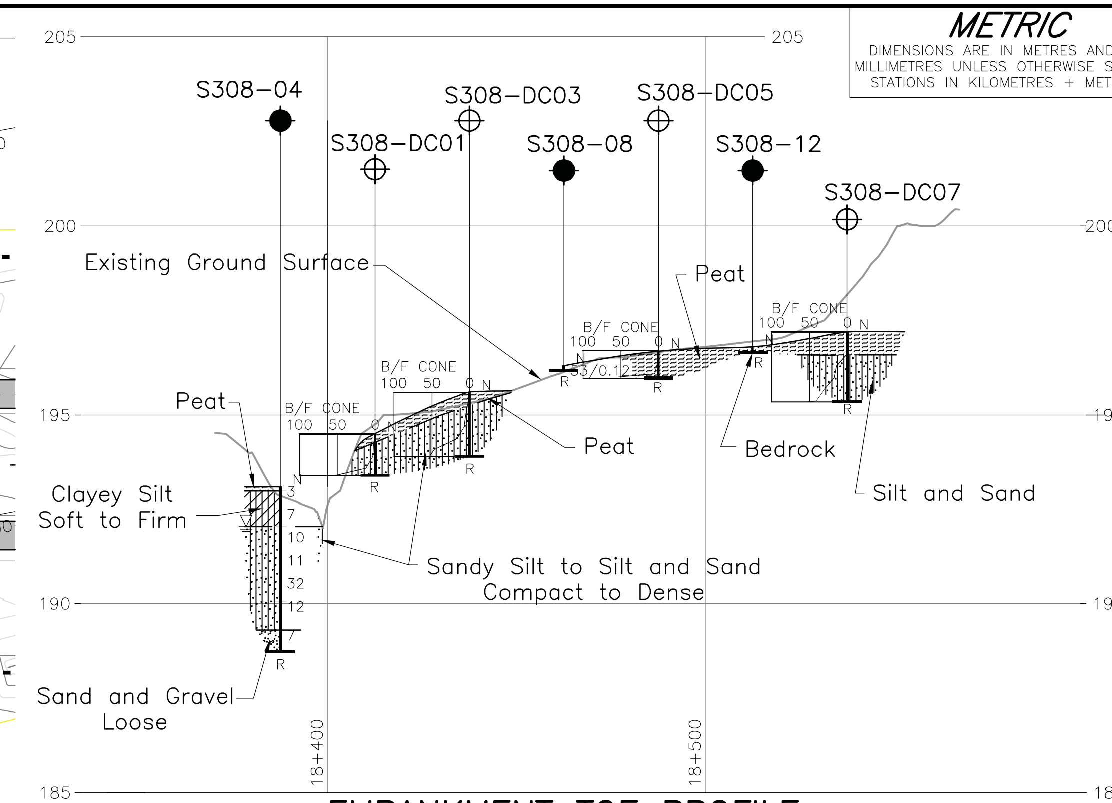
BOREHOLE LOCATIONS AND SOIL STRATA

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



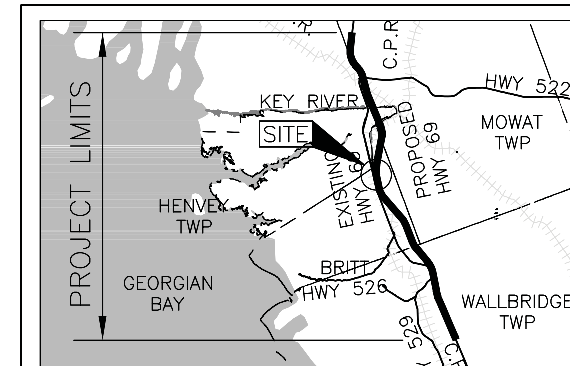
PLAN

SCALE
20 0 20 40 m



B-B' H1 EMBANKMENT TOE PROFILE HIGHWAY 69 (SBL)

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



KEY PLAN

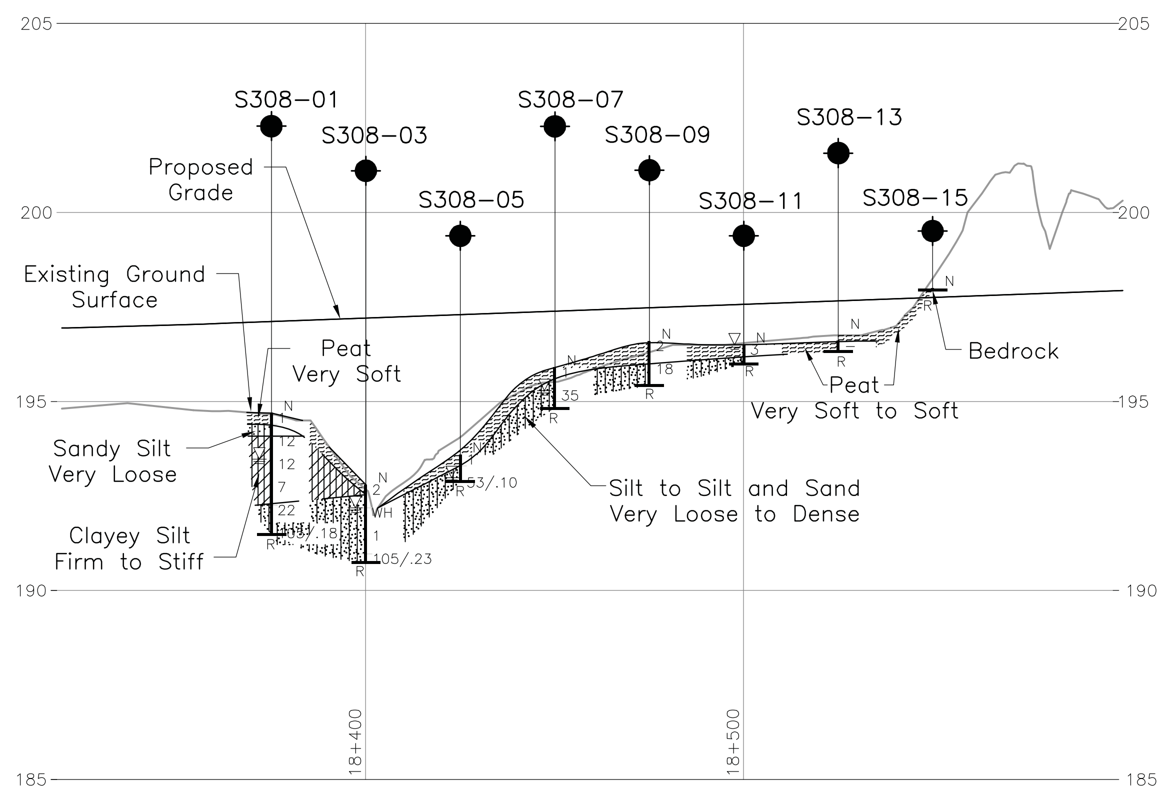
SCALE
5 0 5 10km

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
S308-01	194.7	5080595.3	223022.5
S308-02	194.7	5080605.8	223034.8
S308-03	192.8	5080619.9	223027.1
S308-04	193.1	5080609.7	223013.4
S308-05	193.6	5080644.5	223031.6
S308-06	194.6	5080655.1	223043.3
S308-07	195.9	5080669.1	223036.2
S308-08	196.3	5080683.2	223028.4
S308-09	196.6	5080693.7	223040.8
S308-10	196.3	5080704.4	223051.2
S308-11	196.5	5080718.2	223045.3
S308-12	196.8	5080732.3	223038.1
S308-13	196.6	5080742.8	223049.9
S308-14	196.7	5080753.6	223060.3
S308-15	198.0	5080767.4	223054.4
S308-16	195.5	5080588.5	223059.5
S308-17	195.9	5080598.7	223073.2
S308-18	193.0	5080613.1	223064.1
S308-19	196.6	5080662.2	223073.2
S308-20	197.9	5080672.6	223085.6
S308-21	196.6	5080686.8	223077.7
S308-22	196.3	5080700.6	223071.9
S308-23	197.6	5080711.4	223082.3
S308-24	196.6	5080721.9	223094.1
S308-25	196.4	5080736.0	223086.8



A-A' H1 CENTRELINE PROFILE HIGHWAY 69 (SBL)

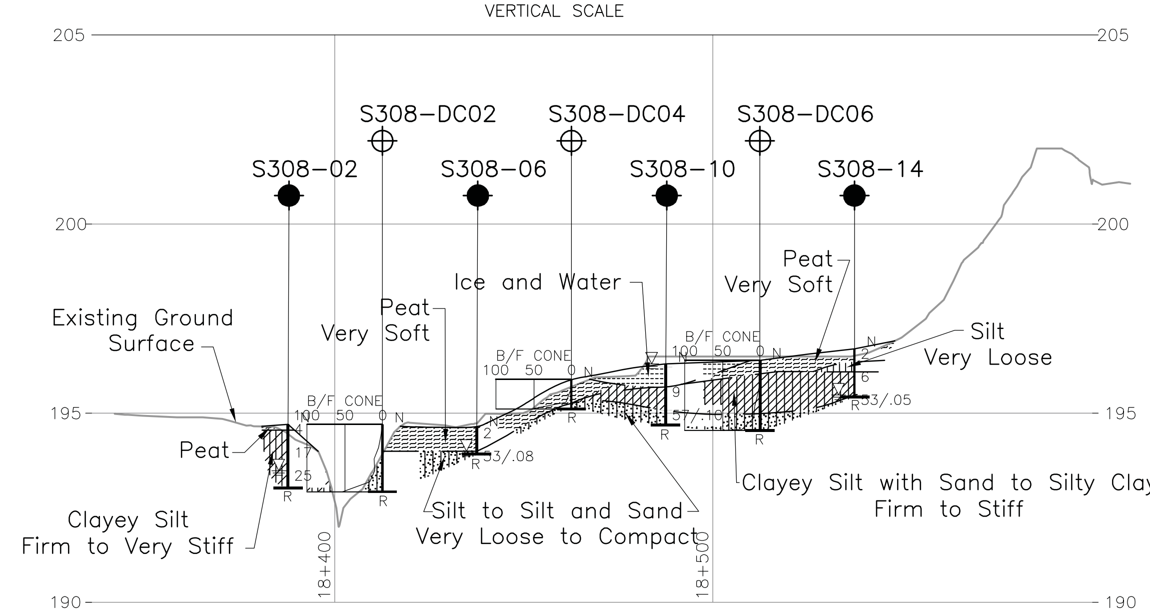
HORIZONTAL SCALE
20 0 20 40 m
2 0 2 4 m
VERTICAL SCALE

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.



C-C' H1 EMBANKMENT TOE PROFILE HIGHWAY 69 (SBL)

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

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
S308-DC01	194.5	5080634.3	223018.0
S308-DC02	194.7	5080630.3	223039.4
S308-DC03	195.6	5080658.8	223023.1
S308-DC04	195.9	5080679.7	223047.2
S308-DC05	196.7	5080707.7	223033.5
S308-DC06	196.4	5080729.0	223055.8
S308-DC07	197.2	5080756.9	223042.6
S308-DC08	195.3	5080602.6	223051.8
S308-DC09	196.0	5080676.1	223066.7
S308-DC10	197.3	5080697.3	223089.5
S308-DC11	196.4	5080725.2	223076.4

REFERENCE

Base plans provided in digital format by URS, drawing file nos. Alignment and Contours from Hwy69_Contour-Plan_C3.dwg, received April 23, 2012 and , Original Ground Surface cut from contour drawing file Hwy69_Contour-Plan_C3.dwg, received April 23, 2012 and the Proposed Grade obtained from drawing file Hwy69_profile March 2012.dwg, received March 14, 2012.

LICENSED PROFESSIONAL ENGINEER J. M. A. COSTA Jan. 2014 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER T. ZALUCKI 100128614 Jan. 2014 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 41H-134

HWY.	PROJECT NO. 09-1111-6014		DIST.
SUBM'D. CC	CHKD. TZ	DATE: May 2013	SITE:
DRAWN: JFC/LL	CHKD. CN	APPD. JPD/JMAC	DWG. H1

PLOT DATE: January 22, 2014

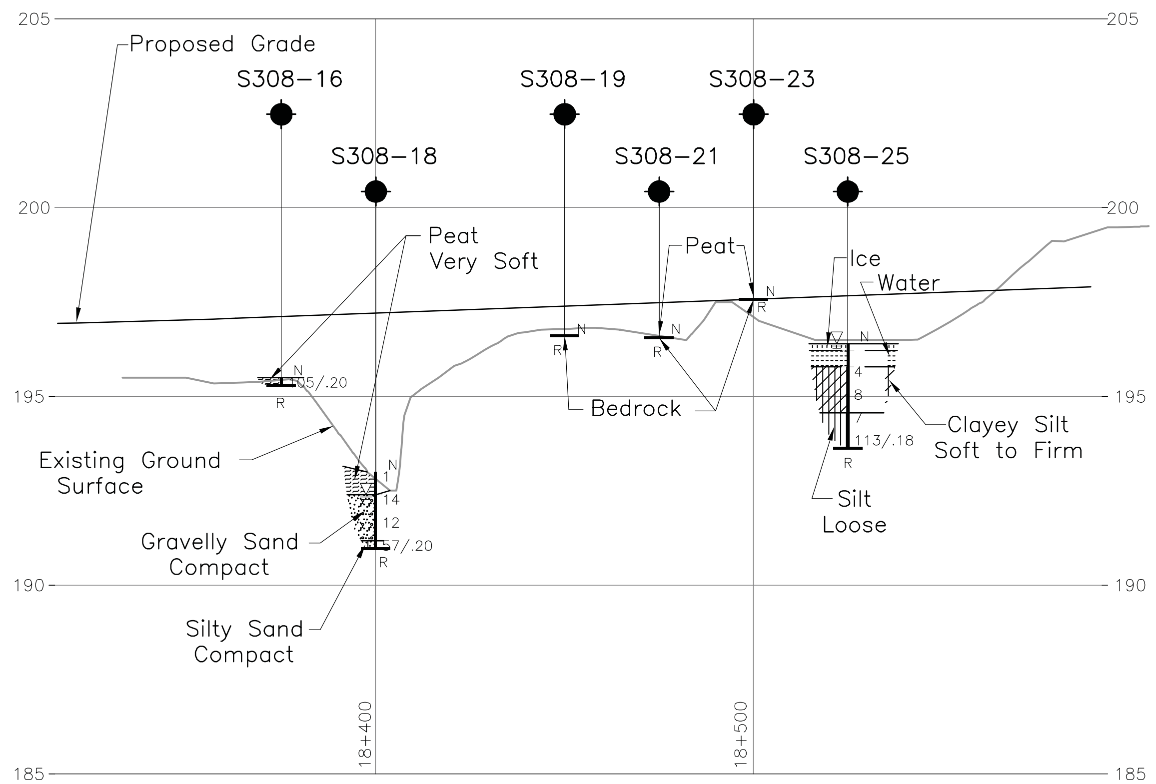
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No.5404–05–01

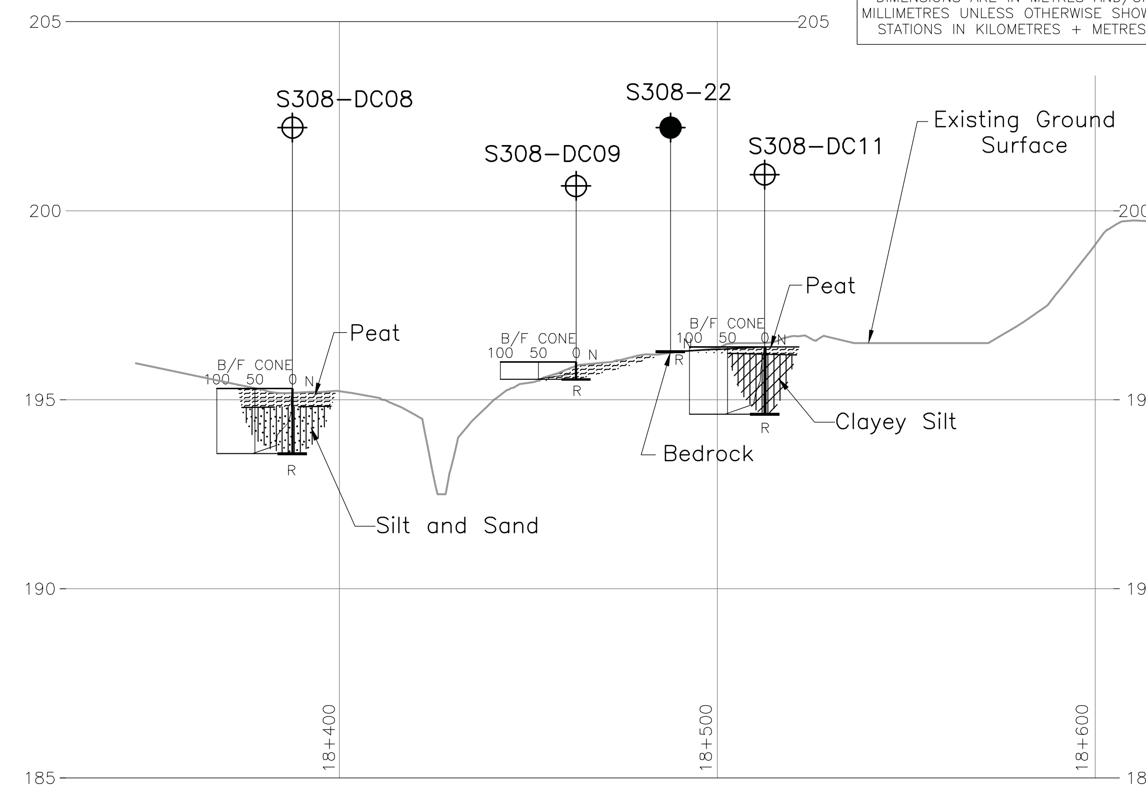
HIGHWAY 69
STA 18+375 TO 18+535 (NBL)
SOIL STRATA

SHEET

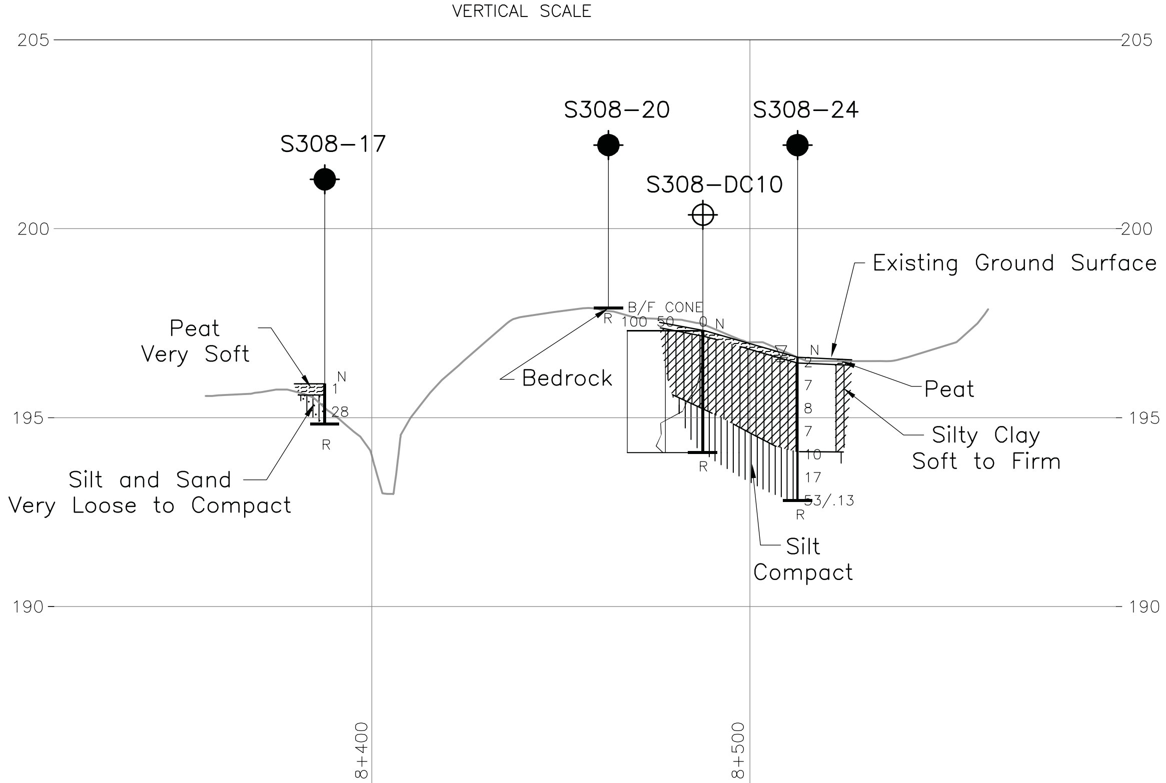
Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



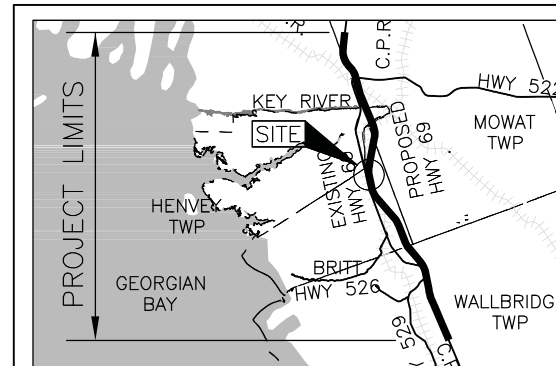
D-D'
H1
CENTRELINE PROFILE
HIGHWAY 69 (NBL)
HORIZONTAL SCALE 20 0 20 40 m
2 0 2 4 m VERTICAL SCALE



E-E'
H1
EMBANKMENT TOE PROFILE
HIGHWAY 69 (NBL)
HORIZONTAL SCALE 20 0 20 40 m
2 0 2 4 m VERTICAL SCALE



F-F'
H1
EMBANKMENT TOE PROFILE
HIGHWAY 69 (NBL)
HORIZONTAL SCALE 20 0 20 40 m
2 0 2 4 m VERTICAL SCALE



KEY PLAN
SCALE 5 0 5 10 km

LEGEND

- Borehole – Current Investigation
- Dynamic Cone Penetration Test
- N 16 — Standard Penetration Test Value 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
S308–16	195.5	5080588.5	223059.5
S308–17	195.9	5080598.7	223073.2
S308–18	193.0	5080613.1	223064.1
S308–19	196.6	5080662.2	223073.2
S308–20	197.9	5080672.6	223085.6
S308–21	196.6	5080686.8	223077.7
S308–22	196.3	5080700.6	223071.9
S308–23	197.6	5080711.4	223082.3
S308–24	196.6	5080721.9	223094.1
S308–25	196.4	5080736.0	223086.8
S308–DC08	195.3	5080602.6	223051.8
S308–DC09	196.0	5080676.1	223066.7
S308–DC10	197.3	5080697.3	223089.5
S308–DC11	196.4	5080725.2	223076.4

NOTES

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

Existing Ground Surface cut from contour drawing file provided in digital format by URS, titled Hwy69_Contour-Plan_C3.dwg, received April 23, 2012 and the Existing and Proposed Grades obtained from drawing file Hwy69_profile March 2012.dwg, received March 14, 2012.

LICENSED PROFESSIONAL ENGINEER J. M. A. COSTA Jan. 2014 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER T. ZALUCKI 100128614 Jan. 2014 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 41H–134

HWY.	PROJECT NO. 09–1111–6014		DIST.
SUBM'D. CC	CHKD. TZ	DATE: May 2013	SITE:
DRAWN: JFC	CHKD. CN	APPD. JPD/JMAC	DWG. H2

PLOT DATE: January 22, 2014

Golder Associates

Foundation Design

RECORD OF BOREHOLE No S308-03 SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01 LOCATION N 5080619.9 ;E 223027.1 ORIGINATED BY ARM
DIST HWY 69 BOREHOLE TYPE Portable Equipment, NW Casing, Wash Boring COMPILED BY MAS
DATUM Geodetic DATE January 27, 2012 CHECKED BY CN/TZ

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
192.8	GROUND SURFACE						
0.0	PEAT (Amorphous), Very soft, Black, Moist	1	SS	2	▽		
192.2 / 0.6	SILT and SAND, some clay, trace organics, Very loose, Grey, Wet	2	SS	WH		192	0 43 44 13
		3	SS	1			
		4	SS	105/0.23		191	Non-Plastic
190.7 / 2.1	END OF BOREHOLE, SPOON AND CASING REFUSAL						

NOTE:

1. Water level in open borehole at a depth of 0.6 m below ground surface (Elev. 192.2 m) upon completion of drilling.

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 01/22/14

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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No S308-04 SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01 LOCATION N 5080609.7 ;E 223013.4 ORIGINATED BY ARM
DIST HWY 69 BOREHOLE TYPE Portable Equipment, NW Casing, Wash Boring COMPILED BY MAS
DATUM Geodetic DATE January 26, 2012 CHECKED BY CN/TZ

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.1	GROUND SURFACE					193	
0.0	PEAT (Amorphous)						
0.1	CLAYEY SILT, trace to some sand, trace organics and containing silt seams, Soft to firm, Brown, Moist	1	SS	3			
		2	SS	7	▽	192	
192.0 / 1.1	Sandy SILT, trace clay, Compact to dense, Brown becoming grey below a depth of 2.4 m, Wet	3	SS	10			
		4	SS	11		191	0 20 76 4
		5	SS	32			
190.0 / 3.1	SILT and SAND, trace to some gravel, trace clay, Compact, Grey, Wet	6	SS	12		190	11 54 33 2
189.3 / 3.8	SAND and GRAVEL, trace silt, Loose, Grey, Wet	7	SS	7		189	
188.7 / 4.4	END OF BOREHOLE, CASING REFUSAL						

NOTES:

1. Water level in open borehole at a depth of 1.1 m below ground surface (Elev. 192.0 m) upon completion of drilling.

2. 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.

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 01/22/14

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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No S308-18 SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01 LOCATION N 5080613.1 ;E 223064.1 ORIGINATED BY ARM
DIST HWY 69 BOREHOLE TYPE Portable Equipment, 70 mm O.D. Solid Stem Hand Auger COMPILED BY MAS
DATUM Geodetic DATE January 27, 2012 CHECKED BY CN/TZ

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.0	GROUND SURFACE						
0.0	PEAT (Amorphous) Very soft Black Moist	1	SS	1	▽		
192.4 0.6	Gravelly SAND, trace to some silt, trace clay, trace organics Compact Grey Wet	2	SS	14		192	
		3	SS	12			27 60 10 3
191.2 2.0	Silty SAND, trace gravel Compact Grey Wet	4	SS	57/0.20		191	
	END OF BOREHOLE SPOON REFUSAL						

NOTES:

1. Water level in open borehole at a depth of 0.6 m below ground surface (Elev. 192.4 m) upon completion of drilling.

2. 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.

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L
WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m³

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

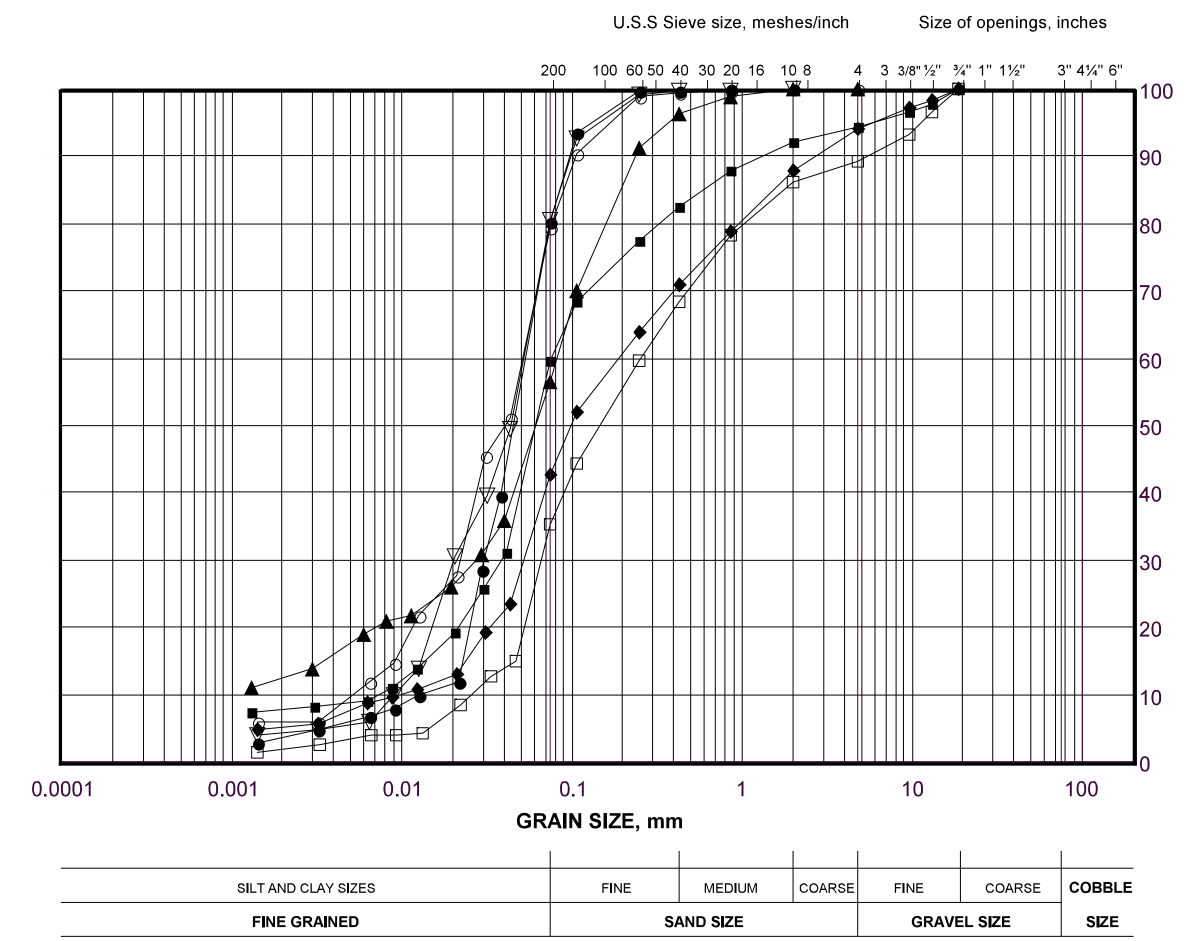
GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 01/22/14

GRAIN SIZE DISTRIBUTION

Sandy Silt to Silt and Sand

Highway 69 (SBL) STA 18+375 to 18+550 (Swamp 308)

FIGURE H.S308-03



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S308-10	2	194.9
■	S308-09	2	194.7
◆	S308-07	2	195.0
▲	S308-03	2	191.9
▽	S308-04	4	191.0
○	S308-01	5	192.0
□	S308-04	6	189.7

Project Number: 09-1111-6014

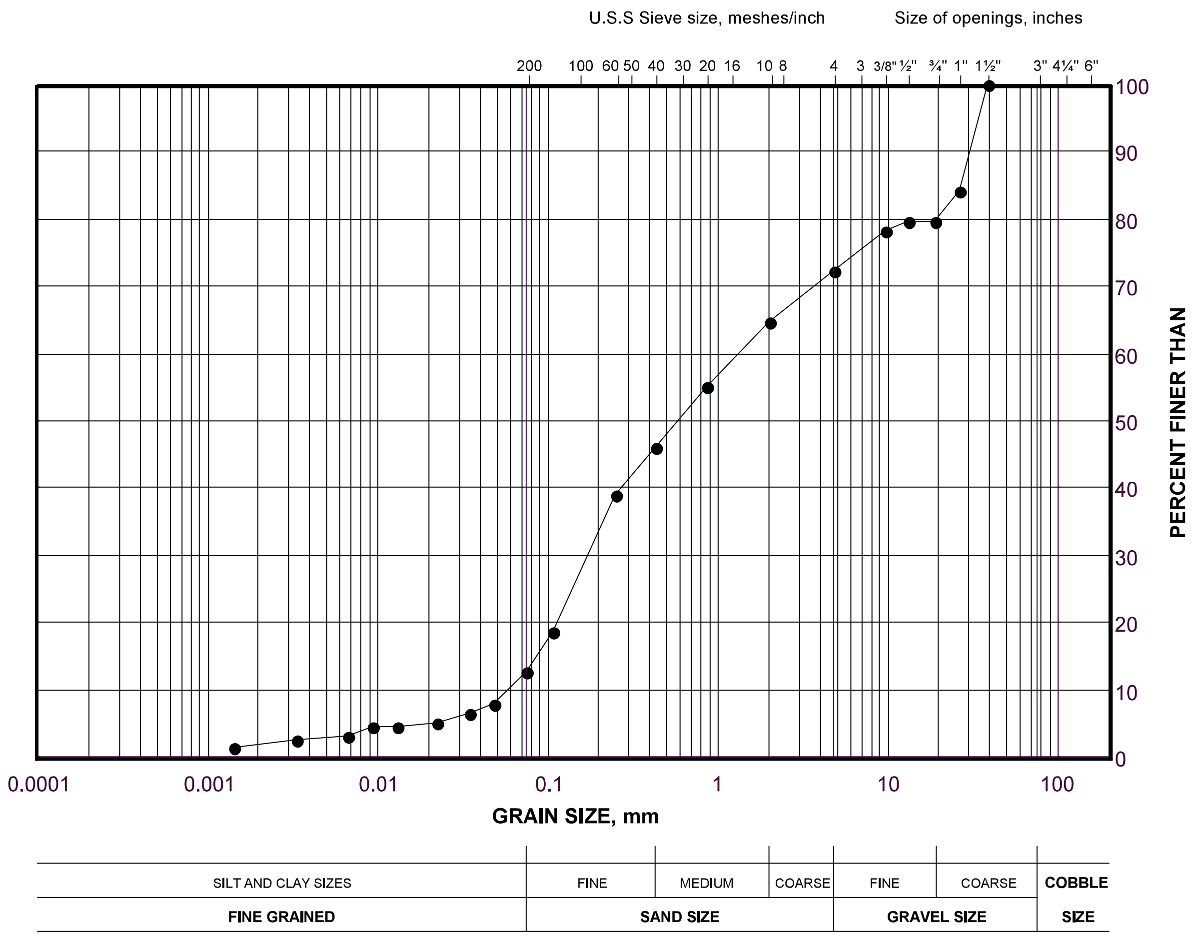
Checked By: TZ

Golder Associates

Date: 05-Mar-13

GRAIN SIZE DISTRIBUTION
Gravelly Sand
Highway 69 (NBL) STA 18+375 to 18+535 (Swamp 308)

FIGURE H.S308-07



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S308-18	3	191.5

Project Number: 09-1111-6014

Checked By: TZ

Golder Associates

Date: 05-Mar-13

SHEET L – C189 - Fisheries Culvert (Station: ± 19+215 Existing Hwy 69 NBL/SBL – Henvey)

- Borehole Location Plan (PML)
- Record of Borehole Logs (PML)
- Laboratory Test Results (PML)
- Rock Core Description and Photographs (PML)

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field work for Culvert C189 at Station 19+215, in the Township of Henvey (Site Nos. 44X-0667/C0 under the NBL and SBL) was carried out between July 15 and 28, 2021.

2. BOREHOLE INFORMATION

A total of three (3) boreholes were advanced along the alignment of the proposed replacement of the existing culvert (Site No. 44X-0667/C0) along the same horizontal and vertical alignment.

Refer to
- Drawing L-1 for the borehole location plan
- Table L-1 for details of borehole origin, borehole location coordinates and borehole elevations/depths
- Record of Borehole sheets and lab results showing details of the subsurface conditions at the borehole locations from current investigation

Table L-1 Structural Culvert Borehole Information

BOREHOLE ID	BOREHOLE LOCATION	MTM ON10 NAD 83 COORDINATES		GROUND SURFACE ELEVATION (m)	BOREHOLE DEPTH (m)
		NORTHING (m)	EASTING (m)		
C189-1	East End (Inlet)	5 081 456.2	221 941.5	183.0	13.7
C189-2	Median	5 081 457.9	221 947.9	183.1	11.6
C189-3	West End (Outlet)	5 081 455.1	221 952.3	184.0	15.1

2.1. Subsurface Conditions

The stratigraphy generally consists of approximately 300 mm of roadway pavement and approximately 3.8 m to 4.3 m of sand fill. A 1.8 m to 4.5 m thick layer of silty clay/clayey silt was encountered below the fill near the culvert inlet and outlet. Following this silty clay/clayey silt layer, and below the fill layer near the culvert median, a 3.8 m to 6.7 m thick layer of silt was encountered, followed by bedrock to the termination depth of drilling. Refer to the Record of Boreholes for details.

The subsurface conditions at this site can be categorized into five (5) general layers as presented below from surface downwards.

2.1.1. Asphalt

A 300 mm thick layer of asphalt was encountered at the existing road surface in Borehole C189-2, which was drilled on the southbound shoulder of Highway 69.

2.1.2. Sand, Trace to And Gravel Fill

3.8 m to 4.3 m of sand, trace to some gravel fill was encountered below the asphalt in Borehole C189-2, and immediately below the ground surface in Boreholes C189-1 and C189-3. The SPT N values of this layer varied from as low as 2 blows to 76 blows per 0.3 m penetration, indicating a very loose to very dense state of compactness. Moisture contents of the samples ranged between 0.9% and 11.9%. The grain size distribution test results of the representative sample selected from this layer are provided in Figure GS-L-1.

2.1.3. Silty Clay/Clayey Silt, Trace Sand

A 1.8 m and 4.5 m thick layer of silty clay/clayey silt was encountered below the sand fill in Boreholes C189-1 and C189-3, respectively. The SPT N value recorded from this layer was 5 blows per 0.3 m penetration, indicating firm consistency. Moisture contents of the samples ranged between 32.0% and 58.8%. The grain size distribution test results of the representative sample selected from this layer are provided in Figure GS-L-2 and the Atterberg limits are presented in Figure PC-L-1.

2.1.4. Silt, Trace Sand to Sandy

A 3.8 m to 6.7 m thick silt, trace sand to sandy deposit was encountered immediately below the silty clay/clayey silt layer in Boreholes C184-1, C184-2, and below the sand fill in Borehole C184-3, and extended to depths ranging from 10.5 m to 12.1 m (EL. 172.5 to EL. 171.5) below the existing ground surface. The SPT N values of this layer ranged from as low as 1 blow to 18 blows per 0.3 m penetration, indicating very loose to compact state of compactness. SPT N values of over 100 blows per 0.3 m penetration were observed near the bedrock surface. Moisture content determinations of the samples tested from this layer ranged from 19.3% and 26.9%, with the exception of one (1) sample from the layer surface in Borehole C184-2, which was 53.7%. The grain size distribution test results of the representative sample selected from this layer are provided in Figure GS-L-3 and the Atterberg limits are presented in Figure PC-L-2.

2.1.5. Bedrock

Bedrock was encountered below the silt deposit in all three (3) investigated boreholes. The presence of bedrock was confirmed by obtaining 3.0 m, 3.0 m, and 3.2 m of rock cores from Boreholes C189-1, C189-2, and C189-3, respectively. Refer to the rock core descriptions and photographs for more detail.

2.2. Groundwater Conditions

Groundwater was observed during drilling at depths 1.4 m (EL. 181.6) and 0.3 m (EL. 183.7) below the existing ground surface in boreholes C189-1 and C189-3, respectively. Upon completion of drilling, groundwater levels were measured at depths 3.1 m (EL. 179.9) and 1.5 m (EL. 182.5) below the existing ground surface in Boreholes C184-1 and C184-3, respectively. Groundwater levels were not encountered during or upon completion of drilling in Borehole C189-2. The creek water level at the inlet of the existing culvert was measured at approximate Elevation 182.5 m, on October 13, 2021.

Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) are based on the information provided by Parsons on March 2, 2018 and the relevant geotechnical data provided in the FIR.

3. PROJECT DESCRIPTION

3.1. General

The existing fisheries culvert crossing existing Highway 69 at Station 19+215 in the Henvey Township is to be replaced. The existing culvert has a 3.1 m span and 2.1 m in height, and approximately 21.4 m in length.

3.2. Proposed Structure

In the absence of a General Arrangement (GA) drawing of the proposed structure, it is anticipated that the existing culvert will be replaced with a culvert of same size, 3.1 m in span, 2.1 m in height and 21.4 m in length, along the same horizontal and vertical alignment. The inlet and outlet invert levels of the proposed culvert are anticipated to remain the same as the existing culvert. New embankment fill, of similar heights as existing Highway 69 embankment, will be placed following removal and replacement of the existing culvert.

3.3. Evaluation of Foundation Alternatives

The foundation alternatives listed below are considered for the replacement culvert.

1. Precast concrete box culvert
2. Cast-in-place concrete culvert

Assuming that the size, length, and vertical and horizontal alignments of the proposed culvert will remain same as the existing culvert, no associated differential settlement and total settlement are anticipated along the length of the proposed culvert.

Based on the site conditions encountered, it is considered that the existing culvert may be installed within the cohesionless fill/sand and gravel. The existing fill/sand and gravel below the culvert invert level should be removed and replaced with compacted granular material to the subgrade level of the replacement culvert. It is estimated that the invert levels of the culverts will be between elevations 180 m and 179 m. For design purposes, factored geotechnical resistances of 105 kPa and 70 kPa at ULS and SLS, respectively, may be considered.

From a geotechnical perspective, both options are feasible. However, precast box culvert construction can be carried out faster than cast-in-place open footing culvert construction resulting in shorter durations for dewatering. Furthermore, the precast box culvert will be more tolerant to the total and differential settlement.

3.4. Culvert Bedding and Cover Materials

Refer to the General Report for preliminary recommendations for materials to be used for culvert bedding and cover purposes.

3.5. Temporary Flow Diversion and Temporary Roadway Protection

For both options, temporary flow diversion or channel will be required to replace the existing culvert in accordance with OPSS.PROV 517, amended by SSP 517F07. It is anticipated the open-cut method will be utilized to replace the existing culvert. Temporary roadway protection will be required in accordance with OPSS.PROV 539, amended by SSP 105S09. The Contractor is responsible for the selection, design, construction and performances of temporary flow channel, cofferdams, if utilized, and temporary roadway protection. Parameters and recommendations for design of temporary flow channel, cofferdam and roadway protection should be determined during the detail design phase of the project. The geotechnical parameters provided in Table G-2 may be used for the preliminary evaluation of temporary protection system.

Table G-2 Preliminary Geotechnical Design Parameters

SOIL TYPE	DESIGN PARAMETERS		UNIT WEIGHT, kN/m^3
	EFFECTIVE FRICTION ANGLE (θ)	UNDRAINED SHEAR STRENGTH, kPa (c_u)	
Sand	30	-	19
Sand and Gravel	32	-	20
Loose Silt	27	-	18
Compact Silt	30	-	18.5
Soft cohesive	-	20	17.5
Firm cohesive	-	40	18

4. APPROACH EMBANKMENT

It is anticipated that there will be no increase in the profile grade of the existing Highway 69. No instability problems are anticipated for the excavated section of the embankment to be reconstructed with similar side slope as the existing. Any soft or compressible zones observed should be removed prior to placing the fill.

5. CONSTRUCTION CONSIDERATIONS

5.1. Staged Construction

The removal of the existing culvert and construction of the new culvert is expected to be carried out in stages. The details of the staged construction should be finalized during the detail design phase of the project.

5.2. Excavation

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

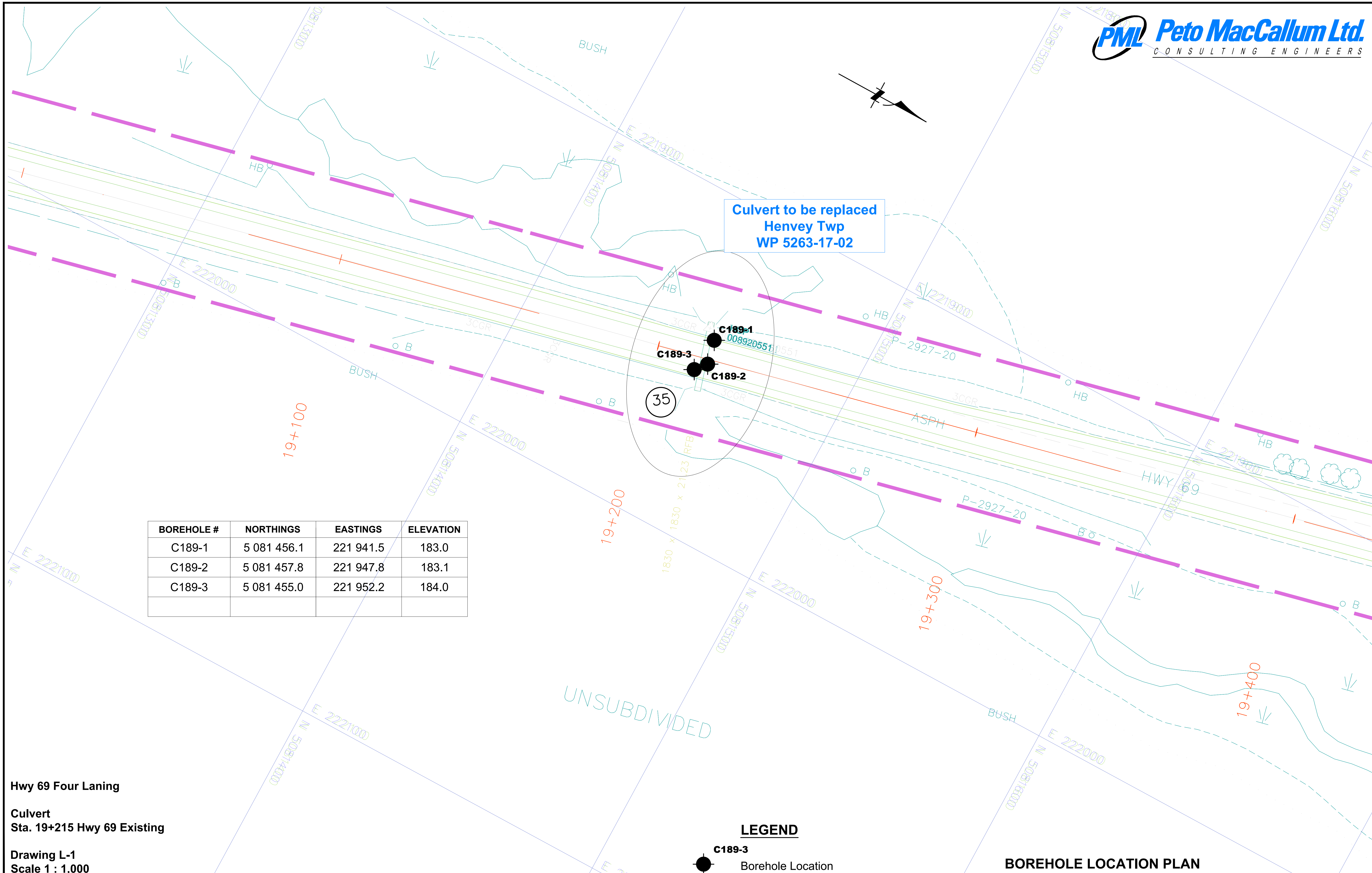
It is anticipated that the excavation will extend through the existing Highway 69 embankment fill into the soft to stiff cohesive soils. In accordance with OHSA, the fill, compact to loose cohesionless and firm to stiff cohesive soils are considered as Type 3 soils. Soft to very soft or very loose soils, soils that run or flows easily unless completely supported, and soils under groundwater are considered as Type 4 soils. The slope of excavation walls should conform to as described in Ont. Reg. 213/92, S. 234. Workers should not enter an unprotected excavation if there is evidence of ongoing groundwater seepage in the pits. Temporary shoring will be required if slopes as described in Ont. Reg. 213/92, S. 234 cannot be provided. Temporary shoring should be in accordance with OPSS.PROV 539, as amended.

Preliminary recommendations for backfilling to the culvert are provided in the General Report.

5.3. Groundwater and Surface Water Control

To prevent basal heave, if any, dewatering may have to be carried out from wells installed along the interior periphery of the excavation to maintain the groundwater level a minimum 0.5 m depth below the base of the excavations. Surface water flow should be directed away from the excavation areas to mitigate disturbance of the native subgrade. For construction in-the-dry, the watercourse will have to be temporarily diverted.

Refer to the General Report for further groundwater control recommendations and requirements for water taking.



BOREHOLE #	NORTHINGS	EASTINGS	ELEVATION
C189-1	5 081 456.1	221 941.5	183.0
C189-2	5 081 457.8	221 947.8	183.1
C189-3	5 081 455.0	221 952.2	184.0

Hwy 69 Four Laning

Culvert
Sta. 19+215 Hwy 69 Existing

Drawing L-1
Scale 1 : 1,000

LEGEND

C189-3
Borehole Location

BOREHOLE LOCATION PLAN

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No C189-1

1 OF 1 **METRIC**

PROJECT Hwy 69 Structural Culvert	COORDINATES Coords: 5 081 456.2 N; 221 941.5 E		ORIGINATED BY M.M.
DIST	HWY 69	BOREHOLE TYPE CFHSA	COMPILED BY N.L.
DATUM Geodetic	DATE 2021.07.28	LATITUDE 45.867958 LONGITUDE -80.567308	CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
183.0	Ground Surface				
0.0	SAND, some gravel Dense to compact, Brown, Moist	1	SS	38	
		2	SS	10	
181.5 / 1.5	SAND AND GRAVEL Loose to very loose, Brown, Moist	3	SS	2	
		4	SS	4	
		5	SS	2	
		6	SS	3	
178.7 / 4.3	SILTY CLAY, trace sand Very soft, Grey, Wet	7	SS	1	0 1 30 69
			VANE		
176.9 / 6.1	SILT, some sand Loose to compact, Grey, Moist	8	SS	13	0 11 83 6
		9	SS	5	
		10	SS	11	
	very dense	11	SS	50/3cm	
172.3 / 10.7	GNEISS BEDROCK Unweathered, black with pink feldspar, banded, hard	RUN 1	RC	--	No Recovery
		RUN 2	RC	RQD 39%	REC 39%
169.3 / 13.7	End of borehole				

Groundwater level observed during drilling (approx. El. 181.8)

Grounwater level measured upon completion of drilling (approx. El. 180.0)

Field vane shear strength: +3 at approx. El. 177.6

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 · SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 · PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L · WATER CONTENT (%) 20 40 60 · UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%

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

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 22-10-26

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No C189-2

1 OF 2 **METRIC**

PROJECT Hwy 69 Structural Culvert	COORDINATES Coords: 5 081 457.9 N; 221 947.9 E		ORIGINATED BY M.M.
DIST	HWY 69	BOREHOLE TYPE CFHSA + RC	COMPILED BY N.L.
DATUM Geodetic	DATE 2021.07.15 - 2021.07.16	LATITUDE 45.867949 LONGITUDE -80.567045	CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
183.1	Ground Surface				
0.0	300mm ASPHALT				
182.8 / 0.3	SAND, some gravel, trace silt Very dense to loose, Brown, Moist to wet (FILL)	1	SS	76	13 77 (10)
		2	SS	16	
		3	SS	9	
		4	SS	4	
		5	SS	4	
		6	SS	6	
178.6 / 4.5	SILT, some clay, trace sand Loose to compact, Grey, Wet	7	SS	8	
		8	SS	4	0 5 83 12
			VANE		
		9	SS	18	
			VANE		
		10	SS	1	
			VANE		
	sandy	11	SS	11	0 25 72 3
		12	SS	50/0cm	
171.5 / 11.6	GNEISS BEDROCK Unweathered, black with pink feldspar, banded, hard	RUN 1	RC	RQD 53%	REC 65%
		RUN 2	RC	RQD 97%	REC 97%
168.5 / 14.6	End of borehole				

Field vane shear strength: +2 at approx. El. 176.6; +2 at approx. El. 174.5; +2 at approx. El. 173.0

Continued Next Page

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 · SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 · PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L · WATER CONTENT (%) 20 40 60 · UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%

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

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 22-10-26

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No C189-2

METRIC

PROJECT Hwy 69 Structural Culvert COORDINATES Coords: 5 081 457.9 N; 221 947.9 E ORIGINATED BY M.M.

DIST HWY 69 BOREHOLE TYPE CFHSA + RC COMPILED BY N.L.

DATUM Geodetic DATE 2021.07.15 - 2021.07.16 LATITUDE 45.867949 LONGITUDE -80.567045 CHECKED BY N.R.

SOIL PROFILE ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
168.1											
	NOTES: 1. Borehole was flushed with drilling water during drilling, thus groundwater level could not be established 2. No cave-in was noted in the borehole upon extraction of hollow stem augers.										

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

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 22-10-26

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No C189-3

METRIC

PROJECT Hwy 69 Structural Culvert COORDINATES Coords: 5 081 455.1 N; 221 952.3 E ORIGINATED BY M.M.

DIST HWY 69 BOREHOLE TYPE CFHSA COMPILED BY N.L.

DATUM Geodetic DATE 2021.07.27 LATITUDE 45.867972 LONGITUDE -80.56699 CHECKED BY N.R.

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	FIELD VANE (sensitivity)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
184.0	Ground Surface						
0.0	SAND, trace/some gravel Dense to loose, Brown, Wet (FILL)	1	SS	32	∇		
		2	SS	10	▼		
		3	SS	16			
		4	SS	11			0 93 (7)
		5	SS	6			
180.2 3.8	CLAYEY SILT, trace sand Stiff to very soft, Grey, Wet	6	SS	3			
			VANE			$+^{3}$	
		7	SS	11			0 1 79 20
			VANE			$+^{2}$	
		8	SS	1			
			VANE			$+^{2}$	
175.7 8.3	SILT, sandy Compact, Grey, Wet	9	SS	14			0 29 67 4
		10	SS	10			
		11	SS	13			
	very dense	12	SS	50/3cm			
171.9 12.1	GNEISS BEDROCK Unweathered, black with pink feldspar, banded, hard	RUN 1	RC	RQD 65%			REC 65%
		RUN 2	RC	RQD 53%			REC 53%

Elevation scale: 183, 182, 181, 180, 179, 178, 177, 176, 175, 174, 173, 172, 171, 170

Continued Next Page

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

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 22-10-26

RECORD OF BOREHOLE No C189-3

METRIC

PROJECT Hwy 69 Structural Culvert COORDINATES Coords: 5 081 455.1 N; 221 952.3 E ORIGINATED BY M.M.

DIST HWY 69 BOREHOLE TYPE CFHSA COMPILED BY N.L.

DATUM Geodetic DATE 2021.07.27 LATITUDE 45.867972 LONGITUDE -80.56699 CHECKED BY N.R.

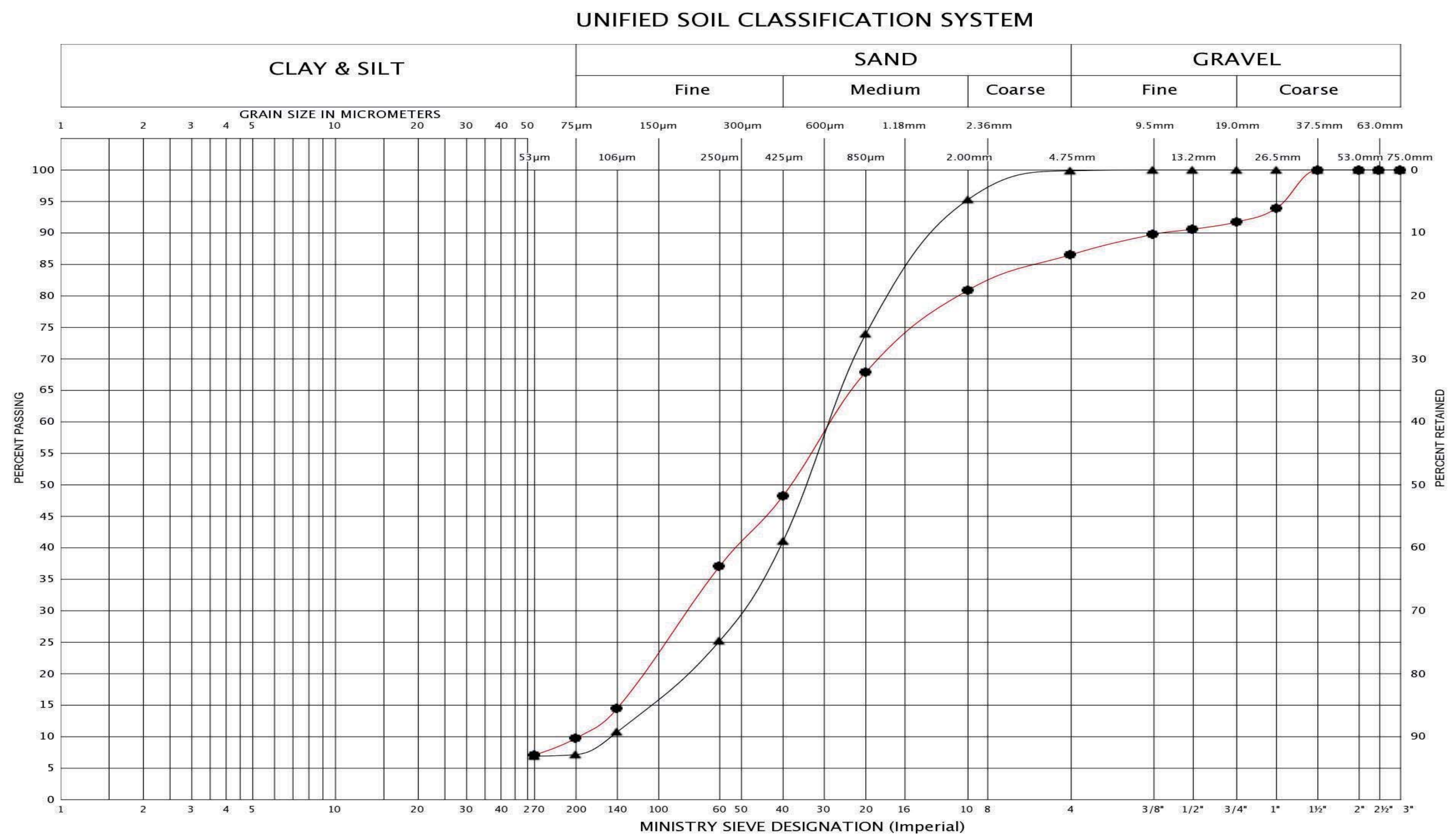
SOIL PROFILE: ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
169.0											
168.9 15.1	End of bedrock										

∇ Groundwater level observed during drilling

▼ Groundwater level measured upon completion of drilling

NOTE: Borehole caved-in at a depth of 4.9 m (EL. xxx) below the ground surface, upon extraction of hollow stem augers.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE



LEGEND			
	BH	C189-2	C189-3
	SAMPLE	1	4
	SYMBOL	●	▲

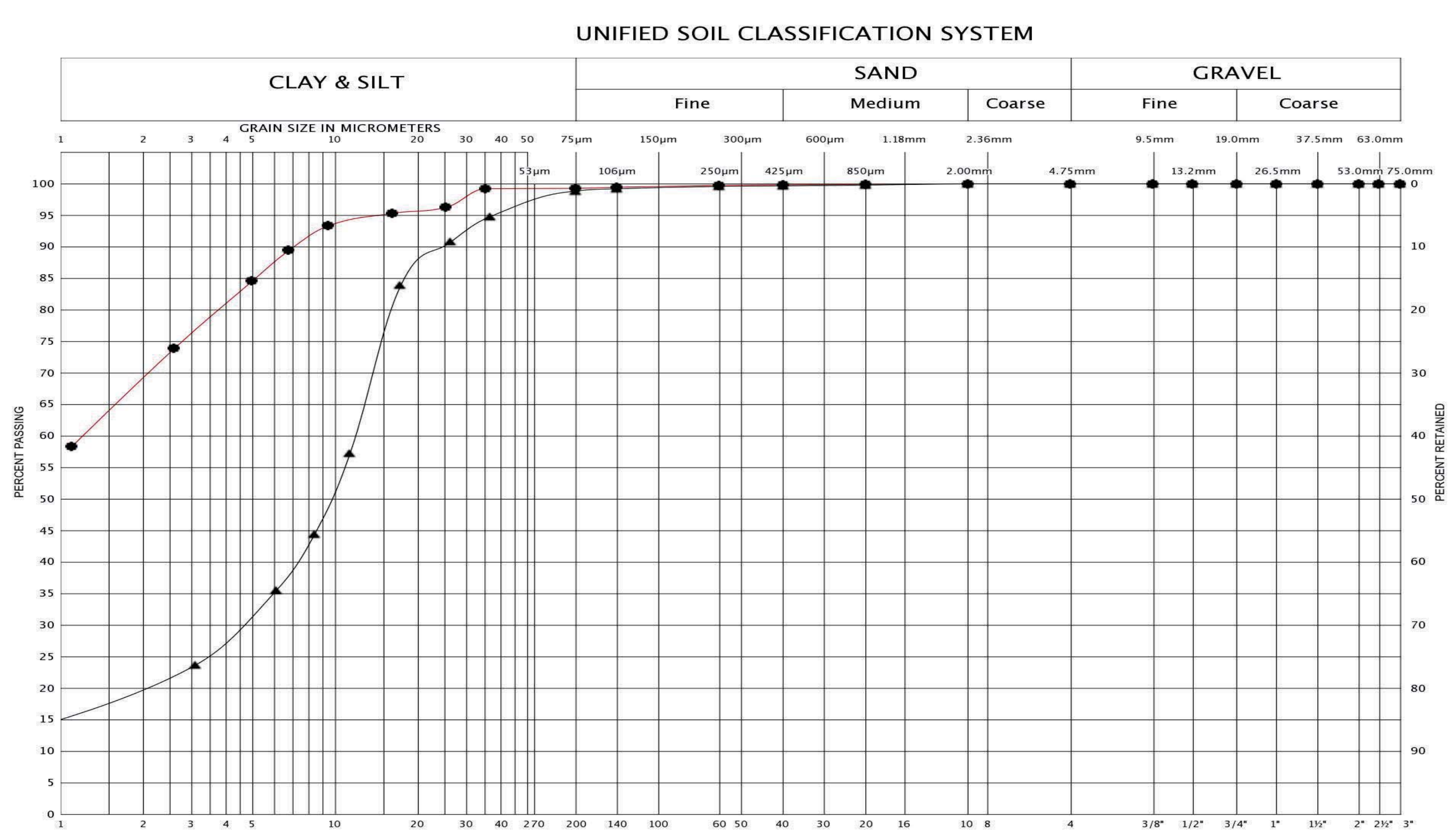
GRAIN SIZE DISTRIBUTION

SAND FILL

FIG No.: GS-L-1

HWY : 69

Project No.: 14TF034G



LEGEND			
	BH	C189-1	C189-3
	SAMPLE	7	7
	SYMBOL	●	▲

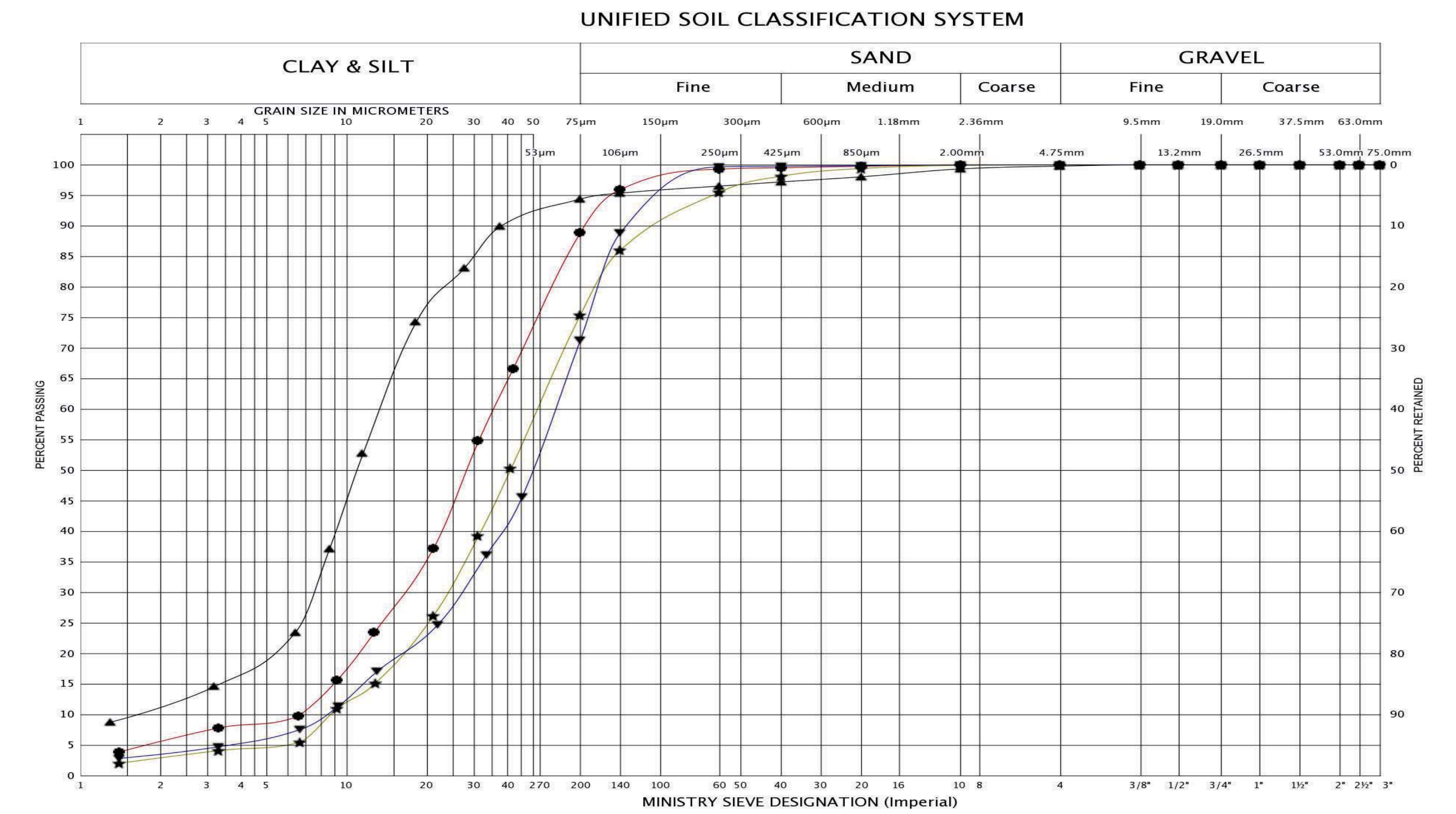
GRAIN SIZE DISTRIBUTION

SILTY CLAY/CLAYEY SILT

FIG No.: GS-L-2

HWY : 69

Project No.: 14TF034G



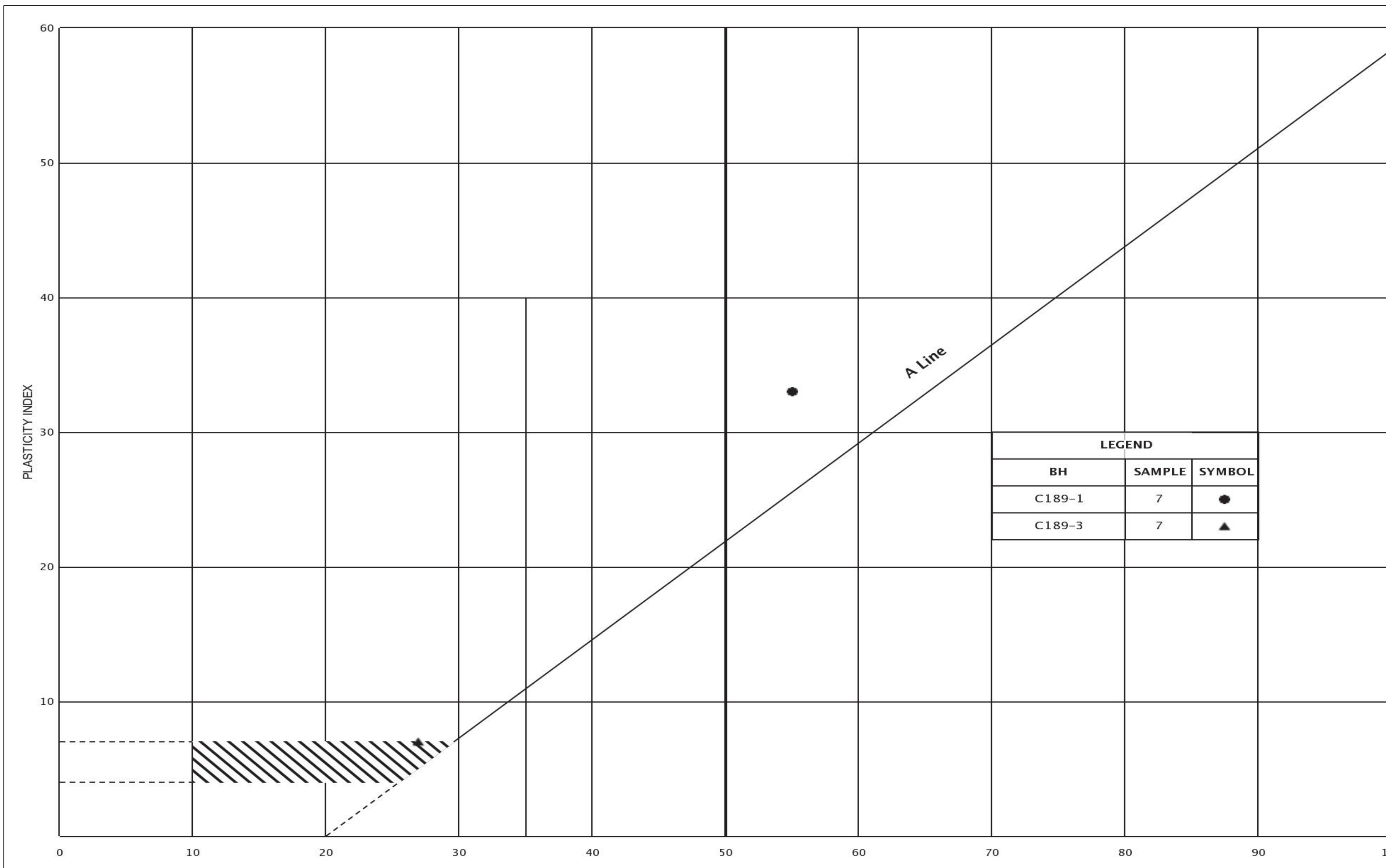
LEGEND					
	BH	C189-1	C189-2	C189-2	C189-3
	SAMPLE	8	8	11	9
	SYMBOL	●	▲	★	▼

Ontario

GRAIN SIZE DISTRIBUTION

SILT

FIG No.:	GS-L-3
HWY :	69
Project No.:	14TF034G



Ontario

PLASTICITY CHART

SILTY CLAY/CLAYEY SILT

FIG No.:	PC-L-1
HWY.:	69
Proj No.	14TF034G

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CONSULTING ENGINEERS

STRENGTH	DISCONTINUITY TYPE	SPACING	FILLING
VH = Very High = >200 MPa	B = Bedding Joint	VW = Very Wide = >3 m	T = Tight, Hard
H = High = 50-200 MPa	J = Cross Joint	W = Wide = 1-3 m	O = Oxidized
M = Medium = 15-50 MPa	F = Fault	M = Moderate = 0.3-1 m	SA = Slightly Altered, Clay Free
L = Low = 4-15 MPa	S = Shear Plane	C = Close = 5-30 cm	S = Sandy, Clay Free
VL = Very Low = 1-4 MPa	BR = Broken Rock	VC = Very Close = <5 cm	Si = Sandy, Silty, Minor Clay
			NC = Non-softening Clay
WEATHERING	**ORIENTATION**	**ROUGHNESS**	SC = Swelling, Soft Clay
U = Unweathered = No signs	F = Flat = 0-20°	RU = Rough Undulating	
S = Slightly = Oxidized	D = Dipping = 20-50°	RP = Rough Planar	
M = Moderately = Discoloured	V = Vertical >50°	SU = Smooth Undulating	
H = Highly = Friable		SP = Smooth Planar	
C = Completely = Soil-Like		LU = Slickensided Undulating	
		LP = Slickensided Planar	

CORE LOG IDENTIFICATION
BOREHOLE #: BH 189-1
PML REF.: 14TF034G
PROJECT: Highway 69 - Structural Culverts and Three Swamps
LOCATION: 1.7km North of Hwy 529 to 3.9km North of Hwy 522, Ontario
DATE: November 10, 2021
LOGGED BY: H. Racher, P.Geo.

Provincial Highways: A Guide to the Description of Rock for Engineering Purposes
MI-47

RUN #	DEPTH TO (m)	CORE RECOVERY (%)	RQD (%)	DEPTH TO (m)	GENERAL DESCRIPTION	STRENGTH	WEATHERING	DISCOUNTINUITIES # OF SETS	TYPE	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	OCCASIONAL FEATURES	DRILLING OBSERVATIONS
1	12.50	39% (0.48m)	39% (0.48m)	13.72	CENTRAL GNEISSIC BELT (MESOPROTEROZOIC) Unweathered, medium to coarse grained, thick bedded to massive, black with pink feldspar, banded, hard, GNEISS	H	U	1	J	D	-	RP	-	-	End of Borehole.	

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CONSULTING ENGINEERS

STRENGTH	DISCONTINUITY TYPE	SPACING	FILLING
VH = Very High = >200 MPa	B = Bedding Joint	VW = Very Wide = >3 m	T = Tight, Hard
H = High = 50-200 MPa	J = Cross Joint	W = Wide = 1-3 m	O = Oxidized
M = Medium = 15-50 MPa	F = Fault	M = Moderate = 0.3-1 m	SA = Slightly Altered, Clay Free
L = Low = 4-15 MPa	S = Shear Plane	C = Close = 5-30 cm	S = Sandy, Clay Free
VL = Very Low = 1-4 MPa	BR = Broken Rock	VC = Very Close = <5 cm	Si = Sandy, Silty, Minor Clay
			NC = Non-softening Clay
WEATHERING	**ORIENTATION**	**ROUGHNESS**	SC = Swelling, Soft Clay
U = Unweathered = No signs	F = Flat = 0-20°	RU = Rough Undulating	
S = Slightly = Oxidized	D = Dipping = 20-50°	RP = Rough Planar	
M = Moderately = Discoloured	V = Vertical >50°	SU = Smooth Undulating	
H = Highly = Friable		SP = Smooth Planar	
C = Completely = Soil-Like		LU = Slickensided Undulating	
		LP = Slickensided Planar	

CORE LOG IDENTIFICATION
BOREHOLE #: BH 189-2
PML REF.: 14TF034G
PROJECT: Highway 69 - Structural Culverts and Three Swamps
LOCATION: 1.7km North of Hwy 529 to 3.9km North of Hwy 522, Ontario
DATE: November 10, 2021
LOGGED BY: H. Racher, P.Geo.

Provincial Highways: A Guide to the Description of Rock for Engineering Purposes
MI-47

RUN #	DEPTH TO (m)	CORE RECOVERY (%)	RQD (%)	DEPTH TO (m)	GENERAL DESCRIPTION	STRENGTH	WEATHERING	DISCOUNTINUITIES # OF SETS	TYPE	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	OCCASIONAL FEATURES	DRILLING OBSERVATIONS
1	11.59	65% (0.99m)	53% (0.80m)	13.11	CENTRAL GNEISSIC BELT (MESOPROTEROZOIC) Unweathered, medium to coarse grained, thick bedded to massive, black with pink feldspar, banded, hard, GNEISS	H	U	3	J	F	C	RP	-	-	Broken rock at 11.59-11.68m.	
								1	BR	-	-	-	-	-		
2	13.11	97% (1.47m)	97% (1.47m)	14.63	CENTRAL GNEISSIC BELT (MESOPROTEROZOIC) Unweathered, medium to coarse grained, thick bedded to massive, black with pink feldspar, banded, hard, GNEISS	H	U	1	J	F	-	RP	-	-	End of Borehole.	
								1	J	D	-	RP	-	-		

Peto MacCallum Ltd.
CONSULTING ENGINEERS

STRENGTH	DISCONTINUITY TYPE	SPACING	FILLING
VH = Very High = >200 MPa	B = Bedding Joint	VW = Very Wide = >3 m	T = Tight, Hard
H = High = 50-200 MPa	J = Cross Joint	W = Wide = 1-3 m	O = Oxidized
M = Medium = 15-50 MPa	F = Fault	M = Moderate = 0.3-1 m	SA = Slightly Altered, Clay Free
L = Low = 4-15 MPa	S = Shear Plane	C = Close = 5-30 cm	S = Sandy, Clay Free
VL = Very Low = 1-4 MPa	BR = Broken Rock	VC = Very Close = <5 cm	Si = Sandy, Silty, Minor Clay
			NC = Non-softening Clay
WEATHERING	**ORIENTATION**	**ROUGHNESS**	SC = Swelling, Soft Clay
U = Unweathered = No signs	F = Flat = 0-20°	RU = Rough Undulating	
S = Slightly = Oxidized	D = Dipping = 20-50°	RP = Rough Planar	
M = Moderately = Discoloured	V = Vertical >50°	SU = Smooth Undulating	
H = Highly = Friable		SP = Smooth Planar	
C = Completely = Soil-Like		LU = Slickensided Undulating	
		LP = Slickensided Planar	

CORE LOG IDENTIFICATION

BOREHOLE #:	BH 189-3
PML REF.:	14TF034G
PROJECT:	Highway 69 - Structural Culverts and Three Swamps
LOCATION:	1.7km North of Hwy 529 to 3.9km North of Hwy 522, Ontario
DATE:	November 10, 2021
LOGGED BY:	H. Racher, P.Geo.

Provincial Highways: A Guide to the Description of Rock for Engineering Purposes
MI-47

RUN #	DEPTH TO (m)	CORE RECOVERY (%)	RQD (%)	DEPTH TO (m)	GENERAL DESCRIPTION	STRENGTH	WEATHERING	DISCOUNTINUITIES # OF SETS	TYPE	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	OCCASIONAL FEATURES	DRILLING OBSERVATIONS
1	12.04	65% (0.99m)	65% (0.99m)	13.56	CENTRAL GNEISSIC BELT (MESOPROTEROZOIC) Unweathered, medium to coarse grained, thick bedded to massive, black with pink feldspar/white quartz, banded, hard, GNEISS	H	U	-	-	-	-	-	-	-		
2	13.56	53% (0.81m)	53% (0.81m)	15.08	CENTRAL GNEISSIC BELT (MESOPROTEROZOIC) Unweathered, medium to coarse grained, thick bedded to massive, black with pink feldspar, banded, hard, GNEISS	H	U	1	J	F	-	RP	-	-	End of Borehole.	

Core Photographs

Borehole 189-1

Borehole 189-1 – RC1

Borehole 189-2

Borehole 189-2 – RC1 and RC2

Borehole 189-3

Borehole 189-3 – RC1 and RC2

SHEET M – CVH-50 – Fisheries/Wildlife Culvert (Station: ± 19+485 Hwy 69 NBL/SBL – Henvey)

- Borehole Locations and Soil Strata (Geocres 41H-134)
- Record of Borehole Logs (Geocres 41H-134)
- Laboratory Test Results (Geocres 41H-134)

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field work for Culvert CVH-50 at Station 19+485 Henvey Township (Site No. 5114-17-10) under Highway 69 NBL/SBL) was carried out by Golder Associates (Golder) between December 6 and 7, 2011, and a foundation investigation report (FIR), Reference 1 below, was completed and submitted to MTO.

A total of 14 boreholes (S310-01 to S310-14) and six (6) DCPTs (DCPTs S310-DC01 to S310-DC06) investigations were conducted by Golder within the Swamp 310 area, along the northbound lanes (NBL) and southbound lanes (SBL) of the proposed Highway 69 alignment. Three (3) of the investigated boreholes (S310-04, S310-12, and S310-13) are deemed relevant for design purposes of the proposed culvert.

The following Reference Report was referenced:

1. Foundation Investigation Report (FIR) –Swamp Crossings and High Fill Areas – Contract 3 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, (GEOCRES No. 41H-134), submitted to URS Canada Inc. (URS) by Golder, February 11, 2014 (Report Number: 09-1111-6014-3520)

Relevant geotechnical data from the reference report are provided in Appendix A-2 of this report, including records of borehole logs and preliminary foundation drawings.

Table M-1 - Borehole Information for Culvert CVH-31

BOREHOLE ID	BOREHOLE LOCATION	MTM NAD 83 COORDINATES		GROUND SURFACE ELEVATION (m)	BOREHOLE DEPTH (m)
		NORTHING (m)	EASTING (m)		
S310-04	Outlet of the proposed culvert	5 081 692.3	223 207.8	193.9	4.6
S310-12	Median of proposed Highway 69, immediate north of culvert	5 081 669.9	223 260.0	194.3	11.4
S310-13	South of proposed culvert, median of proposed Highway 69 NBL	5 081 685.2	223 246.2	194.0	11.4

1.1. Subsurface Conditions

Based on the factual data presented in the Record of Borehole Sheets and Figures completed by Golder, the subsurface conditions encountered during the site investigation carried out by Golder can be categorized into three (3) general soil layers as presented below as presented below from surface downwards.

1.1.1. Topsoil

A layer of topsoil, approximately 200 mm to 300 mm thick, was encountered immediately below the existing ground surface in all three (3) boreholes.

The SPT ‘N’ values in this layer were 3 blows and 5 blows for 30 cm penetration, indicating soft consistency.

1.1.2. Clayey Silt to Silty Clay

A deposit of clayey silt to silty clay, 4.1 m to 10.1 m thick, was encountered below the topsoil layer in all three (3) boreholes. This deposit consists of silt intercepts between approximate elevations of EL.193.8 m and EL. 187.1 m. This layer extended to depths ranging from 4.3 m to 10.4 m (EL. 189.6 m to EL. 183.8 m) below existing grade elevation.

The SPT ‘N’ values in this layer ranged from none (penetration due to weight of hammer and rods) to 11 blows for 30 cm penetration, indicating very soft to stiff consistency.

The moisture contents of samples tested from this layer ranged from approximately 24% to 75%. The results of the sieve analysis tests performed on three (3) representative samples from this layer are provided in Figures J.S310-03, J.S310-05, and J.S310-10. The test results indicate that this deposit consists of 0% gravel, 0% to 8% sand, 75% to 88% silt and 12% to 17% clay sized particles. Atterberg limit tests performed on six (6) representative samples are provided in Figures J.S310-02, J.S310-06, J.S310-11, and J.S310-12. The liquid limits of these samples range from 24 to 81, and the corresponding plastic limits range from 13 and 22, resulting in plasticity index values ranging from 7 to 60.

A total of 15 in-situ vane shear strength (C_u) test were conducted within this clayey deposit between EL. 190.5 m and EL. 184.0 m. The results of the C_u tests conducted above EL. 190.0 m were over 96 kPa, indicating that the existing soil cover up to the elevation is stiff and has high shear strength. Below EL. 190.0 m, the results of the C_u tests ranged from 23 kPa to 50 kPa, with an average value of 42 kPa, indicating that the existing soil cover is compressible and has low shear strength.

1.1.3. Silty Sand/Sand and Gravel

This deposit was encountered below the clayey silt layer all three (3) boreholes, extending to borehole termination depths of 4.6 m and 11.4 m (EL.189.6 m to EL. 182.9 m) below the existing grade.

The SPT ‘N’ values in this layer ranged from as low as 6 blows to over 100 blows for 30 cm penetration, indicating loose to very dense state of compactness.

The moisture content of one (1) sample tested from this layer was approximately 23%.

1.1.4. Inferred Bedrock

Probable bedrock surface was inferred by refusal to further split-spoon and casing advancement in Boreholes S310-04, S310-12 and S310-13 at 4.6 m to 11.4 m (EL. 182.6 m to EL. 189.3 m) below ground surface.

1.1.5. Groundwater Conditions

The groundwater level observed upon completion of drilling was measured at depths ranging from 0.1 m to 0.5 m (EL. 194.0 m to EL. 193.4 m) below the existing ground surface in the three (3) boreholes. Groundwater levels may fluctuate due to the influence of precipitation and seasonal changes.

PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) were based on the following references:

1. Foundation Investigation and Design Report – Swamp Crossings and High Fill Areas – Contract 3, 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, (GEOCRES No. 41H-134), submitted to URS Canada Inc. by Golder Associates, February 11, 2014 (Report Number: 09-1111-6014-3520)
2. Culvert Sections Drawings, provided by Parsons via email dated November 25, 2020
3. Highway 69 Profile Drawings, provided by Parsons via email dated November 25, 2020

2. PROJECT DESCRIPTION

2.1. General

The proposed Fisheries Culvert (Site No. 044-0653/00) is a new structure under the proposed Highway 69 NBL and SBL. The culvert is located within Swamp 310 area in the Township of Henvey.

2.2. Proposed Structure

It is understood that the proposed culvert will have an opening size of 3.0 m in span and a height of 2.4 m. It will be approximately 80.0 m long and will be on a skew of approximately 9 degrees to the new Highway 69 alignment.

The existing ground surface in the vicinity of the culvert alignments varies from approximate EL. 193.9 m to EL. 194.3 m based on the ground elevations at the three borehole locations. The terrain is relatively flat to undulating. A narrow creek traverses the Highway 69 alignment from east to west at approximately Station 19+500.

Based on Reference 3, the proposed invert levels at the inlet and outlet of the proposed culvert and inferred founding levels are summarized in Table M-1 below.

Table M-1: Box Culvert Founding Elevations at Station 19+485 CVH-50 Culvert

LOCATION	PROPOSED CULVERT INVERT ELEVATION	BOTTOM OF BOX CULVERT ELEVATION	SUBGRADE ELEVATION FOR GRANULAR BEDDING	FOUNDING STRATUM
Inlet	193.1 m	192.8 m	192.5 m	Firm to Stiff Clayey Silt
Outlet	192.8 m	192.5 m	192.2 m	Firm Clayey Silt

Note(s): 1: The thickness of the bottom slab of the precast concrete box culvert is assumed to be 0.25 m (minimum).

Based on Reference 2, the height of embankment fill required above the culvert to the proposed grade of Highway 69 NBL and SBL at Station 19+485 is not expected to exceed 5.6 m, including the pavement structure. Reference Report 1 indicates that the maximum height of embankment across Swamp 310 will be 7.0 m.

In the absence of any structural details of the culverts, at the time of writing this report, it is assumed that concrete culverts and fill would impose a dead load of approximately 100 kPa on the founding subgrade.

3. EVALUATION OF FOUNDATION ALTERNATIVES

The foundation alternatives listed below were based on the available information in References 1, 2 and 3 and also considered the construction of the embankments across swamp 310 in Reference Report 1, including the assumed embankment fill required above the culvert that is not expected to exceed 5.6 m. Reference 1 indicates that 7.0 m high rock fill embankment is to be used for preloading with surcharge and toe berm on the outsides of Highway 69 NBL and SBL embankments over Swamp 310 area. It is estimated that 90% of primary consolidation will be completed in 210 days (Highway 69 SBL) to 250 days (Highway 69 NBL).

1. Precast concrete box culverts placed without settlement mitigation
2. Precast concrete box culverts placed after preloading or surcharging
3. Corrugated Steel Plate (CSP) Arch or Circular Culverts

3.1. Option 1: Precast Concrete Box Culverts Placed without Settlement Mitigation

Assuming that the culverts are placed at the proposed subgrade level of EL. 192.5 to EL. 192.2 m, there will be about 7.5 m to 8.5 m (NBL) and 1.8 m to 8.5 m (SBL) thick soft to firm clayey silt to silty clay layer underneath the base of the culverts, which will result in significant total and differential settlements along the length of the culvert. The magnitude of differential settlements expected from the variation in thickness of clayey layer under the imposed load of 100 kPa will be higher than the tolerable limit of 100 mm generally assumed for a precast concrete box culvert.

Specifically, the 7.5 m to 8.5 m thick soft to firm clayey silt to silty clay below the proposed NBL culvert under a load of 100 kPa is expected to undergo a total settlement ranging from 360 to 585 mm and associated estimated differential settlement ranging from 105 to 135 mm. For the SBL culvert, the 1.8 m to 8.5 m thick soft to firm clay below its proposed founding level under the same loading is expected to undergo a total settlement ranging from 40 to 585 mm and associated differential settlement ranging from 430 to 550 mm.

Such relatively large total and differential settlements are not acceptable, considering that the magnitudes are in excess of the tolerable settlement limits for a precast concrete box culvert, and can cause damage to the joints, leading to deterioration of the culvert. Therefore, factored geotechnical resistances at ULS and at SLS for 100 mm of differential settlement are not applicable since the option of placing the proposed culvert on native soils at EL. 192.5 to EL. 192.2 m without settlement mitigation measures is not considered to be feasible.

3.2. Option 2: Precast Concrete Box Culverts after Preloading or Surcharging

The Reference Report 1 recommends the use of preloading consisting of 7.0 m high rockfill, adding a surcharge of 2.0 m high granular surcharge and construct stability berms along embankment toes of NBL and SBL, as well as median fill, to mitigate the post-construction settlement in the area of Swamp 310. The report indicates that under 2.0 m high granular surcharge, 90 % of primary consolidation will be completed in approximately 250 days.

Since there is no existing road or proposed structure where the culverts are proposed, it is recommended that the construction of precast concrete box culverts be coordinated with the construction of the embankment fill across Swamp 310 and the footprint of the culverts preloaded and surcharged simultaneously with the embankments. The scheme may require the placement of temporary CSP pipes under the embankment fill to allow for the local drainage of the creek at approximate Station 198+500, if required. At the appropriate time, the fill used for the preload, the surcharge material and the temporary CSPs would be removed and the precast box culverts would be installed.

In this option 2, the estimated average height over the existing ground including the surcharge will include some 9.0 m of granular soils for ease of excavation after surcharging. These materials would impose an estimated preload and surcharge load of 190 kPa, assuming an average unit weight of 21.0 kN/m^3. For this material placed on the footprint of the culvert sites, it is estimated that the primary consolidation settlement of some 40 to 585 mm will take approximately 8 to 10 months to complete.

Unsuitable/organic materials at the culvert locations should be excavated from the areas under and within the zone of influence of the culverts (minimum of 2 m beyond the culvert walls) and care should be exercised when preparing the subgrade for the embankment construction to minimize excavation concerns. Following the preloading/surcharging period, the exposed subgrade should be inspected and approved before placement of compacted granular mater16ials as specified in OPSS 422.07.06.

The granular material to backfill the precast concrete box culvert should be placed in accordance with OPSS 422.07.07. Granular material should be as specified in accordance with OPSS 422.05.13 and may consist of either Granular ‘A’ or Granular ‘B’ Type II, including a 75 mm levelling course for bedding purposes as required by OPSS 422.07.08.

The precast concrete box culverts after surcharging period may be designed assuming a factored geotechnical resistance of 160 kPa at ULS and 100 kPa at SLS. Following placement of the precast concrete box culvert as recommended and the estimated 7.0 m of fill above the culvert, it is estimated that the total settlements would be less than 100 mm and the differential settlement between 20 mm and 25 mm.

3.3. Option 3: Corrugated Steel Plate (CSP) Arch Culvert on NBL and SBL

Refer to the General Report for preliminary general recommendations for the use of Corrugated Steel Plate (CSP) arch culverts.

4. CULVERT BEDDING AND COVER MATERIALS

Refer to the General Report for preliminary recommendations for materials to be used for culvert bedding and cover purposes.

5. APPROACH EMBANKMENT

The details for design, construction, and mitigation procedures for the embankment through Swamp 310 were presented in the report Reference 1. This report may be consulted for placement of fill for the swamp crossing and no recommendation is provided in this report.

6. CONSTRUCTION CONSIDERATIONS

6.1. Excavation

Considering the existing ground level (EL. 192.8 m to EL. 193.1 m) and the culvert subgrade level (EL. 192.5 to EL. 192.2 m), 1.7 m to 1.8 m deep excavations into native soils are needed for subgrade preparation and slope instability issues are not anticipated. For Option 2, some 11.0 m of cut into the embankment fill would be excavated and the stability of the temporary slope excavation should be assessed at the design-build stage.

The Contractor should consider the type of preloaded and/or surcharge material over the culvert area to facilitate excavation and disposal or reuse of the temporary fill materials.

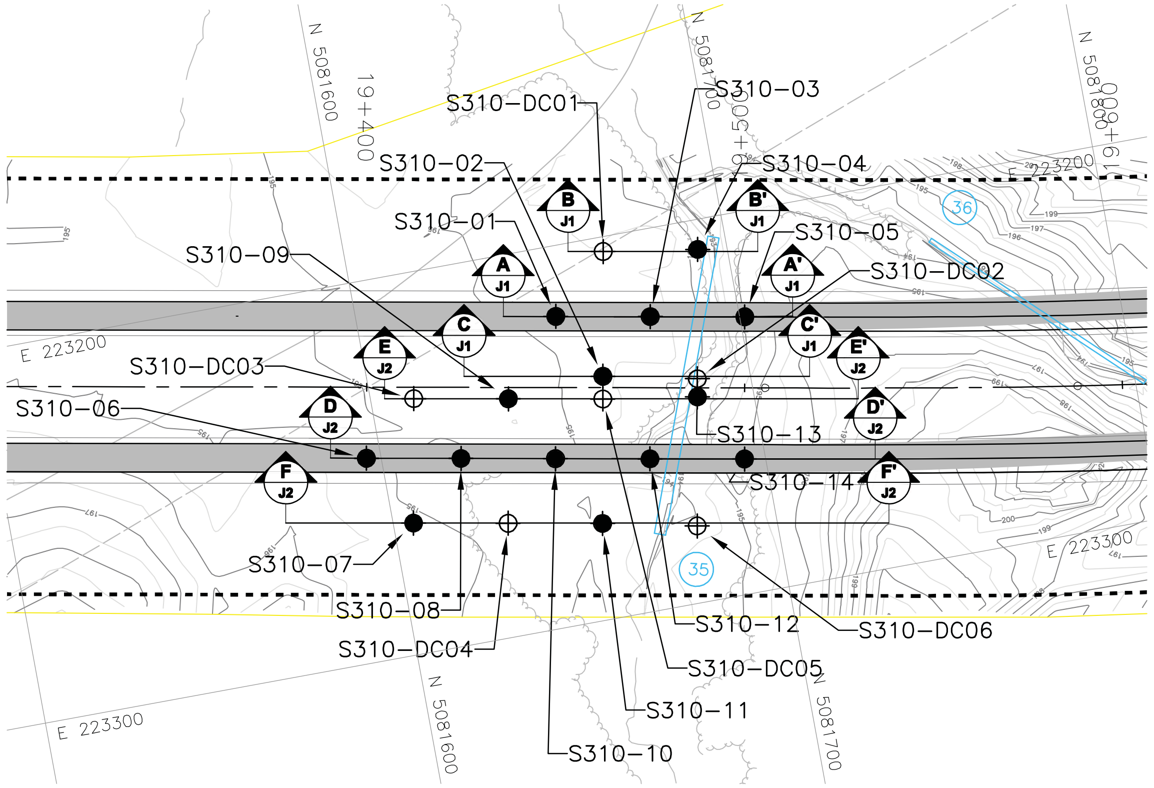
All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

Preliminary recommendations for backfilling to the culvert are provided in the General Report.

6.2. Groundwater and Surface Water Control

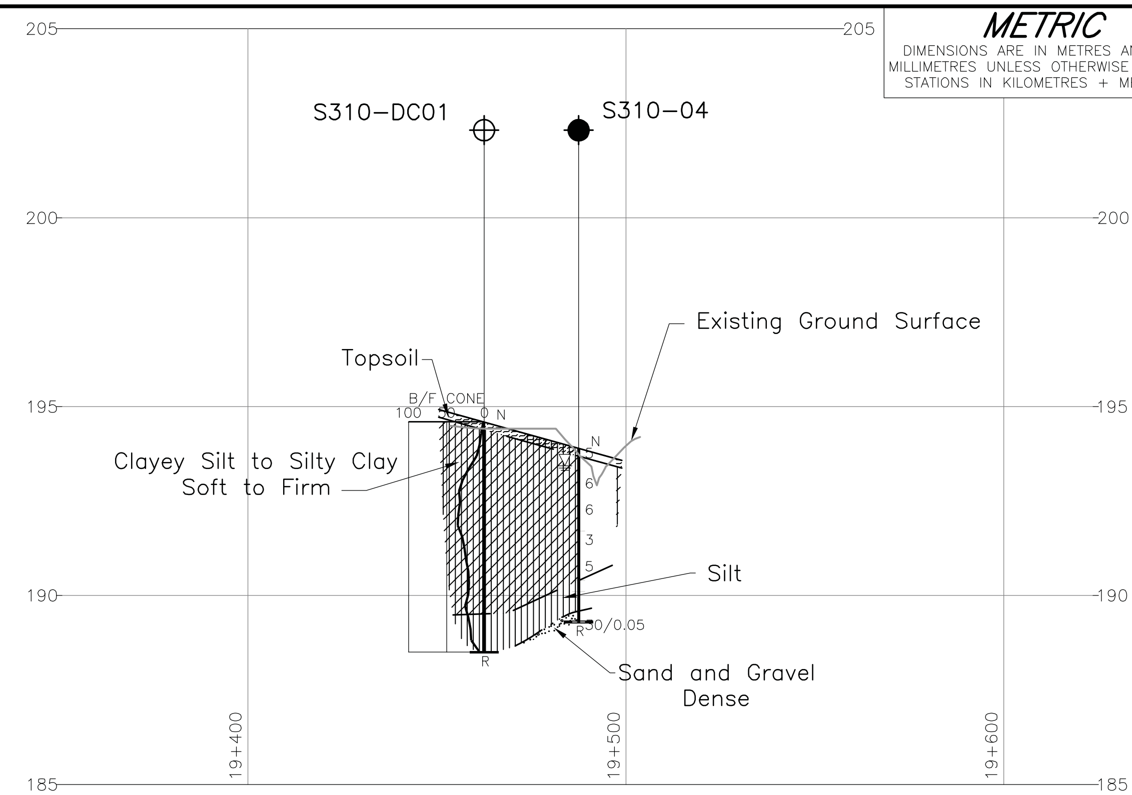
Dewatering may have to be carried out from wells installed along the interior periphery of the excavation to maintain the groundwater level a minimum 0.5 m depth below the base of the excavations. Surface water flow should be directed away from the excavation areas to mitigate disturbance of the native subgrade. For construction in-the-dry, the watercourse will have to be temporarily diverted.

Refer to the General Report for further groundwater control recommendations and requirements for water taking.



PLAN

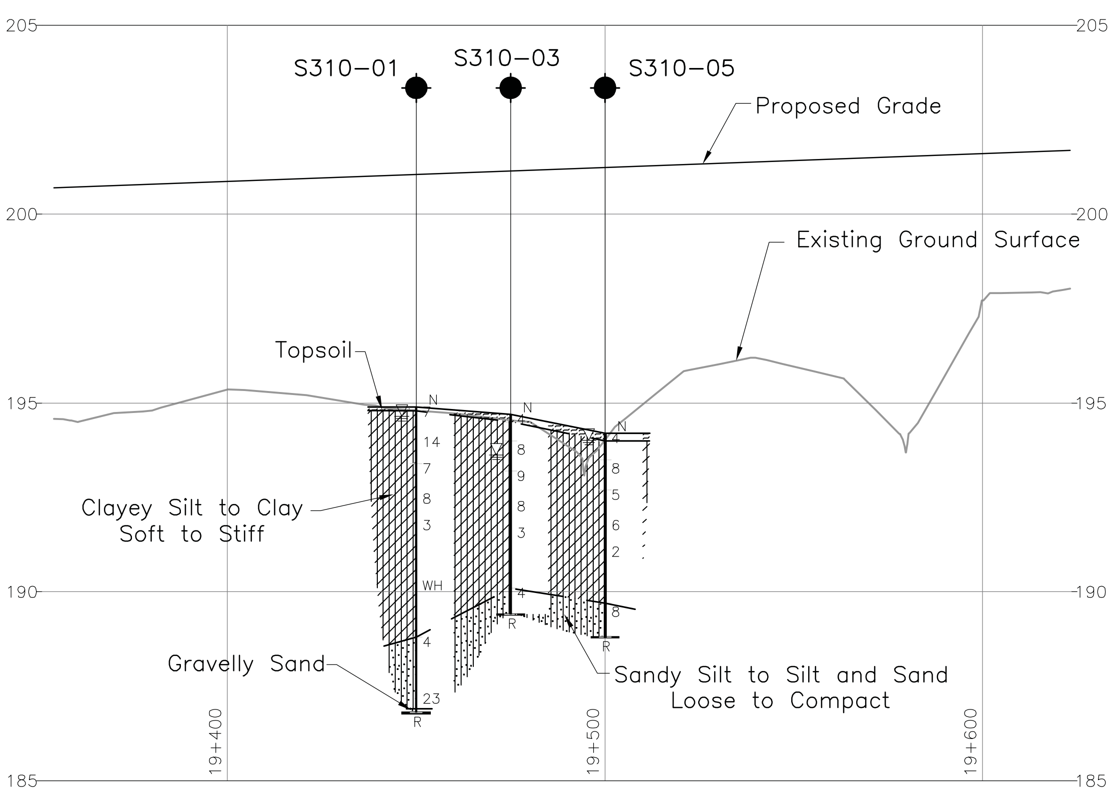
SCALE 20 0 20 40 m



B-B' J1 EMBANKMENT TOE PROFILE
HIGHWAY 69 (SBL)

HORIZONTAL SCALE 20 0 20 40 m

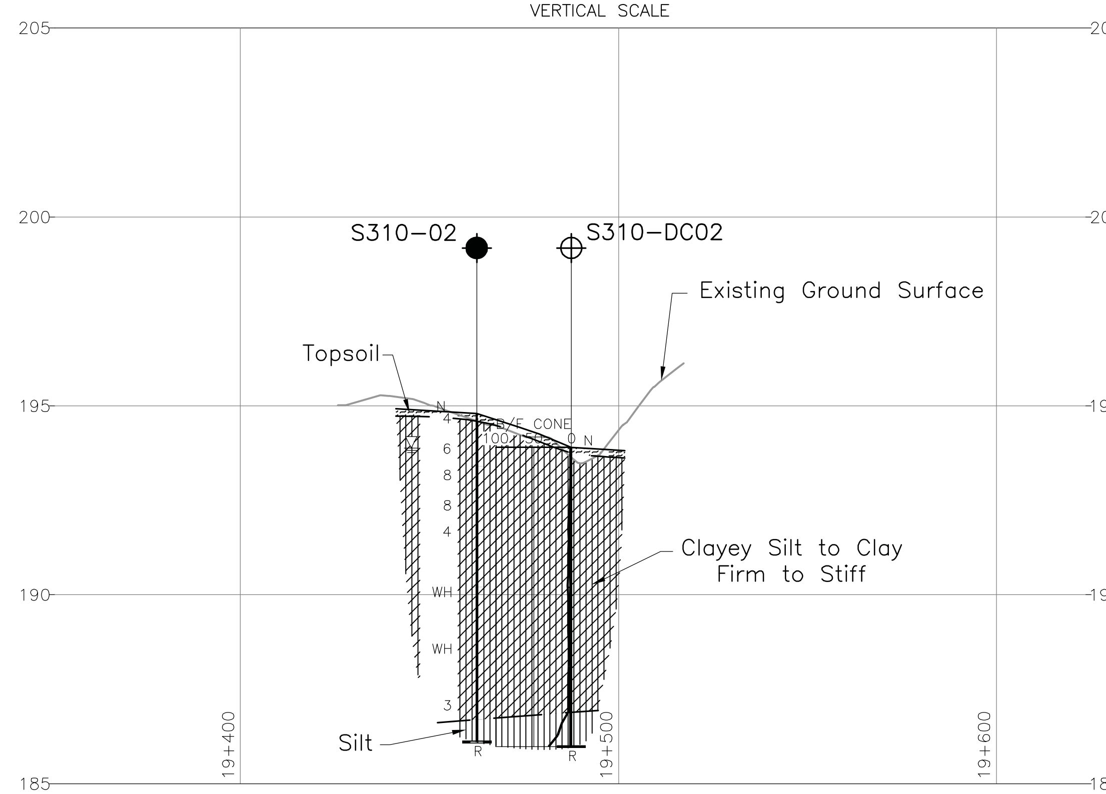
2 0 2 4 m VERTICAL SCALE



A-A' J1 CENTRELINE PROFILE
HIGHWAY 69 (SBL)

HORIZONTAL SCALE 20 0 20 40 m

2 0 2 4 m VERTICAL SCALE



C-C' J1 EMBANKMENT TOE PROFILE
HIGHWAY 69 (SBL)

HORIZONTAL SCALE 20 0 20 40 m

2 0 2 4 m VERTICAL SCALE

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.

LICENSED PROFESSIONAL ENGINEER J. M. A. COSTA Jan. 2014 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER T. ZALUCKI 100128614 Jan. 2014 PROVINCE OF ONTARIO

METRIC

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

CONT No.
WP No. 5404-05-01

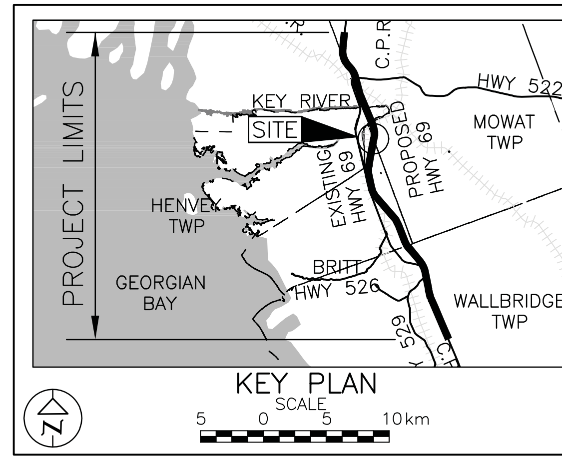
SHEET

HIGHWAY 69

STA 19+450 TO 19+500 (SBL)
STA 19+400 TO 19+500 (NBL)

BOREHOLE LOCATIONS AND SOIL STRATA

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN

SCALE 5 0 5 10km

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
S310-01	194.9	5081652.2	223218.5
S310-02	194.8	5081661.6	223236.3
S310-03	194.7	5081676.8	223223.0
S310-04	193.9	5081692.3	223207.8
S310-05	194.2	5081701.4	223227.6
S310-06	194.9	5081596.2	223246.3
S310-07	195.0	5081605.4	223265.5
S310-08	195.0	5081620.8	223250.9
S310-09	195.1	5081635.9	223237.6
S310-10	194.9	5081645.4	223255.5
S310-11	194.9	5081654.5	223274.6
S310-12	194.3	5081669.9	223260.0
S310-13	194.0	5081685.2	223246.2
S310-14	194.7	5081694.5	223264.6
S310-DC01	194.6	5081667.6	223203.9
S310-DC02	193.9	5081686.1	223241.4
S310-DC03	195.2	5081611.4	223233.1
S310-DC04	195.0	5081629.9	223270.1
S310-DC05	194.8	5081660.5	223242.2
S310-DC06	194.6	5081679.0	223279.8

REFERENCE

Base plans provided in digital format by URS, drawing file nos. Alignment and Contours from Hwy69_Contour-Plan_C3.dwg, received April 23, 2012 and , Existing Ground Surface cut from contour drawing file Hwy69_Contour-Plan_C3.dwg, received April 23, 2012 and the Existing and Proposed Grades obtained from drawing file Hwy69_profile March 2012.dwg, received March 14, 2012.

NO.	DATE	BY	REVISION

Geocres No. 41H-134

HWY. 69		PROJECT NO. 09-1111-6014	DIST.
SUBM'D. AV	CHKD. AV	DATE: May 2013	SITE:
DRAWN: JFC	CHKD. TZ	APPD. JPD/JMAC	DWG. J1

PLOT DATE: January 22, 2014
FILENAME: T:\Projects\2009\09-1111-6014 (URS, Hwy 69, Henvey)\-DK- CONTRACT 3 (SMAMP)-FINAL-STAMPED\09111160140KG01.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

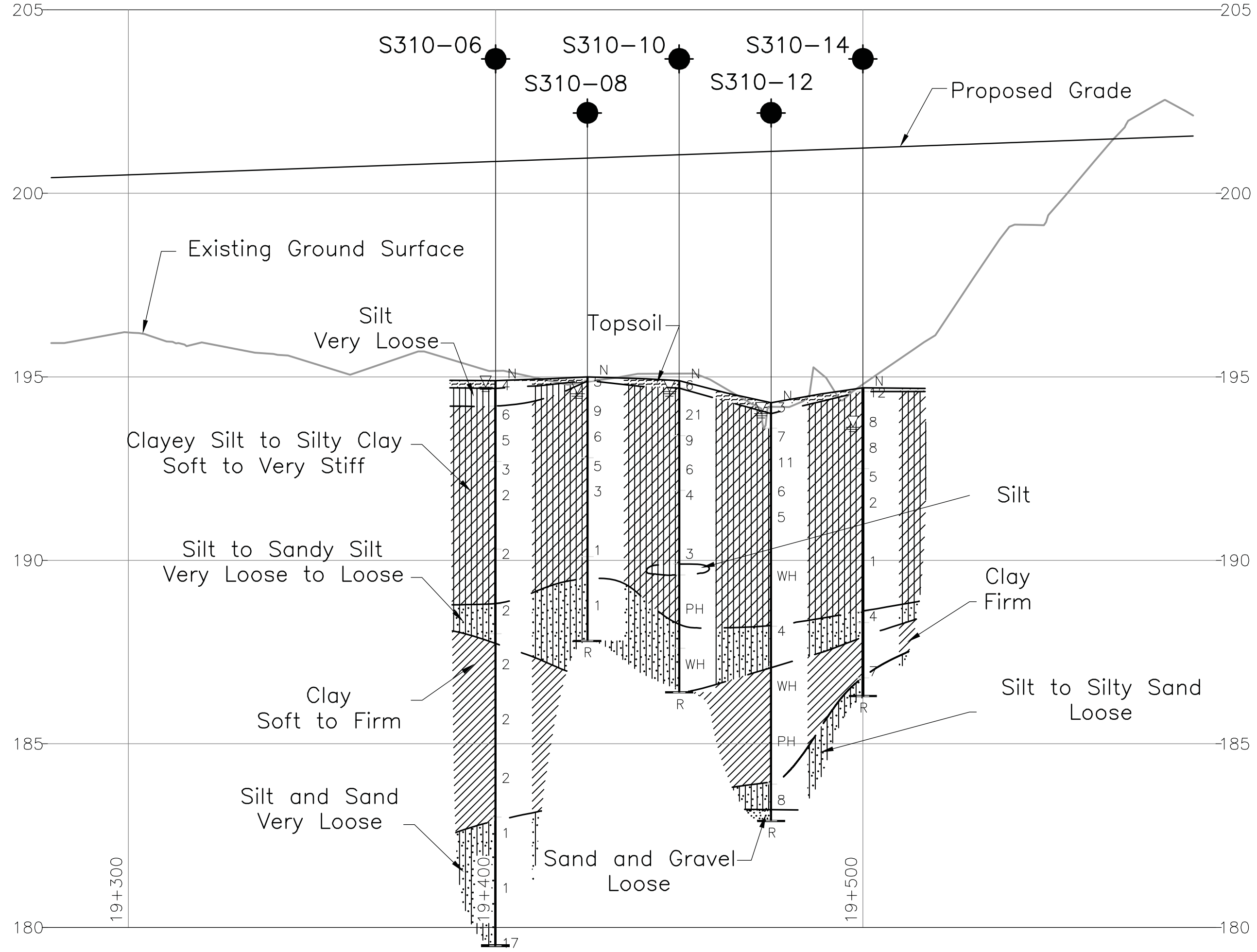
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 5404–05–01

HIGHWAY 69
STA 19+400 TO 19+500 (NBL)
SOIL STRATA

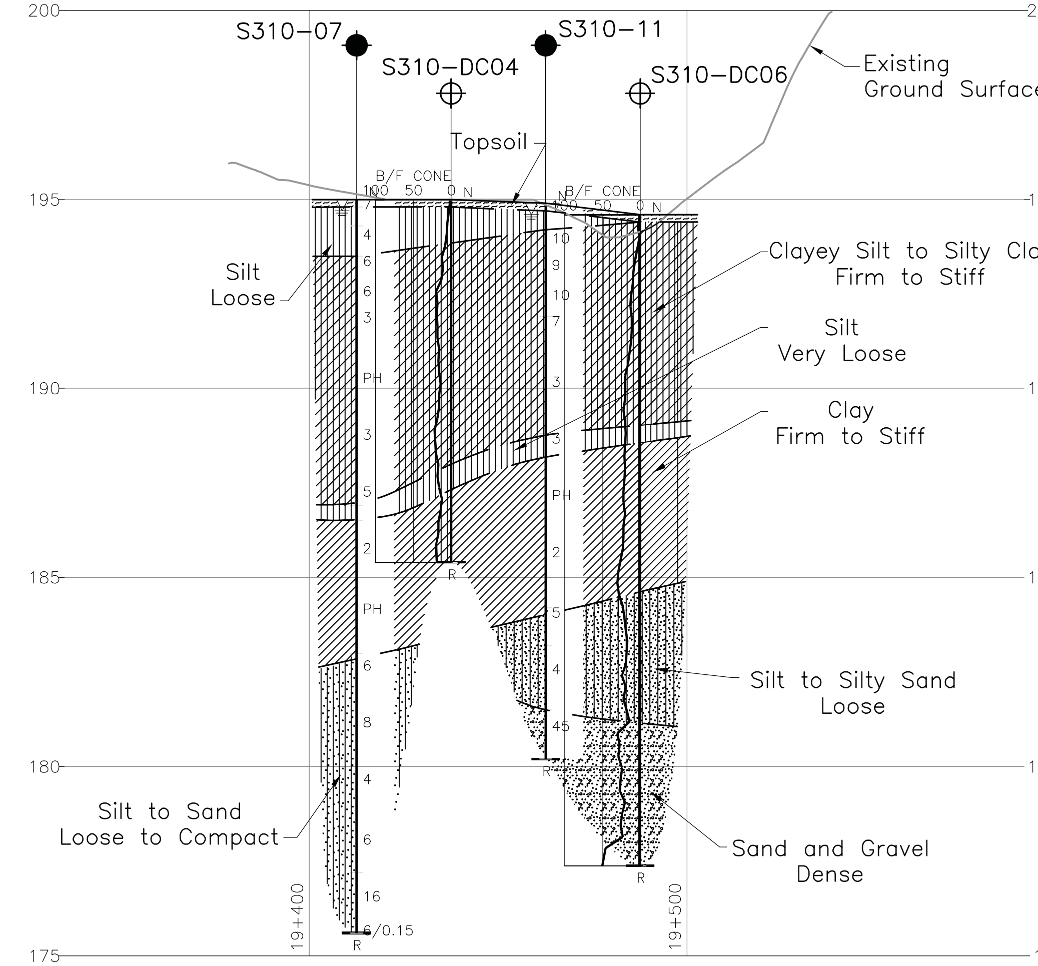
SHEET

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



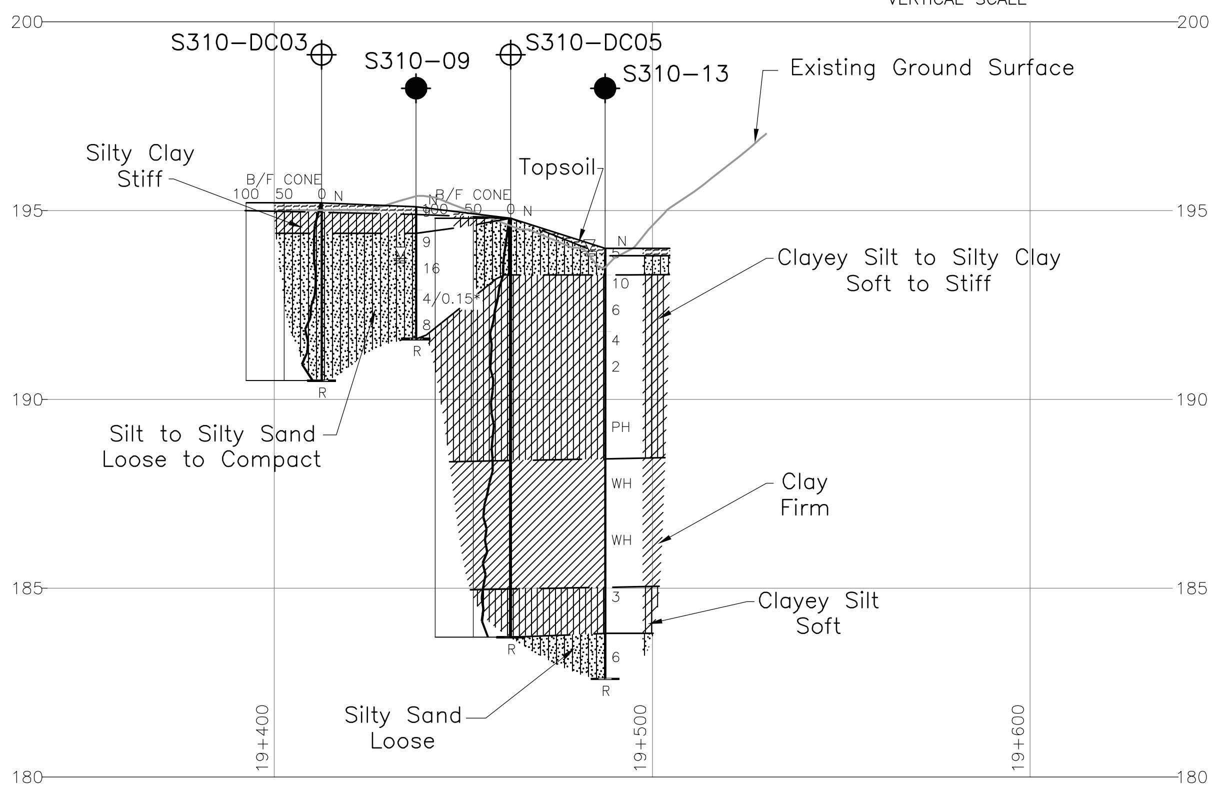
D-D' J1 CENTRELINE PROFILE
HIGHWAY 69 (NBL)

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



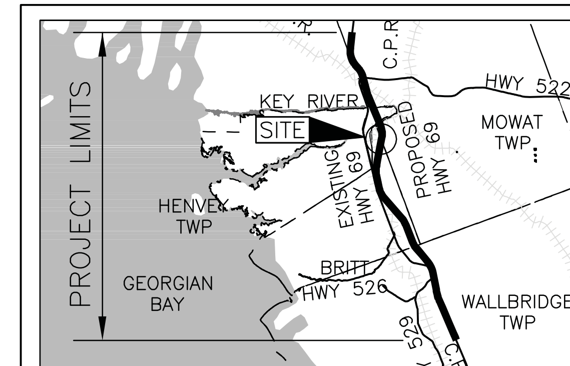
F-F' J1 EMBANKMENT TOE PROFILE
HIGHWAY 69 (NBL)

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



E-E' J1 EMBANKMENT TOE PROFILE
HIGHWAY 69 (NBL)

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



KEY PLAN
SCALE
5 0 5 10km

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
S310–06	194.9	5081596.2	223246.3
S310–07	195.0	5081605.4	223265.5
S310–08	195.0	5081620.8	223250.9
S310–09	195.1	5081635.9	223237.6
S310–10	194.9	5081645.4	223255.5
S310–11	194.9	5081654.5	223274.6
S310–12	194.3	5081669.9	223260.0
S310–13	194.0	5081685.2	223246.2
S310–14	194.7	5081694.5	223264.6
S310–DC03	195.2	5081611.4	223233.1
S310–DC04	195.0	5081629.9	223270.1
S310–DC05	194.8	5081660.5	223242.2
S310–DC06	194.6	5081679.0	223279.8

NOTES

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

LICENSED PROFESSIONAL ENGINEER J. M. A. COSTA Jan. 2014 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER T. ZALUCKI 100128614 Jan. 2014 PROVINCE OF ONTARIO

REFERENCE

Base plans provided in digital format by URS. Existing Ground Surface cut from contour drawing file Hwy69_Contour–Plan_C3.dwg, received April 23, 2012 and the Existing and Proposed Grades obtained from drawing file Hwy69_profile March 2012.dwg, received March 14, 2012.

NO.	DATE	BY	REVISION

Geocres No. 41H–134

HWY. 69	PROJECT NO. 09–1111–6014		DIST.
SUBM'D. AV	CHKD. AV	DATE: May 2013	SITE:
DRAWN: JFC	CHKD. TZ	APPD. JPD/JMAC	DWG. J2

PLOT DATE: January 22, 2014

RECORD OF BOREHOLE No S310-04 SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01 LOCATION N 5081692.3 ;E 223207.8 ORIGINATED BY ID
DIST HWY 69 BOREHOLE TYPE 165 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring COMPILED BY AV
DATUM Geodetic DATE February 10, 2013 CHECKED BY TZ

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)
193.9	GROUND SURFACE
0.0	TOPSOIL
0.2	CLAYEY SILT, trace sand, trace organics, containing rootlets and silty sand seams Firm Brown becoming grey below a depth of 2.3 m Wet
191.7 / 2.2	SILTY CLAY, trace sand Soft to firm Grey Wet
190.4 / 3.5	SILT, trace sand, trace to some clay Grey Wet
189.6	SAND and GRAVEL, trace to some silt Dense Grey Wet
189.3 / 4.6	END OF BOREHOLE SPOON REFUSAL

NOTE:

1. Water level in open borehole at a depth of 0.5 m below ground surface (Elev. 193.4 m) upon completion of drilling.

SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1A / 1B	SS	5	
2	SS	6	
3	SS	6	
4	SS	3	
5A / 5B	SS	5	0 2 86 12
6	SS	30/0.05	

Elevation scale: 193, 192, 191, 190

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L
WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m³

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

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 01/22/14

Golder Associates
Foundation Design

RECORD OF BOREHOLE No S310-12 SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01 LOCATION N 5081669.9 ;E 223260.0 ORIGINATED BY ID
DIST HWY 69 BOREHOLE TYPE 165 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring COMPILED BY CC/AV
DATUM Geodetic DATE February 10, 2013 CHECKED BY TZ

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)
194.3	GROUND SURFACE
0.0	TOPSOIL
194.0 / 0.3	CLAYEY SILT, trace organics, containing silt seams to a depth of 1.5 m Firm to stiff Brown Wet
192.1 / 2.2	CLAYEY SILT, trace to some sand Firm to stiff Brown becoming grey below a depth of 4.6 m Wet
188.2 / 6.1	SILT, trace to some sand Loose Grey Wet
187.1 / 7.2	CLAY Firm Grey Wet
183.9 / 10.4	Silty SAND Loose Grey Wet
183.2	SAND and GRAVEL, trace silt Loose Grey Wet
182.9 / 11.4	END OF BOREHOLE CASING REFUSAL

NOTE:

1. Water level in open borehole at a depth of 0.3 m below ground surface (Elev. 194.0 m) upon completion of drilling.

SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1A / 1B	SS	3	
2	SS	7	
3	SS	11	
4	SS	6	
5	SS	5	0 8 75 17
6	SS	WH	
7	SS	4	
8	SS	WH	
9	TO	PH	
10A / 10B	SS	8	

Elevation scale: 194, 193, 192, 191, 190, 189, 188, 187, 186, 185, 184, 183

Field vane values: >96, >96, 6, 4, 4, 4, 4

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L
WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m³

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

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 01/22/14

Golder Associates

Foundation Design

RECORD OF BOREHOLE No S310-13

SHEET 1 OF 1

METRIC

PROJECT 09-1111-6014

W.P. 5404-05-01

LOCATION N 5081685.2 ;E 223246.2

ORIGINATED BY ID

DIST ____ HWY 69

BOREHOLE TYPE 165 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring

COMPILED BY CC/AV

DATUM Geodetic

DATE February 9, 2013

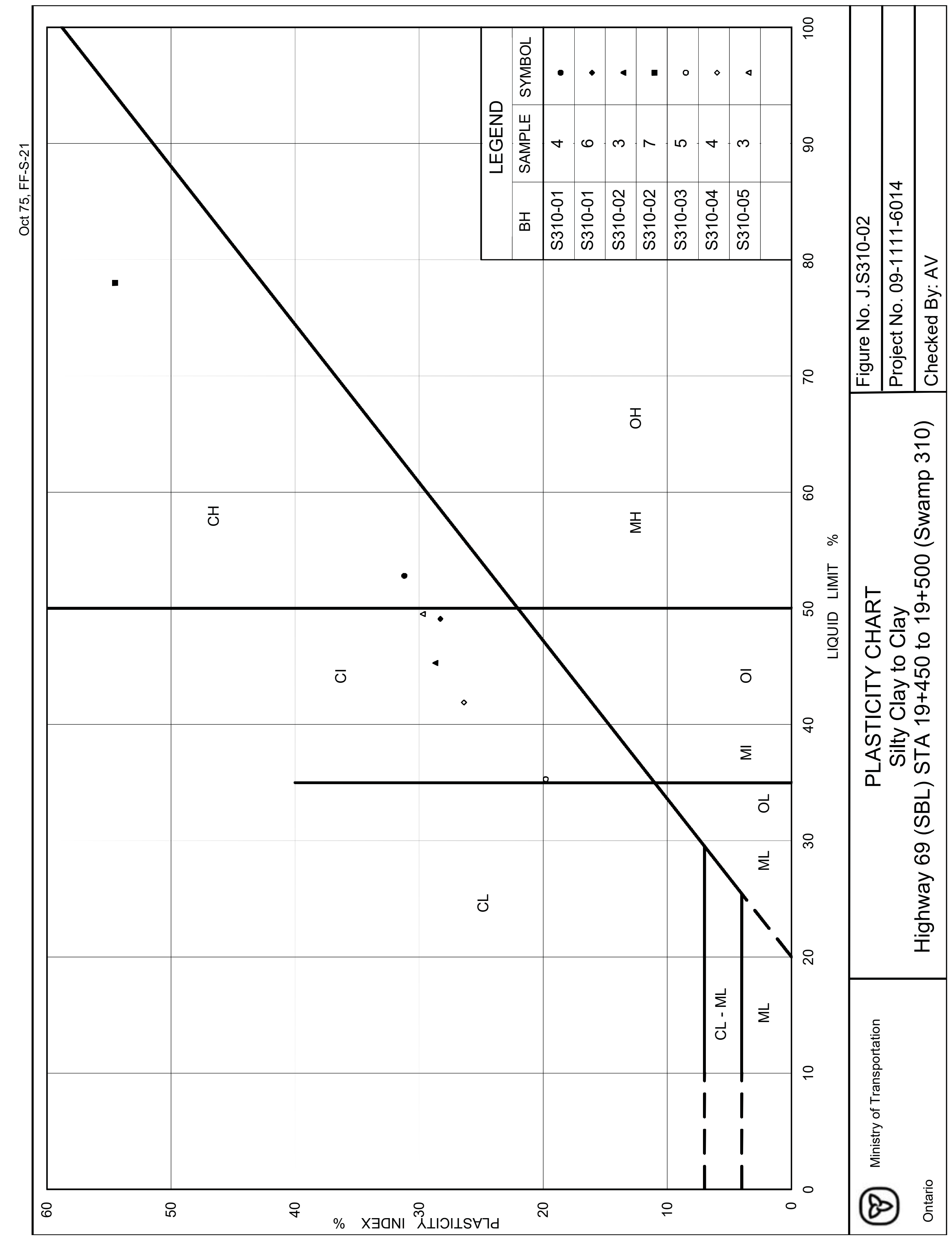
CHECKED BY TZ

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.0	GROUND SURFACE				
0.0	TOPSOIL	1A			
0.2	SILT, some sand, trace clay, containing sand seams Loose Brown Moist to wet	1B	SS	5	
193.3 0.7	CLAYEY SILT, trace to some sand, trace organics Firm to stiff Grey Wet	2	SS	10	
		3	SS	6	
191.8 2.2	SILTY CLAY Soft to firm Grey Wet	4	SS	4	
		5	SS	2	
		6	TO	PH	
188.4 5.6	CLAY Firm Grey Wet	7	SS	WH	
		8	SS	WH	
185.0 9.0	CLAYEY SILT Soft Grey Wet	9	SS	3	0 0 88 12
183.8 10.2	Silty SAND Loose Grey Wet	10	SS	6	
182.6 11.4	END OF BOREHOLE CASING REFUSAL NOTE: 1. Water level in open borehole at a depth of 0.1 m below ground surface (Elev. 193.9 m) upon completion of drilling.				

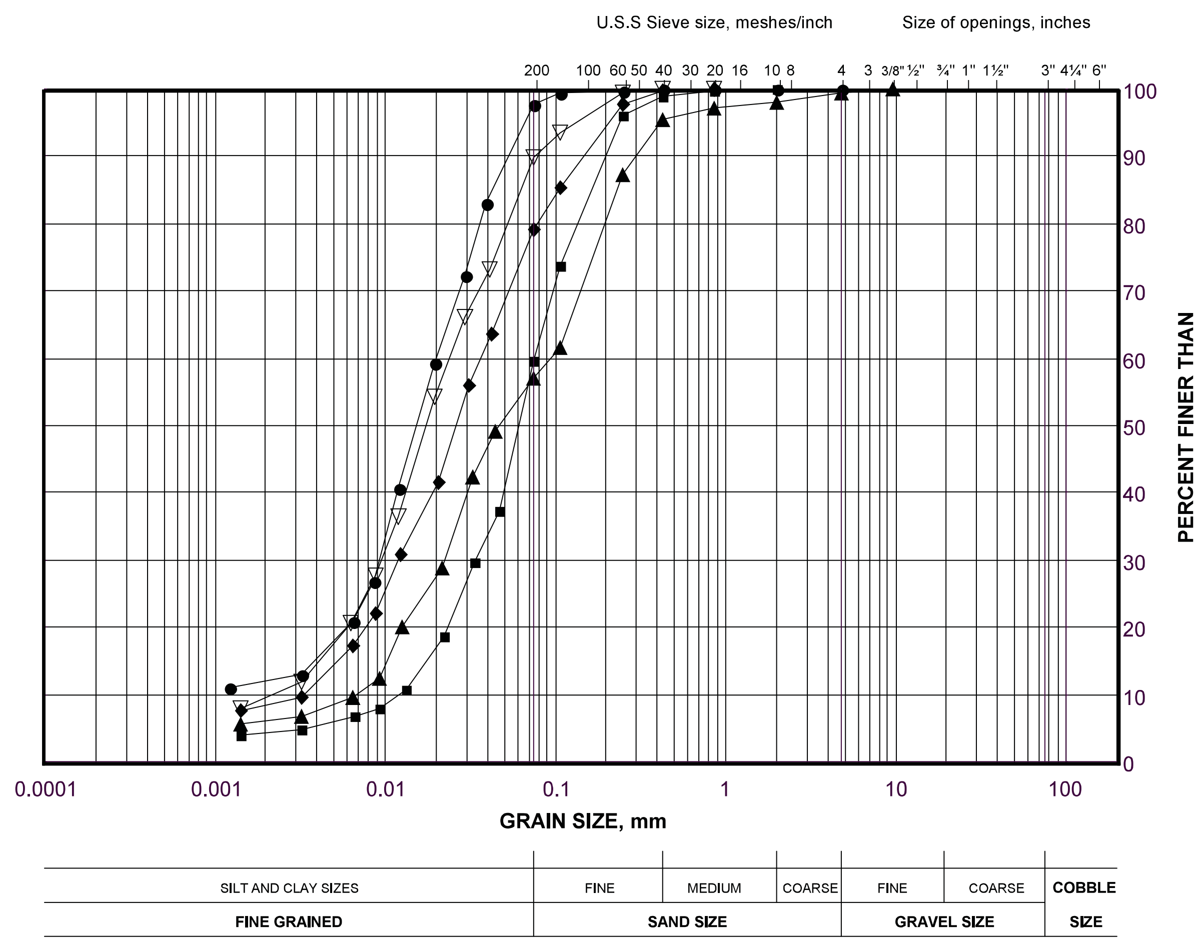
GROUND WATER CONDITIONS · ELEVATION SCALE (193 – 183) · DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) · SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED (20 40 60 80 100) · PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L · WATER CONTENT (%) (20 40 60) · UNIT WEIGHT γ kN/m³

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

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 01/22/14



GRAIN SIZE DISTRIBUTION Silt to Silt and Sand Highway 69 (SBL) STA 19+450 to 19+500 (Swamp 310)	FIGURE J.S310-03



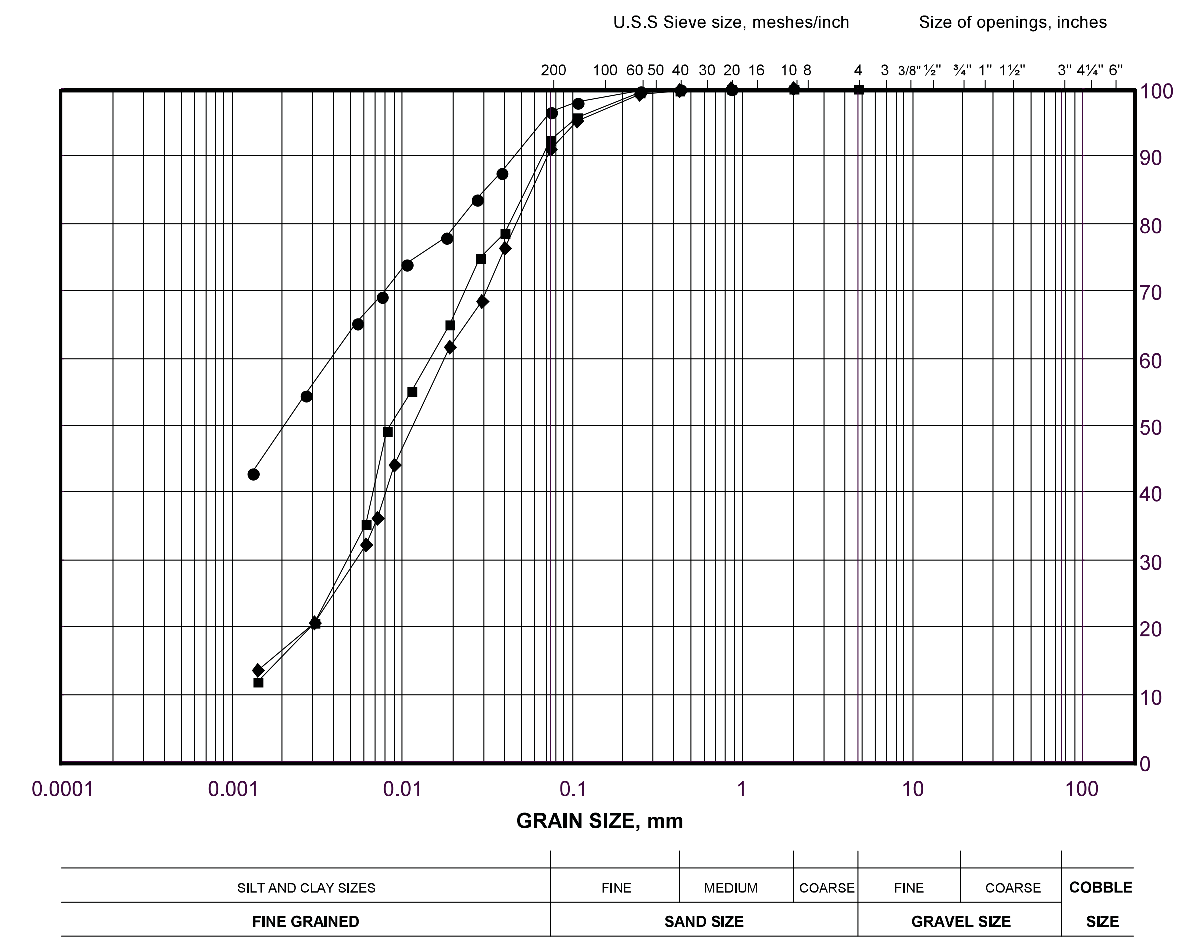
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S310-04	5B	190.3
■	S310-05	6	189.3
◆	S310-03	6	189.8
▲	S310-01	8A	187.1
▽	S310-02	8B	186.6

Project Number: 09-1111-6014

Checked By: AV **Golder Associates** Date: 23-Apr-13

GRAIN SIZE DISTRIBUTION Clayey Silt to Silty Clay Highway 69 (NBL) STA 19+400 to 19+500 (Swamp 310)	FIGURE J.S310-05

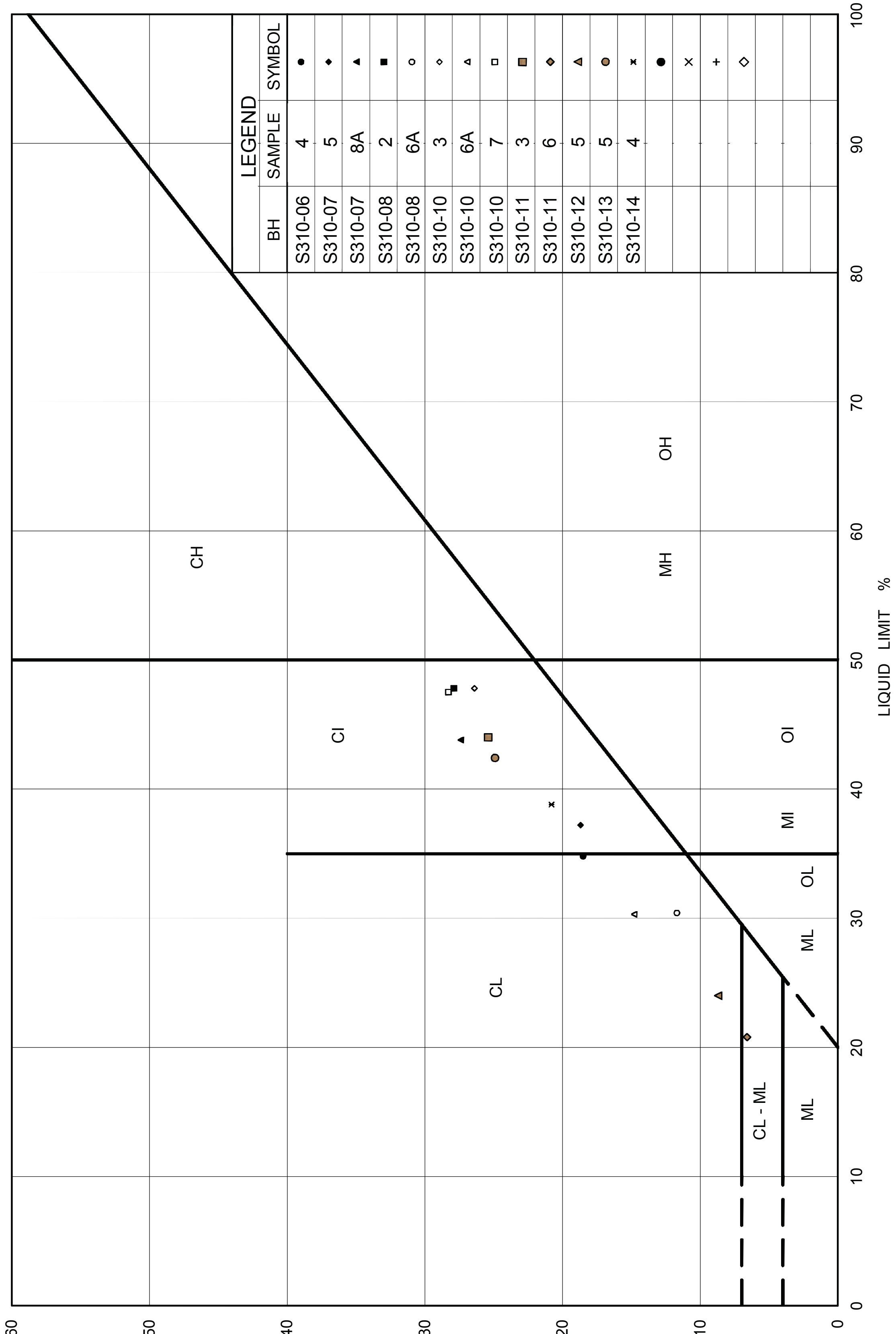


LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S310-10	3	193.1
■	S310-12	5	191.0
◆	S310-11	6	190.0

Project Number: 09-1111-6014

Checked By: AV **Golder Associates** Date: 23-Apr-13



BH	SAMPLE
S310-06	4
S310-07	5
S310-07	8A
S310-08	2
S310-08	6A
S310-10	3
S310-10	6A
S310-10	7
S310-11	3
S310-11	6
S310-12	5
S310-13	5
S310-14	4

PLASTICITY CHART
Clayey Silt to Silty Clay
Highway 69 (NBL) STA 19+400 to 19+500 (Swamp 310)

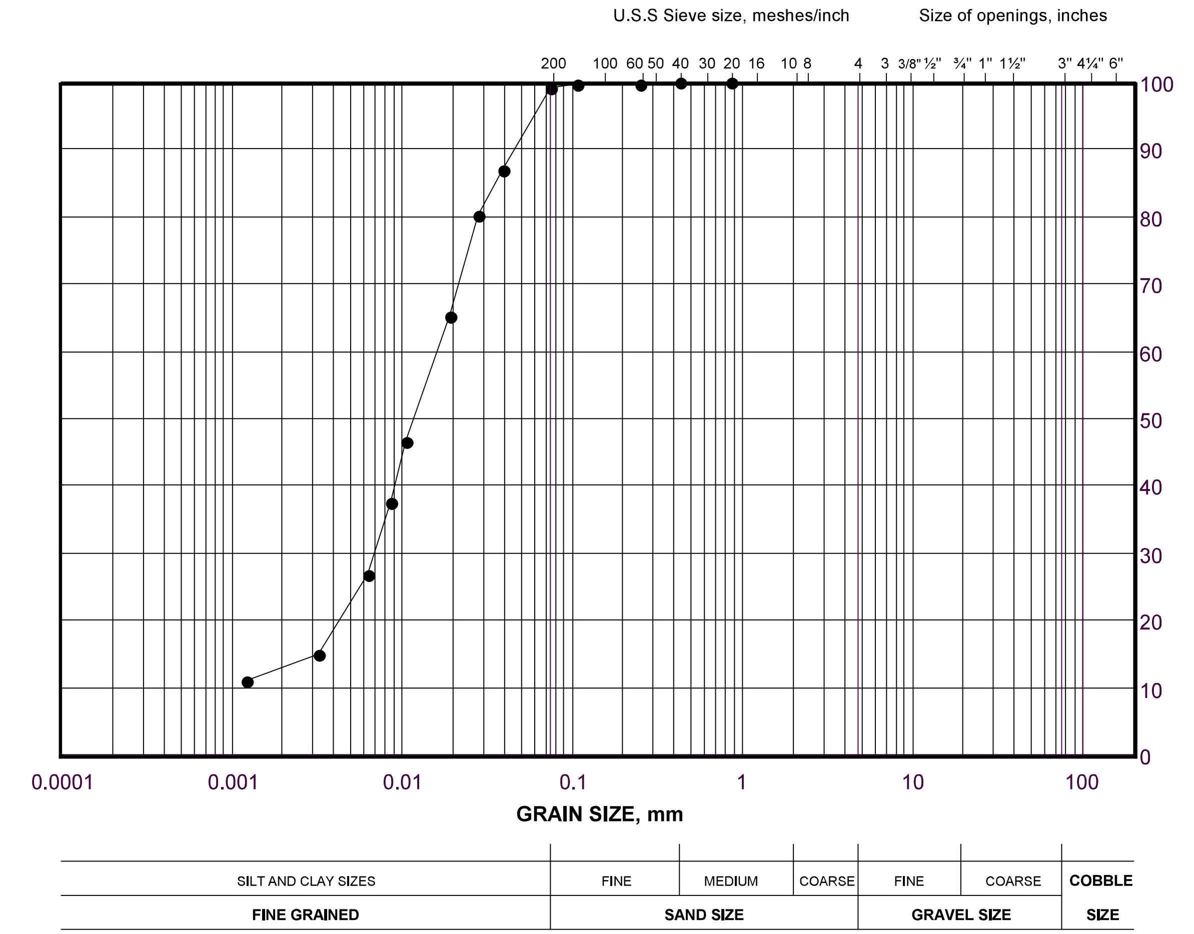
Figure No. J.S310-06
Project No. 09-1111-6014
Checked By: AV

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Clayey Silt
Highway 69 (NBL) STA 19+400 to 19+500 (Swamp 310)

FIGURE J.S310-10



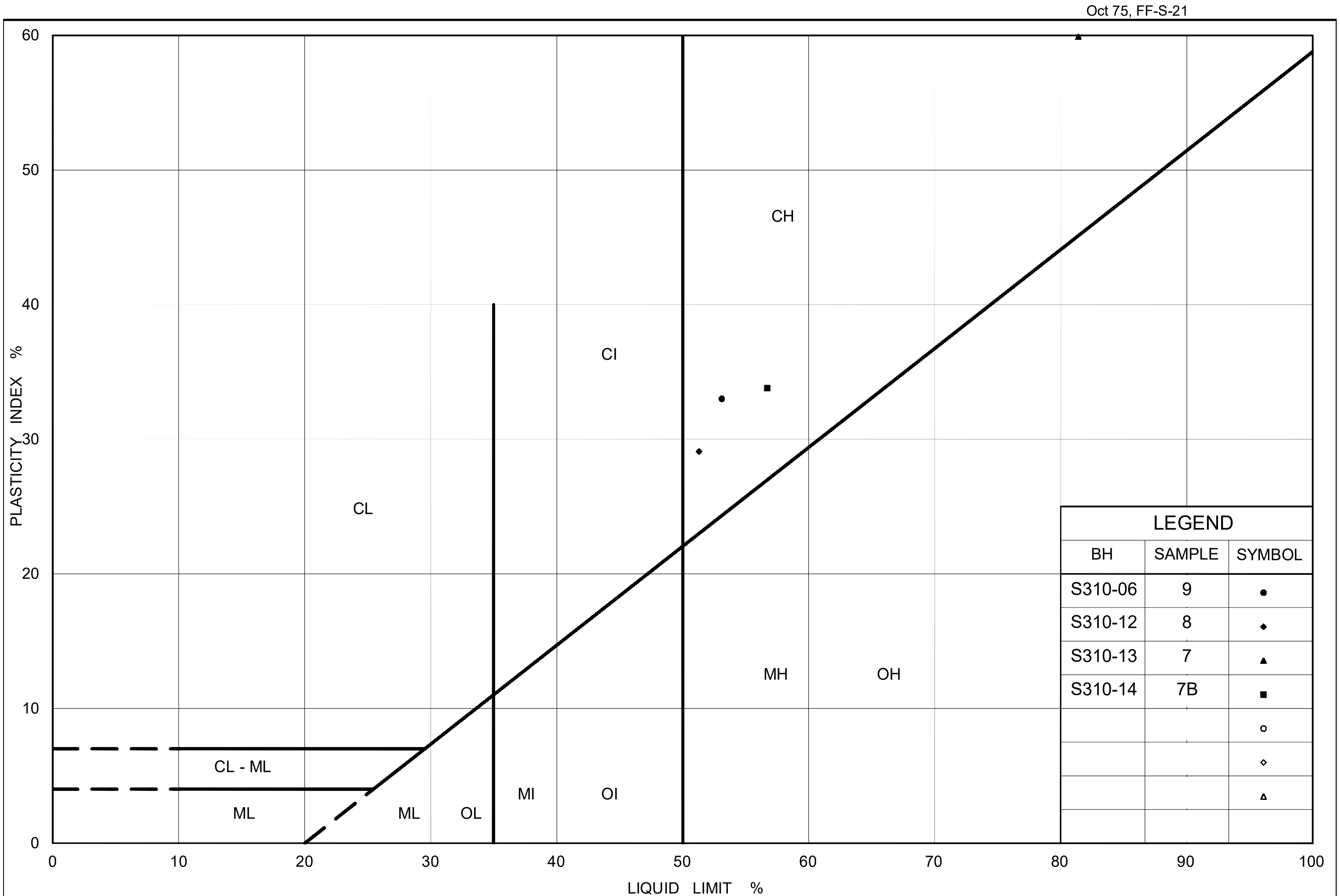
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S310-13	9	184.6

Project Number: 09-1111-6014
Checked By: AV

Golder Associates

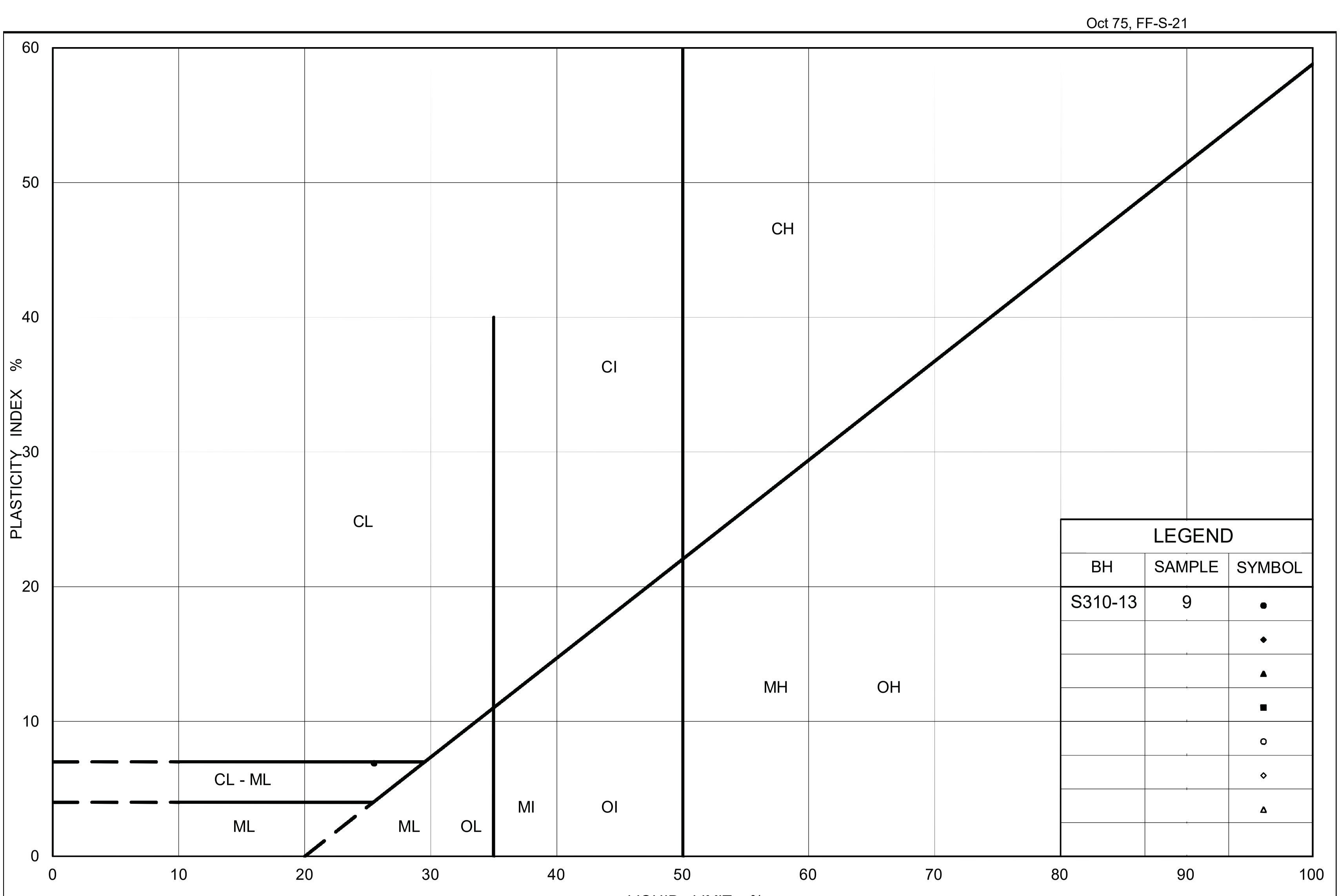
Date: 23-Apr-13



Ministry of Transportation
Ontario

PLASTICITY CHART
Clay
Highway 69 (NBL) STA 19+400 to 19+500 (Swamp 310)

Figure No. J.S310-11
Project No. 09-1111-6014
Checked By: AV



Ministry of Transportation
Ontario

PLASTICITY CHART
Clayey Silt
Highway 69 (NBL) STA 19+400 to 19+500 (Swamp 310)

Figure No. J.S310-12
Project No. 09-1111-6014
Checked By: AV

SHEET P – CVM-1 – Fisheries Culvert (Station: ± 10+405 Hwy 69 NBL/SBL – Mowat)

- Borehole Locations and Soil Strata (Geocres 41H-157)
- Record of Borehole Logs (Geocres 41H-157)
- Laboratory Test Results (Geocres 41H-157)

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field work for the proposed centreline Culvert CVM-1 located at Station 10+405, Mowat Township Site No. TBA was carried out by Golder Associates (Golder) between July 29 and August 7, 2013, and a foundation investigation report (FIR) (Reference No. 1 below) was submitted to MTO.

Six (6) boreholes were advanced by Golder at the proposed location of the culvert across the northbound lane (NBL) and southbound lane (SBL) of the new alignment of Highway 69. Refer to the FIR submitted by Golder for details of the borehole locations and subsurface conditions encountered at the culvert location.

The following documents are referenced:

1. Foundation Investigation Report (FIR) – Culvert at Station 10+405: Contract 5, Highway 69 Four-Laning from 1.7 km North of Highway 529 Northerly to 3.9 km North of Highway 522, Ministry of Transportation, Ontario, GWP 5005-10-00, (GEOCRES No. 41H-157), Submitted to URS Canada Inc. (URS) by Golder., January 12, 2016 (Report Number: 09-1111-6014-5521)
2. Foundation Investigation and Design Report (FIDR), Swamp Crossing, High Fill Areas and Deep Cut - Contract 5, Highway 69 Four-Laning from 1.7 m North of Highway 529 Northerly to 3.9 km North of Highway 522, Ministry of Transportation, Ontario, GWP 5347-08-00; WP 5005-10-01, (GEOCRES No. 41H-164), Submitted to AECOM by Golder, July 27, 2016 (Report Number: 09-1111-6014-5520).

The proposed culvert is located within a swamp crossing identified as Swamp 503 in the report referenced in Reference 2. Refer to this report for the design recommendations, construction and monitoring of embankment across the swamp.

Relevant geotechnical data from the reference reports are included in Appendix A-2 of this report, including records of borehole logs and preliminary foundation drawings.

PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) are based on the information received by PML from Parsons on March 2, 2018 and the subsurface soil and groundwater conditions provided in the report Reference 1.

2. PROJECT DESCRIPTION

2.1 General

The proposed centreline Fisheries Culvert at Station 10+405 is a new structure crossing the new alignment of Highway 69. The proposed culvert is located approximately 550 m east of the existing Highway 69 and some 160 m south of the Key River.

2.2 Proposed Structure (Boreholes C501-01 to C501-06)

Based on Drawings Nos. 2 and 3 dated December 8, 2015, included in the report Reference 1, the proposed culvert will have an opening size of 3.0 m in span and 1.2 m in height and will be approximately 160.0 m long. The alignment of proposed culvert will be on a skew of approximately 60 degrees to the new alignment of Highway 69.

The proposed culvert is located within swamp 503 that is currently inundated with standing water from beaver dams. The existing ground surface in the vicinity of the culvert alignment varies from approximately EL. 185.0 (inlet) to 183.1 m (outlet) and is sloping downward in the from south to the north direction (EL. 195.0 to EL. 186.0)

At the time of the fieldwork, the depths of standing water from beaver dams was approximately 0.8 m to 1.1 m at the inlet and the water level of the ponds varied from EL. 185.8 to EL. 185.2 m. The area of the proposed culvert outlet was in dry condition.

Based on the Drawing No. 3 in the report Reference No. 1, it is understood that the proposed invert and founding levels of proposed culvert are as summarized in Table P-1 below.

Table P-1: Founding Elevations of Culvert CVM-1 at Sta. 10+405 (Centreline)

FOUNDATION LOCATION	PROPOSED CULVERT INVERT ELEVATION, m	BOTTOM OF BOX CULVERT ELEVATION, m	SUBGRADE ELEVATION FOR GRANULAR BEDDING, m	FOUNDING STRATUM
East End (Inlet)	184.2	183.9	183.6	Soft clayey organic silt
West End (Outlet)	182.6	182.3	182.0	Very loose organic silt, some sand, roots

Note(s): 1. The bottom thickness of the precast concrete box culvert is assumed to be 0.25 m and the granular bedding 300 mm thick.

The reports References 1 and 2 indicate that the height of embankment fill required above the culvert to the proposed highway grade will be approximately 9.0 m on the SBL and 7.0 m on the NBL, including the pavement structure.

Based on the available details, it is assumed that the culvert will impose a loading of 250 and 200 kPa on the founding subsoil of the SBL and NBL sections of the culvert, respectively.

2.3 Structure Foundation Subsurface Conditions

The subsurface information reported in the report Reference 1 is summarized in the following paragraph:

The subsurface soil along the proposed culvert alignment varies location to location and consists of topsoil and peat followed by organic silt to clayey organic silt with thickness ranging from 0.6 m to as high as 5.1 m. The organic silt layer is underlain by silt and sand to sand and gravel to the maximum depth of investigation of 12.5 m where refusal to SPT and DCPT was encountered.

It is noted that the thickness of the soil cover in borehole C501-01, C501-2 and C501-03 drilled under the proposed SBL ranges from 2.0 to 2.5 m while in borehole C501-04, CVM-05 and C501-06 drilled for the NBL the thickness of the soil cover ranges from 5.0 to 12.5 m.

In summary, the stratigraphy in the outlet area of the proposed culvert (BHs C501-01 and C501-02) consists of 0.2 m to 0.3 m thick topsoil followed by 0.7 m thick very loose organic silt in BH C501-01 and 0.8 m thick very loose sand in BH C501-02. These deposits are underlain by 0.9 to 1.6 m very loose to compact sand and gravel to sand extending to the termination depth of the boreholes by refusal to SPT and DCPT at EL. 181.7 and EL. 180.6 m. The subsoil conditions encountered in borehole C501-03 drilled under the SBL include 1.1 m of water from a beaver dam followed by 0.3 m of peat and 0.6 m of loose gravelly silt and sand. The borehole was terminated by refusal at 2.9 m depth, EL. 183.2 m.

In the other three boreholes (C501-04, C501-5 and C501-06) the subsoil consists of 0.3 m to 1.4 m thick very soft peat from the bottom of the ponded water between EL. 185.0 and EL. 184.9. The peat layer is followed by very soft to soft organic silt to clayey organic silt with thickness ranging from 1.8 m to 5.1 m. The organic layer is followed by 0.5 to 5.2 m thick cohesionless layers of very loose to very dense sand and gravel to silt and sand.

The reported in-situ vane shear strength (C_u) of the organic clayey soil between EL. 183.0 and EL. 178.0 ranged from 17 to 25 kPa, with an average value of 20 kPa, indicating that the existing cohesive organic soil is compressible and has a soft consistency.

Groundwater was observed at 0.5 m (EL. 182.6 m and EL. 183.2 m) in the two boreholes C501-01 and C501-02 located near the outlet of the proposed culvert. Standing water between EL. 185.2 and EL. 185.8 was record at the location of boreholes C501-03 to C501-06 located near the inlet and middle of the proposed culvert as a result of the ponding caused by beaver dams.

Groundwater levels are subject to seasonal fluctuations and precipitation patterns, and it is anticipated higher during wet periods of the year. It is also assumed that the standing water in the beaver dam ponds will be drained during the construction of the new highway alignment and culverts.

3. EVALUATION OF FOUNDATION ALTERNATIVES

The foundation alternatives recommended in report Reference 2 for the construction of the embankments across Swamp 503 included the excavation of about 3.5 m to 6.5 m of peat and organic silt to organic clayey silt from the SBL and NBL and be replaced with rock fill as the preferred option. It is also recommended that SBL and NBL be preloaded with rock fill for 15 and 95 days, respectively, to mitigate post-construction settlement of the embankment.

Based on the site conditions, the recommended foundation alternatives for this culvert are as follows.

1. Precast concrete box culvert placed on granular replacement fill
2. Corrugated Steel Plate (CSP) Arch Culvert on granular replacement fill

3.1 Option 1: Precast Concrete Box Culvert on Replacement Granular Fill

In view of the variable and compressible soil conditions at this site, it is recommended that the peat and organic silt to clayey organic silt layers be completely removed and replaced with Granular B Type II to support a precast concrete box culvert, in accordance with OPSS 422.07.06.

Under the SBL part of the culvert, excavation of unsuitable soils along the culvert footprint is expected to extend to 0.9 to 1.1 m in boreholes C501-01 and C501-02 and to 1.4 m in borehole C503-3 including 1.1 m of ponded water. These excavations would extend to EL. 182.2 to 183.8 m.

Under the NBL part of the culvert, the excavations in the area of borehole C501-04, C503-5 and C501-06 would extend to depths from 3.0 to 7.3 m, including some 0.8 to 0.9 m of ponded water. These excavations would extend to EL. 178.5 to 182.8 m.

The precast concrete box culvert installed on replacement fill consisting of Granular B Type II placed from the recommended foundation levels may be designed assuming a factored geotechnical resistance of 380 kPa at ULS and 250 kPa at SLS. The estimated total elastic settlement induced under the estimated 250 kPa load of under the SBL and 200 kPa under the NBL is in the range of 15 to 25 mm under the SBL and 45 to 55 mm under the NBL. The associated differential settlement between the SBL and NBL sections of the culvert may be estimated to be in the range of 30 mm to 40 mm. These settlements would be within the tolerable limit of 100 mm generally acceptable for a precast concrete box culvert.

Refer to the General Report for recommendation for excavation and backfilling for the culvert foundations.

3.2 Option 2: Corrugated Steel Plate (CSP) Arch Culvert on Replacement Granular Fill

Refer to the General Report for preliminary general recommendations for the use of Corrugated Steel Plate (CSP) arch culverts.

4. CULVERT BEDDING AND COVER MATERIALS

Refer to the General Report for preliminary recommendations for materials to be used for culvert bedding and cover purposes.

5. APPROACH EMBANKMENT

The details for design, construction, and mitigation procedures for the embankment through Swamp 503 are presented in the report Reference No. 2. This report may be consulted for placement of fill for the swamp crossing and no recommendation is provided in this report.

6. CONSTRUCTION CONSIDERATIONS

6.1 Excavation

About 0.3 m (EL. 183.4) to 6.5 m (EL. 178.5) deep excavation is expected to remove organic soils, spongy areas and soft or unsuitable materials observed within the footprint of the culvert. Refer to report Reference 2 for further recommendations in this regard.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

Preliminary recommendations for culvert backfilling are provided in the General Report.

6.2 Groundwater and Surface Water Control

For construction in-the-dry, the existing beaver dams should be removed for the construction of the embankment and the culvert. Unwatering after beaver dam removal and groundwater dewatering may be carried out from sumps located along the interior periphery of the excavation

Refer to the General Report for further groundwater control recommendations and requirements for water taking.

MINISTRY OF TRANSPORTATION, ONTARIO

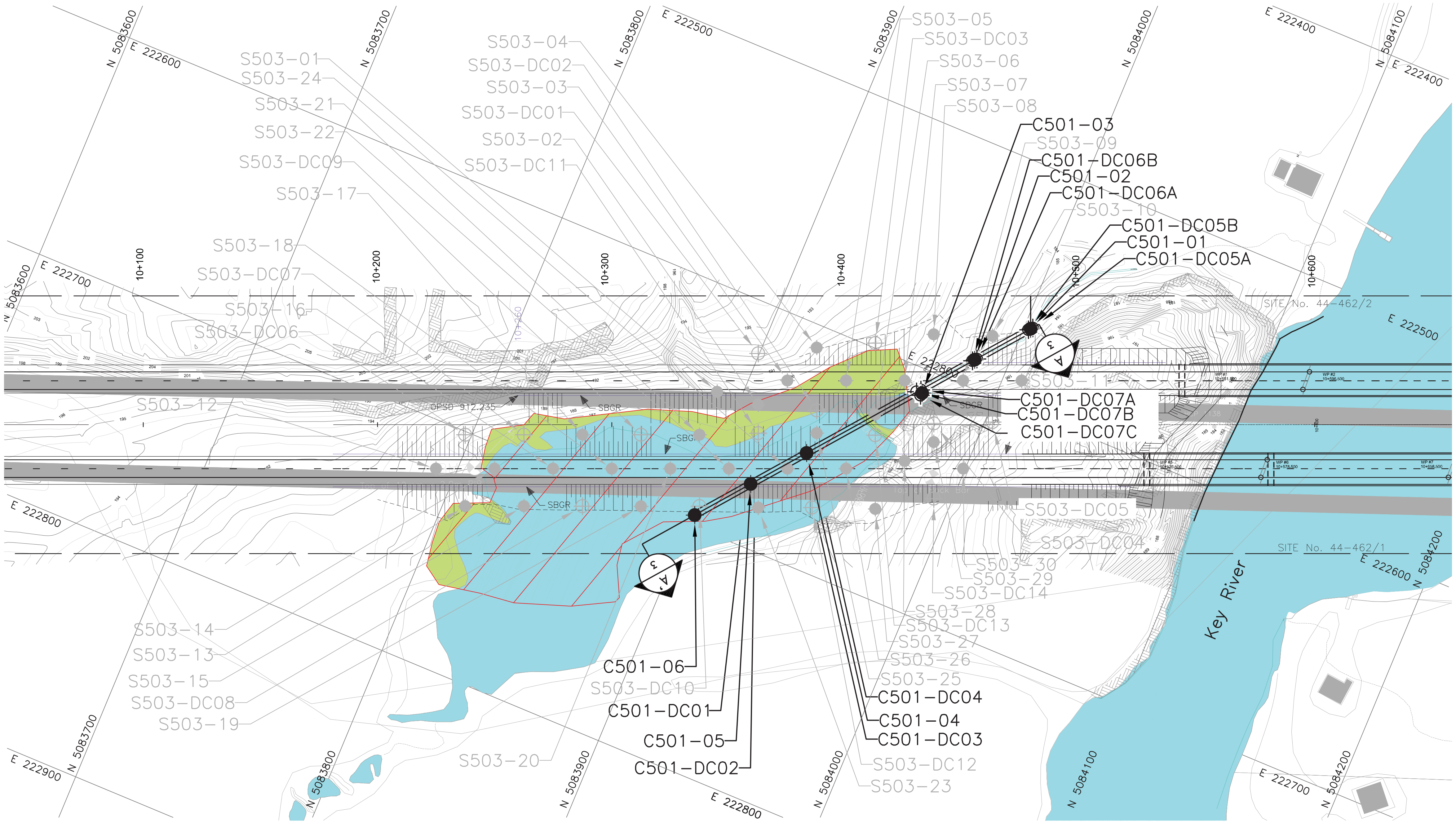
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 5005–10–00

HIGHWAY 69
CULVERT AT STA. 10+405
BOREHOLE LOCATIONS

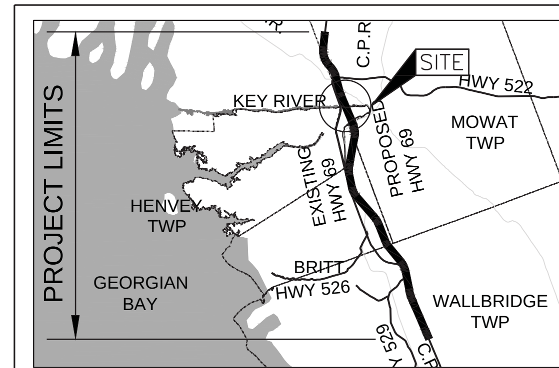
SHEET

Golder Associates



PLAN

SCALE 20 0 20 40 m



KEY PLAN

SCALE 6 0 6 12 km

LEGEND

- Borehole – Current Investigation
- Borehole – Previous Investigation
- Dynamic Cone Penetration Test – Current Investigation
- Dynamic Cone Penetration Test – Previous Investigation

BOREHOLE CO–ORDINATES

No.	ELEVATION	NORTHING	EASTING
C501–01	183.1	5084002.9	222566.9
C501–02	183.7	5083985.9	222588.3
C501–03	185.2	5083970.7	222610.0
C501–04	185.8	5083935.0	222652.6
C501–05	185.8	5083918.0	222673.9
C501–06	185.8	5083901.0	222695.4

BOREHOLE CO–ORDINATES

No.	ELEVATION	NORTHING	EASTING
C501–DC01	185.8	5083916.5	222675.4
C501–DC02	185.8	5083919.4	222672.5
C501–DC03	185.8	5083933.6	222654.0
C501–DC04	185.8	5083936.3	222651.1
C501–DC05A	183.1	5084003.6	222566.2
C501–DC05B	183.1	5084002.2	222567.6
C501–DC06A	183.7	5083986.6	222587.6
C501–DC06B	183.7	5083985.2	222589.0
C501–DC07A	185.2	5083969.6	222609.0
C501–DC07B	185.2	5083968.2	222610.4
C501–DC07C	185.2	5083970.3	222611.1

NOTES

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

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

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

REFERENCE

Base plans provided in digital format by URS, drawing file nos. Alignment and Contours from Hwy69_Contour–Plan_C3.dwg, received April 23, 2012, Existing Ground Surface cut from contour drawing file. Hwy69_Contour–Plan_C5.dwg received August 31, 2012 and the Existing and Proposed Grade obtained from drawing file Hwy 69_profile March 2012.dwg, recieved March 14, 2012.

LICENSED PROFESSIONAL ENGINEER J. M. A. COSTA Jan. 08, 2016 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER A.J.K. BOM 100075715 Jan. 08, 2016 PROVINCE OF ONTARIO

Geocres No. 41H–157

HWY. 69		PROJECT NO. 09–1111–6014	DIST.
SUBM'D. MCK	CHKD. AB	DATE: 8/12/2015	SITE:
DRAWN: JFC	CHKD.	APPD. JMAC	DWG. 2

PLOT DATE: January 7, 2016
FILENAME: T:\Projects\2009\09–1111–6014 (URS, Hwy 69, Henvey)\–YA– (Contract 5 Culvert)\09111160141 4002.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

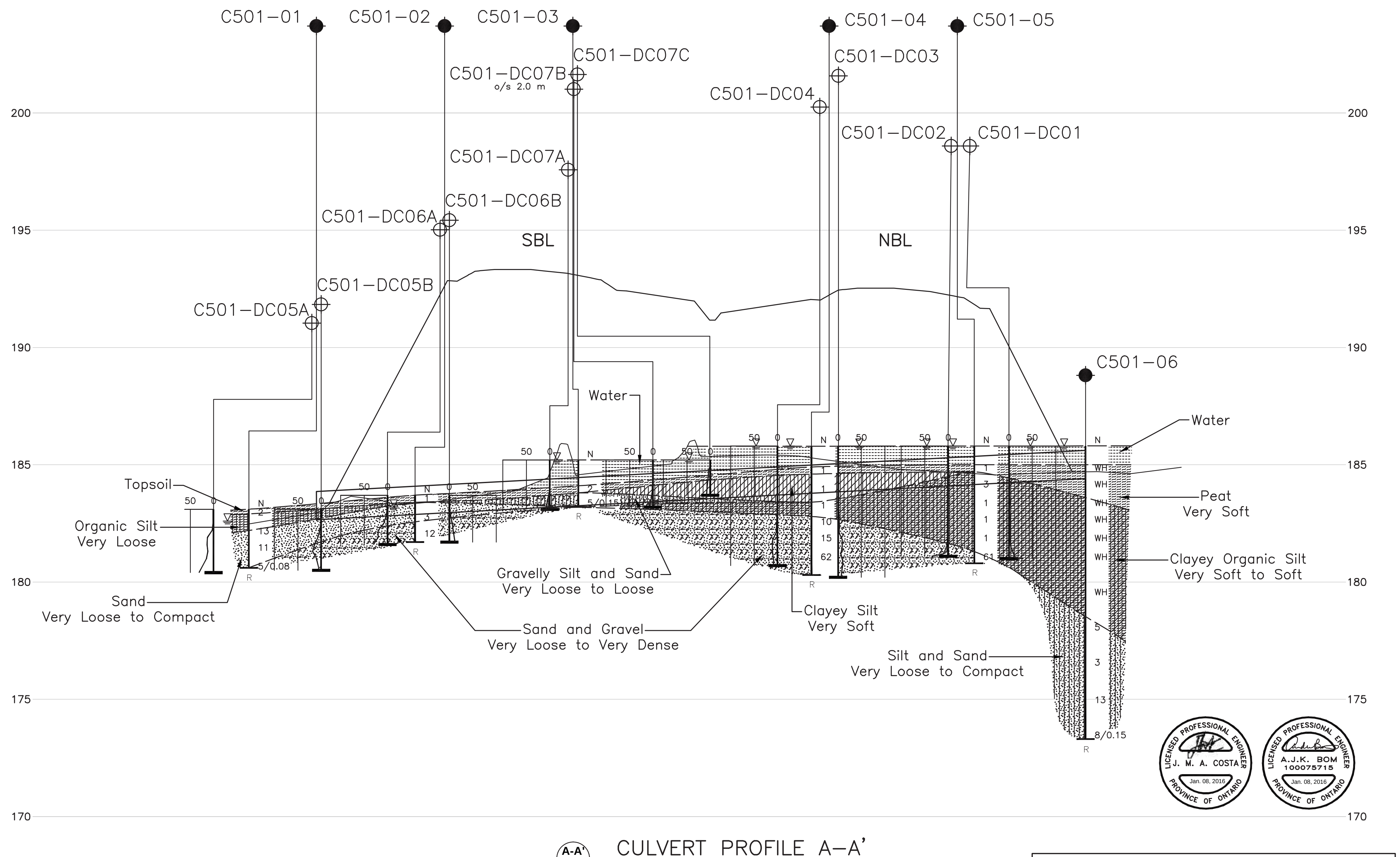
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 5005–10–00

HIGHWAY 69
CULVERT AT STA. 10+405
SOIL STRATA

SHEET

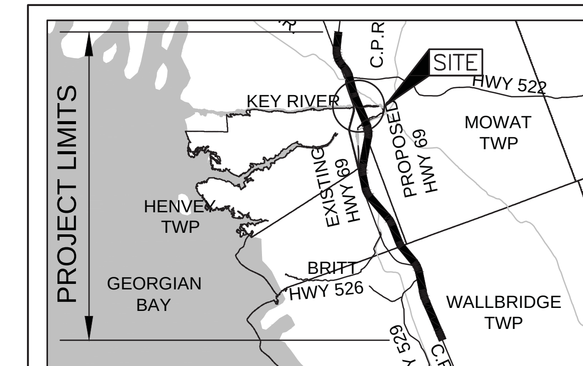
Golder Associates



A-A' 2 CULVERT PROFILE A–A'

HORIZONTAL SCALE 10 0 10 20 m

VERTICAL SCALE 2 0 2 4 m



KEY PLAN
SCALE
6 0 6 12 km

LEGEND

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

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
C501–01	183.1	5084002.9	222566.9
C501–02	183.7	5083985.9	222588.3
C501–03	185.2	5083970.7	222610.0
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C501–05	185.8	5083918.0	222673.9
C501–06	185.8	5083901.0	222695.4

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C501–DC06B	183.7	5083985.2	222589.0
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C501–DC07B	185.2	5083968.2	222610.4
C501–DC07C	185.2	5083970.3	222611.1

NOTES

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NO.	DATE	BY	REVISION

Geocres No. 41H–157

HWY. 69	PROJECT NO. 09–1111–6014		DIST.
SUBM'D. MCK	CHKD. MCK	DATE: 8/12/2015	SITE:
DRAWN: JFC	CHKD. AB	APPD. JMAC	DWG. 3

PLOT DATE: January 7, 2016
FILENAME: T:\Projects\2009\09-1111-6014 (URS, Hwy 69, Henvey)\-YA- (Contract 5 Culvert)\09111160146203.dwg

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
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

Notes: 1 $\tau = c' + \sigma' \tan\phi'$
2 shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d:

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60º 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 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

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

(b) Cohesive Soils

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

IV. SOIL TESTS

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

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

V. MINOR SOIL CONSTITUENTS

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

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

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

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

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

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

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

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

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

GRAIN SIZE

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

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

CORE CONDITION

Total Core Recovery (TCR)

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

Solid Core Recovery (SCR)

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

Rock Quality Designation (RQD)

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

DISCONTINUITY DATA

Fracture Index

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

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90^{o} 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		

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Foundation Design

RECORD OF BOREHOLE No C501-01

SHEET 1 OF 1 **METRIC**

PROJECT 09-1111-6014
G.W.P. 5005-10-01
DIST
HWY 69
DATUM Geodetic
LOCATION N 5084002.9 ;E 222566.9
BOREHOLE TYPE Portable Equipment, NQ Casing, Wash Boring
DATE August 6, 2013
ORIGINATED BY ID
COMPILED BY AV
CHECKED BY CN

ELEV / DEPTH	SOIL PROFILE — DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
183.1	GROUND SURFACE										
0.0	TOPSOIL Dark brown		1A	SS	2	∇	183				
0.2	ORGANIC SILT, some sand, roots Very loose Dark brown to grey Wet		1B						○	OC=6.2%	
182.2 / 0.9	SAND, trace to some silt, trace to some gravel, trace clay Compact Grey Wet		2A	SS	13		182				
			2B						○		11 68 18 3
			3	SS	11		181		○		
180.6			4	SS	5/0.08						
2.5	END OF BOREHOLE SPLIT-SPOON AND CASING REFUSAL										

NOTE:

1. Water level in open borehole at a depth of 0.5 m below ground surface (Elev. 182.6 m) upon completion of drilling.

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 10/1/15

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

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Foundation Design

RECORD OF BOREHOLE No C501-02 SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014

G.W.P. 5005-10-01 LOCATION N 5083985.9 ;E 222588.3 ORIGINATED BY ID

DIST HWY 69 BOREHOLE TYPE Portable Equipment, HQ Casing, Wash Boring COMPILED BY AV

DATUM Geodetic DATE August 6, 2013 CHECKED BY CN

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
183.7	GROUND SURFACE							
0.0 / 183.4	TOPSOIL, Dark brown	1A	SS	1				
0.3	SAND, trace to some gravel, some silt, trace to some clay, trace organics, Very loose, Grey, Wet	1B			▽	183		
182.6 / 1.1		2A	SS	3				9 71 13 7
	SAND and GRAVEL, Very loose to compact, Grey, Wet	2B						
		3	SS	12		182		
181.7 / 2.0	END OF BOREHOLE, SPLIT-SPOON AND CASING REFUSAL							

NOTE:

1. Water level in open borehole at a depth of 0.5 m below ground surface (Elev. 183.2 m) upon completion of drilling.

Chart headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 10/1/15

Golder Associates

Foundation Design

RECORD OF BOREHOLE No C501-03 SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014

G.W.P. 5005-10-01 LOCATION N 5083970.7 ;E 222610.0 ORIGINATED BY ID

DIST HWY 69 BOREHOLE TYPE Portable Equipment, HQ Casing, Wash Boring COMPILED BY AV

DATUM Geodetic DATE August 7, 2013 CHECKED BY CN

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
185.2	WATER SURFACE				▽			
0.0	WATER					185		
184.1						184		
183.8 / 1.4	PEAT (Fibrous), Very soft, Dark brown, Wet	1A	SS	2				
		1B						
183.2 / 2.0	Gravelly SILT and SAND, trace clay, Very loose to loose, Grey, Wet	2	SS	5/0.15				21 33 43 3
	END OF BOREHOLE, SPLIT-SPOON AND CASING REFUSAL							

Chart headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 10/1/15

Golder Associates

RECORD OF BOREHOLE No C501-04 SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014
G.W.P. 5005-10-01 LOCATION N 5083935.0 ;E 222652.6 ORIGINATED BY ID
DIST HWY 69 BOREHOLE TYPE Portable Equipment, HQ Casing, Wash Boring COMPILED BY MCK/AV
DATUM Geodetic DATE July 30, 2013 CHECKED BY CN

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS
185.8	WATER SURFACE					
0.0	WATER					
184.9	PEAT (Fibrous), Very soft, Dark brown, Wet	1A / 1B	SS	1	185	
184.6 / 1.2	CLAYEY SILT, trace organics, trace wood fragments and rootlets, Very soft, Dark grey, Wet	2	SS	1	184	
183.4 / 2.4	Clayey ORGANIC SILT, Very soft, Grey, Wet	3	SS	1	183	OC = 8.7%
182.8 / 3.0	SAND and GRAVEL, Compact to very dense, Grey, Wet	4	SS	10	182	
		5	SS	15		
		6	SS	62	181	
180.3 / 5.5	END OF BOREHOLE, SPLIT-SPOON AND CASING REFUSAL					

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L – WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Water content plot value: 111.2

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

Golder Associates

RECORD OF BOREHOLE No C501-05 SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014
G.W.P. 5005-10-01 LOCATION N 5083918.0 ;E 222673.9 ORIGINATED BY ID
DIST HWY 69 BOREHOLE TYPE Portable Equipment, HQ Casing, Wash Boring COMPILED BY AV
DATUM Geodetic DATE July 29 and 30, 2013 CHECKED BY CN

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS
185.8	WATER SURFACE					
0.0	WATER					
185.0	PEAT (Fibrous), Very soft, Brown, Wet	1A / 1B	SS	1	185	
184.7 / 1.1	ORGANIC SILT, trace to some sand, trace wood fragments and roots to a depth of 2.1 m, Very soft to soft, Dark grey, Wet	2	SS	3	184	
		3	SS	1	183	OC=14.8%
		4	SS	1	182	
		5	SS	1		
181.3 / 4.5	SAND and GRAVEL, Very dense, Grey, Wet	6	SS	61	181	
180.8 / 5.0	END OF BOREHOLE, SPLIT-SPOON REFUSAL					

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L – WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Shear strength plot values: 5, 5
Water content plot values: 168.4, 149.4

NOTE:

1. An additional borehole was advanced South of Borehole C501-05 to carry out in situ field vanes between depths of 2.4 m and 3.9 m below ground surfae (Elev. 182.6 m and 181.1 m) and to obtain Shelby tube samples at depths of 1.3 m and 3.0 m below peat surface (Elev. 183.7 m and 182.0 m).

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 10/1/15

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

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RECORD OF BOREHOLE No C501-06 SHEET 1 OF 2 METRIC

PROJECT 09-1111-6014
G.W.P. 5005-10-01 LOCATION N 5083901.0 ;E 222695.4 ORIGINATED BY ID
DIST HWY 69 BOREHOLE TYPE Portable Equipment, HQ Casing, Wash Boring COMPILED BY MCK/AV
DATUM Geodetic DATE July 29, 2013 CHECKED BY CN

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa (field vane)	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
185.8	WATER SURFACE							
0.0	WATER							
185.0 0.8	PEAT (Fibrous) Very soft Dark brown Wet	1	SS	WH	185			
		2	SS	WH	184		383.2	
183.6 2.2	Clayey ORGANIC SILT Soft Grey Wet	3	SS	WH	183		207.3	
		4	SS	WH	182	6 6		
		5	SS	WH			80 169.7 OC=11.8%	
		6	SS	WH	181			
					180	4		
		7	SS	WH	179	3		
178.5 7.3	SILT and SAND, trace gravel, trace clay Very loose to compact Grey Wet	8	SS	5	178			
					177			
		9	SS	3	176			0 36 63 1
		10	SS	13	175			
					174			
		11	SS	8/0.15				
173.3 12.5	END OF BOREHOLE SPLIT-SPOON AND CASING REFUSAL							

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 10/1/15

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RECORD OF BOREHOLE No C501-06 SHEET 2 OF 2 METRIC

PROJECT 09-1111-6014
G.W.P. 5005-10-01 LOCATION N 5083901.0 ;E 222695.4 ORIGINATED BY ID
DIST HWY 69 BOREHOLE TYPE Portable Equipment, HQ Casing, Wash Boring COMPILED BY MCK/AV
DATUM Geodetic DATE July 29, 2013 CHECKED BY CN

--- CONTINUED FROM PREVIOUS PAGE ---

NOTE:

1.An additional borehole was advanced about 1.5 m South of Borehole C501-06 to carry out in situ field vane at depths of 2.9 m and 3.2 m below ground surface (Elev. 182.1 m and Elev. 181.8 m) and to obtain a Shelby tube sample at a depth of 1.8 m below ground surface (Elev. 183.2 m).

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 10/1/15

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RECORD OF DCPT No C501-DC01

SHEET 1 OF 1

METRIC

PROJECT 09-1111-6014

G.W.P. 5005-10-01

LOCATION N 5083916.5 ;E 222675.4

ORIGINATED BY ID

DIST

HWY 69

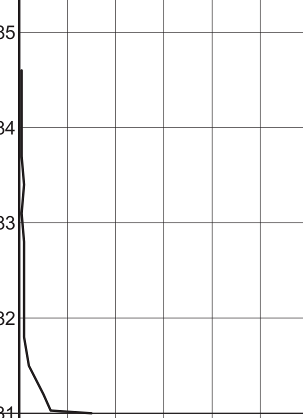
BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test

COMPILED BY AV

DATUM Geodetic

DATE July 30, 2013

CHECKED BY CN

SOIL PROFILE: ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
185.8	WATER SURFACE					▽					
0.0	Dynamic Cone Penetration Test (DCPT)						185 184 183 182 181				
181.0 4.8	END OF DCPT Refusal to Further Penetration (30 Blows / 0.0 m) NOTE: 1. Dynamic Cone Penetration Test was advanced through 0.9 m of water.										

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 10/1/15

Golder Associates

Foundation Design

RECORD OF DCPT No C501-DC02

SHEET 1 OF 1

METRIC

PROJECT 09-1111-6014

G.W.P. 5005-10-01

LOCATION N 5083919.4 ;E 222672.5

ORIGINATED BY ID

DIST

HWY 69

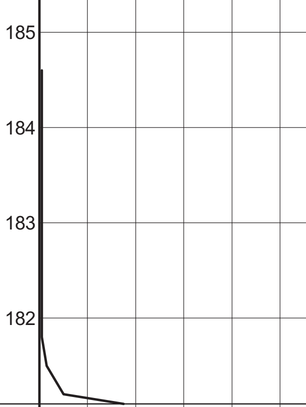
BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test

COMPILED BY AV

DATUM Geodetic

DATE July 30, 2013

CHECKED BY CN

SOIL PROFILE: ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
185.8	WATER SURFACE					▽					
0.0	Dynamic Cone Penetration Test (DCPT)						185 184 183 182				
181.1 4.7	END OF DCPT Refusal to Further Penetration (30 Blows / 0.15 m) NOTE: 1. Dynamic Cone Penetration Test was advanced through 0.9 m of water.										

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 10/1/15

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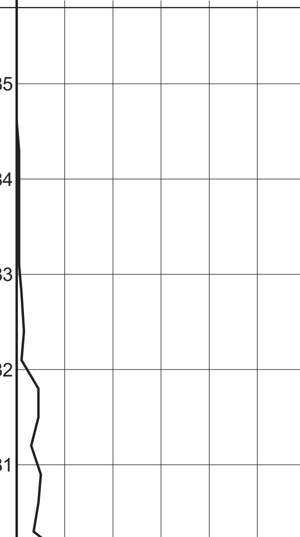
RECORD OF DCPT No C501-DC03 SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014

G.W.P. 5005-10-01 LOCATION N 5083933.6 ;E 222654.0 ORIGINATED BY ID

DIST HWY 69 BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test COMPILED BY AV

DATUM Geodetic DATE July 31, 2013 CHECKED BY CN

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
185.8	WATER SURFACE					▽					
0.0	Dynamic Cone Penetration Test (DCPT)						185 184 183 182 181				
180.2 5.6	END OF DCPT Refusal to Further Penetration (30 Blows / 0.0 m) NOTE: 1. Dynamic Cone Penetration Test was advanced through 0.9 m of water.										

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 10/1/15

Golder Associates

Foundation Design

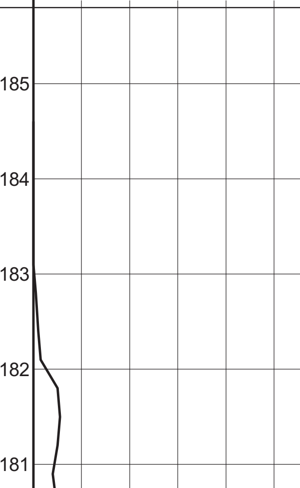
RECORD OF DCPT No C501-DC04 SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014

G.W.P. 5005-10-01 LOCATION N 5083936.3 ;E 222651.1 ORIGINATED BY ID

DIST HWY 69 BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test COMPILED BY AV

DATUM Geodetic DATE July 31, 2013 CHECKED BY CN

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
185.8	WATER SURFACE					▽					
0.0	Dynamic Cone Penetration Test (DCPT)						185 184 183 182 181				
180.7 5.1	END OF DCPT Refusal to Further Penetration NOTE: 1. Dynamic Cone Penetration Test was advanced through 0.9 m of water.										

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 10/1/15

Golder Associates

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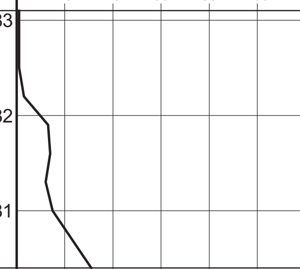
RECORD OF DCPT No C501-DC05A SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014
G.W.P. 5005-10-01 LOCATION N 5084003.6 ;E 222566.2 ORIGINATED BY ID
DIST HWY 69 BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test COMPILED BY AV
DATUM Geodetic DATE August 6, 2013 CHECKED BY CN

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	STRAT PLOT	SAMPLES – NUMBER	SAMPLES – TYPE	SAMPLES – "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P – NATURAL MOISTURE CONTENT w – LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
183.1	GROUND SURFACE										
0.0	Dynamic Cone Penetration Test (DCPT)						183 182 181				
180.4 2.7	END OF DCPT Refusal to Further Penetration (31 Blows / 0.25 m)										

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 10/1/15

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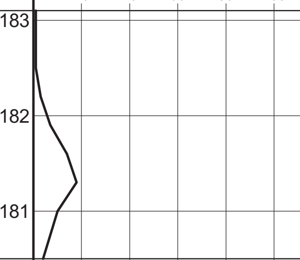
RECORD OF DCPT No C501-DC05B SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014
G.W.P. 5005-10-01 LOCATION N 5084002.2 ;E 222567.6 ORIGINATED BY ID
DIST HWY 69 BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test COMPILED BY AV
DATUM Geodetic DATE August 6, 2013 CHECKED BY CN

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	STRAT PLOT	SAMPLES – NUMBER	SAMPLES – TYPE	SAMPLES – "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P – NATURAL MOISTURE CONTENT w – LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
183.1	GROUND SURFACE										
0.0	Dynamic Cone Penetration Test (DCPT)						183 182 181				
180.5 2.6	END OF DCPT Refusal to Further Penetration										

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 10/1/15

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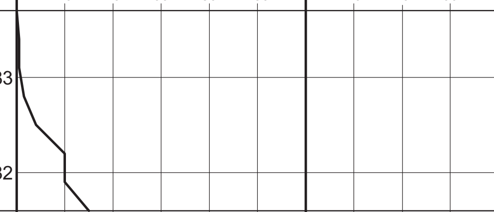
RECORD OF DCPT No C501-DC06A SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014
G.W.P. 5005-10-01 LOCATION N 5083986.6 ;E 222587.6 ORIGINATED BY ID
DIST HWY 69 BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test COMPILED BY AV
DATUM Geodetic DATE August 6, 2013 CHECKED BY CN

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
183.7	GROUND SURFACE										
0.0	Dynamic Cone Penetration Test (DCPT)						183 182				
181.6 2.1	END OF DCPT Refusal to Further Penetration (30 Blows / 0.0 m)										



Legend: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 10/1/15

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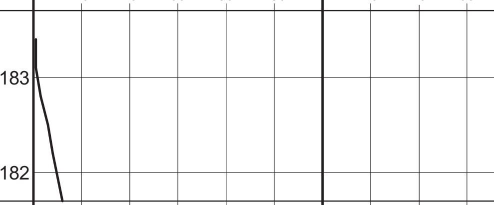
RECORD OF DCPT No C501-DC06B SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014
G.W.P. 5005-10-01 LOCATION N 5083985.2 ;E 222589.0 ORIGINATED BY ID
DIST HWY 69 BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test COMPILED BY AV
DATUM Geodetic DATE August 6, 2013 CHECKED BY CN

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
183.7	GROUND SURFACE										
0.0	Dynamic Cone Penetration Test (DCPT)						183 182				
181.7 2.0	END OF DCPT Refusal to Further Penetration										



Legend: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 10/1/15

Golder Associates

RECORD OF DCPT No C501-DC07A SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014

G.W.P. 5005-10-01 LOCATION N 5083969.6 ;E 222609.0 ORIGINATED BY ID

DIST HWY 69 BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test COMPILED BY AV

DATUM Geodetic DATE August 7, 2013 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
185.2	WATER SURFACE										
0.0	Dynamic Cone Penetration Test (DCPT)						185				
							184				
183.1 2.1	END OF DCPT Refusal to Further Penetration 1. Dynamic Cone Penetration Test was advanced through 1.0 m of water.										

$+^3, \times^3$: Numbers refer to Sensitivity $\bigcirc^{3\%}$ STRAIN AT FAILURE

Golder Associates

RECORD OF DCPT No C501-DC07B SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014

G.W.P. 5005-10-01 LOCATION N 5083968.2 ;E 222610.4 ORIGINATED BY ID

DIST HWY 69 BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test COMPILED BY AV

DATUM Geodetic DATE August 7, 2013 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
185.2	WATER SURFACE										
0.0	Dynamic Cone Penetration Test (DCPT)						185				
							184				
183.2 2.0	END OF DCPT Refusal to Further Penetration 1. Dynamic Cone Penetration Test was advanced through 1.0 m of water.										

$+^3, \times^3$: Numbers refer to Sensitivity $\bigcirc^{3\%}$ STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF DCPT No C501-DC07C SHEET 1 OF 1 METRIC

PROJECT 09-1111-6014

G.W.P. 5005-10-01 LOCATION N 5083970.3 ;E 222611.1 ORIGINATED BY ID

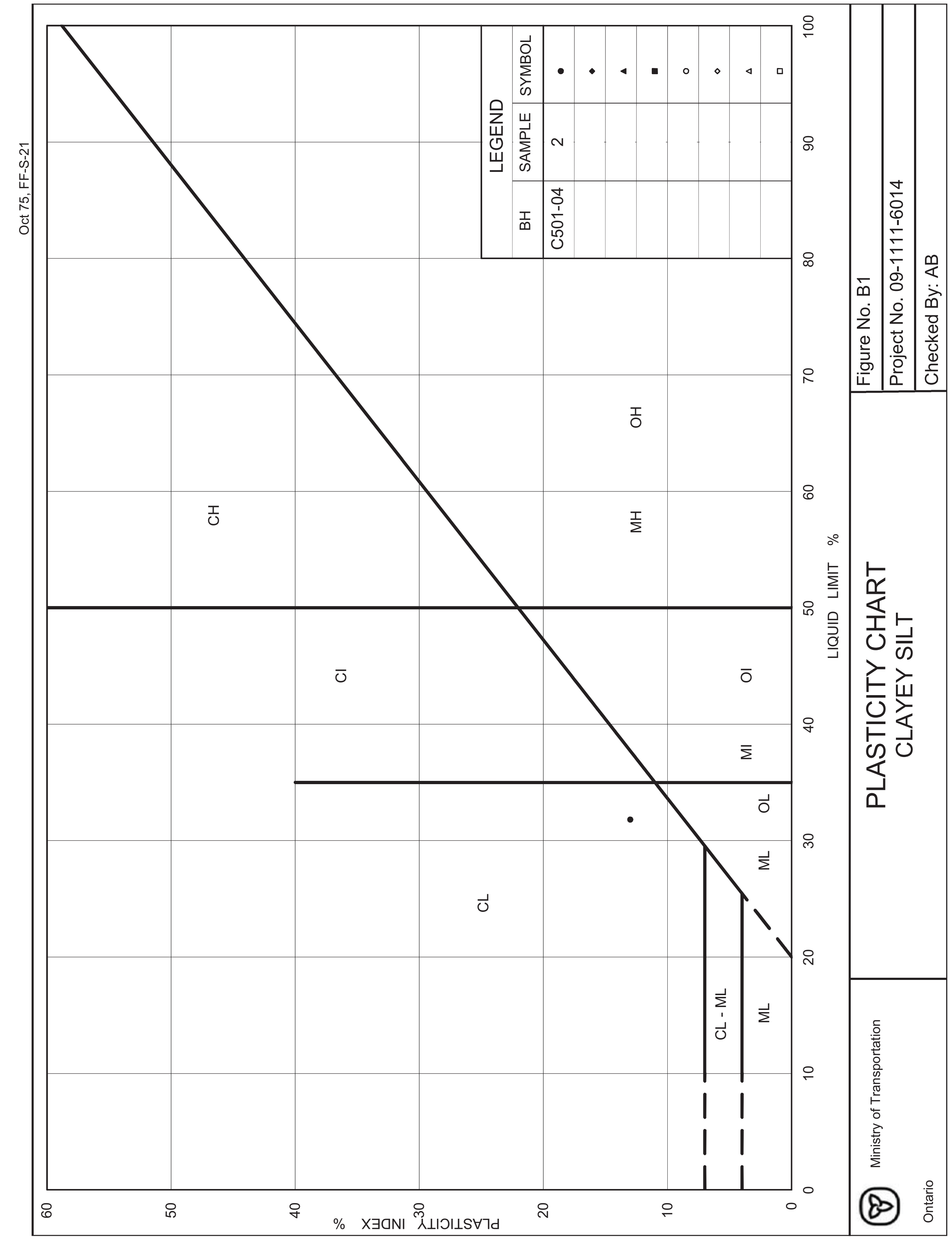
DIST HWY 69 BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test COMPILED BY AV

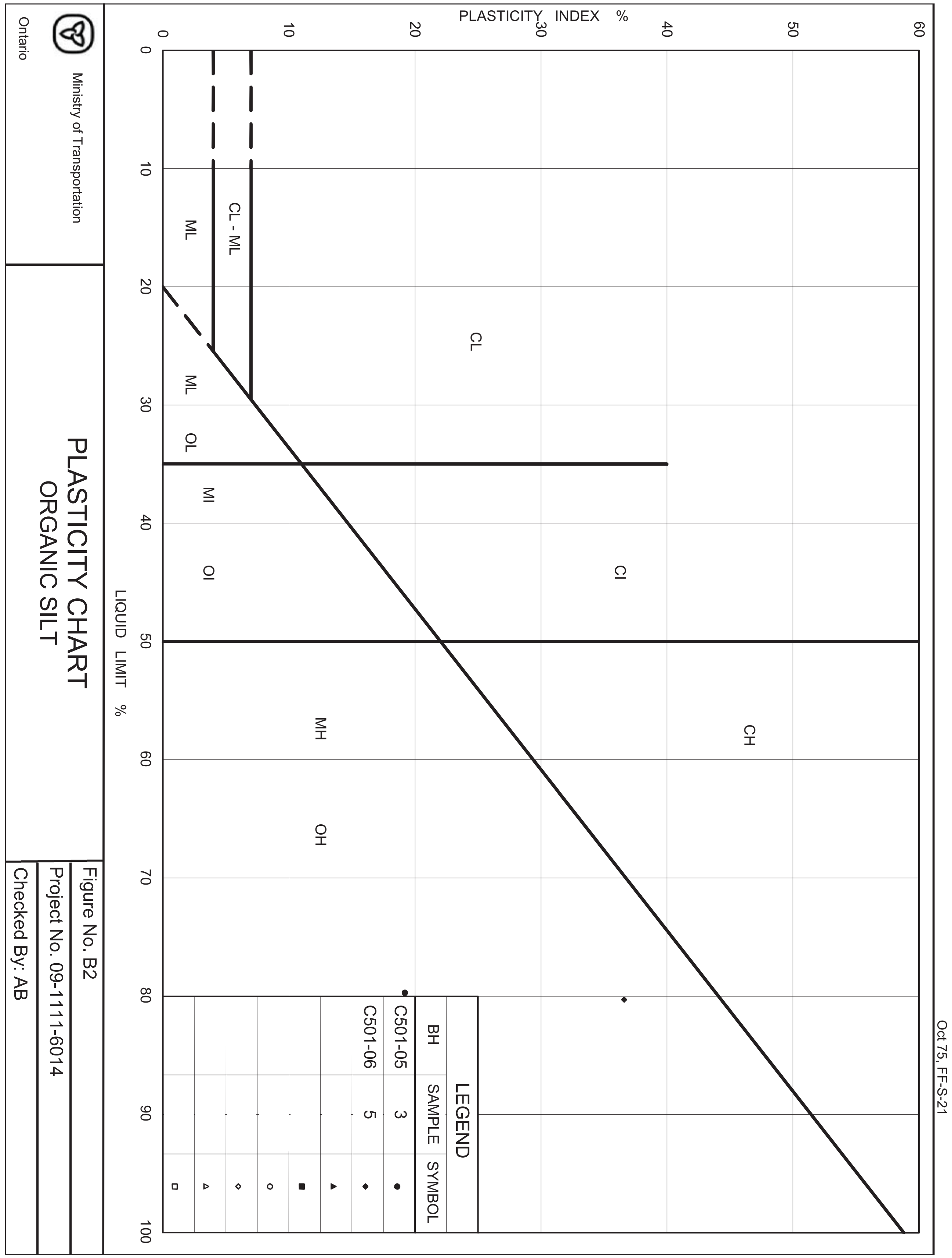
DATUM Geodetic DATE August 7, 2013 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
185.2	WATER SURFACE					▽					
0.0	Dynamic Cone Penetration Test (DCPT)						185				
							184				
183.7 1.5	END OF DCPT Refusal to Further Penetration (Hammer Bouncing)										

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 10/1/15

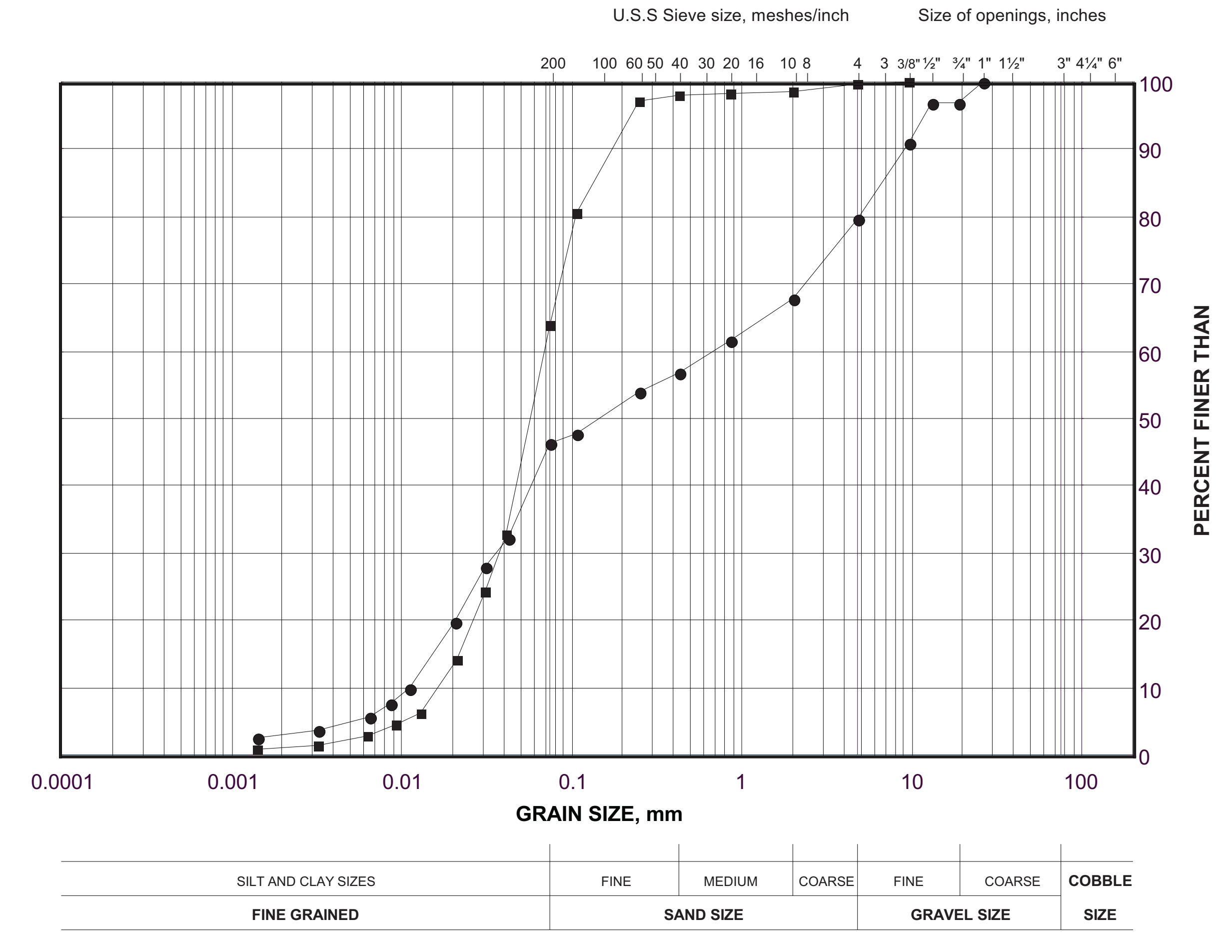




GRAIN SIZE DISTRIBUTION

SILT and SAND

FIGURE B3



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C501-03	2	183.2
■	C501-06	9	176.4

Project Number: 09-1111-6014

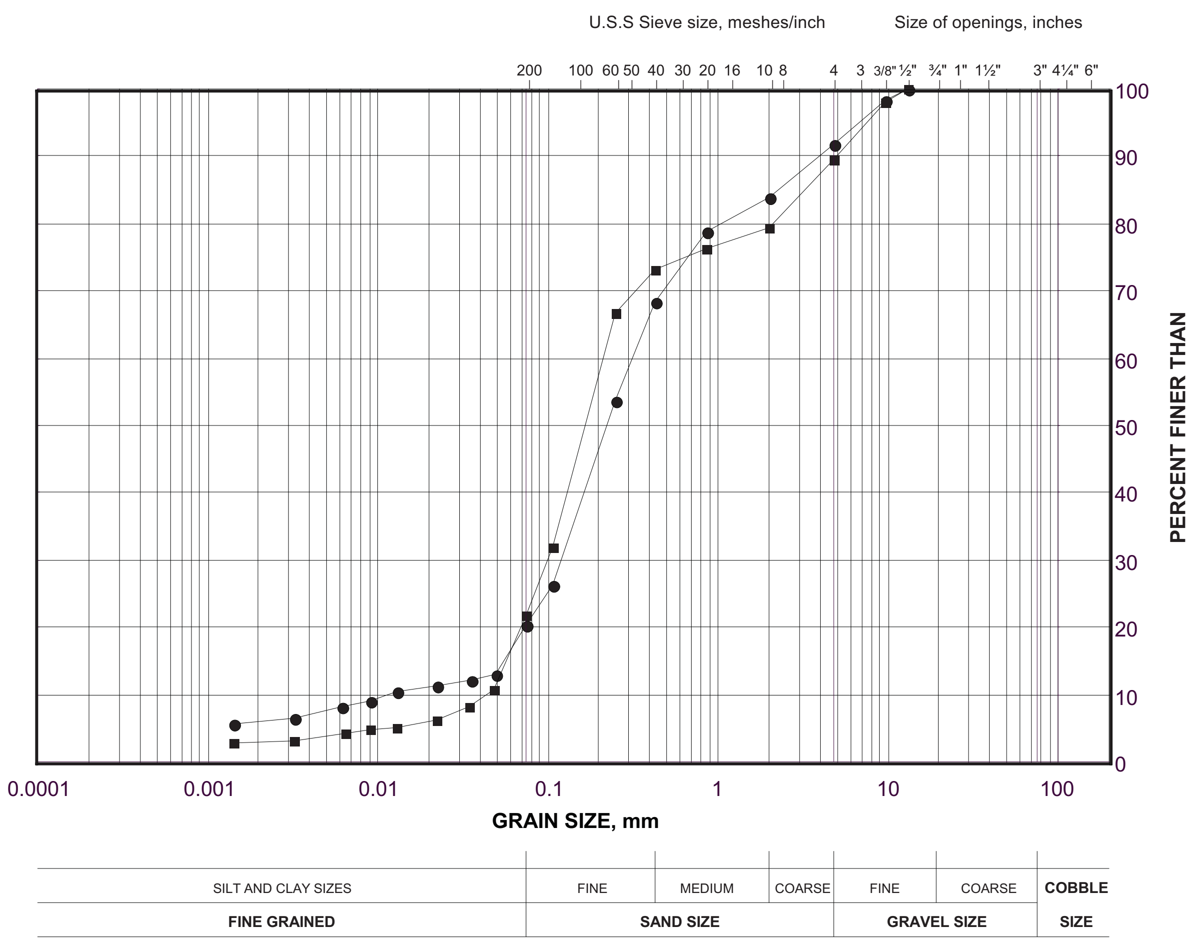
Checked By: AB

Golder Associates

Date: 27-Jul-15

GRAIN SIZE DISTRIBUTION
SAND

FIGURE B4



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C501-02	2A	182.8
■	C501-01	2B	181.9

Project Number: 09-1111-6014

Checked By: AB

Golder Associates

Date: 27-Jul-15

SHEET Q – CVM-2 – Fisheries/Wildlife Culvert (Station: ± 12+587 Hwy 69/522 I/C-S-E/W RAMP – Mowat)

- Borehole Locations and Soil Strata (Geocres 41H-133)
- Record of Borehole Logs (Geocres 41H-133)
- Laboratory Test Results (Geocres 41H-133)

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field work for the Culvert CVM-2 (Site No. 44-627/C3) was carried out by Golder Associates (Golder) between August 9 and 24, 2012, and a foundation investigation report (FIR) was submitted to MTO (Reference 1 below).

Three (3) boreholes were advanced by Golder at the proposed location of the culvert on S-EW Ramp of the interchange of the new alignment of Highway 69 and Highway 522. Refer to the FIR submitted by Golder for details of the borehole locations and subsurface conditions encountered at the culvert locations.

The following documents are referenced:

1. Foundation Investigation Report (FIR): Culverts - Contract 4, Highway 69 Four-Laning from 1.7 km North of Highway 529 Northerly to 3.9 km North of Highway 522, Ministry of Transportation, Ontario, GWP 5347-08-00; WP 5347-08-01, (GEOCRES No. 41H-133), Submitted to URS Canada Inc. by Golder Associates Ltd., October 9, 2013 (Report Number: 09-1111-6014-4521)
2. Foundation Investigation and Design Report (FIDR), Swamp Crossings and High Fill Areas - Contract 4, Highway 69 Four-Laning from 1.7 km North of Highway 529 Northerly to 3.9 km North of Highway 522, Ministry of Transportation, Ontario, GWP 5347-08-00; WP 5347-08-01, (GEOCRES No. 41H-135), Submitted to URS Canada Inc. by Golder Associates Ltd., November 29, 2013 (Report Number: 09-1111-6014-4520).

The proposed culvert is located within the swamp crossing identified as Swamp 401 in the report referenced in Reference 2. Refer to this report for the design recommendations, construction and monitoring of the embankment across the swamp.

Relevant geotechnical data from the reference reports are included in Appendix A-2 of this report, including records of borehole logs and preliminary foundation drawings.

PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) are based on the information received by PML from Parsons on March 2, 2018 and the subsurface soil and groundwater conditions provided in the report (Reference 1).

2. PROJECT DESCRIPTION

2.1. General

The proposed Fisheries/Wildlife (SAR) Culvert CVM-2 is a new structure located near the intersection of the new alignment of Highway 69 and Highway 522. The proposed culvert will be located north of and approximately parallel a set of existing CNR tracks. The railway tracks will be removed for the construction of the Highway 69 Four-Laning.

2.2. Proposed Structure

A preliminary general arrangement (GA) drawing for the proposed culvert was not available at the time of preparing this report. Based on the Drawing No. 2 dated October, 2013, the culvert will have an opening size of 3.0 m in span, 2.4 m in height, and will be approximately 42.0 m long. The alignment of the proposed culvert will be on a skew of approximately 50 degrees to the proposed alignment of the S-EW ramp. The proposed culvert is located within a swamp identified as Swamp 401. The existing ground surface in the vicinity of the culvert alignment varies from approximately EL. 180.0 to 179.9 m and the ground profile is generally flat.

Based on the Drawing No. 2 in report reference 1, the invert and founding levels of the proposed culvert are summarized in Table Q-1 below.

Table Q-1 Culvert Founding Elevations at Station 12+587 S-EW Ramp (Site No. 44-627/C3)

FOUNDATION LOCATION	PROPOSED CULVERT INVERT ELEVATION	BOTTOM OF BOX CULVERT ELEVATION	SUBGRADE ELEVATION FOR GRANULAR BEDDING	FOUNDING STRATUM
West End (Inlet)	179.5 m	179.2 m	178.9 m	Very soft organic clay
East End (Outlet)	179.3 m	179.0 m	178.7 m	Very soft clayey organic silt

Note(s): 1. The bottom thickness of the precast concrete box culvert is assumed 0.25 m (minimum).

The height of embankment fill required above the culverts to the proposed grades of ramp at Station 12+587 is not expected to exceed 3.0 m, including the pavement structure, above the box culvert. The report Reference 2 indicates that the maximum height of embankment across Swamp 401will be 4.0 m, approximately EL. 184.0 m.

In the absence of structural details of the culvert, it is assumed that the culvert is expected to impose a maximum load of 105 kPa on the founding subsoil.

2.3. Structure Foundation Subsurface Conditions (Boreholes C401-6 to C401-8)

Refer to the subsurface information in Report Reference No. 1, which is summarized in the following paragraph:

In general, the stratigraphy encountered along the culvert is layered and generally consists of an upper deposit of peat, organic clay to clayey organic silt to clay of high plasticity with a cohesionless interlayer, a deposit of sand to sand and silt underlain by the main cohesive deposit of clayey silt to silt, silty clay to clay transitioning to clayey silt, and then silt at depth.

In summary, the local stratigraphy consists of 0.2 m thick fibrous peat followed by 1.6 m to 2.0 m of very soft organic clay to clayey organic silt, which is underlain by 1.9 m to 3.0 m thick very soft clay to clayey silt with an 0.4 to 0.6 m thick interlayer of very loose to loose sand and gravel, sand and silt, and sand. The clayey layer is underlain by 3.1 m to 5.3 m of very loose to loose cohesionless deposit consisting of silty sand to sand. This sandy deposit is underlain by some 10.7 m of cohesive very soft to stiff clayey silt to clay followed by 4.1 m of loose to compact silt to the augering termination depth of 25.0 m. Below this depth, all the boreholes were advanced by Dynamic Cone Penetration Test (DCPT) to 30.5 m, where refusals to DCPT were encountered.

The in-situ vane shear strength (C_u) of the thicker clayey soil reported above ranged from 37 kPa to 83 kPa, with an average value of 54 kPa.

Upon completion of augering, the groundwater levels measured in the boreholes ranged from ground level (EL. 180.0 m) to 0.7 m (EL. 179.3 m) below existing ground surface. Groundwater levels are subject to seasonal fluctuations and precipitation patterns. It is anticipated that the groundwater level in this area would be higher during wet periods of the year.

For the purpose of this preliminary FDR, the compression index (C_c) value of 0.61 and the void ratio (e_o) of 1.59 reported in the obtained in borehole S401-36 (report Reference 2) were used to estimate the magnitude of total settlement expected under the imposed load of 105 kPa and assuming that the local clayey deposit is normally consolidated.

3. EVALUATION OF FOUNDATION ALTERNATIVES

Based on the information available in the report Reference 1, it is assumed that a box culvert will be placed at about EL. 179.1± on the S-EW Ramp. A maximum embankment fill height of 4.0 m will be required for the proposed road grade in the area of culvert.

If the culvert is placed at the proposed subgrade level of ±EL. 178.8 m, there will be about 1.8 m to 2.2 m thick very soft to soft organic clay to organic clayey silt layer underneath the base of culvert. The primary consolidation and secondary compression of organic silt would result in total and differential settlements in the range of 360 to 435 mm. Consequently, due to excessive total settlements, the very soft soils are unsuitable as subgrade support medium for cast-in-place or pre-cast concrete culverts and as specified in OPSS 422.07.06. Also, the magnitude of differential settlements expected from the variation in thickness of organic layer under the imposed load of 105 kPa would be some 270 to 325 mm, and these differential settlements would be significantly higher than the tolerable limit of 25 mm for a cast-in-place culvert or 100 mm generally assumed for a precast concrete box culvert.

Based on this preliminary analysis, it is recommended that settlement mitigation measures be implemented to install/construct this culvert. These measures should include the excavation of the very soft to soft soils and replacement with compacted backfill in accordance with OPSS 422.07.06 and should be coordinated with the mitigation measures for the embankment construction recommended in the report Reference 2. This report recommends partial excavation of up to 7.0 m of near surface organic silt and preloading incorporating wick drains as the preferred mitigation alternative for post construction settlement across Swamp 401.

The recommended foundation alternatives for this culvert are discussed below.

1. Precast concrete box culvert placed on granular replacement fill after preloading
2. Precast concrete box culvert placed on granular replacement fill without settlement mitigation
3. Corrugated Steel Plate (CSP) Arch or Circular Culvert

3.1. Option 1: Precast Concrete Box Culvert on Granular Replacement Fill after Preloading

To mitigate the post-construction total and differential settlements to a tolerable limit for a precast concrete culvert, the culvert should be installed after the highway embankment is constructed as recommended in the report Reference 2 and summarized in the above text of this report. If 4.0 m of preload consisting of Granular B Type II embankment fill is placed over the existing subgrade level grade, the estimated post-construction settlement may be reduced to about 100 mm within 9 to 12 months.

The precast concrete box culvert placed on compacted fill consisting of Granular B Type II may be designed assuming factored geotechnical resistances of 170 kPa at ULS and 110 kPa at SLS. The total maximum settlement induced under the SLS load of 110 kPa may be expected to be in the order of 100 mm and the associated differential settlement may be in the range of 50 mm, that are typically adequate for precast concrete culverts.

The construction of this precast concrete box culvert should be coordinated with the local embankment construction to allow the footprint of the culvert to be preloaded along with the embankment fill across Swamp 401. Temporary drainage with CSP pipes placed under the fill can be implemented, if required. The settlements of the embankment under the preloaded area of influence of the culvert could be monitored and the installation of culvert undertaken once the on-going settlements and differential settlements reach a tolerable limit for the precast concrete box culvert. At the appropriate time to be designed by the Project Co engineers, the fill material and temporary CSPs would be removed and the precast box culvert would be installed on replacement fill. If the unsuitable fill is not replaced at the time of the embankment construction, the depth of excavation should be 2.0 m below the culvert bedding subgrade (EL. 176.7). Otherwise, the replacement fill should be inspected at the base of bedding level and approved or further compacted if required.

Further recommendations for fill placement and culvert construction are provided in the General Report.

3.2. Option 2: Precast Concrete Box Culverts on Replacement Fill Without Settlement Mitigation

For Option 2, the 1.8 m to 2.2 m thick, very soft organic clay to clayey organic silt layer below the proposed founding level of the culvert would be excavated and replaced with granular fill to the proposed founding level, however mitigation of embankment settlement would not be carried out.

If the settlement mitigation measures are not implemented, the remaining 1.9 m to 3.0 m of clayey soil under an imposed load of 105 kPa is expected to undergo a total settlement ranging from 360 to 435 mm and the estimated differential settlement would be in the order of 270 to 325 mm.

Such relatively large total and differential settlements are not acceptable considering that the magnitudes are in excess of the tolerable settlement limits for a precast concrete box culvert, and can cause damage to the joints, leading to deterioration of the culvert. Therefore, factored geotechnical resistances at ULS and at SLS for 100 mm of differential settlement are not applicable since the option of placing the proposed culverts for both NBL and SBL on native soils at ±EL. 179.1 m without settlement mitigation measures is not considered to be feasible.

3.3. Option 3: Corrugated Steel Plate (CSP) Arch Culvert

Refer to the General Report for preliminary general recommendations for the use of Corrugated Steel Plate (CSP) arch culverts.

4. CULVERT BEDDING AND COVER MATERIALS

Refer to the General Report for preliminary recommendations for materials to be used for culvert bedding and cover purposes.

5. APPROACH EMBANKMENT

The details for design, construction, and settlement mitigation procedures for the embankment to be constructed over Swamp 401 are presented in the report Reference 2, Section 2.1. This report can be consulted for placement of fill for the swamp crossing and no other recommendations are provided in this report.

Refer to the General Report for erosion and scour protection that should be provided for the design and construction of the approach embankments to the culvert.

6. CONSTRUCTION CONSIDERATIONS

6.1. Excavation

Assuming that the preloading option is implemented, the 4.0 m high embankment fill in place at the culvert location would need to be removed to the appropriate depth designed by the Project Co. Since the staging of this excavation will depend on the contractor methodology, the geometry and stability of the temporary excavated slope should be assessed at the detail design stage.

Should the culvert area be preloaded and/or surcharged, the Contractor should consider the type of material to place in the culvert area to be able to excavate and dispose or re-use the temporary fill materials.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

Preliminary recommendations for culvert backfilling are included in the General Report.

6.2. Groundwater and Surface Water Control

Surface water flow should be directed away from the excavation areas to mitigate disturbance and weakening of the subgrade. Dewatering may be carried out from sumps along the interior periphery of the excavation to maintain the groundwater level a minimum of depth of 0.5 m below the base of excavations. For construction in-the-dry, the water will have to be temporarily diverted.

Furthermore, depending on the drainage channel flow at the time of the construction, the surface water flow could be passed through the construction area by means of a temporary pipe or diverted by pumping from the excavation.

The contractor should be responsible for the selection, performance and detailed design of the dewatering system including the cofferdam, if required. The dewatering system should be designed to conform to the requirement of OPSS 517 and SP517F01. For the NSSP FOUN0003, details shall be provided by the Design Build specialist at the detail design stage, as required.

MINISTRY OF TRANSPORTATION, ONTARIO

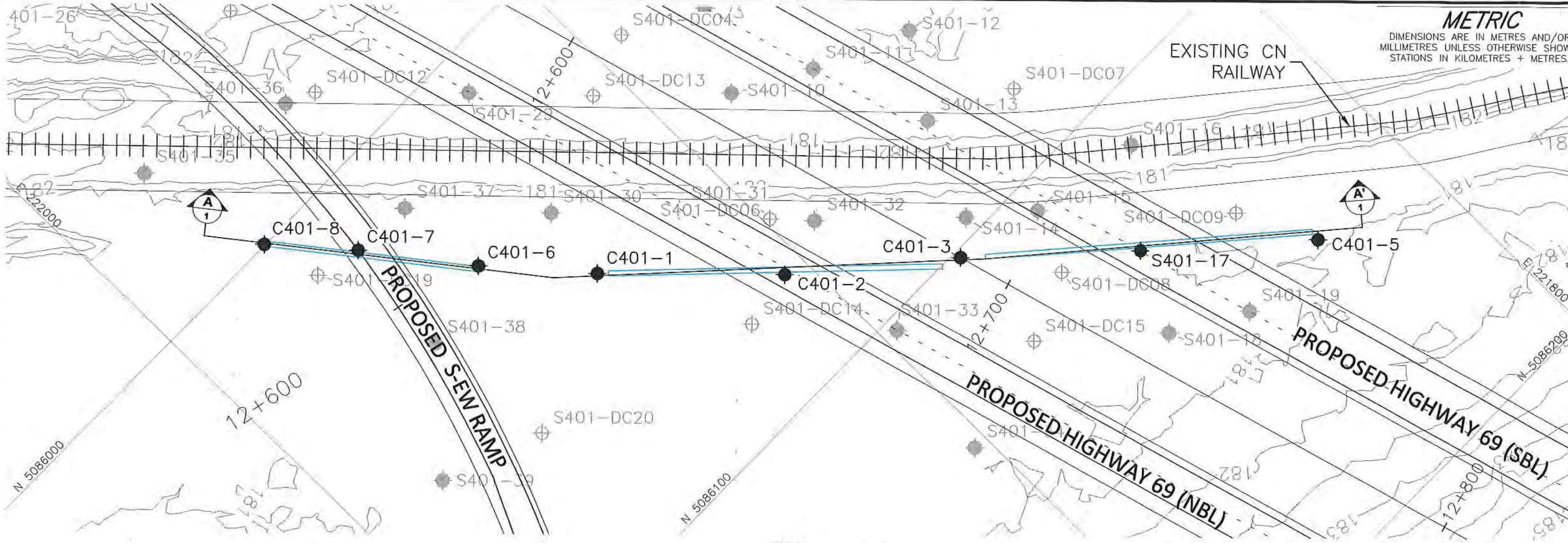
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

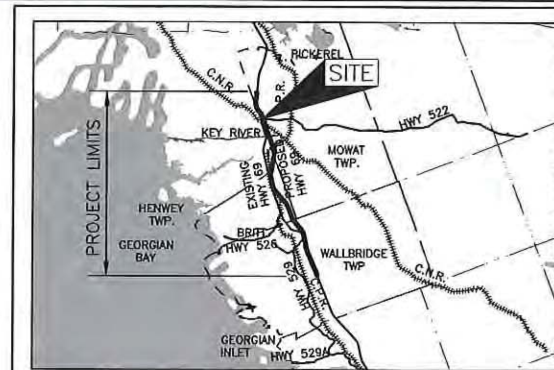
CONT No.
WP No. 5347-08-01

SHEET

HIGHWAY 69/522 INTERCHANGE
CULVERTS – CONTRACT 4
BORERHOLE LOCATIONS AND SOIL STRATA

Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA





KEY PLAN
SCALE
10 0 10 20 km

LEGEND

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

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
C401-1	180.0	5086051.7	221930.8
C401-2	180.1	5086078.8	221904.7
C401-3	179.9	5086101.5	221877.7
C401-5	180.3	5086150.3	221825.0
C401-6	179.9	5086033.6	221946.2
C401-7	180.0	5086014.1	221960.9
C401-8	180.0	5085999.8	221973.1
S401-17	180.1	5086126.4	221851.4

NOTES

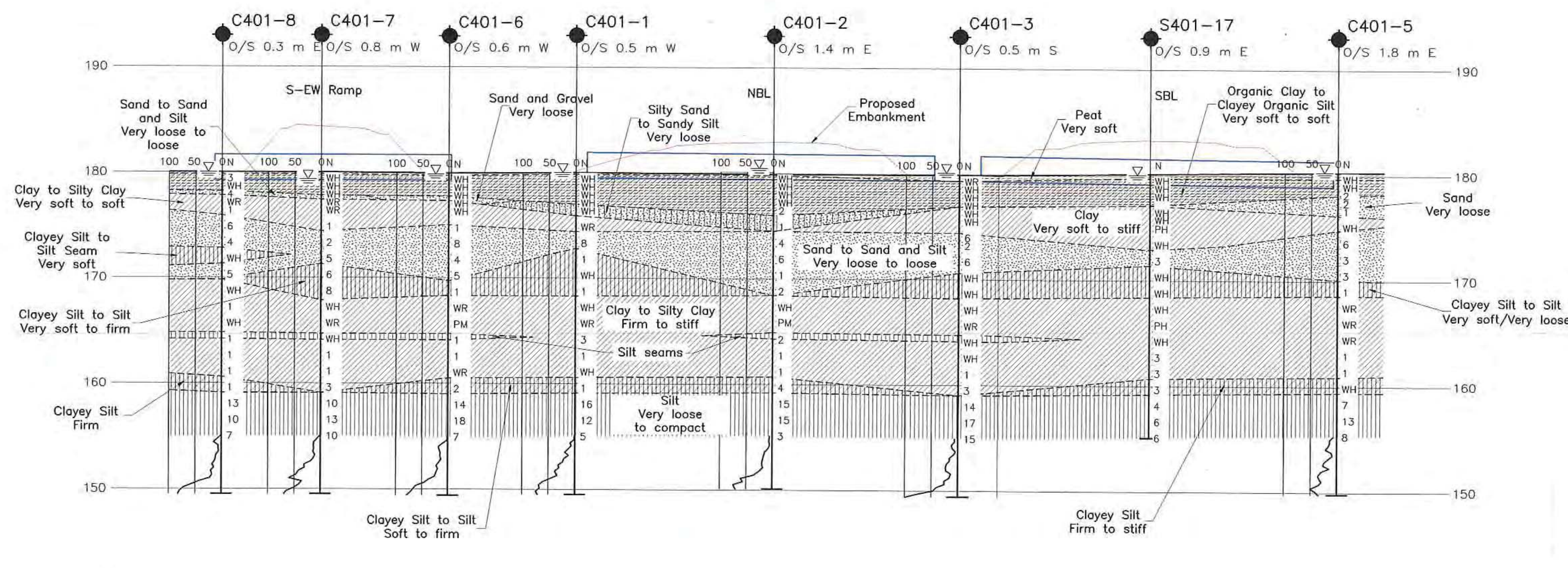
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

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

REFERENCE

Base plans provided in digital format by URS, drawing file Alignment received OCT 07, 2011, Hwy69_contours-C4-LIDAR-smoothed FEB 16, 2012. Keyplan received APR 16, 2010.



A–A′
1
PROFILE
HIGHWAY 69/522 INTERCHANGE
HORIZONTAL SCALE
10 0 10 20 m
5 0 5 10 m
VERTICAL SCALE

LICENSED PROFESSIONAL ENGINEER S.E.M. COYNE 90471921 OCT 9, 2013 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER J.M.A. COSTA OCT 9, 2013 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 41H-133			
HWY. 69		PROJECT NO. 09-1111-6014	DIST.
SUBM'D. AC	CHKD.	DATE: OCT 2013	SITE:
DRAWN: TB	CHKD. SEMC	APPD. JMAC	DWG. 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
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:
The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

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

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

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

III. SOIL DESCRIPTION

(a) Cohesionless Soils

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

(b) Cohesive Soils

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

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

Percent 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

Golder Associates

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

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
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

Notes: 1 $\tau = c' + \sigma' \tan\phi'$
2 shear strength = (compressive strength)/2

Golder Associates

RECORD OF BOREHOLE No C401-1

 METRIC

PROJECT 09-1111-6014			
W.P. 5347-08-01	LOCATION N 5086051.7; E 221930.8		ORIGINATED BY SA
DIST	HWY 69/522 I/C	BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring	COMPILED BY AC
DATUM GEODETIC	DATE August 16 and 21, 2012		CHECKED BY SEMC

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
180.0	GROUND SURFACE				
0.0	PEAT (Fibrous)				
0.2	Very soft Black Wet	1	SS	WH	
	Organic CLAY Very soft Dark grey to black Wet	2	SS	WH	
		3	SS	WH	
		4	SS	WH	
177.0 / 3.0	Silty SAND Very loose Grey Wet	5	SS	WH	
175.9 / 4.1	CLAY Soft Grey Wet	6	SS	WR	
174.4 / 5.6	SAND Loose Grey Wet	7	SS	8	
172.8 / 7.2	CLAYEY SILT, some sand Very soft Grey Wet	8	SS	1	0 16 68 16
		9	SS	WH	
		10	SS	1	
168.3 / 11.7	CLAY Firm to stiff Grey Wet	11	SS	WH	
		12	SS	WR	

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

Continued Next Page

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

SUD-MTO 001 09111116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No C401-1

 METRIC

PROJECT 09-1111-6014			
W.P. 5347-08-01	LOCATION N 5086051.7; E 221930.8		ORIGINATED BY SA
DIST	HWY 69/522 I/C	BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring	COMPILED BY AC
DATUM GEODETIC	DATE August 16 and 21, 2012		CHECKED BY SEMC

— CONTINUED FROM PREVIOUS PAGE —

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	CLAY Firm to stiff Grey Wet	13	SS	3	
	Faint reddish-grey layers at 16.8 m depth.	14	SS	1	
		15	SS	WH	
160.6 / 19.4	CLAYEY SILT Firm Grey Wet	16	SS	1	1 1 83 15
159.1 / 20.9	SILT, trace to some sand, trace clay Loose to compact Grey Wet	17	SS	16	
		18	SS	12	0 10 87 3
		19	SS	5	
155.0 / 25.0	END OF BOREHOLE START OF DCPT				

Continued Next Page

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

SUD-MTO 001 09111116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No C401-1

 METRIC

PROJECT 09-1111-6014			
W.P. 5347-08-01	LOCATION N 5086051.7; E 221930.8		ORIGINATED BY SA
DIST	HWY 69/522 I/C	BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring	COMPILED BY AC
DATUM GEODETIC	DATE August 16 and 21, 2012		CHECKED BY SEMC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	— CONTINUED FROM PREVIOUS PAGE —										
149.5 / 30.5	END OF DCPT										
	Note:										
	1. Water level at ground surface (Elev. 180.0 m) upon completion of drilling.										

Shear strength legend: ○ UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × REMOULDED. Water content: PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L.

SUD-MTO 001 09111116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

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

Golder Associates

RECORD OF BOREHOLE No C401-2

 METRIC

PROJECT 09-1111-6014			
W.P. 5347-08-01	LOCATION N 5086078.8; E 221904.7		ORIGINATED BY SA
DIST	HWY 69	BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring	COMPILED BY AC
DATUM GEODETIC	DATE August 14 and 15, 2012		CHECKED BY SEMC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
180.1	WATER LEVEL				
0.0	WATER				
0.3	PEAT (Fibrous)	1	SS	WH	
	Organic CLAY Very soft Dark grey to black Wet	2	SS	WH	
		3	SS	WH	
		4	SS	WH	
		5	SS	2	
176.0 / 4.1	Sandy SILT, some sand, some clay Very loose Grey Wet	6	SS	1	
174.5 / 5.6	SAND, trace to some silt to Silty SAND, trace to some clay Loose Grey Wet	7	SS	4	
		8	SS	6	0 93 6 1
		9	SS	1	
	An approximately 150 mm thick silt seam encountered at 9.4 m depth.				
	Two approximately 100 mm thick silty clay seams encountered in Sample 10.	10	SS	2	
168.4 / 11.7	CLAY to SILTY CLAY Firm to stiff Grey Wet	11	SS	WH	
	No recovery in Sample 12.	12	TO	PM	

Continued Next Page

Elevation scale: 180, 179, 178, 177, 176, 175, 174, 173, 172, 171, 170, 169, 168, 167, 166

Plot annotations: 144; 169; 148.4; 5

SUD-MTO 001 09111116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No C401-2

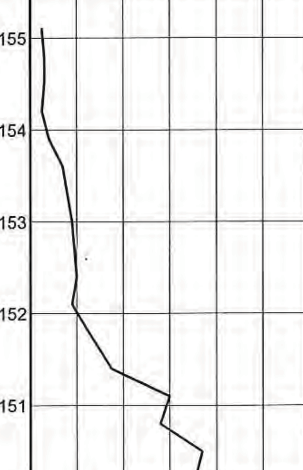
 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01
DIST ____ HWY 69
DATUM GEODETIC

LOCATION N 5086078.8; E 221904.7
BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring
DATE August 14 and 15, 2012

ORIGINATED BY SA
COMPILED BY AC
CHECKED BY SEMC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	— CONTINUED FROM PREVIOUS PAGE —				165		
	CLAY to SILTY CLAY Firm to stiff Grey Wet	13	SS	2			0 2 92 6
	Approximately 600 mm thick silt layer at 15.2 m depth.				164		
		14	SS	1	163	+ 4	
	Faint reddish-brown layer at 18.3 m depth.	15	SS	1	162		
					161	+ 4	
160.7 19.4	CLAYEY SILT Firm Grey Wet	16	SS	4	160		
159.2 20.9	SILT, trace to some sand, trace clay Very loose to compact Grey Wet	17	SS	15	159		
					158		
		18	SS	15	157		0 8 87 5
					156		
		19	SS	3			
155.1 25.0	END OF BOREHOLE START OF DCPT				155		
					154		
					153		
					152		
					151		
150.1							



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

SUD-MTO 001 09111116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

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RECORD OF BOREHOLE No C401-2

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01
DIST ____ HWY 69
DATUM GEODETIC

LOCATION N 5086078.8; E 221904.7
BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring
DATE August 14 and 15, 2012

ORIGINATED BY SA
COMPILED BY AC
CHECKED BY SEMC

ELEV / DEPTH	DESCRIPTION
	— CONTINUED FROM PREVIOUS PAGE —
30.0	END OF DCPT

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

SUD-MTO 001 09111116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No C401-3

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01 LOCATION N 5086101.5; E 221877.7 ORIGINATED BY GM
DIST HWY 69 BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring COMPILED BY AC
DATUM GEODETIC DATE August 13, 2012 CHECKED BY SEMC

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
179.9	GROUND SURFACE							
0.0	PEAT (Fibrous) Very soft Black Wet	1	SS	WR				
179.3 / 0.6	Clayey ORGANIC SILT Very soft Dark grey to black Wet	2	SS	WH	179			
		3	SS	WH	178	165, 158.7		OC=7.2%
		4	SS	WH				
176.9 / 3.0	CLAY Soft to stiff Grey Wet	5	SS	WH	177			
		6	SS	WH	176	113.7		
					175			
174.4 / 5.5	SAND, some silt, trace clay Very loose to loose Grey Wet	7	SS	6	174			
		8	SS	2	173			0 80 17 3
		9	SS	6	172			
					171			
170.6 / 9.3	SILT, trace to some clay, trace sand Very loose Grey Wet	10	SS	WH	170			
		11	SS	WH	169		NP	0 2 88 10
168.2 / 11.7	CLAY TO CLAYEY SILT Firm to stiff Grey Wet				168			
		12	SS	WH	167			
		13	SS	WR	166			
					165			

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100 (field vane values plotted with sensitivity 5, 6, 2)

PLASTIC LIMIT W_P – NATURAL MOISTURE CONTENT W – LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No C401-3

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01 LOCATION N 5086101.5; E 221877.7 ORIGINATED BY GM
DIST HWY 69 BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring COMPILED BY AC
DATUM GEODETIC DATE August 13, 2012 CHECKED BY SEMC

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---						
	CLAY TO CLAYEY SILT Firm to stiff Grey Wet	14	SS	WH	164		0 0 95 5
	Approximately 600 mm thick silt layer at 15.2 m depth.	15	SS	WH	163		
					162		
	Faint reddish-brown layer at 18.3 m depth.	16	SS	1	161		
		17	SS	3	160		
159.0 / 20.9	SILT, trace to some clay Compact Grey Wet				159		
		18	SS	14	158	NP	0 0 88 12
		19	SS	17	157		
					156		
		20	SS	15	155		
154.9 / 25.0	END OF BOREHOLE START OF DCPT				154		
					153		
					152		
					151		
					150		

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100 (field vane values plotted with sensitivity 4, 6)

PLASTIC LIMIT W_P – NATURAL MOISTURE CONTENT W – LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No C401-3

 METRIC

PROJECT 09-1111-6014

W.P. 5347-08-01 | LOCATION N 5086101.5; E 221877.7 | ORIGINATED BY GM

DIST ____ HWY 69 | BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring | COMPILED BY AC

DATUM GEODETIC | DATE August 13, 2012 | CHECKED BY SEMC

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
149.4 30.5	END OF DCPT Note: 1. Water level at 0.2 m above ground surface (Elev. 180.1 m) upon completion of drilling.										

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

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

Golder Associates

RECORD OF BOREHOLE No C401-5

 METRIC

PROJECT 09-1111-6014

W.P. 5347-08-01 | LOCATION N 5086150.3; E 221825.0 | ORIGINATED BY SA

DIST ____ HWY 69 | BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring | COMPILED BY AC

DATUM GEODETIC | DATE August 9 and 10, 2012 | CHECKED BY SEMC

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
180.3	GROUND SURFACE					
0.0	PEAT (Fibrous) Very soft Brown Wet	1	SS	WH	180	
179.7 0.6	Organic CLAY Very soft Dark grey to black Wet	2	SS	WH	179	
		3	SS	2		
178.1 2.2	SAND, some silt, trace to some clay, trace gravel Very loose Grey Wet	4	SS	2	178	1 74 19 6
		5	SS	1	177	
176.2 4.1	CLAY Very soft Grey Wet	6	SS	WH	176	
174.8 5.5	SAND and SILT, some clay Very loose to loose Grey Wet	7	SS	6	175, 174	0 55 32 13
		8	SS	3	173, 172	
		9	SS	3	171	
170.1 10.2	SILT, trace to some sand, trace to some clay Very loose Grey Wet	10	SS	1	170, 169	0 7 84 9
168.6 11.7	SILTY CLAY to CLAY Firm to stiff Grey Wet	11	SS	WR	168, 167	
		12	SS	WR	166	

Continued Next Page

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

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

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RECORD OF BOREHOLE No C401-5

 METRIC

PROJECT 09-1111-6014			
W.P. 5347-08-01	LOCATION N 5086150.3; E 221825.0		ORIGINATED BY SA
DIST	HWY 69	BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring	COMPILED BY AC
DATUM GEODETIC	DATE August 9 and 10, 2012		CHECKED BY SEMC

ELEV / DEPTH	SOIL PROFILE — DESCRIPTION	SAMPLES — NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---						
	SILTY CLAY to CLAY Firm to stiff Grey Wet	13	SS	WR	165		
					164		
		13 B	SS	1	163		
	Faint reddish-brown layers at 18.3 m depth.	14	SS	1	162		0 0 52 48
160.9 / 19.4	CLAYEY SILT Firm Grey Wet	15	SS	WH	161 / 160		
159.4 / 20.9	SILT, some sand, trace clay Loose to compact Grey Wet	16	SS	7	159	NP	
		17	SS	13	158 / 157		
		18	SS	8	156		1 15 79 5
155.3 / 25.0	END OF BOREHOLE START OF DCPT				155 / 154 / 153 / 152 / 151		

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

Continued Next Page

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

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

Foundation Design

RECORD OF BOREHOLE No C401-5

 METRIC

PROJECT 09-1111-6014			
W.P. 5347-08-01	LOCATION N 5086150.3; E 221825.0		ORIGINATED BY SA
DIST	HWY 69	BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring	COMPILED BY AC
DATUM GEODETIC	DATE August 9 and 10, 2012		CHECKED BY SEMC

ELEV / DEPTH	SOIL PROFILE — DESCRIPTION	ELEVATION SCALE
	--- CONTINUED FROM PREVIOUS PAGE ---	150
149.8 / 30.5	END OF DCPT Note: 1. Water level at ground surface (Elev. 180.3 m) upon completion of drilling.	

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

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No C401-6

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01 LOCATION N 5086033.6; E 221946.2 ORIGINATED BY SA
DIST HWY 69/522 I/C BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring COMPILED BY AC
DATUM GEODETIC DATE August 21 and 22, 2012 CHECKED BY SEMC

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
179.9	GROUND SURFACE				
0.0	PEAT (Fibrous)				
0.2	Organic CLAY, Very soft, Dark grey to black, Wet	1	SS	WH	
		2	SS	WH	
		3	SS	WH	
177.7	SAND and GRAVEL, Very loose, Grey, Wet	4	SS	WH	
177.3 / 2.6	CLAY, Very soft, Grey, Wet	5	SS	WH	
175.0 / 4.9	SAND, trace silt, trace gravel, Loose, Grey, Wet. Approximately 200 mm thick silt seams encountered at 4.9 m and 7.6 m depth.	6	SS	1	
		7	SS	8	1 97 (2)
		8	SS	4	
		9	SS	5	
169.7 / 10.2	CLAYEY SILT, trace to some sand, Very soft, Grey, Wet	10	SS	1	0 7 70 23
168.3 / 11.6	CLAY, Firm to stiff, Grey, Wet	11	SS	WR	
		12	TO	PM	

Ground water level symbol at ground surface. Water content values plotted off-scale: 128.3 (Sample 2), 157.4 (Sample 5). Field vane: 3 (at approx. El. 167).

Elevation scale: 179 to 165.

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

SUD-MTO 001 091116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No C401-6

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01 LOCATION N 5086033.6; E 221946.2 ORIGINATED BY SA
DIST HWY 69/522 I/C BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring COMPILED BY AC
DATUM GEODETIC DATE August 21 and 22, 2012 CHECKED BY SEMC

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	CLAY, Firm to stiff, Grey, Wet	13	SS	1	
	Approximately 600 mm thick silt layer at 15.2 m depth.				
	Faint reddish-brown layer at 16.8 m depth	14	SS	1	0 0 41 59
		15	SS	WR	
160.5 / 19.4	CLAYEY SILT to SILT, trace sand, trace to some clay, Soft, Grey, Wet	16	SS	2	0 1 83 16
159.0 / 20.9	SILT, some sand, trace clay, Loose to compact, Grey, Wet	17	SS	14	
	No recovery in Sample 18.	18	SS	18	
		19	SS	7	0 19 77 4
154.9 / 25.0	END OF BOREHOLE, START OF DCPT				

Field vane sensitivities plotted: 3, 6, 3.

Elevation scale: 164 to 150.

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

SUD-MTO 001 091116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

RECORD OF BOREHOLE No C401-6

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01
DIST ______ HWY 69/522 I/C
DATUM GEODETIC

LOCATION N 5086033.6; E 221946.2
BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring
DATE August 21 and 22, 2012

ORIGINATED BY SA
COMPILED BY AC
CHECKED BY SEMC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	— CONTINUED FROM PREVIOUS PAGE —										
149.4 30.5	END OF DCPT										
	Note: 1. Water level at a depth of 0.1 m below ground surface (Elev. 179.8 m) upon completion of drilling.										

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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No C401-7

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01
DIST ______ HWY 69/522 I/C
DATUM GEODETIC

LOCATION N 5086014.1; E 221960.9
BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring
DATE August 22 and 23, 2012

ORIGINATED BY SA
COMPILED BY AC
CHECKED BY SEMC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
180.0	GROUND SURFACE										
0.0	PEAT (Fibrous) Brown Wet		1	SS	WH	∇					
0.2	Clayey ORGANIC SILT Very soft Dark grey to black Wet		2	SS	WH		179		138 / 138		
			3	SS	WH		178				
177.8	SAND and SILT Very loose Grey Wet		4	SS	WR						
177.4 2.6	CLAY, trace to some sand Very soft Grey Wet		5	SS	WR		177		68		
							176				
			6	SS	1		175				
174.4 5.6	SAND, trace silt Very loose to loose Grey Wet						174				
			7	SS	2		173				
			8	SS	5		172				0 95 (5)
171.3 8.7	CLAYEY SILT Firm Grey Wet						171				
			9	SS	6		170				
	An approximately 150 mm thick sand seam at 10.9 m depth.		10	SS	8		169				
168.8 11.2	SILTY CLAY Firm to stiff Grey Wet						168				
			11	SS	WH		167	5			
	Faint reddish-brown layers at 13.7 m depth.		12	SS	WR		166	5			

Continued Next Page

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

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No C401-7

 METRIC

PROJECT	09-1111-6014		
W.P.	5347-08-01	LOCATION	N 5086014.1; E 221960.9
DIST	HWY 69/522 I/C	BOREHOLE TYPE	Portable Equipment, NW Casing and Wash Boring
DATUM	GEODETIC	DATE	August 22 and 23, 2012
ORIGINATED BY	SA	COMPILED BY	AC
CHECKED BY	SEMC		

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa / DCPT	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---								
	SILTY CLAY Firm to stiff Grey Wet	13	SS	WH					
	Approximately 600 mm thick silt layer at 15.2 m depth.				164				
	Faint reddish-brown layers between 16.8 m and 18.9 m depth.	14	SS	1	163				
					162	+ 4			
		15	SS	1					
					161	+ 3			
		16	SS	3	160				
159.1 20.9	SILT, trace to some clay Compact Grey Wet				159				
		17	SS	10	158		○		0 0 92 8
		18	SS	13	157				
					156				
		19	SS	10					
155.0 25.0	END OF BOREHOLE START OF DCPT				155				
					154				
					153				
					152				
					151				

Continued Next Page

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

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No C401-7

 METRIC

PROJECT	09-1111-6014		
W.P.	5347-08-01	LOCATION	N 5086014.1; E 221960.9
DIST	HWY 69/522 I/C	BOREHOLE TYPE	Portable Equipment, NW Casing and Wash Boring
DATUM	GEODETIC	DATE	August 22 and 23, 2012
ORIGINATED BY	SA	COMPILED BY	AC
CHECKED BY	SEMC		

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)
	--- CONTINUED FROM PREVIOUS PAGE ---
149.5 30.5	END OF DCPT Note: 1. Water level at a depth of 0.7 m below ground surface (Elev. 179.3 m) upon completion of drilling.

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

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

Foundation Design

RECORD OF BOREHOLE No C401-8

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01
DIST ______ HWY 69/522 I/C
DATUM GEODETIC
LOCATION N 5085999.8; E 221973.1
BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring
DATE August 23 and 24, 2012
ORIGINATED BY SA
COMPILED BY AC
CHECKED BY SEMC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
180.0	GROUND SURFACE				
0.0	PEAT (Fibrous)				
0.2	Clayey ORGANIC SILT, Very soft, Dark grey to black, Wet	1	SS	3	OC=5.2%
		2	SS	WH	
178.2	SAND, Loose, Grey, Wet	3	SS	4	
177.8 / 2.2	SILTY CLAY, Very soft, Grey, Wet	4	SS	WR	
		5	SS	1	
175.9 / 4.1	Silty SAND, some clay to SAND, trace gravel, Loose, Grey, Wet	6	SS	6	3 59 23 15
		7	SS	4	
172.8 / 7.2	CLAYEY SILT to SILT, some sand, trace gravel, Very soft, Grey, Wet	8	SS	WH	1 20 62 17
171.3 / 8.7	SAND, Loose, Brown, Wet	9	SS	5	
169.8 / 10.2	SILTY CLAY, Firm to stiff, Grey, Wet	10	SS	WH	
		11	SS	1	
		12	SS	WH	

Continued Next Page

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

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

SUD-MTO 001 09111116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

Foundation Design

RECORD OF BOREHOLE No C401-8

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01
DIST ______ HWY 69/522 I/C
DATUM GEODETIC
LOCATION N 5085999.8; E 221973.1
BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring
DATE August 23 and 24, 2012
ORIGINATED BY SA
COMPILED BY AC
CHECKED BY SEMC

— CONTINUED FROM PREVIOUS PAGE —

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILTY CLAY, Firm to stiff, Grey, Wet	13	SS	1	0 0 74 26
	Approximately 600 mm thick clayey silt seam at 15.2 m depth.				
	Faint reddish-brown layer at 16.8 m depth.	14	SS	1	
		15	SS	1	
160.6 / 19.4	CLAYEY SILT, Firm, Grey, Wet	16	SS	1	
159.1 / 20.9	SILT, trace to some clay, Loose to compact, Grey, Wet	17	SS	13	0 0 91 9
		18	SS	10	
		19	SS	7	
155.0 / 25.0	END OF BOREHOLE START OF DCPT				

Continued Next Page

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

SUD-MTO 001 09111116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Foundation Design

Golder Associates

RECORD OF BOREHOLE No C401-8

 METRIC

PROJECT 09-1111-6014			
W.P. 5347-08-01	LOCATION N 5085999.8; E 221973.1	ORIGINATED BY SA	
DIST	HWY 69/522 I/C	BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring	COMPILED BY AC
DATUM GEODETIC	DATE August 23 and 24, 2012	CHECKED BY SEMC	

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 | SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100 | PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 20 40 60 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES
	--- CONTINUED FROM PREVIOUS PAGE ---				
149.5 30.5	END OF DCPT Note: 1. Water level at ground surface (Elev. 180.0 m) upon completion of drilling.				

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

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

Foundation Design

Golder Associates

RECORD OF BOREHOLE No S401-17

 METRIC

PROJECT 09-1111-6014			
W.P. 5347-08-01	LOCATION N 5086126.4; E 221851.4	ORIGINATED BY ID	
DIST	HWY 69	BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW casing and Wash Boring	COMPILED BY AC
DATUM GEODETIC	DATE June 5, 2012	CHECKED BY SEMC	

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 | SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100 | PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 20 40 60 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS (GR SA SI CL)
180.1	GROUND SURFACE				
0.0	PEAT (Fibrous) Brown Wet	1	SS	WH	
179.7 0.4	Organic CLAY Soft Dark grey Wet	2	SS	WH	
		3	SS	WH	
177.1 3.0	CLAY Very soft to soft Grey Wet	4	SS	WH	
		5	SS	WH	
	Approximately 600 mm thick silt layer at 3.0 m depth	6	TO	PH	
	Approximately 150 mm thick sand seam at 6.1 m depth.	7	SS	WH	
172.9 7.2	SAND, trace to some silt Very loose Grey Wet	8	SS	3	0 90 8 2
171.4 8.7	CLAYEY SILT Very soft Grey Wet	9	SS	WH	
		10	SS	WH	
168.4 11.7	CLAY Firm to stiff Grey to brown Wet	11	SS	WH	
		12	TO	PH	

Elevation scale: 180, 179, 178, 177, 176, 175, 174, 173, 172, 171, 170, 169, 168, 167, 166

Water content annotations: 94.1 (at approx. 179); 81, 111.8 (at approx. 176)

Field vane sensitivity annotations: 4, 2, 3, 2, 3, 3

Continued Next Page

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No S401-17

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01
LOCATION N 5086126.4; E 221851.4
ORIGINATED BY ID
DIST HWY 69
BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW casing and Wash Boring
COMPILED BY AC
DATUM GEODETIC
DATE June 5, 2012
CHECKED BY SEMC

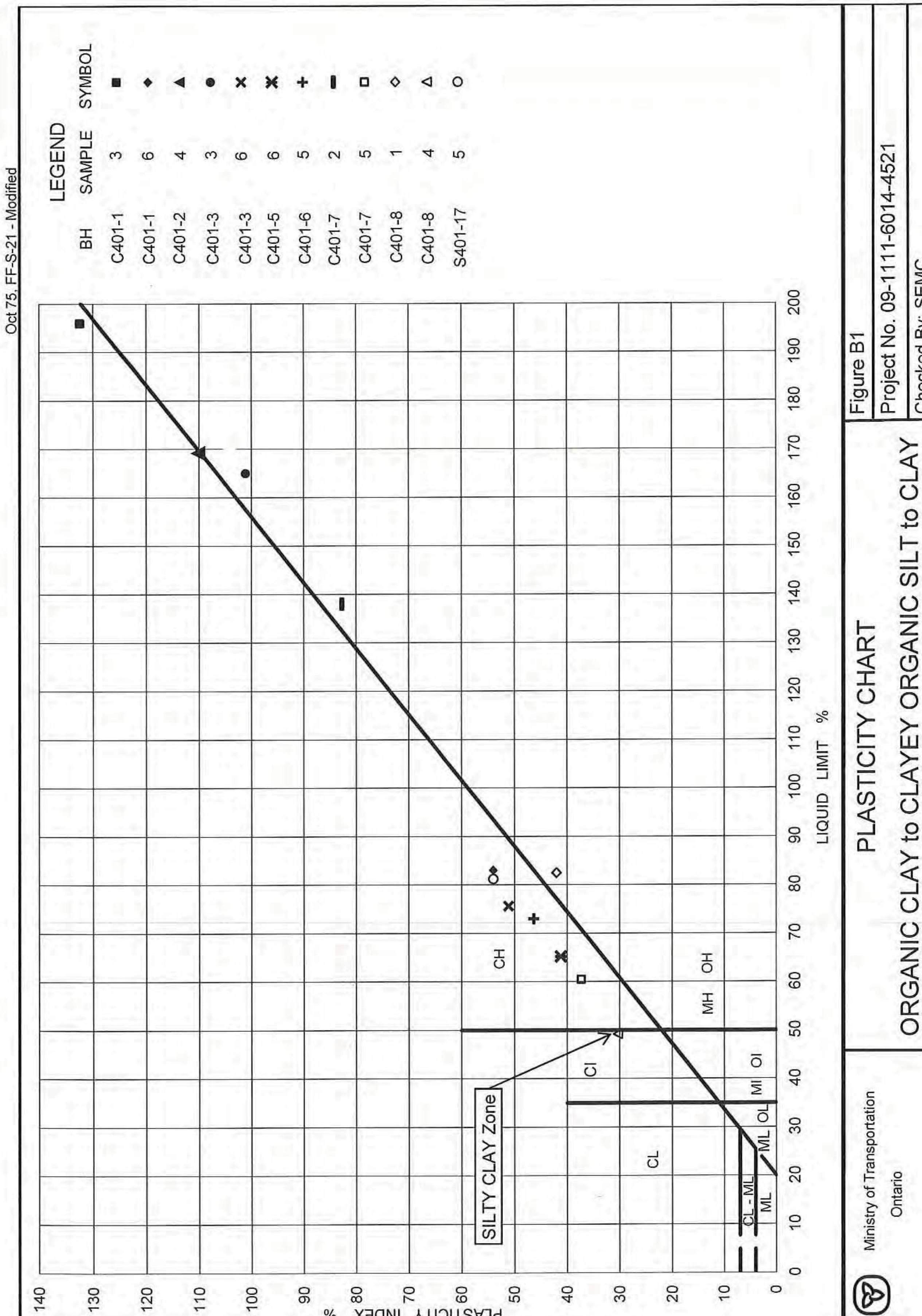
ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---				
	CLAY Firm to stiff Grey to brown Wet Faint reddish-brown layers below 15.2 m depth.	13	SS	WH	
		14	SS	3	
		15	SS	3	
160.7 / 19.4	CLAYEY SILT Stiff Grey Wet	16	SS	3	
159.2 / 20.9	SILT, some clay Very loose to loose Grey Wet	17	SS	4	0 0 87 13
		18	SS	6	
		19	SS	6	
155.1 / 25.0	END OF BOREHOLE Note: 1. Water level at a depth of 0.1 m below ground surface (Elev. 180.0 m) upon completion of				

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (165–156); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL.

Field vane readings (sensitivity): 3, 5, 4, 4

$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

SUD-MTO 001 09111116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:



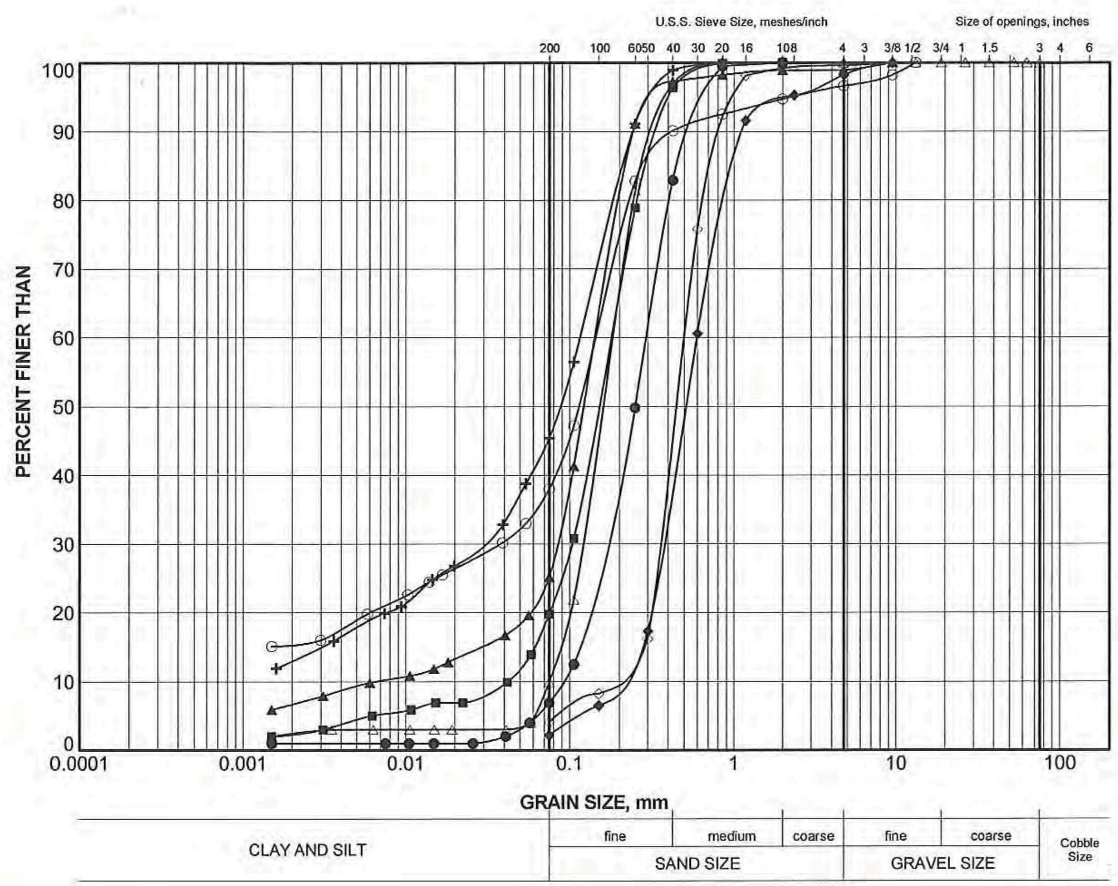
PLASTICITY CHART

ORGANIC CLAY to CLAYEY ORGANIC SILT to CLAY

Figure B1

Project No. 09-1111-6014-4521

Checked By: SEMC



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C401-2	8	172.2
■	C401-3	8	173.5
▲	C401-5	4	177.7
+	C401-5	7	173.9
◆	C401-6	7	173.5
◇	C401-7	8	172.1
○	C401-8	6	175.1
△	S401-17	8	172.2

PROJECT

HIGHWAY 69
CULVERTS - CONTRACT 4

TITLE

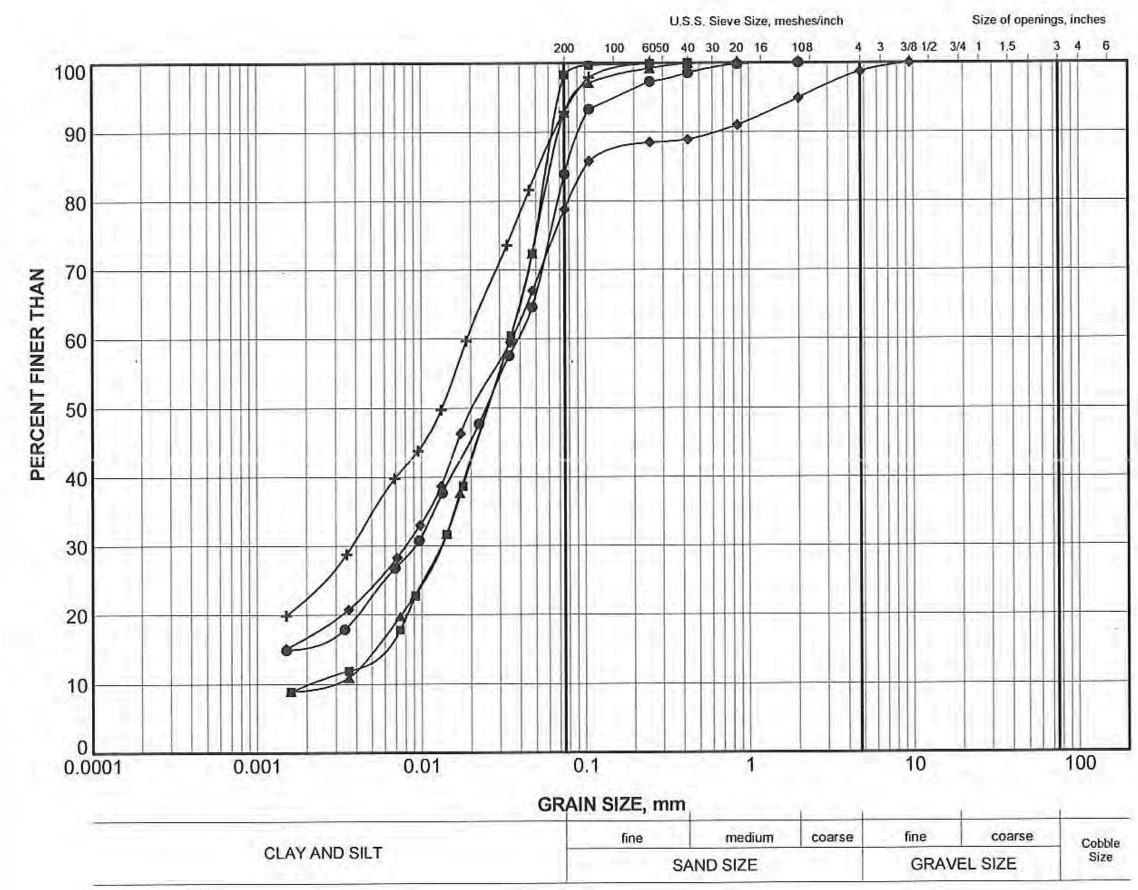
GRAIN SIZE DISTRIBUTION

SAND to SAND AND SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No. 09-1111-6014			FILE 0911116014_T4521_C.GPJ
DRAWN	TB	May 2013	SCALE N/A REV.
CHECK	SEMC	May 2013	FIGURE B2
APPR	JMAC	May 2013	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C401-1	8	172.1
■	C401-3	11	168.9
▲	C401-5	10	169.3
+	C401-6	10	168.9
◆	C401-8	8	172.1

PROJECT

HIGHWAY 69/522 I/C
CULVERTS - CONTRACT 4

TITLE

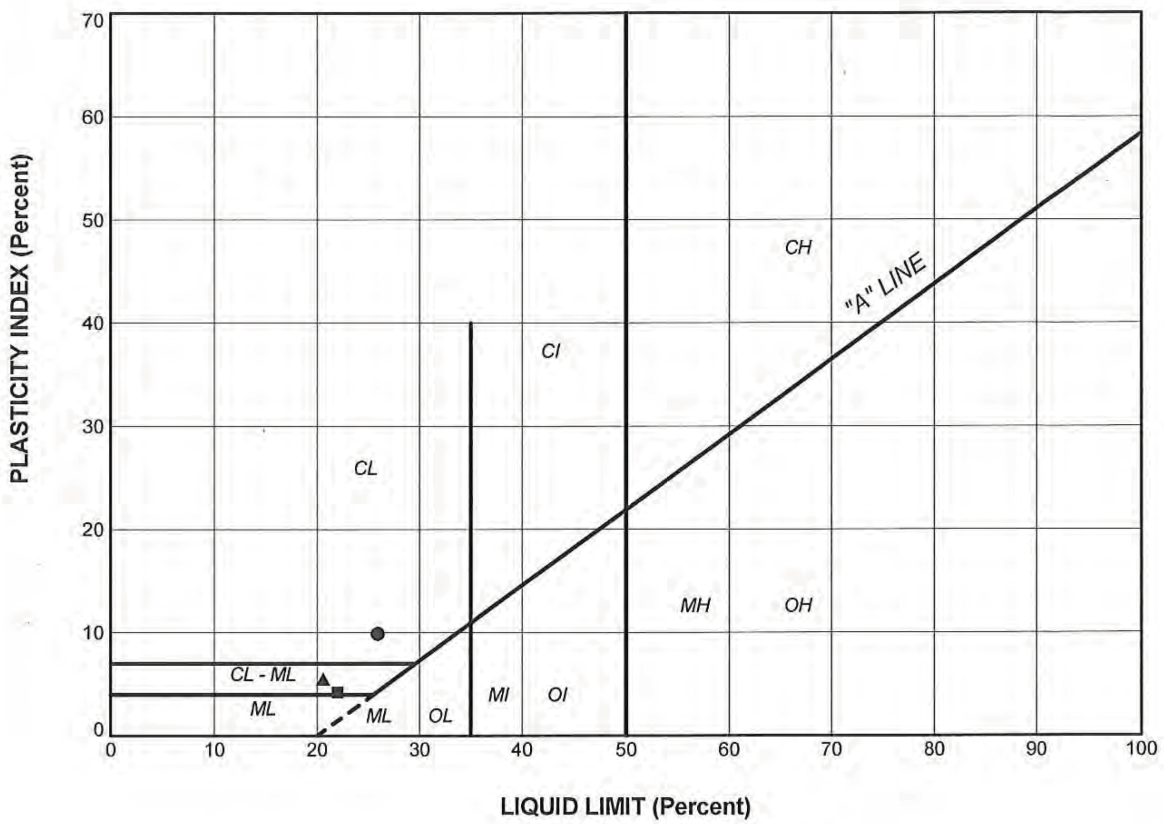
GRAIN SIZE DISTRIBUTION

CLAYEY SILT to SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No. 09-1111-6014			FILE 0911116014_T4521_C.GPJ
DRAWN	TB	May 2013	SCALE N/A REV.
CHECK	SEMC	May 2013	FIGURE B3
APPR	JMAC	May 2013	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C401-1	10	25.9	16.0	9.9
■	C401-2	9	22.0	17.8	4.2
▲	C401-8	8	20.6	15.1	5.5

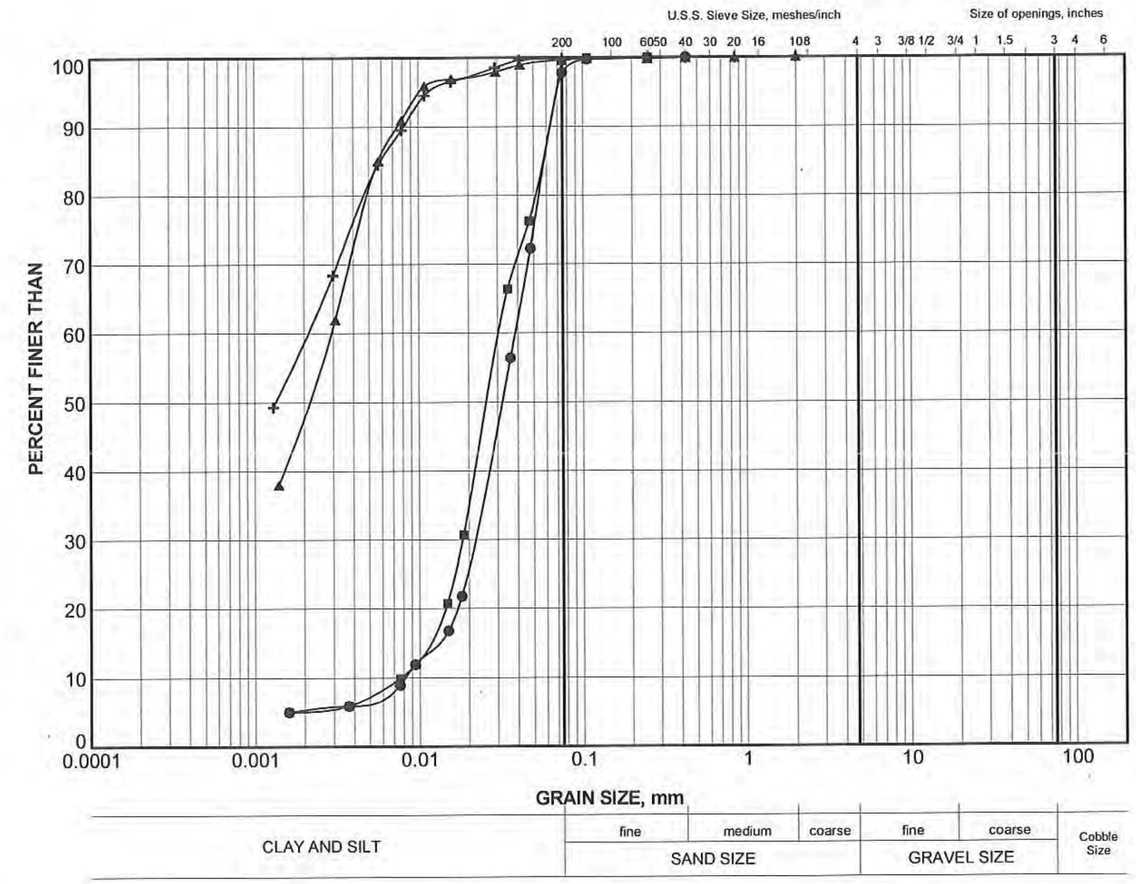
PROJECT
HIGHWAY 69/522 I/C
CULVERTS - CONTRACT 4

TITLE
PLASTICITY CHART
CLAYEY SILT to SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014	FILE No. 0911116014_T4521_C.GPJ	
DRAWN	TB	May 2013	SCALE N/A	REV.
CHECK	SEMC	May 2013	
APPR	JMAC	May 2013	FIGURE B4

SUD-MTO PL (NEW) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C401-2	13	164.6
■	C401-3	14	164.4
▲	C401-5	14	161.7
+	C401-6	14	162.8

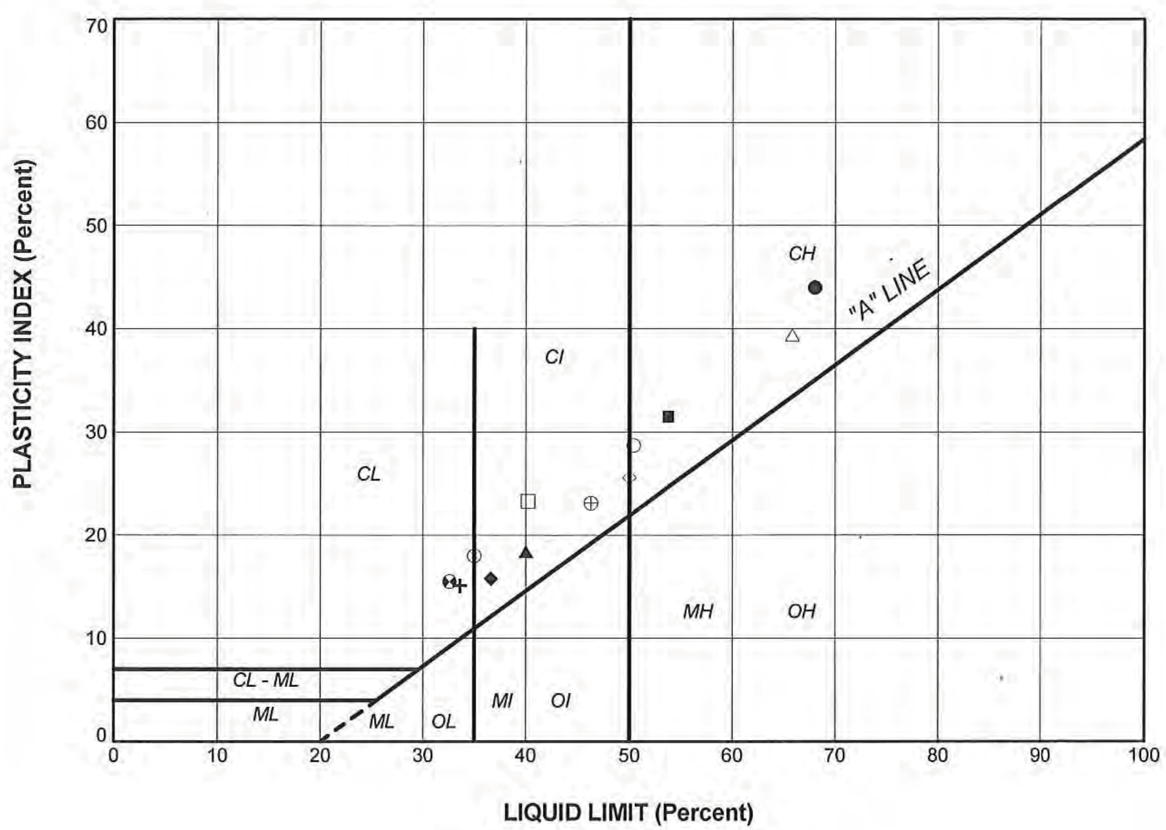
PROJECT
HIGHWAY 69/522 I/C
CULVERTS - CONTRACT 4

TITLE
GRAIN SIZE DISTRIBUTION
SILTY CLAY to CLAY

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014	FILE 0911116014_T4521_C.GPJ	
DRAWN	TB	May 2013	SCALE N/A	REV
CHECK	SEMC	May 2013	
APPR	JMAC	May 2013	FIGURE B5

SUD-MTO GSD (NEW) GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C401-1	12	68.0	24.0	44.0
■	C401-2	11	53.8	22.3	31.5
▲	C401-2	15	40.0	21.6	18.4
✚	C401-3	13	33.6	18.5	15.1
◆	C401-5	13	36.6	20.8	15.8
◇	C401-5	14	50.0	24.4	25.6
○	C401-6	11	50.4	21.7	28.7
△	C401-6	14	65.8	26.4	39.4
⊗	C401-7	11	35.0	17.0	18.0
⊕	C401-7	15	46.3	23.2	23.1
□	C401-8	10	40.2	16.9	23.3
⊖	C401-8	13	32.6	17.1	15.5

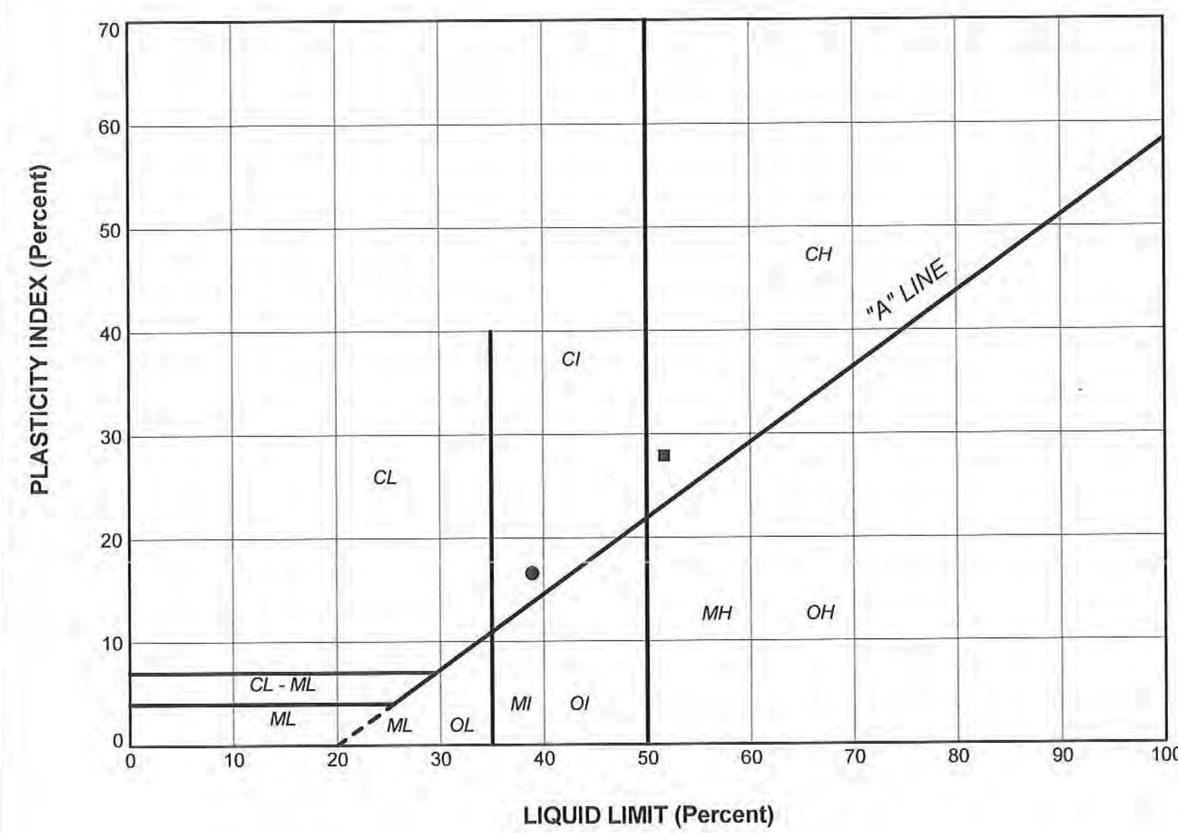
PROJECT
HIGHWAY 69/522 I/C
CULVERTS - CONTRACT 4

TITLE
PLASTICITY CHART
CLAYEY SILT to SILTY CLAY to CLAY

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014		FILE No.0911116014_T4521_C.GPJ	
DRAWN	TB	May 2013	SCALE N/A	REV.
CHECK	SEMC	May 2013	**FIGURE B6.1**	
APPR	JMAC	May 2013		

SUD-MTO PL (NEW) GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C401-8	15	38.9	22.3	16.6
■	S401-17	13	51.7	23.8	27.9

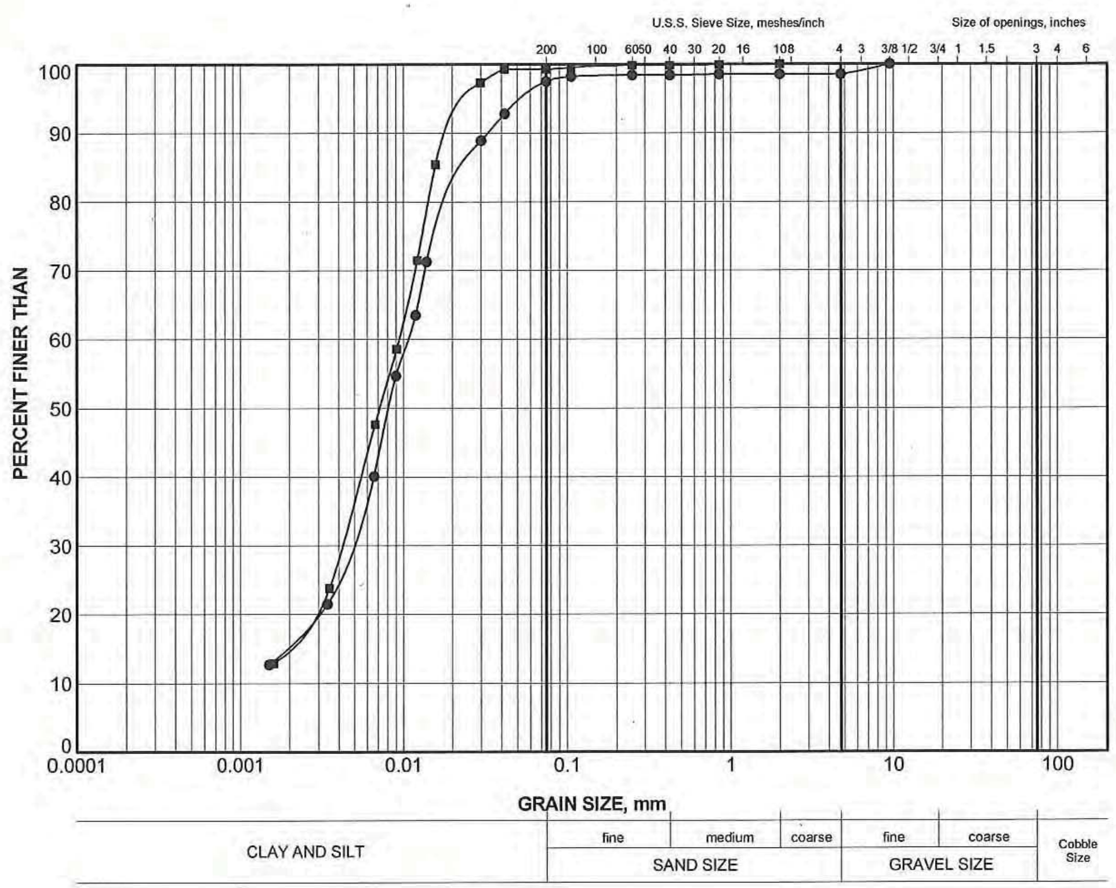
PROJECT
HIGHWAY 69
CULVERTS - CONTRACT 4

TITLE
PLASTICITY CHART
SILTY CLAY to CLAY

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014		FILE No.0911116014_T4521_C.GPJ	
DRAWN	TB	May 2013	SCALE N/A	REV
CHECK	SEMC	May 2013	**FIGURE B6.2**	
APPR	JMAC	May 2013		

SUD-MTO PL (NEW) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C401-1	16	159.9
■	C401-6	16	159.8

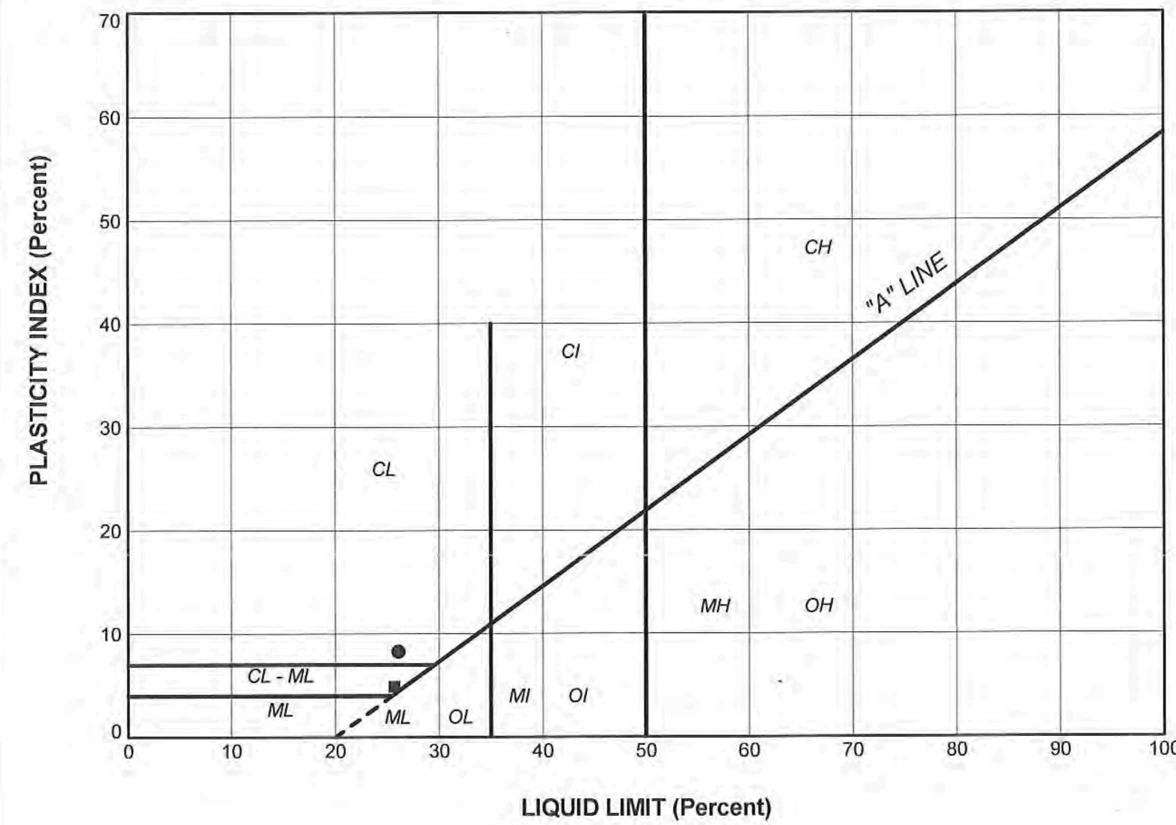
PROJECT
HIGHWAY 69/522 I/C
CULVERTS - CONTRACT 4

TITLE
GRAIN SIZE DISTRIBUTION
CLAYEY SILT to SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014	FILE 0911116014_T4521_C.GPJ	
DRAWN	TB	May 2013	SCALE N/A REV.
CHECK	SEMC	May 2013	FIGURE B7
APPR	JMAC	May 2013	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C401-1	16	26.1	17.8	8.3
■	C401-6	16	25.7	20.8	4.9

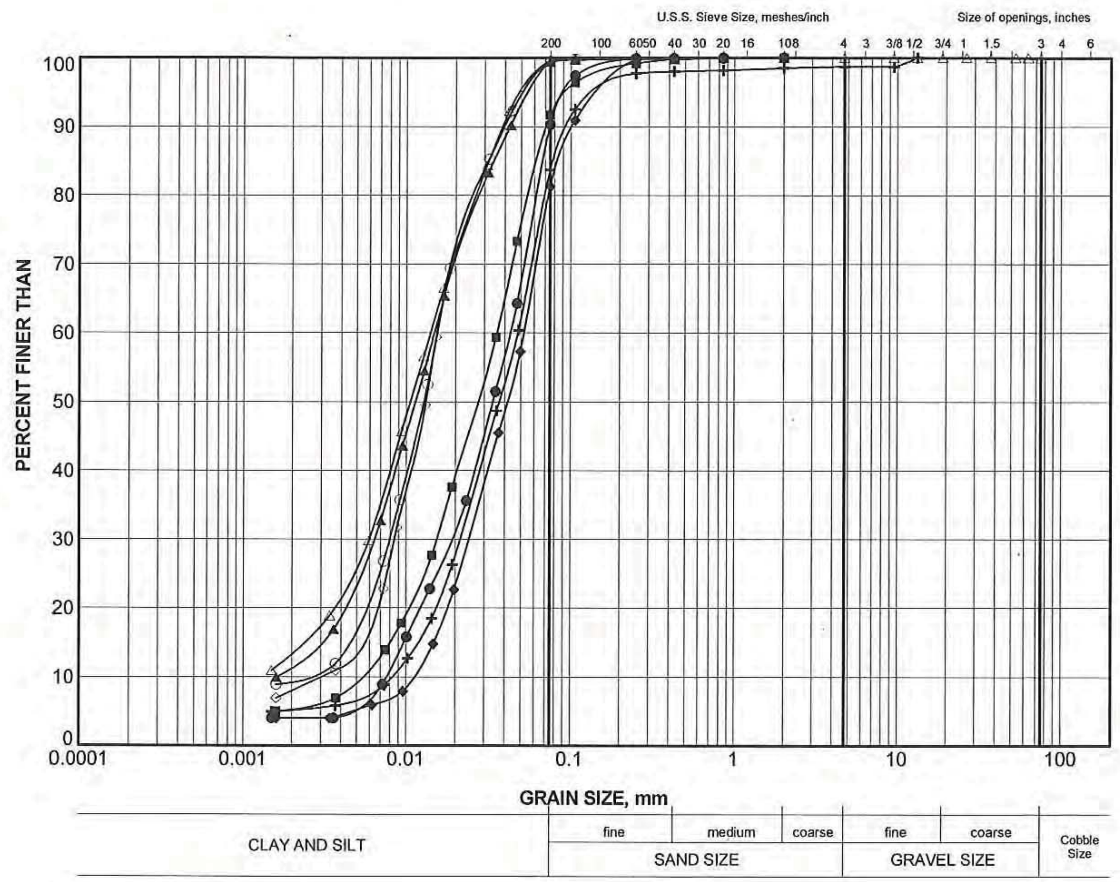
PROJECT
HIGHWAY 69/522 I/C
CULVERTS - CONTRACT 4

TITLE
PLASTICITY CHART
CLAYEY SILT TO SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014	FILE No.0911116014_T4521_C.GPJ	
DRAWN	TB	May 2013	SCALE N/A REV.
CHECK	SEMC	May 2013	FIGURE B8
APPR	JMAC	May 2013	

SUD-MTO PL (NEW) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C401-1	18	156.8
■	C401-2	18	156.9
▲	C401-3	18	158.3
+	C401-5	18	155.6
◆	C401-6	19	155.2
◇	C401-7	17	158.4
○	C401-8	17	158.4
△	S401-17	17	158.5

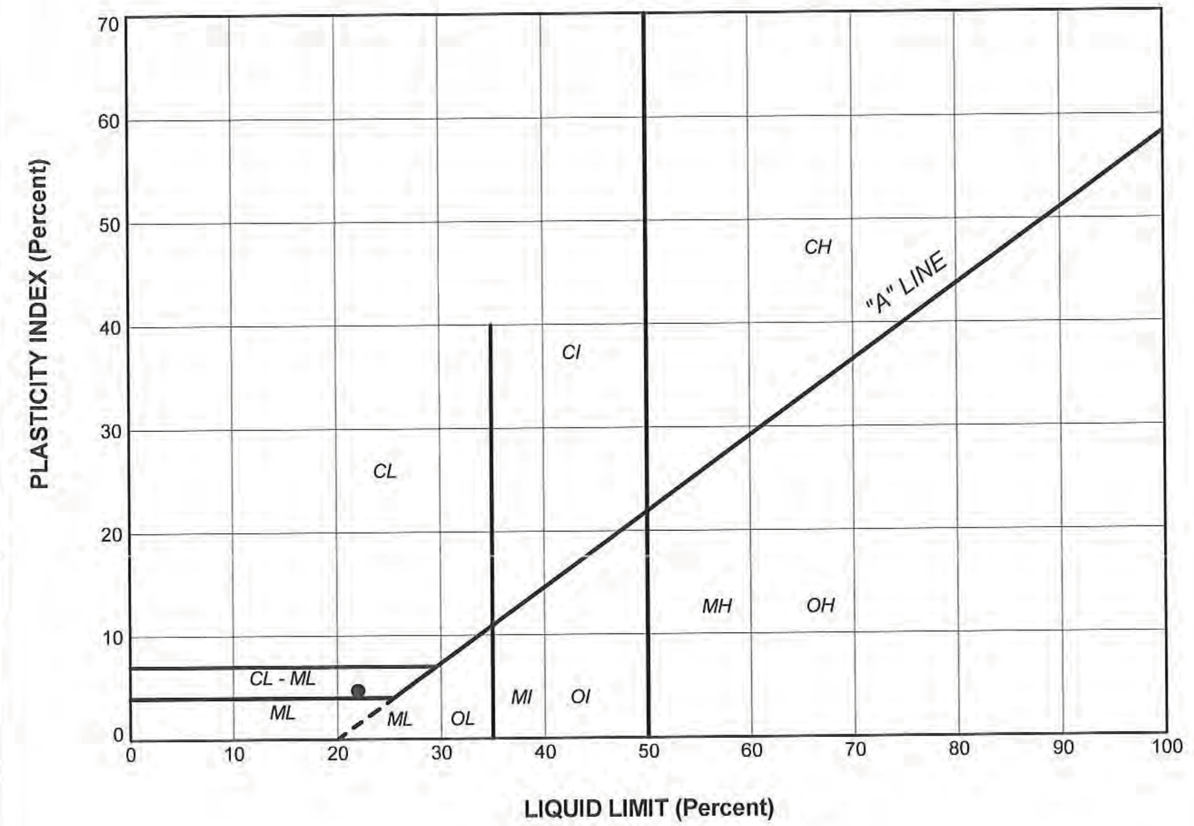
PROJECT
HIGHWAY 69
CULVERTS - CONTRACT 4

TITLE
GRAIN SIZE DISTRIBUTION
SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014	FILE 0911116014_T4521_C.GPJ	
DRAWN	TB	May 2013	SCALE N/A REV.
CHECK	SEMC	May 2013	FIGURE B9
APPR	JMAC	May 2013	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	S401-17	17	22.0	17.3	4.7

PROJECT
HIGHWAY 69
CULVERTS - CONTRACT 4

TITLE
PLASTICITY CHART
SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No	09-1111-6014	FILE No 0911116014_T4521_C.GPJ	
DRAWN	TB	May 2013	SCALE N/A REV
CHECK	SEMC	May 2013	FIGURE B10
APPR	JMAC	May 2013	

SUD-MTO PL (NEW) GLDR_LDN.GDT

SHEET R – CVM-3 – Fisheries/Wildlife Culvert (Station: ± 12+660 Hwy 69 NBL – Mowat)

- Borehole Locations and Soil Strata (Geocres 41H-133)
- Record of Borehole Logs (Geocres 41H-133)
- Laboratory Test Results (Geocres 41H-133)

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field work for Culvert CVM-3 located at Station 12+660 Mowat Township on the Northbound Lanes (NBL) of Highway 69 new alignment was carried out by Golder Associates (Golder) between August 9 and 24, 2012, and a Foundation Investigation Report (FIR), report Reference 1 below was submitted to MTO

Three (3) boreholes were advanced by Golder at the proposed culvert location. Refer to the FIR submitted by Golder for details of the borehole locations and subsurface conditions encountered at the culvert location.

The following documents are referenced:

1. Foundation Investigation Report (FIR) - Culverts: - Contract 4, Highway 69 Four-Laning from 1.7 km North of Highway 529 Northerly to 3.9 Km North of Highway 522, Ministry of Transportation, Ontario, GWP 5347-08-00; WP 5347-08-01, (GEOCRES No. 41H-133), Submitted to URS Canada Inc. by Golder Associates Ltd., October 9, 2013 (Report Number: 09-1111-6014-4521)
2. Foundation Investigation and Design Report (FIDR), Swamp Crossings and High Fill Areas - Contract 4, Highway 69 Four-Laning from 1.7 Km North of Highway 529 Northerly to 3.9 Km North of Highway 522, Ministry of Transportation, Ontario, GWP 5347-08-00; WP 5347-08-01,(GEOCRES No. 41H-135), Submitted to URS Canada Inc. by Golder Associates Ltd., November 29, 2013 (Report Number: 09-1111-6014-4520).

The proposed culvert is located within Swamp 401, as identified in report Reference 2. Refer to this report for the design recommendations, including construction and monitoring of the embankments across the swamp.

Relevant geotechnical details from the report Reference 1 are included in Appendix A-2 of this report, including records of borehole logs and preliminary foundation drawings

PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) are based on the information received by PML from Parsons on March 2, 2018 and the sub-surface soil and groundwater conditions provided in the report Reference 1.

2. PROJECT DESCRIPTION

2.1. General

The proposed Fisheries/Wildlife (SAR) Culvert CVM-3 is a new structure under the NBL of the new alignment of Highway 69. The proposed culvert will be located in Swamp 401, approximately 550 m east of the Highway 69 and some 160 m north of the existing Key River Bridge and north of the existing CNR tracks. The railway tracks will be removed during the Highway 69 four-laning.

2.2. Proposed Structure

Based on the Drawing No. 2 dated October, 2013, included in the report Reference 1, the culvert will have an opening size of 3.0 m in span, 2.4 m in height and will be approximately 65.0 m long. The alignment of the proposed culvert will be on a skew of approximately 55 degrees to the new alignment of Highway 69, as shown on Drawing No. 2. The existing ground surface in the vicinity of the culvert alignment varies from approximately EL. 180.1 to 179.9 m and the ground profile is generally flat.

The proposed culvert invert i and subgrade founding levels are summarized in Table R-1 below.

Table R-1: Founding Elevations of Box Culvert at Station 12+660 Highway 69 NBL (Site No. 44-627/1)

FOUNDATION LOCATION	PROPOSED CULVERT INVERT ELEVATION, m	BOTTOM OF BOX CULVERT ELEVATION, m	SUBGRADE ELEVATION FOR GRANULAR BEDDING, m	FOUNDING STRATUM
East End (Inlet)	179.5	179.2	178.9	Very soft organic clay
West End (Outlet)	179.4	179.1	178.8	Very soft clayey organic silt

Note(s): 1. The bottom thickness of the precast concrete box culvert is assumed 0.25 m.

The height of embankment fill required above the culvert to the proposed grade of the re-aligned highway is not expected to exceed 1.0 m, including the pavement structure. Although the report Reference 2 indicates that the maximum height of embankment across Swamp 401 will be 7.5 m, the total embankment height above existing ground surface near the culvert location is approximately 2.5 to 3.0 m.

In the absence of structural details of the culvert, it is assumed for the purpose of this report that the culvert will impose a load of 60 kPa on the founding subgrade.

2.3. Structure Foundation Subsurface Conditions (Boreholes C401-1, C41-2 and C401-3)

Refer to the subsurface information in report Reference 1, which was summarized in the following paragraph:

In general, the stratigraphy encountered along the culvert is layered and generally consists of an upper deposit of peat, organic clay to clayey organic silt to clay of high plasticity with a cohesionless interlayer, a deposit of sand to sand and silt underlain by the main cohesive deposit of clayey silt to silt, silty clay to clay transitioning to clayey silt, and then silt at depth.

In summary, the stratigraphy consists of 0.2 to 0.6 m thick fibrous peat followed by 2.4 m to 3.8 m of very soft organic clay to organic clayey silt. This is underlain by alternate layers of very loose silty sand, sand, silt and very soft clay to depths ranging from 7.2 to 11.7 m. These layers are followed by a 9.2 to 13.7 m thick, soft to stiff clay to clayey silt deposit, which is underlain by loose to compact silt to depths of 25.0 m where augering was terminated. Below this depth, the boreholes were continued by Dynamic Cone Penetration Test (DCPT) to depths ranging from 25.0 to 30.5 m, where further advancement refusals were encountered.

The in-situ vane shear strength (C_u) of clayey soil between EL. 176.0 and EL. 160.0 m reported in the borehole logs range from 27 kPa to 73 kPa, with an average value of 51 kPa.

Upon completion of augering, the groundwater levels measured in all three (3) Boreholes ranged from EL. 180.0 m to EL. 180.1 m. Groundwater levels are subject to seasonal fluctuations and precipitation patterns. It is anticipated that the groundwater level in this area would be higher during wet periods of the year.

For the purpose of this preliminary FDR, consolidation test data from Borehole S401-11 that was advanced in the vicinity of the proposed culvert for the investigation of Swamp 401 embankment construction (report Reference 2) was used to estimate the settlements under the proposed culvert. A reported compression index (C_c) value of 0.62 and void ratio (e_o) of 1.51 were used to estimate the magnitude of settlements under an imposed load of 60 kPa, assuming that the clayey deposit encountered at this site is normally consolidated.

3. EVALUATION OF FOUNDATION ALTERNATIVES

The evaluation of foundation alternatives was based on data provided in the report Reference 1. If the culvert was placed at the proposed subgrade level of ±EL. 178.8 m, the primary and secondary consolidation of 2.5 m to 3.5 m thick very soft organic clay to organic clayey silt layers remaining under the base of the culvert, would result in relatively large total settlements in the order of 90 to 250 mm and differential settlements in the order of 70 to 190 mm for the estimated load of 60 kPa.

The magnitude of the estimated total and differential settlements from the variation in thickness of organic layer would be higher than the tolerable limit of 25 mm and 100 mm generally assumed for cast-in-place and precast concrete box culverts, respectively.

Consequently, the very soft soils are considered unsuitable as subgrade support medium for cast-in-place or pre-cast concrete culverts due to excessive settlements. Accordingly, settlement mitigation measures should be implemented for the culvert foundation. The settlement mitigation measures for the culvert and the highway embankment construction in Swamp 401 recommended in report Reference 2 should be coordinated. The report recommends partial excavation of up to 7.0 m of the upper zone of organic and soft soils and a preloading program incorporating wick drains as the preferred mitigation alternative for mitigation of construction settlement of Swamp 401 embankments.

The recommended Foundation alternatives for this culvert are discussed below.

1. Precast concrete box culvert placed on granular replacement fill after preloading/surcharging
2. Precast concrete box culvert on replacement fill without settlement mitigation
3. Corrugated Steel Plate (CSP) Arch or Circular Culvert

3.1. Option 1: Precast Concrete Box Culvert on Granular Replacement Fill after Preloading

To mitigate the post-construction total and differential settlements to a tolerable limit, the culvert should be constructed after the highway embankment is constructed as recommend in the report Reference 2. A minimum preload of 1.5 m of Granular B Type II above the proposed embankment level at the culvert location should be placed for a period of 9 to 12 months to reduce the post construction settlement to about 60 mm to 100 mm.

The precast concrete box culvert installed on replacement fill consisting of Granular B Type II may be designed for factored geotechnical resistances of 150 kPa at ULS and 100 kPa at SLS. The total settlement induced under the estimated load of 60 kPa may be expected to be in the range of 60 to 100 mm and the associated differential settlement may be in the range of 25 mm to 40 mm.

The construction of the precast concrete box culvert should be coordinated with the construction of the embankment over swamp 401. To minimize potential slope instability during construction of the culvert, the footprint of the culvert should be preloaded along with the placement of embankment fill across Swamp 401. The settlement under the culvert preload should be monitored and the installation of the culvert may be started once the remaining settlements and differential settlements reach a tolerable limit for the precast concrete box culvert. Temporary CSP pipes may need to be placed under the embankment fill to allow for continued drainage, if required. At the appropriate time, the fill used for the preload material and the temporary CSPs would be removed to the proposed subgrade level and the precast box culvert would be installed.

Refer to the General Report for details of the replacement fill materials and construction.

3.2. Option 2: Precast Concrete Box Culvert on Replacement Fill Without Settlement Mitigation

Similar to Option 1, the 2.5 m to 3.5 m thick soft organic clay to organic clayey silt layer below the proposed founding level of the culvert would have to be excavated and replaced with granular backfill to the proposed founding level. If the settlement mitigation measures were not implemented, the remaining 1.5 to 2.5 m of clayey soil under an estimated load of 60 kPa would be expected to undergo a total settlement ranging from 90 to 250 mm and the associated differential settlement may be expected in the range of 70 mm to 190 mm.

Such relatively large total and differential settlements are not acceptable considering that the magnitudes are in excess of the tolerable settlement limits for a precast concrete box culvert and can cause damage to the joints, leading to deterioration of the culvert. Therefore, factored geotechnical resistances at ULS and at SLS for 100 mm of differential settlement are not applicable since the option of placing the proposed culverts for both

NBL and SBL on native soils at ±EL. 179.1 m without settlement mitigation measures is not considered to be feasible.

3.3. Option 3: Corrugated Steel Plate (CSP) Arch Culvert

Refer to the General Report for preliminary general recommendations for the use of Corrugated Steel Plate (CSP) arch culverts.

4. CULVERT BEDDING AND COVER MATERIALS

Refer to the General Report for preliminary recommendations for materials to be used for culvert bedding and cover purposes.

5. APPROACH EMBANKMENT

The details for design, construction, and mitigation procedures for the embankment through Swamp 401 are presented in report Reference 2. This report should be consulted for placement of fill for the swamp crossing and no recommendation is provided in this report.

6. CONSTRUCTION CONSIDERATIONS

6.1. Excavation

Assuming that the preloading and/or surcharging option is implemented, the approximately 3.0 m high embankment fill in place for the embankment preloading stage at the culvert location would need to be removed and the stability of the temporary excavated slope should be assessed at the detail design stage.

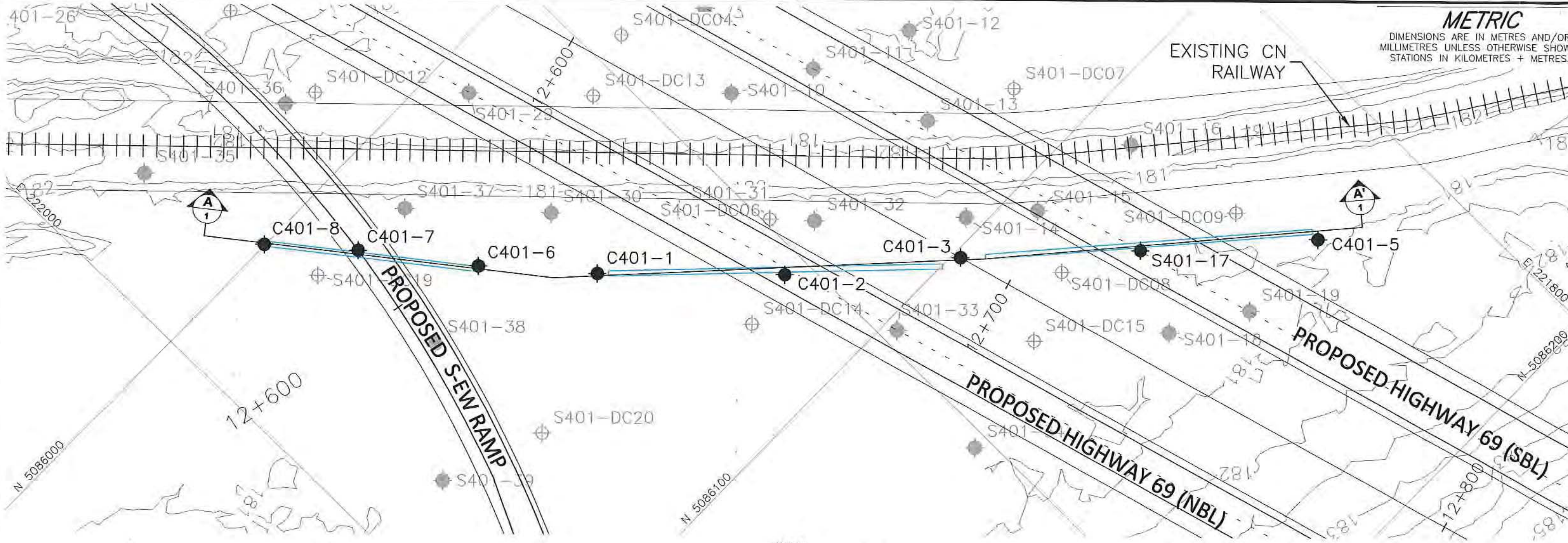
Should the culvert area be preloaded and/or surcharged, the Contractor should consider the type of material to place in the culvert area to be able to excavate and dispose or re-use the temporary fill materials.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

6.2. Groundwater and Surface Water Control

Refer to the General Report for further groundwater control recommendations and requirements for water taking.

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

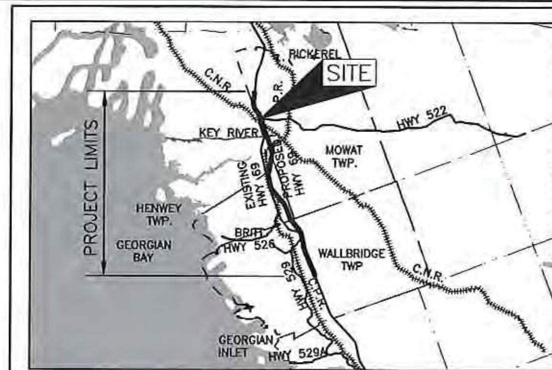


CONT No.
WP No. 5347-08-01

SHEET

HIGHWAY 69/522 INTERCHANGE
CULVERTS – CONTRACT 4
BOREHOLE LOCATIONS AND SOIL STRATA

Golder Associates
Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



KEY PLAN
SCALE
10 0 10 20 km

LEGEND

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

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
C401-1	180.0	5086051.7	221930.8
C401-2	180.1	5086078.8	221904.7
C401-3	179.9	5086101.5	221877.7
C401-5	180.3	5086150.3	221825.0
C401-6	179.9	5086033.6	221946.2
C401-7	180.0	5086014.1	221960.9
C401-8	180.0	5085999.8	221973.1
S401-17	180.1	5086126.4	221851.4

NOTES

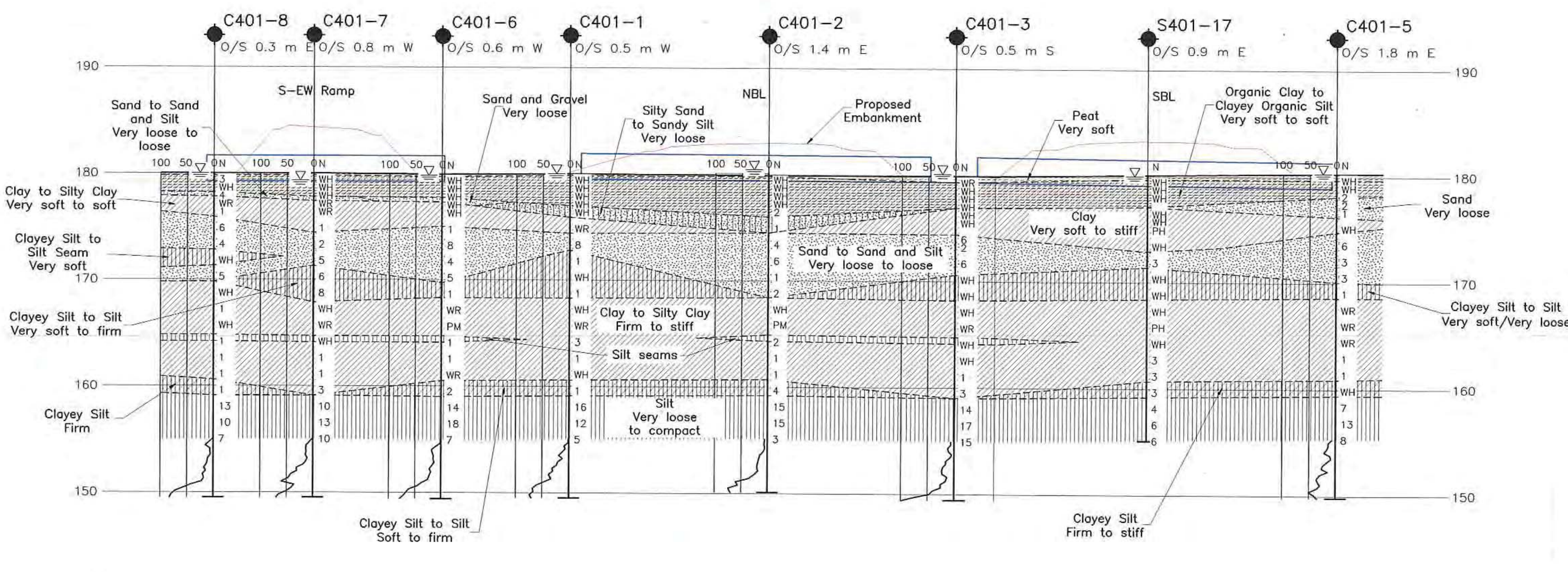
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

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

REFERENCE

Base plans provided in digital format by URS, drawing file Alignment received OCT 07, 2011, Hwy69_contours-C4-LIDAR-smoothed FEB 16, 2012. Keyplan received APR 16, 2010.



PROFILE
A–A' / 1
HIGHWAY 69/522 INTERCHANGE
HORIZONTAL SCALE
10 0 10 20 m
5 0 5 10 m
VERTICAL SCALE

LICENSED PROFESSIONAL ENGINEER S.E.M. COYNE 90471921 OCT 9, 2013 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER J.M.A.COSTA OCT 9, 2013 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 41H-133			
HWY. 69		PROJECT NO. 09-1111-6014	DIST.
SUBM'D. AC	CHKD.	DATE: OCT 2013	SITE:
DRAWN: TB	CHKD. SEMC	APPD. JMAC	DWG. 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
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:
The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

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

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

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

III. SOIL DESCRIPTION

(a) Cohesionless Soils

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

(b) Cohesive Soils

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

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

Percent 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

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

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
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

Notes: 1 $\tau = c' + \sigma' \tan\phi'$
2 shear strength = (compressive strength)/2

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RECORD OF BOREHOLE No C401-1

 METRIC

PROJECT 09-1111-6014			
W.P. 5347-08-01	LOCATION N 5086051.7; E 221930.8	ORIGINATED BY SA
DIST	HWY 69/522 I/C	BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring	COMPILED BY AC
DATUM GEODETIC		DATE August 16 and 21, 2012	CHECKED BY SEMC

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

ELEV / DEPTH	DESCRIPTION
180.0	GROUND SURFACE
0.0	PEAT (Fibrous) Very soft Black Wet
0.2	Organic CLAY Very soft Dark grey to black Wet
177.0 / 3.0	Silty SAND Very loose Grey Wet
175.9 / 4.1	CLAY Soft Grey Wet
174.4 / 5.6	SAND Loose Grey Wet
172.8 / 7.2	CLAYEY SILT, some sand Very soft Grey Wet
168.3 / 11.7	CLAY Firm to stiff Grey Wet

NUMBER	TYPE	"N" VALUES	Field vane / water content / remarks
1	SS	WH	W = 120.6
2	SS	WH	
3	SS	WH	W = 196; W_L = 163.5
4	SS	WH	
5	SS	WH	
6	SS	WR	W = 83; W_L = 102.5
7	SS	8	
8	SS	1	GR 0, SA 16, SI 68, CL 16
9	SS	WH	
10	SS	1	
11	SS	WH	
12	SS	WR	

Field vane sensitivity values plotted: 4 (at approx. 174.5), 6 (at approx. 169.9), 5 (at approx. 166.8).

Elevation scale: 179, 178, 177, 176, 175, 174, 173, 172, 171, 170, 169, 168, 167, 166

Continued Next Page

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

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

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RECORD OF BOREHOLE No C401-1

 METRIC

PROJECT 09-1111-6014			
W.P. 5347-08-01	LOCATION N 5086051.7; E 221930.8	ORIGINATED BY SA
DIST	HWY 69/522 I/C	BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring	COMPILED BY AC
DATUM GEODETIC		DATE August 16 and 21, 2012	CHECKED BY SEMC

— CONTINUED FROM PREVIOUS PAGE —

ELEV / DEPTH	DESCRIPTION
	CLAY Firm to stiff Grey Wet
	Faint reddish-grey layers at 16.8 m depth.
160.6 / 19.4	CLAYEY SILT Firm Grey Wet
159.1 / 20.9	SILT, trace to some sand, trace clay Loose to compact Grey Wet
155.0 / 25.0	END OF BOREHOLE START OF DCPT

NUMBER	TYPE	"N" VALUES	Remarks / grain size (GR SA SI CL)
13	SS	3	
14	SS	1	
15	SS	WH	
16	SS	1	1 1 83 15
17	SS	16	
18	SS	12	0 10 87 3
19	SS	5	

Field vane sensitivity values plotted: 3 (at approx. 162.3), 6 (at approx. 160.8).

Elevation scale: 164, 163, 162, 161, 160, 159, 158, 157, 156, 155, 154, 153, 152, 151

Continued Next Page

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

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

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Foundation Design

RECORD OF BOREHOLE No C401-1

 METRIC

PROJECT	09-1111-6014
W.P.	5347-08-01
DIST	
HWY	69/522 I/C
DATUM	GEODETIC
LOCATION	N 5086051.7; E 221930.8
BOREHOLE TYPE	Portable Equipment, NW Casing and Wash Boring
DATE	August 16 and 21, 2012
ORIGINATED BY	SA
COMPILED BY	AC
CHECKED BY	SEMC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	— CONTINUED FROM PREVIOUS PAGE —										
149.5 / 30.5	END OF DCPT										
	Note:										
	1. Water level at ground surface (Elev. 180.0 m) upon completion of drilling.										

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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No C401-2

 METRIC

PROJECT	09-1111-6014
W.P.	5347-08-01
DIST	
HWY	69
DATUM	GEODETIC
LOCATION	N 5086078.8; E 221904.7
BOREHOLE TYPE	Portable Equipment, NW Casing and Wash Boring
DATE	August 14 and 15, 2012
ORIGINATED BY	SA
COMPILED BY	AC
CHECKED BY	SEMC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT / PLOT NOTES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
180.1	WATER LEVEL				180		
0.0	WATER						
0.3	PEAT (Fibrous) / Organic CLAY, Very soft, Dark grey to black, Wet	1	SS	WH			
		2	SS	WH	179	144	
		3	SS	WH	178		
		4	SS	WH		169 / 148.4	
		5	SS	2	177		
176.0 / 4.1	Sandy SILT, some sand, some clay, Very loose, Grey, Wet				176		
		6	SS	1	175		
174.5 / 5.6	SAND, trace to some silt to Silty SAND, trace to some clay, Loose, Grey, Wet				174		
		7	SS	4	173		
		8	SS	6	172		0 93 6 1
		9	SS	1	171		
	An approximately 150 mm thick silt seam encountered at 9.4 m depth.				170		
	Two approximately 100 mm thick silty clay seams encountered in Sample 10.	10	SS	2	169		
168.4 / 11.7	CLAY to SILTY CLAY, Firm to stiff, Grey, Wet				168		
		11	SS	WH	167	5	
	No recovery in Sample 12.	12	TO	PM	166		

Continued Next Page

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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No C401-2

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01
LOCATION N 5086078.8; E 221904.7
ORIGINATED BY SA
DIST HWY 69
BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring
COMPILED BY AC
DATUM GEODETIC
DATE August 14 and 15, 2012
CHECKED BY SEMC

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100 | PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%)

— CONTINUED FROM PREVIOUS PAGE —

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
	CLAY to SILTY CLAY Firm to stiff Grey Wet	13	SS	2	165	0	2	92	6
	Approximately 600 mm thick silt layer at 15.2 m depth.				164				
		14	SS	1	163				
					162				
	Faint reddish-brown layer at 18.3 m depth.	15	SS	1	161				
160.7 19.4	CLAYEY SILT Firm Grey Wet	16	SS	4	160				
159.2 20.9	SILT, trace to some sand, trace clay Very loose to compact Grey Wet	17	SS	15	159, 158				
		18	SS	15	157	0	8	87	5
					156				
		19	SS	3					
155.1 25.0	END OF BOREHOLE START OF DCPT				155, 154, 153, 152, 151				
150.1									

Field vane values: 4 (at approx. 162.5), 4 (at approx. 161)

Continued Next Page

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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No C401-2

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01
LOCATION N 5086078.8; E 221904.7
ORIGINATED BY SA
DIST HWY 69
BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring
COMPILED BY AC
DATUM GEODETIC
DATE August 14 and 15, 2012
CHECKED BY SEMC

— CONTINUED FROM PREVIOUS PAGE —

ELEV DEPTH	DESCRIPTION
30.0	END OF DCPT

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

Golder Associates

RECORD OF BOREHOLE No C401-3

 METRIC

PROJECT 09-1111-6014			
W.P. 5347-08-01	LOCATION N 5086101.5; E 221877.7	ORIGINATED BY GM	
DIST	HWY 69	BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring	COMPILED BY AC
DATUM GEODETIC	DATE August 13, 2012	CHECKED BY SEMC	

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
179.9	GROUND SURFACE
0.0	PEAT (Fibrous) Very soft Black Wet
179.3 / 0.6	Clayey ORGANIC SILT Very soft Dark grey to black Wet
176.9 / 3.0	CLAY Soft to stiff Grey Wet
174.4 / 5.5	SAND, some silt, trace clay Very loose to loose Grey Wet
170.6 / 9.3	SILT, trace to some clay, trace sand Very loose Grey Wet
168.2 / 11.7	CLAY TO CLAYEY SILT Firm to stiff Grey Wet

SAMPLES

NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	WR		
2	SS	WH		
3	SS	WH		165 / 156.7 OC=7.2%
4	SS	WH		
5	SS	WH		
6	SS	WH		113.7
7	SS	6		
8	SS	2		0 80 17 3
9	SS	6		
10	SS	WH		
11	SS	WH	NP	0 2 88 10
12	SS	WH		
13	SS	WR		

Field vane sensitivity values plotted: 5 (approx. El. 175.2), 6 (approx. El. 166.8), 2 (approx. El. 165.4).

Elevation scale: 179, 178, 177, 176, 175, 174, 173, 172, 171, 170, 169, 168, 167, 166, 165

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

Continued Next Page

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

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

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RECORD OF BOREHOLE No C401-3

 METRIC

PROJECT 09-1111-6014			
W.P. 5347-08-01	LOCATION N 5086101.5; E 221877.7	ORIGINATED BY GM	
DIST	HWY 69	BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring	COMPILED BY AC
DATUM GEODETIC	DATE August 13, 2012	CHECKED BY SEMC	

SOIL PROFILE

— CONTINUED FROM PREVIOUS PAGE —

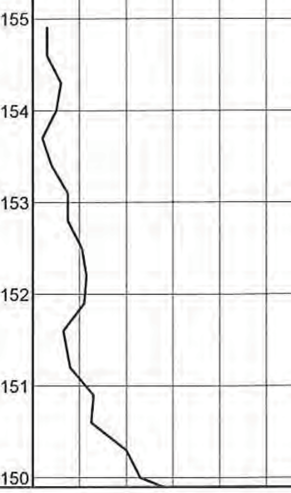
ELEV / DEPTH	DESCRIPTION
	CLAY TO CLAYEY SILT Firm to stiff Grey Wet. Approximately 600 mm thick silt layer at 15.2 m depth. Faint reddish-brown layer at 18.3 m depth.
159.0 / 20.9	SILT, trace to some clay Compact Grey Wet
154.9 / 25.0	END OF BOREHOLE START OF DCPT

SAMPLES

NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
14	SS	WH		0 0 95 5
15	SS	WH		
16	SS	1		
17	SS	3		
18	SS	14	NP	0 0 88 12
19	SS	17		
20	SS	15		

Field vane sensitivity values plotted: 4 (approx. El. 162.2), 6 (approx. El. 160.7).

Elevation scale: 164, 163, 162, 161, 160, 159, 158, 157, 156, 155, 154, 153, 152, 151, 150



Continued Next Page

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

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No C401-3

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01 LOCATION N 5086101.5; E 221877.7 ORIGINATED BY GM
DIST HWY 69 BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring COMPILED BY AC
DATUM GEODETIC DATE August 13, 2012 CHECKED BY SEMC

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	STRAT PLOT	SAMPLES – NUMBER	SAMPLES – TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L – WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
149.4 / 30.5	END OF DCPT Note: 1. Water level at 0.2 m above ground surface (Elev. 180.1 m) upon completion of drilling.										

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

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RECORD OF BOREHOLE No C401-5

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01 LOCATION N 5086150.3; E 221825.0 ORIGINATED BY SA
DIST HWY 69 BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring COMPILED BY AC
DATUM GEODETIC DATE August 9 and 10, 2012 CHECKED BY SEMC

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLES – NUMBER	SAMPLES – TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
180.3	GROUND SURFACE						
0.0	PEAT (Fibrous) Very soft Brown Wet	1	SS	WH	180		
179.7 / 0.6	Organic CLAY Very soft Dark grey to black Wet	2	SS	WH	179	86.5	
		3	SS	2			
178.1 / 2.2	SAND, some silt, trace to some clay, trace gravel Very loose Grey Wet	4	SS	2	178		1 74 19 6
		5	SS	1	177		
176.2 / 4.1	CLAY Very soft Grey Wet	6	SS	WH	176	92.5	
174.8 / 5.5	SAND and SILT, some clay Very loose to loose Grey Wet	7	SS	6	175, 174		0 55 32 13
		8	SS	3	173, 172		
		9	SS	3	171		
170.1 / 10.2	SILT, trace to some sand, trace to some clay Very loose Grey Wet	10	SS	1	170, 169		0 7 84 9
168.6 / 11.7	SILTY CLAY to CLAY Firm to stiff Grey Wet	11	SS	WR	168, 167		
		12	SS	WR	166		

Continued Next Page

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

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RECORD OF BOREHOLE No C401-5

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01 LOCATION N 5086150.3; E 221825.0 ORIGINATED BY SA
DIST ___ HWY 69 BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring COMPILED BY AC
DATUM GEODETIC DATE August 9 and 10, 2012 CHECKED BY SEMC

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
	--- CONTINUED FROM PREVIOUS PAGE ---											
	SILTY CLAY to CLAY Firm to stiff Grey Wet	13	SS	WR	165							
					164	5						
		13 B	SS	1	163							
	Faint reddish-brown layers at 18.3 m depth.	14	SS	1	162				0	0	52	48
					161	4						
160.9 19.4	CLAYEY SILT Firm Grey Wet	15	SS	WH	160							
159.4 20.9	SILT, some sand, trace clay Loose to compact Grey Wet	16	SS	7	159			NP				
					158							
		17	SS	13	157							
					156							
		18	SS	8					1	15	79	5
155.3 25.0	END OF BOREHOLE START OF DCPT				155							
					154							
					153							
					152							
					151							

Continued Next Page

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

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RECORD OF BOREHOLE No C401-5

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01 LOCATION N 5086150.3; E 221825.0 ORIGINATED BY SA
DIST ___ HWY 69 BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring COMPILED BY AC
DATUM GEODETIC DATE August 9 and 10, 2012 CHECKED BY SEMC

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
	--- CONTINUED FROM PREVIOUS PAGE ---											
149.8					150							
30.5	END OF DCPT Note: 1. Water level at ground surface (Elev. 180.3 m) upon completion of drilling.											

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

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RECORD OF BOREHOLE No C401-6

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01 LOCATION N 5086033.6; E 221946.2 ORIGINATED BY SA
DIST HWY 69/522 I/C BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring COMPILED BY AC
DATUM GEODETIC DATE August 21 and 22, 2012 CHECKED BY SEMC

ELEV DEPTH	SOIL PROFILE – DESCRIPTION
179.9	GROUND SURFACE
0.0	PEAT (Fibrous)
0.2	Organic CLAY Very soft Dark grey to black Wet
177.7	SAND and GRAVEL Very loose Grey Wet
177.3 2.6	CLAY Very soft Grey Wet
175.0 4.9	SAND, trace silt, trace gravel Loose Grey Wet Approximately 200 mm thick silt seams encountered at 4.9 m and 7.6 m depth.
169.7 10.2	CLAYEY SILT, trace to some sand Very soft Grey Wet
168.3 11.6	CLAY Firm to stiff Grey Wet

SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	WH	
2	SS	WH	
3	SS	WH	
4	SS	WH	
5	SS	WH	
6	SS	1	
7	SS	8	1 97 (2)
8	SS	4	
9	SS	5	
10	SS	1	0 7 70 23
11	SS	WR	
12	TO	PM	

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × REMOULDED
20 40 60 80 100

PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L
WATER CONTENT (%) 20 40 60

128.3
107.4

UNIT WEIGHT γ kN/m³

ELEVATION SCALE: 179, 178, 177, 176, 175, 174, 173, 172, 171, 170, 169, 168, 167, 166, 165

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

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RECORD OF BOREHOLE No C401-6

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01 LOCATION N 5086033.6; E 221946.2 ORIGINATED BY SA
DIST HWY 69/522 I/C BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring COMPILED BY AC
DATUM GEODETIC DATE August 21 and 22, 2012 CHECKED BY SEMC

ELEV DEPTH	SOIL PROFILE – DESCRIPTION
	--- CONTINUED FROM PREVIOUS PAGE ---
	CLAY Firm to stiff Grey Wet Approximately 600 mm thick silt layer at 15.2 m depth. Faint reddish-brown layer at 16.8 m depth
160.5 19.4	CLAYEY SILT to SILT, trace sand, trace to some clay Soft Grey Wet
159.0 20.9	SILT, some sand, trace clay Loose to compact Grey Wet No recovery in Sample 18.
154.9 25.0	END OF BOREHOLE START OF DCPT

SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
13	SS	1	
14	SS	1	0 0 41 59
15	SS	WR	
16	SS	2	0 1 83 16
17	SS	14	
18	SS	18	
19	SS	7	0 19 77 4

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × REMOULDED
20 40 60 80 100

PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L
WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

ELEVATION SCALE: 164, 163, 162, 161, 160, 159, 158, 157, 156, 155, 154, 153, 152, 151, 150

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

RECORD OF BOREHOLE No C401-6

 METRIC

PROJECT 09-1111-6014			
W.P. 5347-08-01	LOCATION N 5086033.6; E 221946.2	ORIGINATED BY SA	
DIST	HWY 69/522 I/C	BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring	COMPILED BY AC
DATUM GEODETIC	DATE August 21 and 22, 2012	CHECKED BY SEMC	

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	— CONTINUED FROM PREVIOUS PAGE —										
149.4 / 30.5	END OF DCPT Note: 1. Water level at a depth of 0.1 m below ground surface (Elev. 179.8 m) upon completion of drilling.										

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

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

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RECORD OF BOREHOLE No C401-7

 METRIC

PROJECT 09-1111-6014			
W.P. 5347-08-01	LOCATION N 5086014.1; E 221960.9	ORIGINATED BY SA	
DIST	HWY 69/522 I/C	BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring	COMPILED BY AC
DATUM GEODETIC	DATE August 22 and 23, 2012	CHECKED BY SEMC	

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
180.0	GROUND SURFACE				
0.0	PEAT (Fibrous)				
0.2	Brown Wet	1	SS	WH	
	Clayey ORGANIC SILT Very soft Dark grey to black Wet	2	SS	WH	
		3	SS	WH	
177.8	SAND and SILT Very loose				
177.4 / 2.6	Grey Wet	4	SS	WR	
	CLAY, trace to some sand Very soft Grey Wet	5	SS	WR	
		6	SS	1	
174.4 / 5.6	SAND, trace silt Very loose to loose Grey Wet	7	SS	2	
		8	SS	5	0 95 (5)
171.3 / 8.7	CLAYEY SILT Firm Grey Wet	9	SS	6	
	An approximately 150 mm thick sand seam at 10.9 m depth.	10	SS	8	
168.8 / 11.2	SILTY CLAY Firm to stiff Grey Wet	11	SS	WH	
	Faint reddish-brown layers at 13.7 m depth.	12	SS	WR	

Elevation scale: 179, 178, 177, 176, 175, 174, 173, 172, 171, 170, 169, 168, 167, 166

Continued Next Page

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

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

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RECORD OF BOREHOLE No C401-7

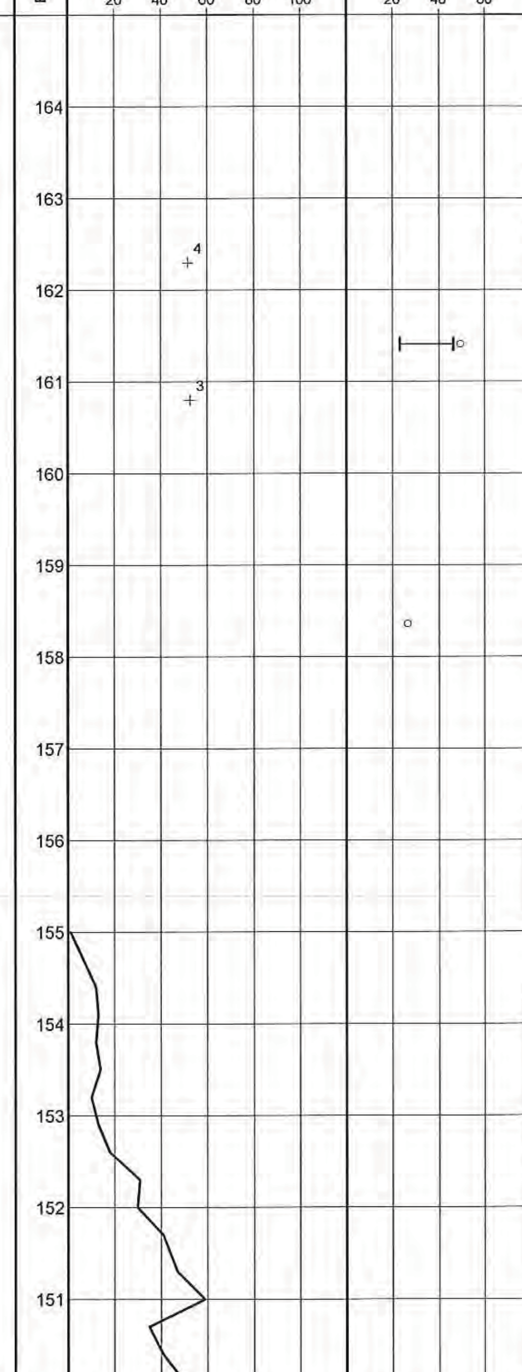
 METRIC

PROJECT 09-1111-6014			
W.P. 5347-08-01	LOCATION N 5086014.1; E 221960.9	ORIGINATED BY SA	
DIST	HWY 69/522 I/C	BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring	COMPILED BY AC
DATUM GEODETIC	DATE August 22 and 23, 2012	CHECKED BY SEMC	

SOIL PROFILE / SAMPLES / GROUND WATER CONDITIONS / ELEVATION SCALE / DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100) / PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L — WATER CONTENT (%) (20 40 60) / UNIT WEIGHT γ kN/m³ / REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILTY CLAY Firm to stiff Grey Wet Approximately 600 mm thick silt layer at 15.2 m depth. Faint reddish-brown layers between 16.8 m and 18.9 m depth.	13	SS	WH	
		14	SS	1	
		15	SS	1	
		16	SS	3	
159.1 20.9	SILT, trace to some clay Compact Grey Wet	17	SS	10	0 0 92 8
		18	SS	13	
		19	SS	10	
155.0 25.0	END OF BOREHOLE START OF DCPT				



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

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RECORD OF BOREHOLE No C401-7

 METRIC

PROJECT 09-1111-6014			
W.P. 5347-08-01	LOCATION N 5086014.1; E 221960.9	ORIGINATED BY SA	
DIST	HWY 69/522 I/C	BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring	COMPILED BY AC
DATUM GEODETIC	DATE August 22 and 23, 2012	CHECKED BY SEMC	

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION
149.5 30.5	END OF DCPT Note: 1. Water level at a depth of 0.7 m below ground surface (Elev. 179.3 m) upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No C401-8

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01
DIST ____ HWY 69/522 I/C
DATUM GEODETIC

LOCATION N 5085999.8; E 221973.1
BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring
DATE August 23 and 24, 2012

ORIGINATED BY SA
COMPILED BY AC
CHECKED BY SEMC

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
180.0	GROUND SURFACE
0.0	PEAT (Fibrous)
0.2	Clayey ORGANIC SILT Very soft Dark grey to black Wet
178.2	SAND Loose Grey Wet
177.8 / 2.2	SILTY CLAY Very soft Grey Wet
175.9 / 4.1	Silty SAND, some clay to SAND, trace gravel Loose Grey Wet
172.8 / 7.2	CLAYEY SILT to SILT, some sand, trace gravel Very soft Grey Wet
171.3 / 8.7	SAND Loose Brown Wet
169.8 / 10.2	SILTY CLAY Firm to stiff Grey Wet

SAMPLES

NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	3	OC=5.2%	
2	SS	WH		
3	SS	4		
4	SS	WR		
5	SS	1		
6	SS	6		3 59 23 15
7	SS	4		
8	SS	WH		1 20 62 17
9	SS	5		
10	SS	WH		
11	SS	1		
12	SS	WH		

GROUND WATER CONDITIONS ▽

ELEVATION SCALE: 179, 178, 177, 176, 175, 174, 173, 172, 171, 170, 169, 168, 167, 166

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED: 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%): 20 40 60

83

4

2

Continued Next Page

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

SUD-MTO 001 09111116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

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RECORD OF BOREHOLE No C401-8

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01
DIST ____ HWY 69/522 I/C
DATUM GEODETIC

LOCATION N 5085999.8; E 221973.1
BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring
DATE August 23 and 24, 2012

ORIGINATED BY SA
COMPILED BY AC
CHECKED BY SEMC

SOIL PROFILE

— CONTINUED FROM PREVIOUS PAGE —

ELEV / DEPTH	DESCRIPTION
	SILTY CLAY Firm to stiff Grey Wet Approximately 600 mm thick clayey silt seam at 15.2 m depth. Faint reddish-brown layer at 16.8 m depth.
160.6 / 19.4	CLAYEY SILT Firm Grey Wet
159.1 / 20.9	SILT, trace to some clay Loose to compact Grey Wet
155.0 / 25.0	END OF BOREHOLE START OF DCPT

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
13	SS	1	0 0 74 26
14	SS	1	
15	SS	1	
16	SS	1	
17	SS	13	0 0 91 9
18	SS	10	
19	SS	7	

ELEVATION SCALE: 164, 163, 162, 161, 160, 159, 158, 157, 156, 155, 154, 153, 152, 151

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED: 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%): 20 40 60

5

4

Continued Next Page

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

SUD-MTO 001 09111116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

Foundation Design

RECORD OF BOREHOLE No C401-8

 METRIC

PROJECT 09-1111-6014

W.P. 5347-08-01 LOCATION N 5085999.8; E 221973.1 ORIGINATED BY SA

DIST HWY 69/522 I/C BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring COMPILED BY AC

DATUM GEODETIC DATE August 23 and 24, 2012 CHECKED BY SEMC

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L – WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
149.5 30.5	END OF DCPT Note: 1. Water level at ground surface (Elev. 180.0 m) upon completion of drilling.										

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

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

Foundation Design

RECORD OF BOREHOLE No S401-17

 METRIC

PROJECT 09-1111-6014

W.P. 5347-08-01 LOCATION N 5086126.4; E 221851.4 ORIGINATED BY ID

DIST HWY 69 BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW casing and Wash Boring COMPILED BY AC

DATUM GEODETIC DATE June 5, 2012 CHECKED BY SEMC

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
180.1	GROUND SURFACE				
0.0	PEAT (Fibrous) Brown Wet	1	SS	WH	
179.7 0.4	Organic CLAY Soft Dark grey Wet	2	SS	WH	
		3	SS	WH	
177.1 3.0	CLAY Very soft to soft Grey Wet	4	SS	WH	
		5	SS	WH	
	Approximately 600 mm thick silt layer at 3.0 m depth	6	TO	PH	
	Approximately 150 mm thick sand seam at 6.1 m depth.	7	SS	WH	
172.9 7.2	SAND, trace to some silt Very loose Grey Wet	8	SS	3	0 90 8 2
171.4 8.7	CLAYEY SILT Very soft Grey Wet	9	SS	WH	
		10	SS	WH	
168.4 11.7	CLAY Firm to stiff Grey to brown Wet	11	SS	WH	
		12	TO	PH	

Elevation scale: 180, 179, 178, 177, 176, 175, 174, 173, 172, 171, 170, 169, 168, 167, 166

Continued Next Page

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

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

Foundation Design

RECORD OF BOREHOLE No S401-17

 METRIC

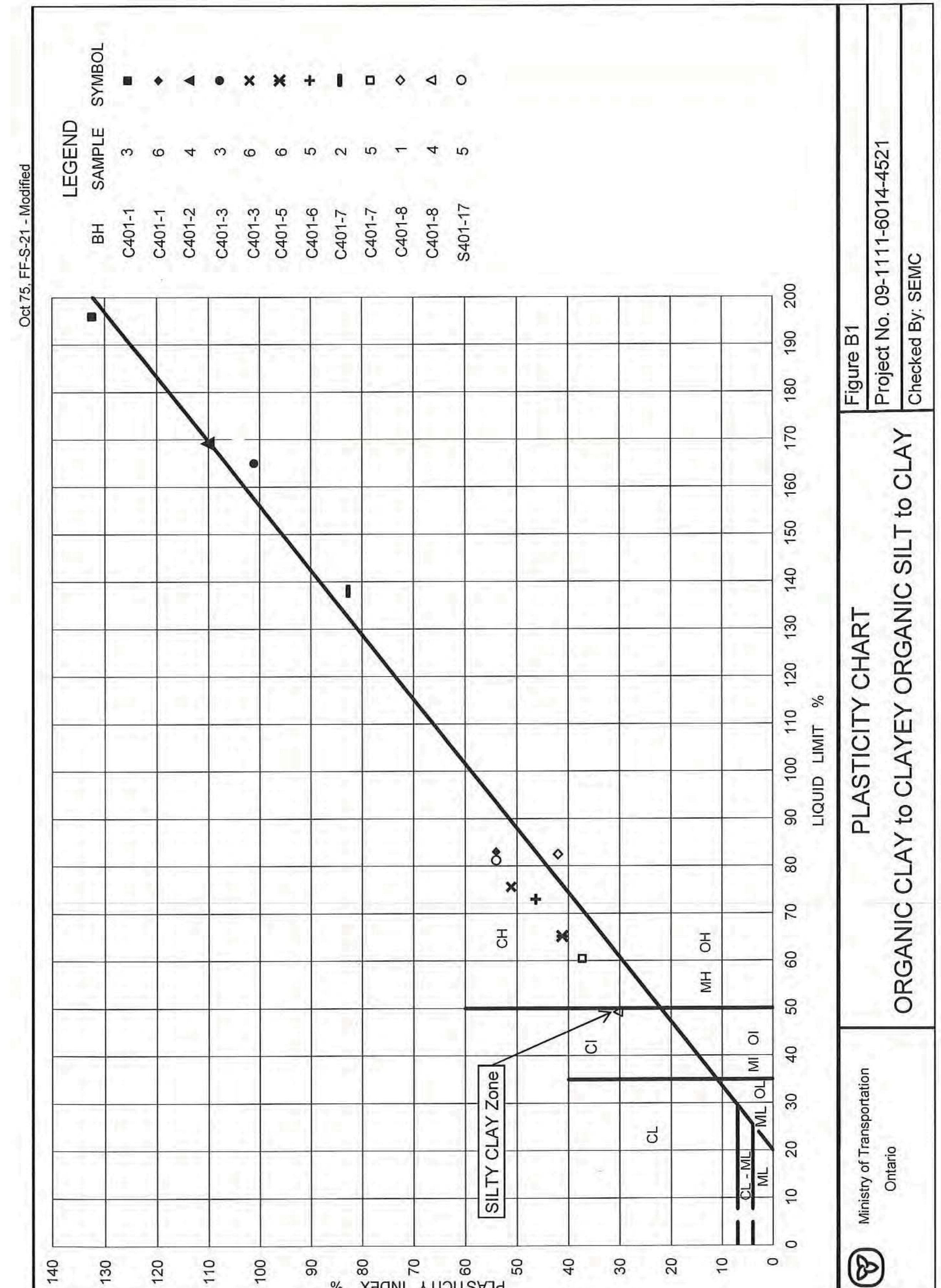
PROJECT 09-1111-6014			
W.P. 5347-08-01	LOCATION N 5086126.4; E 221851.4	ORIGINATED BY ID	
DIST HWY 69	BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW casing and Wash Boring	COMPILED BY AC	
DATUM GEODETIC	DATE June 5, 2012	CHECKED BY SEMC	

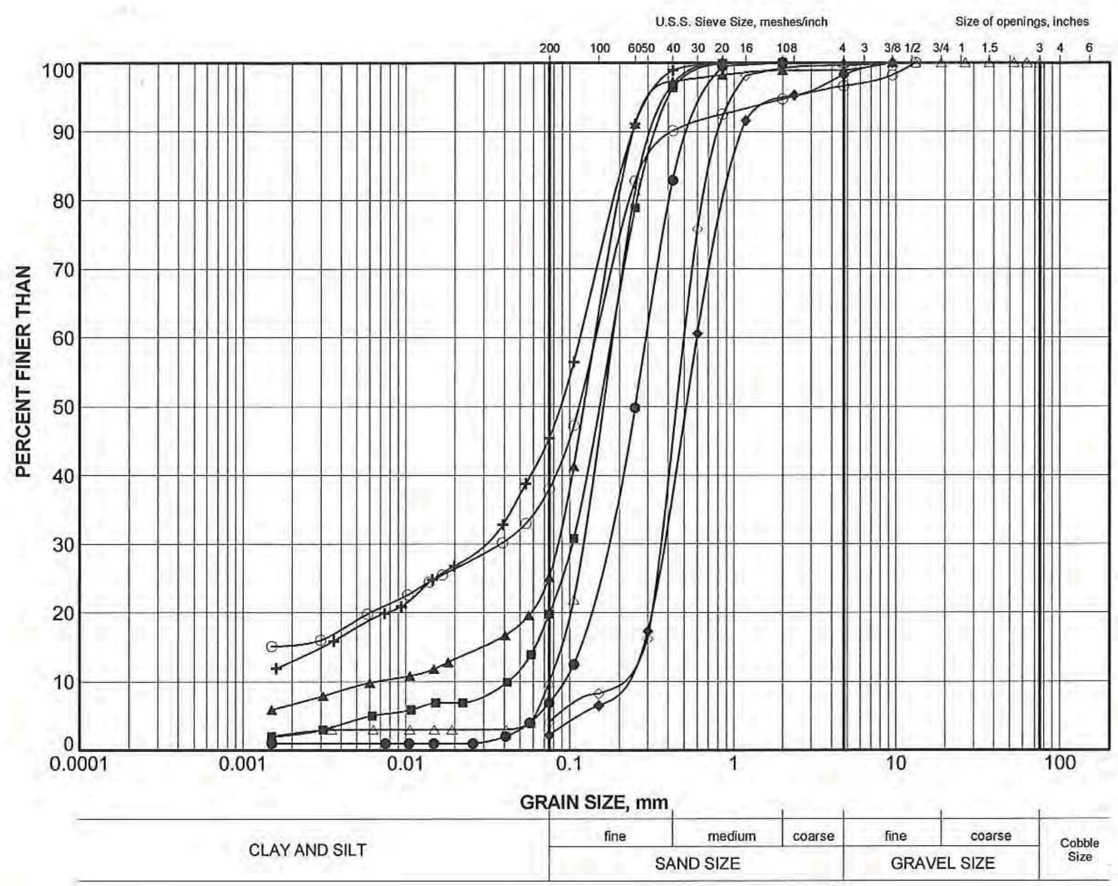
ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
	--- CONTINUED FROM PREVIOUS PAGE ---								
	CLAY Firm to stiff Grey to brown Wet Faint reddish-brown layers below 15.2 m depth.	13	SS	WH	165				
					164				
		14	SS	3	163				
					162				
		15	SS	3	161				
160.7 / 19.4	CLAYEY SILT Stiff Grey Wet	16	SS	3	160				
159.2 / 20.9	SILT, some clay Very loose to loose Grey Wet				159				
		17	SS	4	158	0	0	87	13
		18	SS	6	157				
					156				
155.1 / 25.0		19	SS	6					
	END OF BOREHOLE Note: 1. Water level at a depth of 0.1 m below ground surface (Elev. 180.0 m) upon completion of								

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

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

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:





LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C401-2	8	172.2
■	C401-3	8	173.5
▲	C401-5	4	177.7
+	C401-5	7	173.9
◆	C401-6	7	173.5
◇	C401-7	8	172.1
○	C401-8	6	175.1
△	S401-17	8	172.2

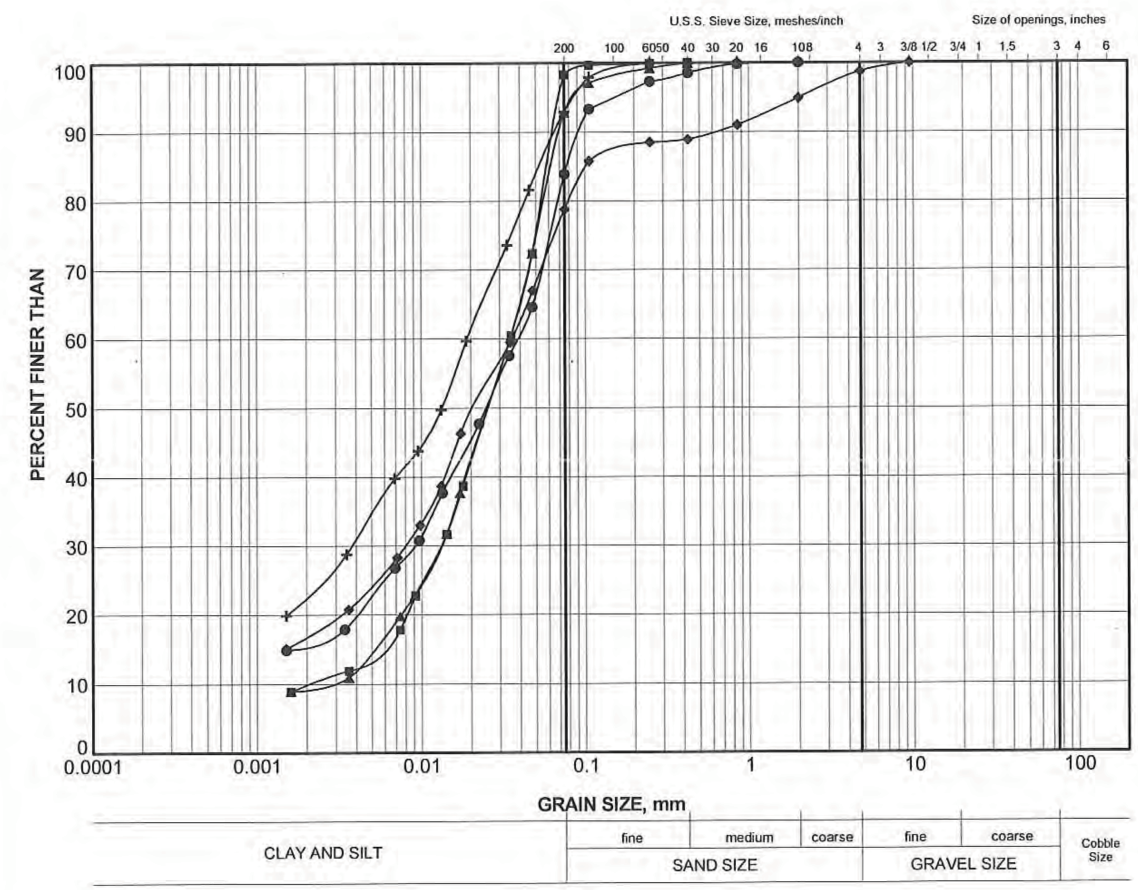
PROJECT
HIGHWAY 69
CULVERTS - CONTRACT 4

TITLE
GRAIN SIZE DISTRIBUTION
SAND to SAND AND SILT

Golder Associates SUDBURY, ONTARIO

PROJECT No.	09-1111-6014	FILE 0911116014_T4521_C.GPJ
DRAWN TB	May 2013	SCALE N/A REV.
CHECK SEMC	May 2013	FIGURE B2
APPR JMAC	May 2013	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C401-1	8	172.1
■	C401-3	11	168.9
▲	C401-5	10	169.3
+	C401-6	10	168.9
◆	C401-8	8	172.1

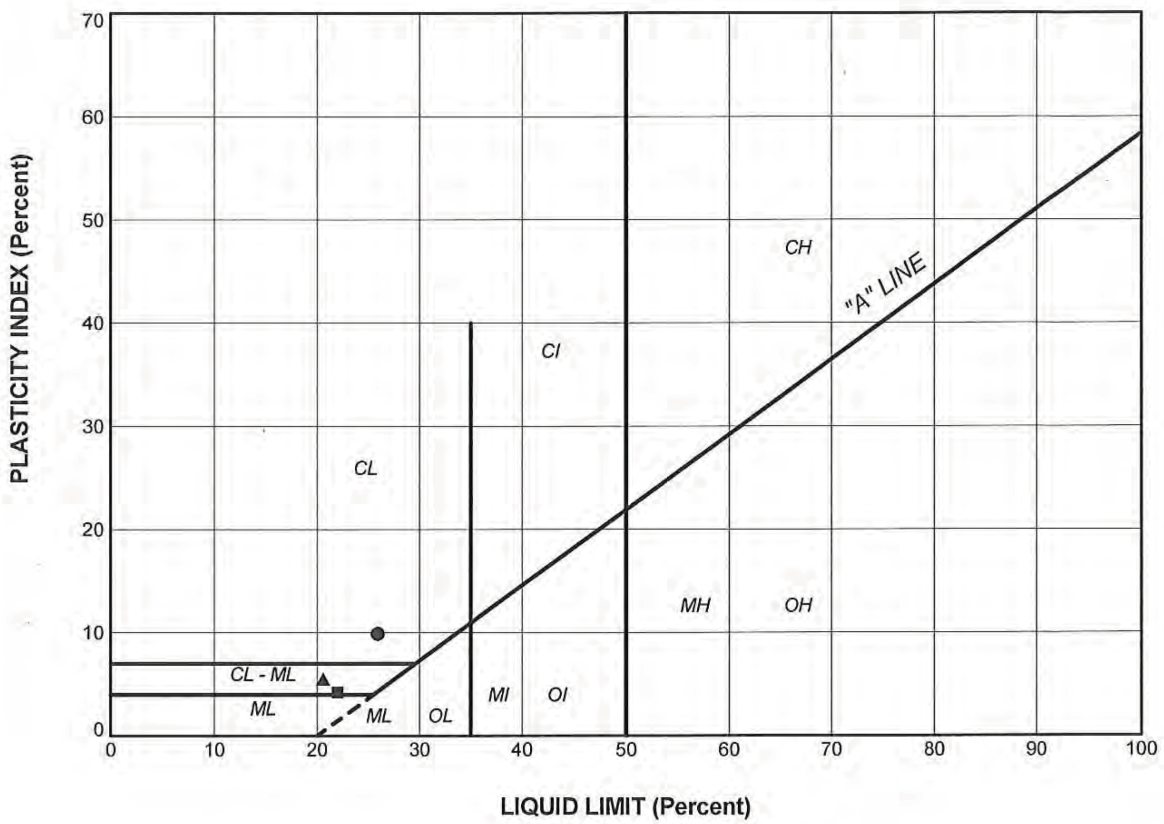
PROJECT
HIGHWAY 69/522 I/C
CULVERTS - CONTRACT 4

TITLE
GRAIN SIZE DISTRIBUTION
CLAYEY SILT to SILT

Golder Associates SUDBURY, ONTARIO

PROJECT No.	09-1111-6014	FILE 0911116014_T4521_C.GPJ
DRAWN TB	May 2013	SCALE N/A REV.
CHECK SEMC	May 2013	FIGURE B3
APPR JMAC	May 2013	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C401-1	10	25.9	16.0	9.9
■	C401-2	9	22.0	17.8	4.2
▲	C401-8	8	20.6	15.1	5.5

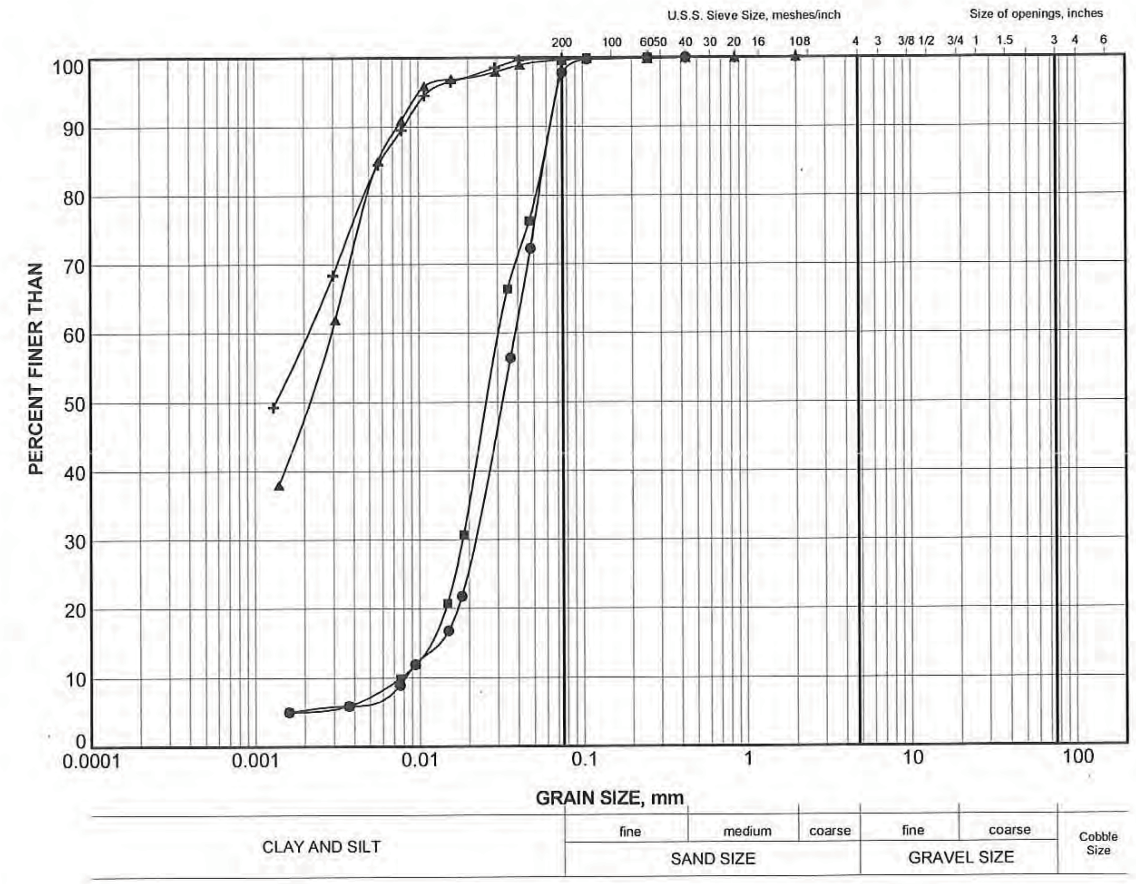
PROJECT
HIGHWAY 69/522 I/C
CULVERTS - CONTRACT 4

TITLE
PLASTICITY CHART
CLAYEY SILT to SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014		FILE No. 0911116014_T4521_C.GPJ		
DRAWN	TB	May 2013	SCALE	N/A	REV.
CHECK	SEMC	May 2013	FIGURE B4		
APPR	JMAC	May 2013			

SUD-MTO PL (NEW) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C401-2	13	164.6
■	C401-3	14	164.4
▲	C401-5	14	161.7
+	C401-6	14	162.8

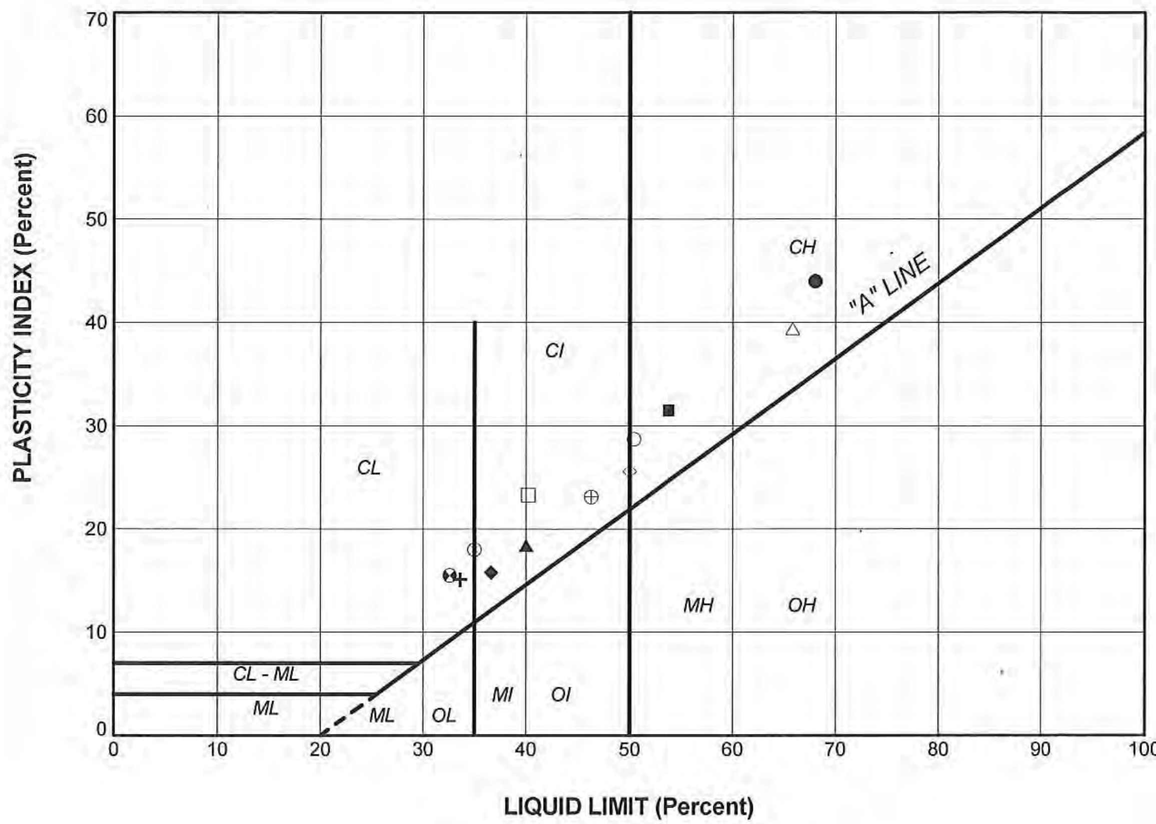
PROJECT
HIGHWAY 69/522 I/C
CULVERTS - CONTRACT 4

TITLE
GRAIN SIZE DISTRIBUTION
SILTY CLAY to CLAY

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014		FILE 0911116014_T4521_C.GPJ		
DRAWN	TB	May 2013	SCALE	N/A	REV
CHECK	SEMC	May 2013	FIGURE B5		
APPR	JMAC	May 2013			

SUD-MTO GSD (NEW) GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C401-1	12	68.0	24.0	44.0
■	C401-2	11	53.8	22.3	31.5
▲	C401-2	15	40.0	21.6	18.4
✚	C401-3	13	33.6	18.5	15.1
◆	C401-5	13	36.6	20.8	15.8
◇	C401-5	14	50.0	24.4	25.6
○	C401-6	11	50.4	21.7	28.7
△	C401-6	14	65.8	26.4	39.4
⊗	C401-7	11	35.0	17.0	18.0
⊕	C401-7	15	46.3	23.2	23.1
□	C401-8	10	40.2	16.9	23.3
⊖	C401-8	13	32.6	17.1	15.5

PROJECT
HIGHWAY 69/522 I/C
CULVERTS - CONTRACT 4

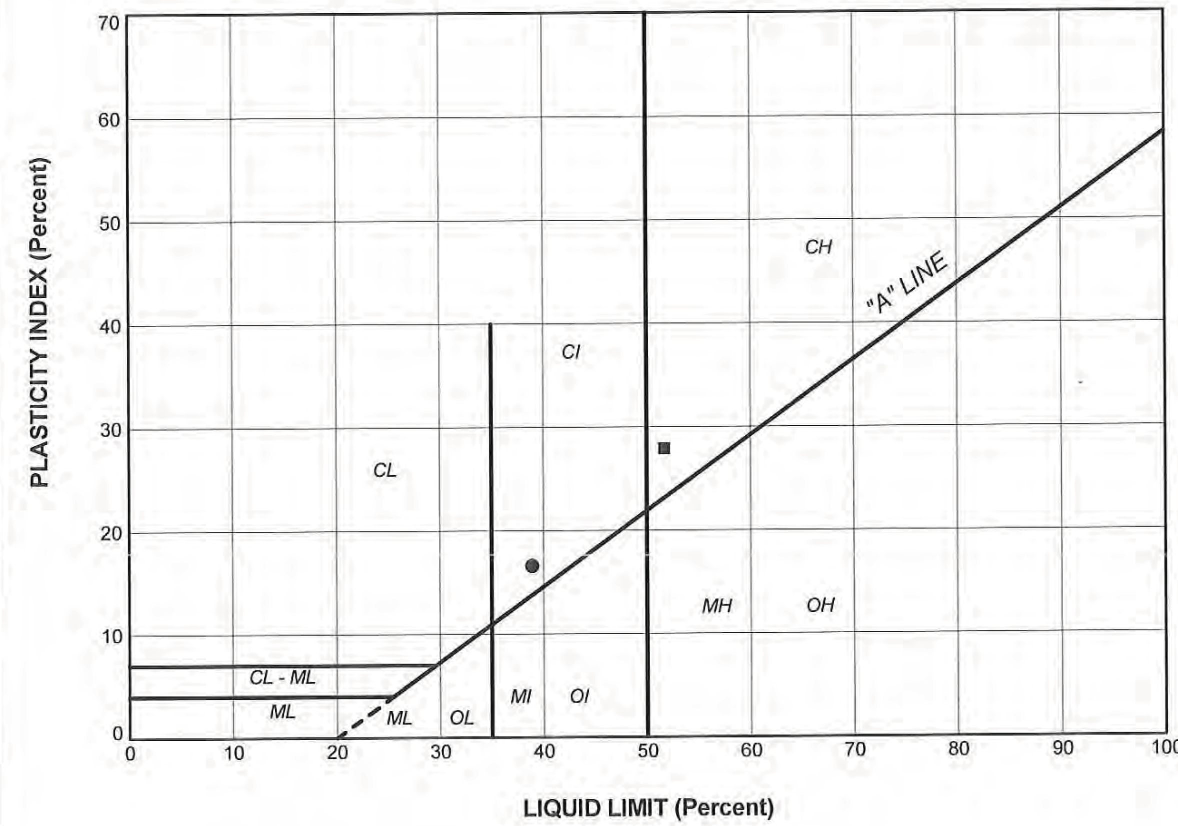
TITLE
PLASTICITY CHART
CLAYEY SILT to SILTY CLAY to CLAY

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014	FILE No. 0911116014_T4521_C.GPJ	
DRAWN	TB	May 2013	SCALE N/A REV.
CHECK	SEMC	May 2013	
APPR	JMAC	May 2013	

FIGURE B6.1

SUD-MTO PL (NEW) GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C401-8	15	38.9	22.3	16.6
■	S401-17	13	51.7	23.8	27.9

PROJECT
HIGHWAY 69
CULVERTS - CONTRACT 4

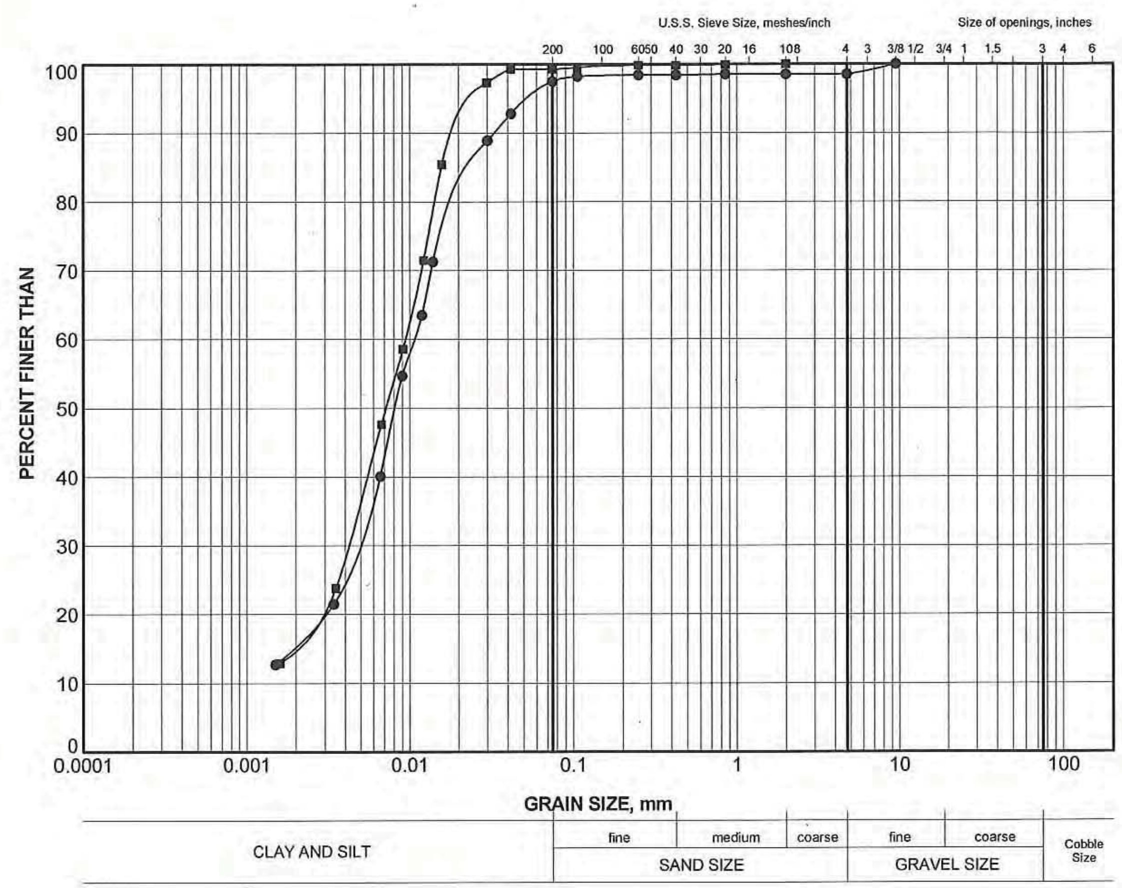
TITLE
PLASTICITY CHART
SILTY CLAY to CLAY

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014	FILE No. 0911116014_T4521_C.GPJ	
DRAWN	TB	May 2013	SCALE N/A REV.
CHECK	SEMC	May 2013	
APPR	JMAC	May 2013	

FIGURE B6.2

SUD-MTO PL (NEW) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C401-1	16	159.9
■	C401-6	16	159.8

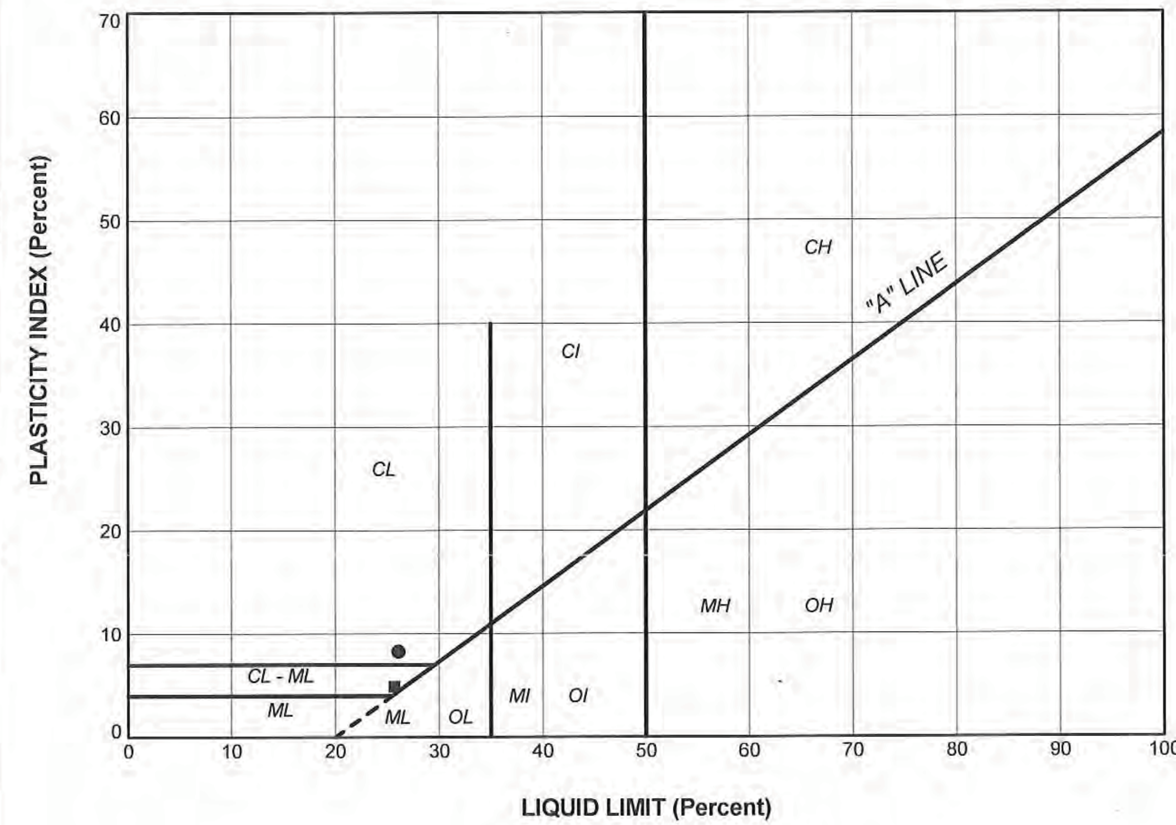
PROJECT
HIGHWAY 69/522 I/C
CULVERTS - CONTRACT 4

TITLE
GRAIN SIZE DISTRIBUTION
CLAYEY SILT to SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014	FILE 0911116014_T4521_C.GPJ	
DRAWN	TB	May 2013	SCALE N/A REV.
CHECK	SEMC	May 2013	FIGURE B7
APPR	JMAC	May 2013	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C401-1	16	26.1	17.8	8.3
■	C401-6	16	25.7	20.8	4.9

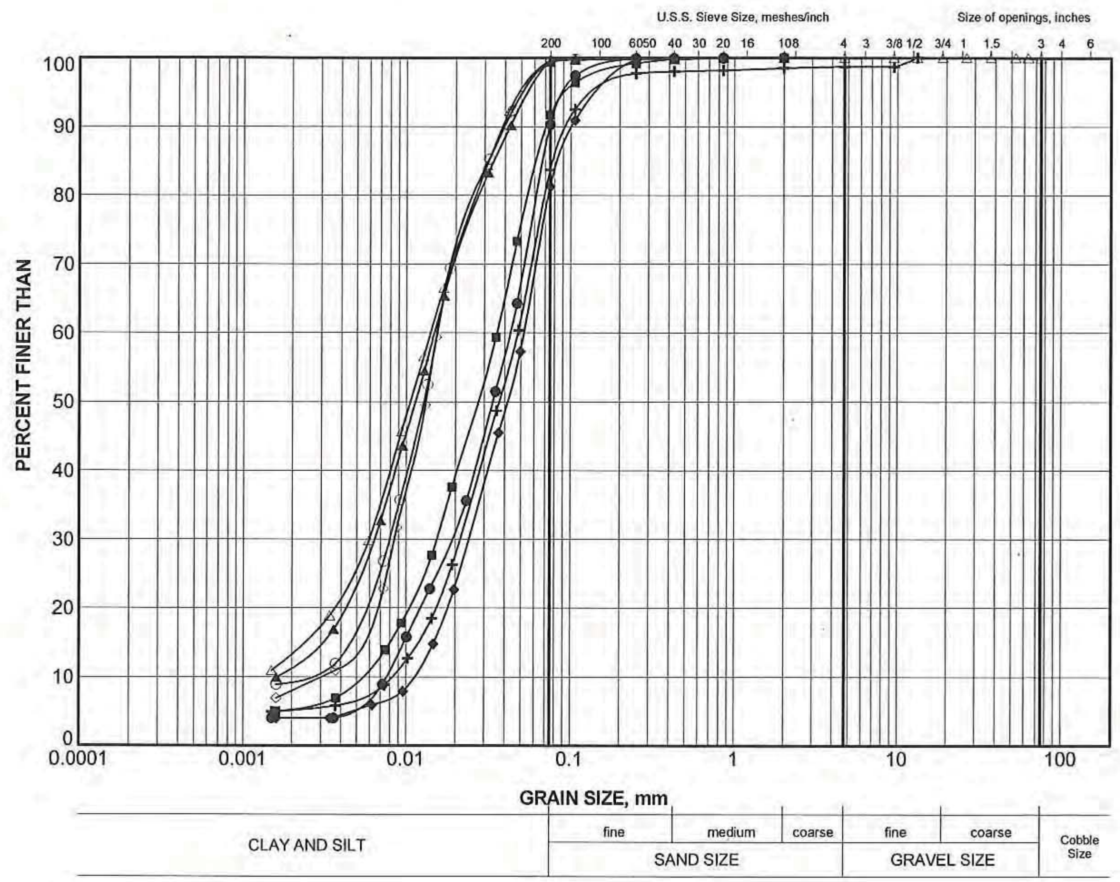
PROJECT
HIGHWAY 69/522 I/C
CULVERTS - CONTRACT 4

TITLE
PLASTICITY CHART
CLAYEY SILT TO SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014	FILE No.0911116014_T4521_C.GPJ	
DRAWN	TB	May 2013	SCALE N/A REV.
CHECK	SEMC	May 2013	FIGURE B8
APPR	JMAC	May 2013	

SUD-MTO PL (NEW) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C401-1	18	156.8
■	C401-2	18	156.9
▲	C401-3	18	158.3
+	C401-5	18	155.6
◆	C401-6	19	155.2
◇	C401-7	17	158.4
○	C401-8	17	158.4
△	S401-17	17	158.5

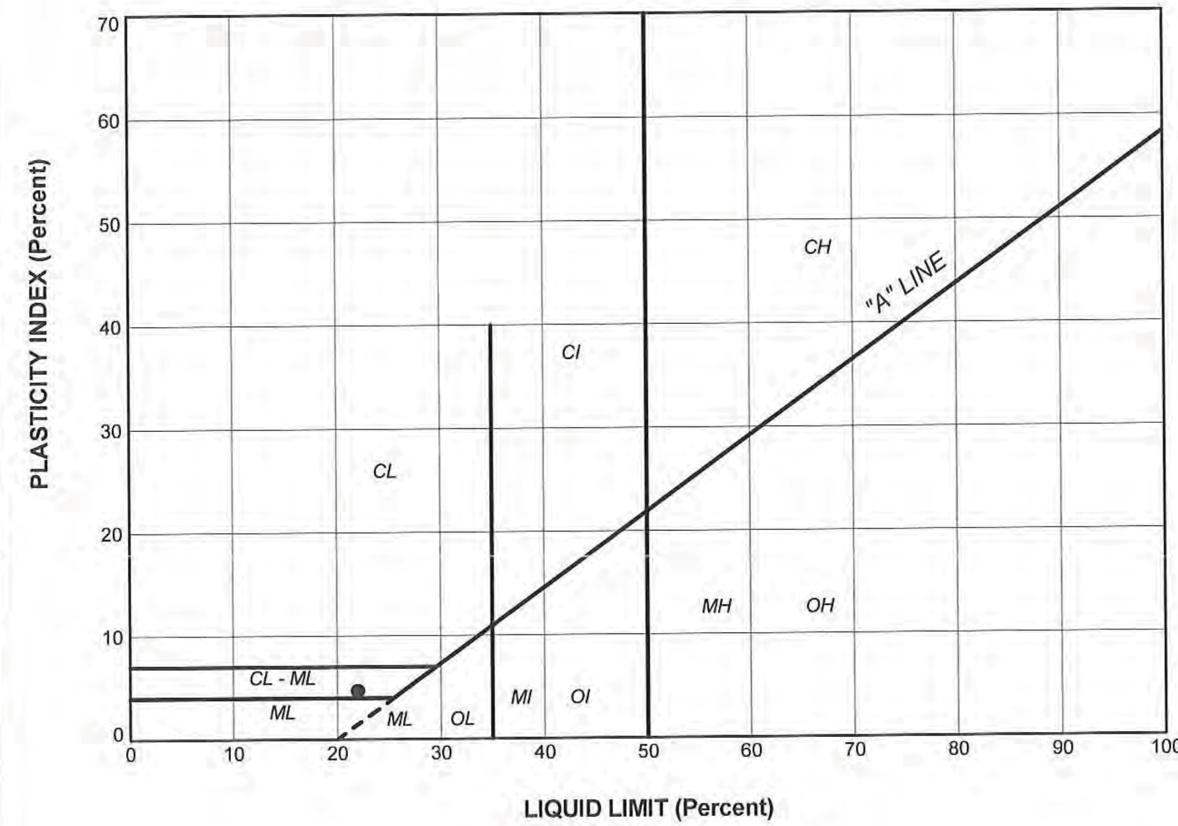
PROJECT
HIGHWAY 69
CULVERTS - CONTRACT 4

TITLE
GRAIN SIZE DISTRIBUTION
SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014	FILE 0911116014_T4521_C.GPJ	
DRAWN	TB	May 2013	SCALE N/A REV.
CHECK	SEMC	May 2013	
APPR	JMAC	May 2013	FIGURE B9

SUD-MTO GSD (NEW) GLDR_LDN.GDT



SOIL TYPE	PLASTICITY
C = Clay	L = Low
M = Silt	I = Intermediate
O = Organic	H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	S401-17	17	22.0	17.3	4.7

PROJECT
HIGHWAY 69
CULVERTS - CONTRACT 4

TITLE
PLASTICITY CHART
SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No	09-1111-6014	FILE No 0911116014_T4521_C.GPJ	
DRAWN	TB	May 2013	SCALE N/A REV
CHECK	SEMC	May 2013	
APPR	JMAC	May 2013	FIGURE B10

SUD-MTO PL (NEW) GLDR_LDN.GDT

SHEET S – CVM-4 – Fisheries/Wildlife Culvert (Station: ± 12+718 Hwy 69 SBL – Mowat)

- Borehole Locations and Soil Strata (Geocres 41H-133)
- Record of Borehole Logs (Geocres 41H-133)
- Laboratory Test Results (Geocres 41H-133)

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field work for the Culvert CVM-4 at Station 12+718 Mowat Township of the Southbound Lanes (SBL) Highway 69 new alignment was carried out by Golder Associates (Golder) between August 9 and 24, 2012, and a foundation investigation report (FIR) Reference 1 below was submitted to MTO.

Three (3) boreholes were advanced by Golder at the proposed culvert location. Refer to the FIR submitted by Golder for details of the borehole locations and subsurface conditions encountered at the culvert location.

The following documents are referenced:

1. Foundation Investigation Report (FIR) - Culverts: - Contract 4, Highway 69 Four-Laning from 1.7 km North of Highway 529 Northerly to 3.9 km North of Highway 522, Ministry of Transportation, Ontario, GWP 5347-08-00; WP 5347-08-01, (GEOCRES No. 41H-133), Submitted to URS Canada Inc. by Golder, October 9, 2013 (Report Number: 09-1111-6014-4521)
2. Foundation Investigation and Design Report (FIDR), Swamp Crossings and High Fill Areas - Contract 4, Highway 69 Four-Laning from 1.7 km North of Highway 529 Northerly to 3.9 km North of Highway 522, Ministry of Transportation, Ontario, GWP 5347-08-00; WP 5347-08-01, (GEOCRES No. 41H-135), Submitted to URS by Golder, November 29, 2013 (Report Number: 09-1111-6014-4520).

The proposed culvert is located within Swamp 401, as identified in report Reference 2. Refer to this report for the design recommendations, including construction and monitoring of the embankments across the swamp.

Relevant geotechnical details from the report Reference 1 are included in Appendix A-2 of this report, including records of borehole logs and preliminary foundation drawings.

PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) are based on the information received by PML from Parsons on March 2, 2018 and the subsurface soil and groundwater conditions provided in the report Reference 1.

2. PROJECT DESCRIPTION

2.1. General

The proposed Fisheries/Wildlife (SAR) Culvert CVM-4 is a new structure under the SBL of the new alignment of Highway 69. The proposed culvert will be installed in Swamp 401 approximately 550 m east of the existing Highway 69 and some 160 m south of the Key River Bridge and north of the existing CNR tracks. The railway tracks will be removed during the Highway 69 four-laning.

2.2. Proposed Structure

Based on the Drawing No. 2 dated October, 2013, presented in the report Reference No. 1, it is proposed to place the culvert at Sta. 12+718 under the SBL of the new alignment of Highway 69. The proposed culvert will have an opening of 3.0 m in span, 2.4 m in height, and will be approximately 65.0 m long. The alignment of proposed culvert will be on a skew of approximately 55 degrees to the new alignment of Highway 69. The proposed culvert is located within a swamp identified as Swamp 401 in the FIR submitted by Golder. The existing ground surface in the vicinity of the culvert alignment varies from approximately Elevations 180.3 m to 179.9 m and the ground profile is generally flat.

The proposed culvert invert and subgrade founding levels are summarized in Table S-1 below.

Table S-1: Founding Elevations of Box Culvert at Station 12+718 Highway 69 SBL (Site No. 44-627/2)

FOUNDATION LOCATION	PROPOSED CULVERT INVERT ELEVATION, m	BOTTOM OF BOX CULVERT ELEVATION, m	SUBGRADE ELEVATION FOR GRANULAR BEDDING, m	FOUNDING STRATUM
East End (Inlet)	179.0	178.7	178.4	Very soft clayey organic silt
West End (Outlet)	178.8	178.5	178.2	Soft organic clay

Note(s): 1. The bottom thickness of the precast concrete box culvert is assumed 0.25 m.

The height of embankment fill required above the culverts to the proposed grades of the re-aligned highway at Station 12+718 SBL is not expected to exceed 2.0 m, including the pavement structure, above the box culvert. The report Reference 2 indicates that the maximum height of embankment across Swamp 401 will be 7.5 m.

In the absence of structural details of the culvert, it is assumed or this report that the culvert is expected to impose a load of 85 kPa on the founding subsoil.

2.3. Structure Foundation Subsurface Conditions (Boreholes C401-3, C401-5 and S401-17)

Refer to the subsurface information in the report Reference 1, which was summarized in the following paragraph:

In general, the stratigraphy encountered along the three culverts is layered and generally consists of an upper deposit of peat, organic clay to clayey organic silt to clay of high plasticity with a cohesionless interlayer, a deposit of sand to sand and silt underlain by the main cohesive deposit of clayey silt to silt, silty clay to clay transitioning to clayey silt, and then silt at depth.

The subsurface and groundwater conditions encountered in the three (3) Boreholes (C401-3, C401-5 and S401.7) drilled along the proposed culvert alignment are summarized below.

In summary, the stratigraphy consists of 0.4 to 0.6 m thick fibrous peat followed by 1.6 m to 2.6 m of very soft to soft organic clay to clayey organic silt. This layer is underlain by 1.4 m to 4.2 m thick very soft to stiff clay of high plasticity. In borehole C401-5, organic clay is followed by 1.9 m thick very loose sand, which is underlain by 1.4 m thick very soft clay. The clay layer is underlain by a 1.5 m to 6.2 m thick cohesionless deposit of very loose to loose sand, sand and silt and silt. These cohesionless deposits are underlain by cohesive deposits consisting of very soft to stiff clayey silt to clay to a depth of 20.9 m, which is underlain by very loose to compact silt to the augering termination depth of 25.0 m. Below this depth, two boreholes (C401-3 and C401-5) were advanced by Dynamic Cone Penetration Test (DCPT) to depths ranging from 25.0 m to 30.5 m, where refusals to DCPT were encountered.

The in-situ vane shear strength (Cu) of clayey soil between EL. 178.0 and EL. 159.0 reported in the borehole logs range from 11 kPa to 77 kPa, with an average value of 48 kPa.

Upon completion of augering, the groundwater levels measured in all three (3) Boreholes ranged from EL. 180.3 to EL. 180.0 m. Groundwater level is subject to seasonal fluctuations and precipitation patterns. It is anticipated that the groundwater level in this area would be higher during wet periods of the year.

For the purpose of this preliminary FDR, consolidation test data from Borehole S401-11 that was advanced in the vicinity of the proposed culvert for the investigation of Swamp 401 embankment construction (report Reference 2) was used to estimate the settlements under the proposed culvert. A reported compression index (Cc) value of 0.62 and void ratio (eo) of 1.51 were used to estimate the magnitude of settlements under an imposed load of 60 kPa, assuming that the clayey deposit encountered at this site is normally consolidated.

3. EVALUATION OF FOUNDATION ALTERNATIVES

The evaluation of foundation alternatives was based on data provided in the report Reference 1. If the culvert is placed at the proposed subgrade level of EL. 178.3±, the primary and secondary consolidation of 0.5 m to 1.8 m thick very soft organic clay to organic clayey silt layers remaining under the base of the culvert, would result in relatively large total settlements in the order of 160 and 465 mm and differential settlements in the order of 100 to 300 mm under the estimated load of 85 kPa.

The magnitude of the estimated total and differential settlements from the variation in thickness of organic layer would be higher than the tolerable limit of 25 mm and 100 mm generally assumed for cast-in-place and precast concrete box culverts, respectively.

Consequently, the very soft soils are considered unsuitable as subgrade support medium for cast-in-place or pre-cast concrete culverts due to excessive settlements. Accordingly, settlement mitigation measures should be implemented for the culvert foundation. The settlement mitigation measures for the culvert and the highway embankment construction in Swamp 401 recommended in report Reference 2 should be coordinated. The report recommends partial excavation of up to 7.0 m of upper zone of organic and soft soils and a preloading program incorporating wick drains as the preferred mitigation alternative for mitigation of construction settlement of Swamp 401 embankments.

The foundation alternatives for this culvert are discussed below.

1. Precast concrete box culvert placed on replacement fill after preloading.
2. Precast concrete box culvert placed on replacement fill without settlement mitigation.
3. Corrugated Steel Plate (CSP) Arch or Circular Culvert.

3.1. Option 1: Precast Concrete Box Culvert on Granular Replacement Fill after Preloading

To mitigate the post-construction total and differential settlements to a tolerable limit, the culvert should be constructed after the highway embankment is constructed as recommend in the Report Reference 2. A minimum preload of 1.5 m of Granular B Type II above the proposed embankment level at the culvert location should be placed for a period of 9 to 12 months to reduce the post construction settlement to about 60 mm to 100 mm.

The precast concrete box culvert installed on replacement fill consisting of Granular B Type II may be designed for a factored geotechnical resistance of 130 kPa at ULS and 85 kPa at SLS. The total settlement induced under the estimated load of 85 kPa may be expected to be in the range of 25 mm to 40 mm and the associated differential settlement may be in the range of 20 mm to 30 mm.

The construction of precast concrete box culverts should be coordinated with the construction of the embankment over Swamp 401. To minimize potential slope instability during construction of the culvert, the footprint of the culvert should be preloaded along with the placement of embankment fill across Swamp 401. The settlement under the culvert preload should be monitored and the installation of the culvert may be started once the remaining settlements and differential settlements reach a tolerable limit for the precast concrete box culvert. Temporary CSP pipes may need to be placed under the embankment fill to allow for continued drainage, if required. At the appropriate time, the fill used for the preload material and the temporary CSPs would be removed to the proposed subgrade level and the precast box culvert would be installed.

Refer to the General Report for details of the replacement fill materials and construction.

3.2. Option 2: Precast Concrete Box Culvert on Replacement Fill Without Settlement Mitigation

Similar to Option 1, the 0.2 m to 1.4 m thick, very soft organic clay to clayey organic silt layer below the proposed founding level of the culvert will have to be removed and replaced with granular back fill to the proposed founding level. The remaining 1.5 m to 4.2 m of clayey soil under an imposed load of 85 kPa at SLS is expected to undergo a total settlement ranging from 160 mm to 465 mm and the associated differential settlement may be expected in the order of 100 mm to 300 mm.

Such relatively large total and differential settlements are not acceptable considering that the magnitudes are in excess of the tolerable settlement limits for a precast concrete box culvert, and can cause damage to the joints, leading to deterioration of the culvert. Therefore, the factored geotechnical resistances at ULS and at SLS for 100 mm of differential settlement are not applicable since the option of placing the proposed culverts for both NBL and SBL on native soils at ±EL. 178.1 m without settlement mitigation measures is not considered to be feasible.

3.3. Option 3: Corrugated Steel Plate (CSP) Arch Culvert

Refer to the General Report for preliminary general recommendations for the use of Corrugated Steel Plate (CSP) arch culverts.

4. CULVERT BEDDING AND COVER MATERIALS

Refer to the General Report for preliminary recommendations for materials to be used for culvert bedding and cover purposes.

5. APPROACH EMBANKMENT

The details for design, construction, and mitigation procedures for the embankment through Swamp 401 are presented in report Reference 2. This report should be consulted for placement of fill for the swamp crossing and no recommendation is provided in this report.

6. CONSTRUCTION CONSIDERATIONS

6.1. Excavation

Assuming that the preloading and/or surcharging option is implemented, the approximately 4.5 m high embankment fill in place at the culvert location for the embankment pre-loading would need to be removed and the stability of the temporary excavated slope should be assessed at the detail design stage.

Should the culvert area be preloaded and/or surcharged, the Contractor should consider the type of material to place in the culvert area to be able to excavate and dispose or re-use the temporary fill materials.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

Preliminary recommendations for culvert backfilling are provided in the General Report.

6.2. Groundwater and Surface Water Control

Refer to the General Report for further groundwater control recommendations and requirements for water taking.

MINISTRY OF TRANSPORTATION, ONTARIO

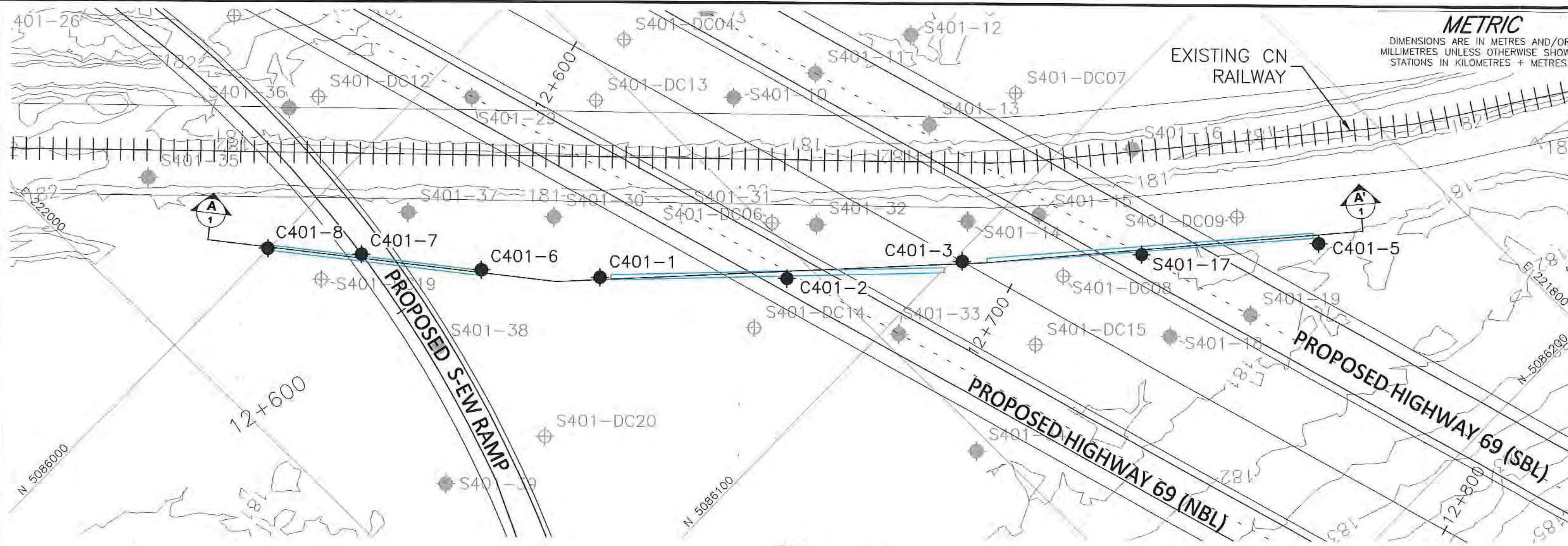
CONT No.
WP No. 5347-08-01

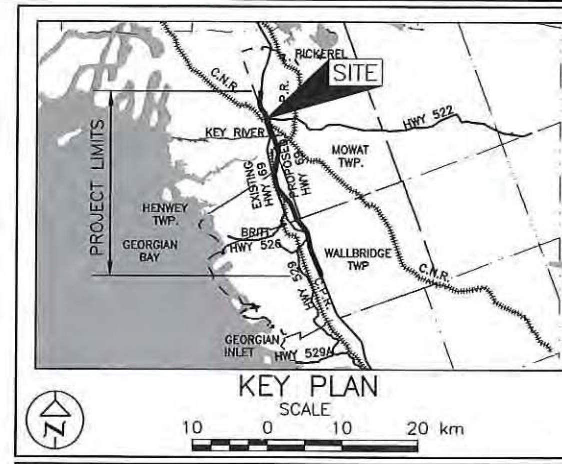
SHEET

HIGHWAY 69/522 INTERCHANGE
CULVERTS – CONTRACT 4
BOREHOLE LOCATIONS AND SOIL STRATA

Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA

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

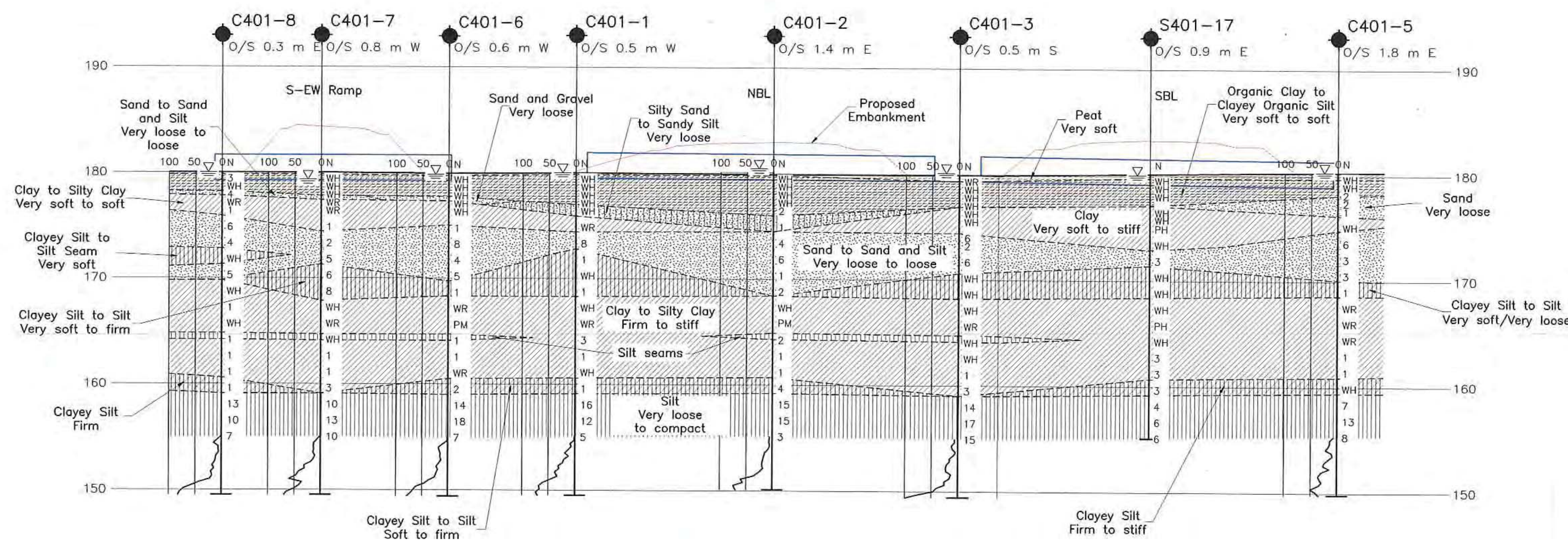




LEGEND

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

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
C401-1	180.0	5086051.7	221930.8
C401-2	180.1	5086078.8	221904.7
C401-3	179.9	5086101.5	221877.7
C401-5	180.3	5086150.3	221825.0
C401-6	179.9	5086033.6	221946.2
C401-7	180.0	5086014.1	221960.9
C401-8	180.0	5085999.8	221973.1
S401-17	180.1	5086126.4	221851.4



A–A' / 1
PROFILE
HIGHWAY 69/522 INTERCHANGE
HORIZONTAL SCALE
10 0 10 20 m
5 0 5 10 m
VERTICAL SCALE

NOTES

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

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

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

REFERENCE

Base plans provided in digital format by URS, drawing file Alignment received OCT 07, 2011, Hwy69_contours-C4-LIDAR-smoothed FEB 16, 2012. Keyplan received APR 16, 2010.

LICENSED PROFESSIONAL ENGINEER S.E.M. COYNE 90471921 OCT 9, 2013 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER J.M.A.COSTA OCT 9, 2013 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 41H-133			
HWY. 69		PROJECT NO. 09-1111-6014	DIST.
SUBM'D. AC	CHKD.	DATE: OCT 2013	SITE:
DRAWN: TB	CHKD. SEMC	APPD. JMAC	DWG. 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
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:
The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

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

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

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

III. SOIL DESCRIPTION

(a) Cohesionless Soils

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

(b) Cohesive Soils
Consistency

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

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

Percent 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

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

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
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

Notes: 1 $\tau = c' + \sigma' \tan\phi'$
2 shear strength = (compressive strength)/2

Golder Associates

Foundation Design

RECORD OF BOREHOLE No C401-1

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01 | LOCATION N 5086051.7; E 221930.8 | ORIGINATED BY SA
DIST HWY 69/522 I/C | BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring | COMPILED BY AC
DATUM GEODETIC | DATE August 16 and 21, 2012 | CHECKED BY SEMC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	PLOT READINGS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
180.0	GROUND SURFACE						
0.0	PEAT (Fibrous)						
0.2	Very soft, Black, Wet	1	SS	WH		120.6	
	Organic CLAY, Very soft, Dark grey to black, Wet	2	SS	WH	179		
		3	SS	WH	178	196 / 163.5	
		4	SS	WH			
177.0 / 3.0	Silty SAND, Very loose, Grey, Wet	5	SS	WH	177		
175.9 / 4.1	CLAY, Soft, Grey, Wet				176		
		6	SS	WR	175	83 / 102.5; + 4	
174.4 / 5.6	SAND, Loose, Grey, Wet				174		
		7	SS	8			
172.8 / 7.2	CLAYEY SILT, some sand, Very soft, Grey, Wet				173		
		8	SS	1	172		0 16 68 16
					171		
		9	SS	WH			
					170	+ 6	
		10	SS	1	169		
168.3 / 11.7	CLAY, Firm to stiff, Grey, Wet				168		
		11	SS	WH			
					167	+ 5	
		12	SS	WR	166		

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

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

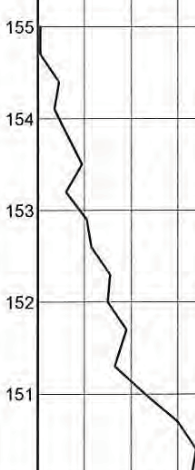
Foundation Design

RECORD OF BOREHOLE No C401-1

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01 | LOCATION N 5086051.7; E 221930.8 | ORIGINATED BY SA
DIST HWY 69/522 I/C | BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring | COMPILED BY AC
DATUM GEODETIC | DATE August 16 and 21, 2012 | CHECKED BY SEMC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	PLOT READINGS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	— CONTINUED FROM PREVIOUS PAGE —						
	CLAY, Firm to stiff, Grey, Wet	13	SS	3			
					164		
	Faint reddish-grey layers at 16.8 m depth.	14	SS	1	163		
					162	+ 3	
		15	SS	WH			
					161	+ 6	
160.6 / 19.4	CLAYEY SILT, Firm, Grey, Wet						
		16	SS	1	160		1 1 83 15
159.1 / 20.9	SILT, trace to some sand, trace clay, Loose to compact, Grey, Wet				159		
		17	SS	16			
					158		
					157		
		18	SS	12			0 10 87 3
					156		
		19	SS	5			
155.0 / 25.0	END OF BOREHOLE, START OF DCPT				155		
					154		
					153		
					152		
					151		



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

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RECORD OF BOREHOLE No C401-1

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01 LOCATION N 5086051.7; E 221930.8 ORIGINATED BY SA
DIST HWY 69/522 I/C BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring COMPILED BY AC
DATUM GEODETIC DATE August 16 and 21, 2012 CHECKED BY SEMC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	— CONTINUED FROM PREVIOUS PAGE —										
149.5 / 30.5	END OF DCPT Note: 1. Water level at ground surface (Elev. 180.0 m) upon completion of drilling.										

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

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

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RECORD OF BOREHOLE No C401-2

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01 LOCATION N 5086078.8; E 221904.7 ORIGINATED BY SA
DIST HWY 69 BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring COMPILED BY AC
DATUM GEODETIC DATE August 14 and 15, 2012 CHECKED BY SEMC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
180.1	WATER LEVEL				
0.0	WATER				
0.3	PEAT (Fibrous) Organic CLAY Very soft Dark grey to black Wet	1	SS	WH	
		2	SS	WH	
		3	SS	WH	
		4	SS	WH	
		5	SS	2	
176.0 / 4.1	Sandy SILT, some sand, some clay Very loose Grey Wet	6	SS	1	
174.5 / 5.6	SAND, trace to some silt to Silty SAND, trace to some clay Loose Grey Wet	7	SS	4	
		8	SS	6	0 93 6 1
	An approximately 150 mm thick silt seam encountered at 9.4 m depth.	9	SS	1	
	Two approximately 100 mm thick silty clay seams encountered in Sample 10.	10	SS	2	
168.4 / 11.7	CLAY to SILTY CLAY Firm to stiff Grey Wet	11	SS	WH	
	No recovery in Sample 12.	12	TO	PM	

Elevation scale: 180, 179, 178, 177, 176, 175, 174, 173, 172, 171, 170, 169, 168, 167, 166

Plot annotations: 144; 169; 148.4; 5

Continued Next Page

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

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Foundation Design

RECORD OF BOREHOLE No C401-2

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01
DIST HWY 69
DATUM GEODETIC

LOCATION N 5086078.8; E 221904.7
BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring
DATE August 14 and 15, 2012

ORIGINATED BY SA
COMPILED BY AC
CHECKED BY SEMC

ELEV DEPTH	SOIL PROFILE — DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	— CONTINUED FROM PREVIOUS PAGE —					
	CLAY to SILTY CLAY, Firm to stiff, Grey, Wet	13	SS	2	165	0 2 92 6
	Approximately 600 mm thick silt layer at 15.2 m depth.				164	
		14	SS	1	163	
					162	
	Faint reddish-brown layer at 18.3 m depth.	15	SS	1	161	
160.7 / 19.4	CLAYEY SILT, Firm, Grey, Wet	16	SS	4	160	
159.2 / 20.9	SILT, trace to some sand, trace clay, Very loose to compact, Grey, Wet	17	SS	15	159	
					158	
		18	SS	15	157	0 8 87 5
					156	
		19	SS	3		
155.1 / 25.0	END OF BOREHOLE, START OF DCPT				155	
					154	
					153	
					152	
					151	
150.1						

Column headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; STRAT PLOT; GROUND WATER CONDITIONS.

Field vane values plotted: 4 (at approx. elev. 162.5), 4 (at approx. elev. 161).

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

Foundation Design

RECORD OF BOREHOLE No C401-2

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01
DIST HWY 69
DATUM GEODETIC

LOCATION N 5086078.8; E 221904.7
BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring
DATE August 14 and 15, 2012

ORIGINATED BY SA
COMPILED BY AC
CHECKED BY SEMC

ELEV DEPTH	SOIL PROFILE — DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	— CONTINUED FROM PREVIOUS PAGE —					
30.0	END OF DCPT					

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No C401-3

 METRIC

PROJECT	09-1111-6014		
W.P.	5347-08-01	LOCATION	N 5086101.5; E 221877.7
DIST		HWY	69
BOREHOLE TYPE	Portable Equipment, NW Casing and Wash Boring		
DATUM	GEODETIC	DATE	August 13, 2012
ORIGINATED BY	GM	COMPILED BY	AC
CHECKED BY	SEMC		

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION
179.9	GROUND SURFACE
0.0	PEAT (Fibrous) Very soft Black Wet
179.3 / 0.6	Clayey ORGANIC SILT Very soft Dark grey to black Wet
176.9 / 3.0	CLAY Soft to stiff Grey Wet
174.4 / 5.5	SAND, some silt, trace clay Very loose to loose Grey Wet
170.6 / 9.3	SILT, trace to some clay, trace sand Very loose Grey Wet
168.2 / 11.7	CLAY TO CLAYEY SILT Firm to stiff Grey Wet

SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT / REMARKS	UNIT WEIGHT γ (kN/m³)	GR	SA	SI	CL
1	SS	WR						
2	SS	WH						
3	SS	WH	165, 150.7, OC=7.2%					
4	SS	WH						
5	SS	WH						
6	SS	WH	113.7					
7	SS	6						
8	SS	2			0	80	17	3
9	SS	6						
10	SS	WH						
11	SS	WH		NP	0	2	88	10
12	SS	WH						
13	SS	WR						

Elevation scale: 179, 178, 177, 176, 175, 174, 173, 172, 171, 170, 169, 168, 167, 166, 165

Dynamic Cone Penetration Resistance Plot: 20 40 60 80 100. Shear Strength kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100. Plastic Limit W_P, Natural Moisture Content W, Liquid Limit W_L; Water Content (%) 20 40 60.

Field vane sensitivity values plotted: 5, 6, 2

Continued Next Page

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

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No C401-3

 METRIC

PROJECT	09-1111-6014		
W.P.	5347-08-01	LOCATION	N 5086101.5; E 221877.7
DIST		HWY	69
BOREHOLE TYPE	Portable Equipment, NW Casing and Wash Boring		
DATUM	GEODETIC	DATE	August 13, 2012
ORIGINATED BY	GM	COMPILED BY	AC
CHECKED BY	SEMC		

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION
	CLAY TO CLAYEY SILT Firm to stiff Grey Wet. Approximately 600 mm thick silt layer at 15.2 m depth. Faint reddish-brown layer at 18.3 m depth.
159.0 / 20.9	SILT, trace to some clay Compact Grey Wet
154.9 / 25.0	END OF BOREHOLE START OF DCPT

SAMPLE NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ (kN/m³)	GR	SA	SI	CL
14	SS	WH		0	0	95	5
15	SS	WH					
16	SS	1					
17	SS	3					
18	SS	14	NP	0	0	88	12
19	SS	17					
20	SS	15					

Elevation scale: 164, 163, 162, 161, 160, 159, 158, 157, 156, 155, 154, 153, 152, 151, 150

Field vane sensitivity values plotted: 4, 6

Continued Next Page

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

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No C401-3

 METRIC

PROJECT 09-1111-6014			
W.P. 5347-08-01	LOCATION N 5086101.5; E 221877.7	ORIGINATED BY GM	
DIST	HWY 69	BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring	COMPILED BY AC
DATUM GEODETIC	DATE August 13, 2012	CHECKED BY SEMC	

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLE NUMBER	SAMPLE TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---							
149.4 / 30.5	END OF DCPT Note: 1. Water level at 0.2 m above ground surface (Elev. 180.1 m) upon completion of drilling.							

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED: 20 40 60 80 100
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%): 20 40 60
UNIT WEIGHT γ kN/m³

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

Golder Associates

RECORD OF BOREHOLE No C401-5

 METRIC

PROJECT 09-1111-6014			
W.P. 5347-08-01	LOCATION N 5086150.3; E 221825.0	ORIGINATED BY SA	
DIST	HWY 69	BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring	COMPILED BY AC
DATUM GEODETIC	DATE August 9 and 10, 2012	CHECKED BY SEMC	

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	SAMPLE TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
180.3	GROUND SURFACE					
0.0	PEAT (Fibrous) Very soft Brown Wet	1	SS	WH	180	
179.7 / 0.6	Organic CLAY Very soft Dark grey to black Wet	2	SS	WH	179	
		3	SS	2		
178.1 / 2.2	SAND, some silt, trace to some clay, trace gravel Very loose Grey Wet	4	SS	2	178	1 74 19 6
		5	SS	1	177	
176.2 / 4.1	CLAY Very soft Grey Wet	6	SS	WH	176, 175	
174.8 / 5.5	SAND and SILT, some clay Very loose to loose Grey Wet	7	SS	6	174	0 55 32 13
		8	SS	3	173, 172	
		9	SS	3	171	
170.1 / 10.2	SILT, trace to some sand, trace to some clay Very loose Grey Wet	10	SS	1	170, 169	0 7 84 9
168.6 / 11.7	SILTY CLAY to CLAY Firm to stiff Grey Wet	11	SS	WR	168, 167	
		12	SS	WR	166	

Water content plot labels: 86.5 (sample 2), 92.5 (sample 6). Field vane sensitivity labels: 3, 6.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED: 20 40 60 80 100
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%): 20 40 60
UNIT WEIGHT γ kN/m³

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No C401-5

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01
DIST HWY 69
DATUM GEODETIC

LOCATION N 5086150.3; E 221825.0
BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring
DATE August 9 and 10, 2012

ORIGINATED BY SA
COMPILED BY AC
CHECKED BY SEMC

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
	SILTY CLAY to CLAY Firm to stiff Grey Wet	13	SS	WR	165					
					164					
		13 B	SS	1	163					
	Faint reddish-brown layers at 18.3 m depth.	14	SS	1	162		0	0	52	48
160.9 19.4	CLAYEY SILT Firm Grey Wet				161					
		15	SS	WH	160					
159.4 20.9	SILT, some sand, trace clay Loose to compact Grey Wet	16	SS	7	159	NP				
					158					
		17	SS	13	157					
		18	SS	8	156		1	15	79	5
155.3 25.0	END OF BOREHOLE START OF DCPT				155					
					154					
					153					
					152					
					151					

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100 (field vane values: 5, 4)
PLASTIC LIMIT W_P – NATURAL MOISTURE CONTENT W – LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

Continued Next Page

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

SUD-MTO 001 091116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No C401-5

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01
DIST HWY 69
DATUM GEODETIC

LOCATION N 5086150.3; E 221825.0
BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring
DATE August 9 and 10, 2012

ORIGINATED BY SA
COMPILED BY AC
CHECKED BY SEMC

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	ELEVATION SCALE
		150
149.8 30.5	END OF DCPT Note: 1. Water level at ground surface (Elev. 180.3 m) upon completion of drilling.	

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

SUD-MTO 001 091116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No C401-6

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01
LOCATION N 5086033.6; E 221946.2
ORIGINATED BY SA
DIST HWY 69/522 I/C
BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring
COMPILED BY AC
DATUM GEODETIC
DATE August 21 and 22, 2012
CHECKED BY SEMC

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
179.9	GROUND SURFACE				
0.0	PEAT (Fibrous)				
0.2	Organic CLAY Very soft Dark grey to black Wet	1	SS	WH	
		2	SS	WH	
		3	SS	WH	
177.7	SAND and GRAVEL Very loose Grey Wet	4	SS	WH	
177.3 / 2.6	CLAY Very soft Grey Wet	5	SS	WH	
175.0 / 4.9	SAND, trace silt, trace gravel Loose Grey Wet Approximately 200 mm thick silt seams encountered at 4.9 m and 7.6 m depth.	6	SS	1	
		7	SS	8	1 97 (2)
		8	SS	4	
		9	SS	5	
169.7 / 10.2	CLAYEY SILT, trace to some sand Very soft Grey Wet	10	SS	1	0 7 70 23
168.3 / 11.6	CLAY Firm to stiff Grey Wet	11	SS	WR	
		12	TO	PM	

Continued Next Page

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

SUD-MTO 001 091116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No C401-6

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01
LOCATION N 5086033.6; E 221946.2
ORIGINATED BY SA
DIST HWY 69/522 I/C
BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring
COMPILED BY AC
DATUM GEODETIC
DATE August 21 and 22, 2012
CHECKED BY SEMC

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---				
	CLAY Firm to stiff Grey Wet Approximately 600 mm thick silt layer at 15.2 m depth.	13	SS	1	
	Faint reddish-brown layer at 16.8 m depth.	14	SS	1	0 0 41 59
		15	SS	WR	
160.5 / 19.4	CLAYEY SILT to SILT, trace sand, trace to some clay Soft Grey Wet	16	SS	2	0 1 83 16
159.0 / 20.9	SILT, some sand, trace clay Loose to compact Grey Wet	17	SS	14	
	No recovery in Sample 18.	18	SS	18	
		19	SS	7	0 19 77 4
154.9 / 25.0	END OF BOREHOLE START OF DCPT				

Continued Next Page

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

SUD-MTO 001 091116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No C401-6

 METRIC

PROJECT 09-1111-6014 | LOCATION N 5086033.6; E 221946.2 | ORIGINATED BY SA
W.P. 5347-08-01 | BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring | COMPILED BY AC
DIST | HWY 69/522 I/C | DATE August 21 and 22, 2012 | CHECKED BY SEMC
DATUM GEODETIC

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	— CONTINUED FROM PREVIOUS PAGE —							
149.4 30.5	END OF DCPT Note: 1. Water level at a depth of 0.1 m below ground surface (Elev. 179.8 m) upon completion of drilling.							

Chart headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

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

Golder Associates

RECORD OF BOREHOLE No C401-7

 METRIC

PROJECT 09-1111-6014 | LOCATION N 5086014.1; E 221960.9 | ORIGINATED BY SA
W.P. 5347-08-01 | BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring | COMPILED BY AC
DIST | HWY 69/522 I/C | DATE August 22 and 23, 2012 | CHECKED BY SEMC
DATUM GEODETIC

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
180.0	GROUND SURFACE					
0.0	PEAT (Fibrous) Brown Wet	1	SS	WH		
0.2	Clayey ORGANIC SILT Very soft Dark grey to black Wet	2	SS	WH	179	
		3	SS	WH	178	
177.8	SAND and SILT Very loose Grey Wet	4	SS	WR		
177.4 2.6	CLAY, trace to some sand Very soft Grey Wet	5	SS	WR	177	
					176	
		6	SS	1	175	
174.4 5.6	SAND, trace silt Very loose to loose Grey Wet	7	SS	2	174	
					173	
		8	SS	5	172	0 95 (5)
171.3 8.7	CLAYEY SILT Firm Grey Wet				171	
		9	SS	6	170	
	An approximately 150 mm thick sand seam at 10.9 m depth.	10	SS	8	169	
168.8 11.2	SILTY CLAY Firm to stiff Grey Wet				168	
		11	SS	WH	167	
	Faint reddish-brown layers at 13.7 m depth.	12	SS	WR	166	

Chart headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

Plot labels: 138, 68, 5, 5

Continued Next Page

SUD-MTO 001 0911116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

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

RECORD OF BOREHOLE No C401-7

 METRIC

PROJECT 09-1111-6014			
W.P. 5347-08-01	LOCATION N 5086014.1; E 221960.9	ORIGINATED BY SA
DIST	HWY 69/522 I/C	BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring	COMPILED BY AC
DATUM GEODETIC		DATE August 22 and 23, 2012	CHECKED BY SEMC

Column legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT W_L; WATER CONTENT (%) (20 40 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GRAIN SIZE (GR SA SI CL)
	SILTY CLAY Firm to stiff Grey Wet	13	SS	WH	
	Approximately 600 mm thick silt layer at 15.2 m depth.				
	Faint reddish-brown layers between 16.8 m and 18.9 m depth.	14	SS	1	
		15	SS	1	
		16	SS	3	
159.1 / 20.9	SILT, trace to some clay Compact Grey Wet	17	SS	10	0 0 92 8
		18	SS	13	
		19	SS	10	
155.0 / 25.0	END OF BOREHOLE START OF DCPT				

Elevation scale: 164, 163, 162, 161, 160, 159, 158, 157, 156, 155, 154, 153, 152, 151

Continued Next Page

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

RECORD OF BOREHOLE No C401-7

 METRIC

PROJECT 09-1111-6014			
W.P. 5347-08-01	LOCATION N 5086014.1; E 221960.9	ORIGINATED BY SA
DIST	HWY 69/522 I/C	BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring	COMPILED BY AC
DATUM GEODETIC		DATE August 22 and 23, 2012	CHECKED BY SEMC

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION
149.5 / 30.5	END OF DCPT Note: 1. Water level at a depth of 0.7 m below ground surface (Elev. 179.3 m) upon completion of drilling.

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

Foundation Design

Golder Associates

RECORD OF BOREHOLE No C401-8

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01 LOCATION N 5085999.8; E 221973.1 ORIGINATED BY SA
DIST HWY 69/522 I/C BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring COMPILED BY AC
DATUM GEODETIC DATE August 23 and 24, 2012 CHECKED BY SEMC

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED (20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (20 40 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ELEV / DEPTH	DESCRIPTION
180.0	GROUND SURFACE
0.0	PEAT (Fibrous)
0.2	Clayey ORGANIC SILT Very soft Dark grey to black Wet
178.2	SAND Loose Grey Wet
177.8 / 2.2	SILTY CLAY Very soft Grey Wet
175.9 / 4.1	Silty SAND, some clay to SAND, trace gravel Loose Grey Wet
172.8 / 7.2	CLAYEY SILT to SILT, some sand, trace gravel Very soft Grey Wet
171.3 / 8.7	SAND Loose Brown Wet
169.8 / 10.2	SILTY CLAY Firm to stiff Grey Wet

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	3	OC=5.2%
2	SS	WH	
3	SS	4	
4	SS	WR	
5	SS	1	
6	SS	6	3 59 23 15
7	SS	4	
8	SS	WH	1 20 62 17
9	SS	5	
10	SS	WH	
11	SS	1	
12	SS	WH	

ELEVATION SCALE: 179, 178, 177, 176, 175, 174, 173, 172, 171, 170, 169, 168, 167, 166

Water content plot annotations: 83, 69.8. Field vane sensitivity: 4, 2.

Continued Next Page

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

SUD-MTO 001 09111160014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Foundation Design

Golder Associates

RECORD OF BOREHOLE No C401-8

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01 LOCATION N 5085999.8; E 221973.1 ORIGINATED BY SA
DIST HWY 69/522 I/C BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring COMPILED BY AC
DATUM GEODETIC DATE August 23 and 24, 2012 CHECKED BY SEMC

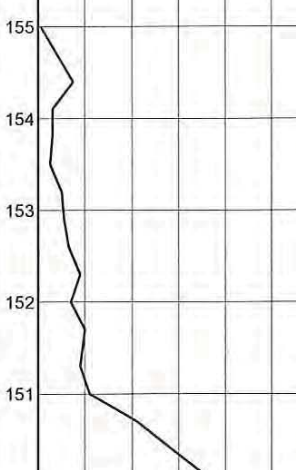
— CONTINUED FROM PREVIOUS PAGE —

ELEV / DEPTH	DESCRIPTION
	SILTY CLAY Firm to stiff Grey Wet Approximately 600 mm thick clayey silt seam at 15.2 m depth. Faint reddish-brown layer at 16.8 m depth.
160.6 / 19.4	CLAYEY SILT Firm Grey Wet
159.1 / 20.9	SILT, trace to some clay Loose to compact Grey Wet
155.0 / 25.0	END OF BOREHOLE START OF DCPT

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
13	SS	1	0 0 74 26
14	SS	1	
15	SS	1	
16	SS	1	
17	SS	13	0 0 91 9
18	SS	10	
19	SS	7	

ELEVATION SCALE: 164, 163, 162, 161, 160, 159, 158, 157, 156, 155, 154, 153, 152, 151

Field vane sensitivity: 5, 4.



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

SUD-MTO 001 09111160014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:

Golder Associates

Foundation Design

RECORD OF BOREHOLE No C401-8

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01
DIST ______ HWY 69/522 I/C
DATUM GEODETIC

LOCATION N 5085999.8; E 221973.1
BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring
DATE August 23 and 24, 2012

ORIGINATED BY SA
COMPILED BY AC
CHECKED BY SEMC

SOIL PROFILE | SAMPLES (NUMBER, TYPE, "N" VALUES) | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED | PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ELEV / DEPTH	DESCRIPTION
	— CONTINUED FROM PREVIOUS PAGE —
149.5 / 30.5	END OF DCPT

Note:

1. Water level at ground surface (Elev. 180.0 m) upon completion of drilling.

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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No S401-17

 METRIC

PROJECT 09-1111-6014
W.P. 5347-08-01
DIST ______ HWY 69
DATUM GEODETIC

LOCATION N 5086126.4; E 221851.4
BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW casing and Wash Boring
DATE June 5, 2012

ORIGINATED BY ID
COMPILED BY AC
CHECKED BY SEMC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
180.1	GROUND SURFACE				
0.0	PEAT (Fibrous) Brown Wet	1	SS	WH	
179.7 / 0.4	Organic CLAY Soft Dark grey Wet	2	SS	WH	
		3	SS	WH	
177.1 / 3.0	CLAY Very soft to soft Grey Wet	4	SS	WH	
		5	SS	WH	
	Approximately 600 mm thick silt layer at 3.0 m depth	6	TO	PH	
	Approximately 150 mm thick sand seam at 6.1 m depth.	7	SS	WH	
172.9 / 7.2	SAND, trace to some silt Very loose Grey Wet	8	SS	3	0 90 8 2
171.4 / 8.7	CLAYEY SILT Very soft Grey Wet	9	SS	WH	
		10	SS	WH	
168.4 / 11.7	CLAY Firm to stiff Grey to brown Wet	11	SS	WH	
		12	TO	PH	

Continued Next Page

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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No S401-17

 METRIC

PROJECT 09-1111-6014			
W.P. 5347-08-01	LOCATION N 5086126.4; E 221851.4	ORIGINATED BY ID	
DIST ___ HWY 69	BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW casing and Wash Boring	COMPILED BY AC	
DATUM GEODETIC	DATE June 5, 2012	CHECKED BY SEMC	

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	GR	SA	SI	CL
	— CONTINUED FROM PREVIOUS PAGE —										
	CLAY Firm to stiff Grey to brown Wet Faint reddish-brown layers below 15.2 m depth.		13	SS	WH		165				
			14	SS	3		164, 163				
			15	SS	3		162, 161				
160.7 / 19.4	CLAYEY SILT Stiff Grey Wet		16	SS	3		160				
159.2 / 20.9	SILT, some clay Very loose to loose Grey Wet		17	SS	4		159	0	0	87	13
			18	SS	6		158, 157				
			19	SS	6		156				
155.1 / 25.0	END OF BOREHOLE Note: 1. Water level at a depth of 0.1 m below ground surface (Elev. 180.0 m) upon completion of										

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED — 20 40 60 80 100

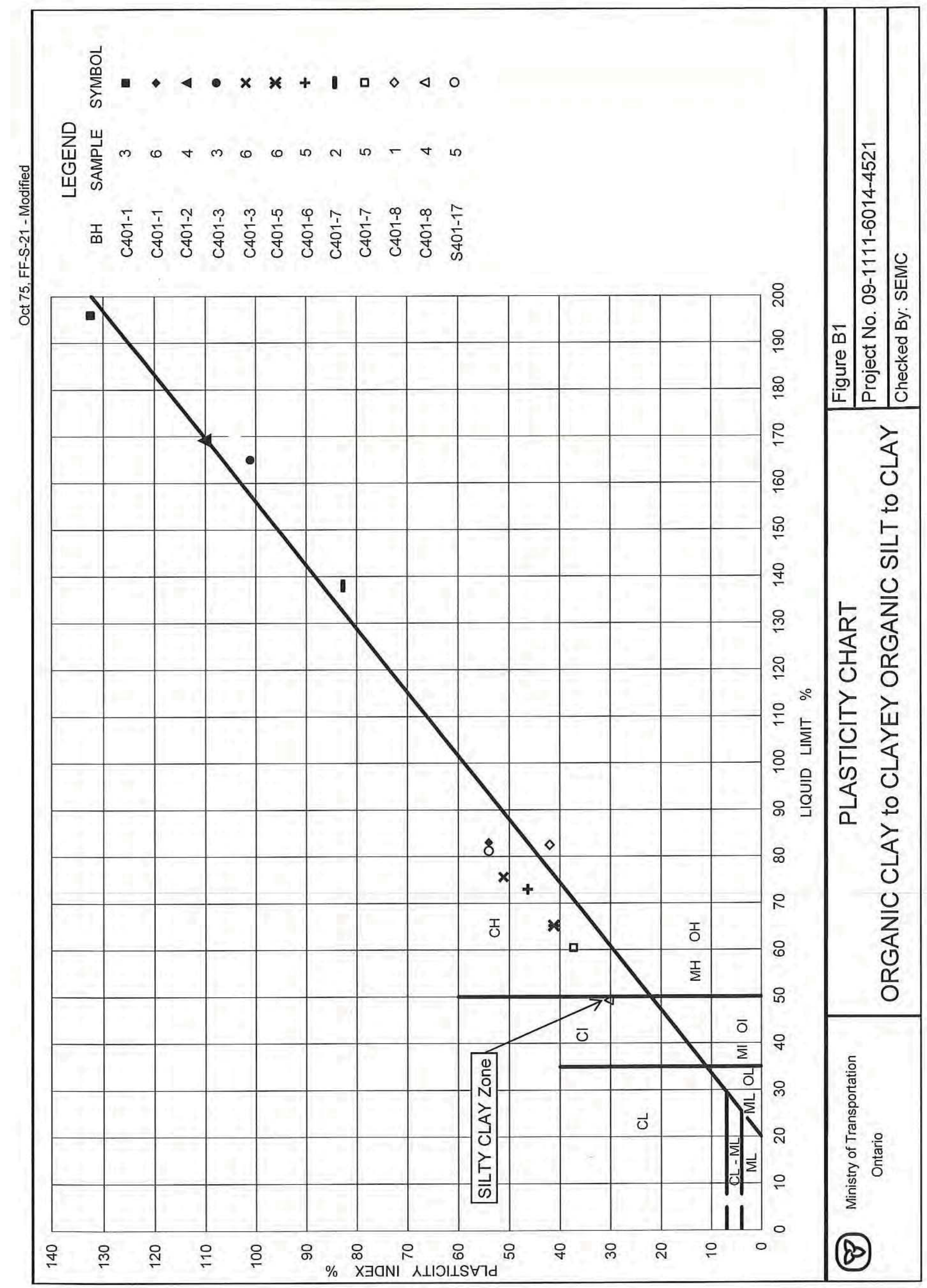
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

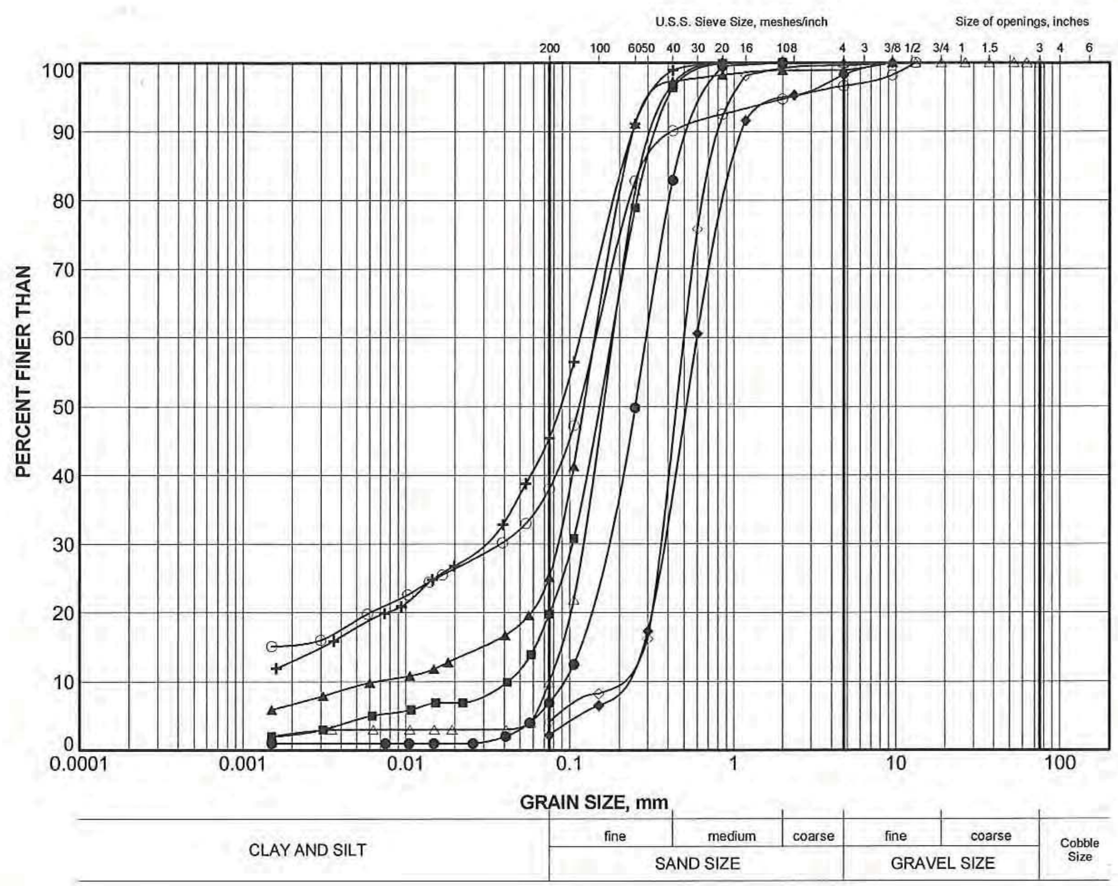
UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

$+^3, \times^3$: Numbers refer to Sensitivity $\bigcirc^{3\%}$ STRAIN AT FAILURE

SUD-MTO 001 091116014_T4521_C.GPJ GAL-MISS.GDT 14/05/13 DATA INPUT:





LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C401-2	8	172.2
■	C401-3	8	173.5
▲	C401-5	4	177.7
+	C401-5	7	173.9
◆	C401-6	7	173.5
◇	C401-7	8	172.1
○	C401-8	6	175.1
△	S401-17	8	172.2

PROJECT

HIGHWAY 69
CULVERTS - CONTRACT 4

TITLE

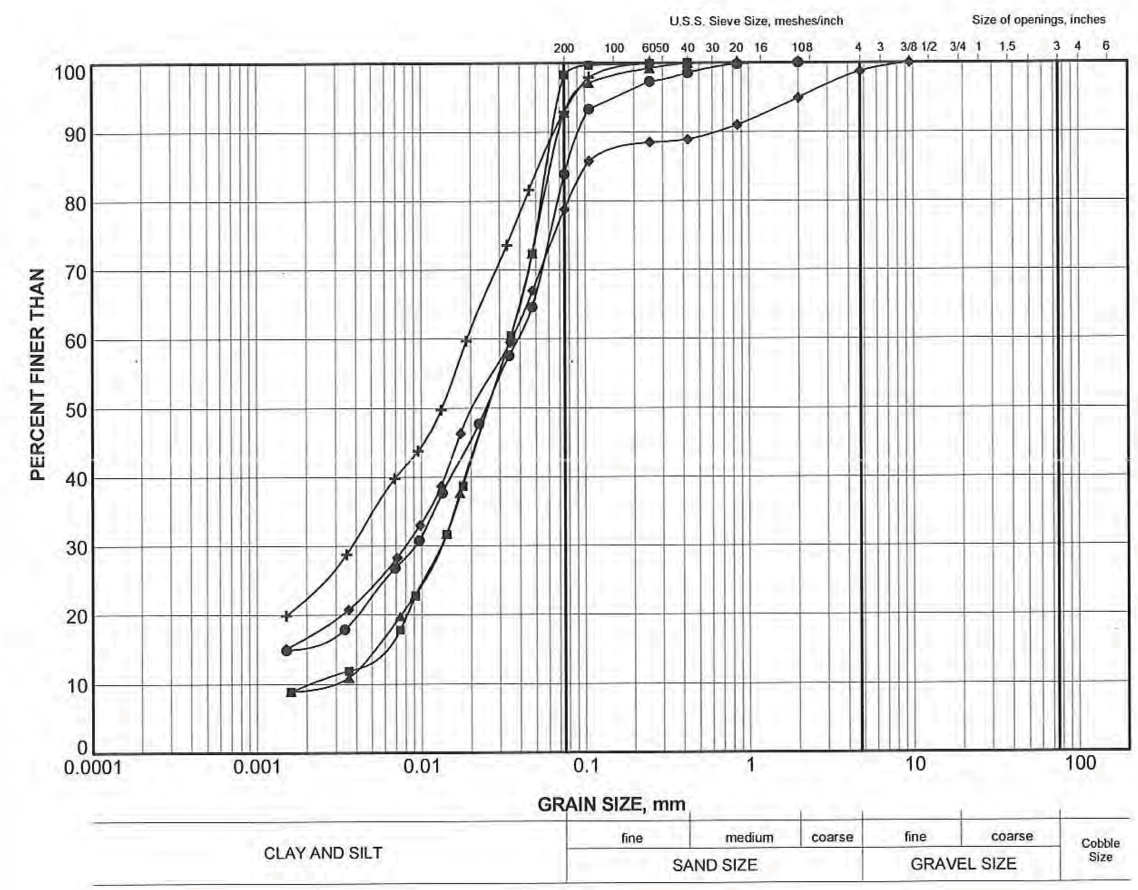
GRAIN SIZE DISTRIBUTION

SAND to SAND AND SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014	FILE 0911116014_T4521_C.GPJ	
DRAWN	TB	May 2013	SCALE N/A REV.
CHECK	SEMC	May 2013	FIGURE B2
APPR	JMAC	May 2013	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C401-1	8	172.1
■	C401-3	11	168.9
▲	C401-5	10	169.3
+	C401-6	10	168.9
◆	C401-8	8	172.1

PROJECT

HIGHWAY 69/522 I/C
CULVERTS - CONTRACT 4

TITLE

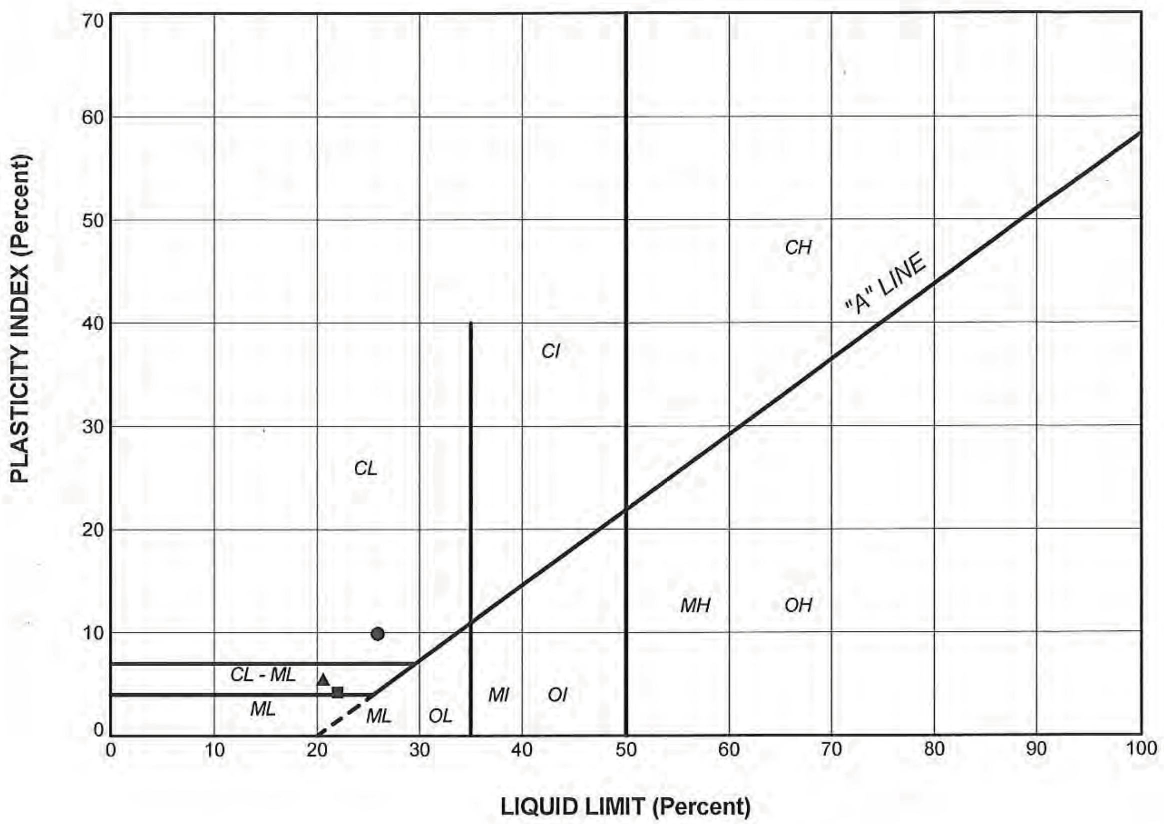
GRAIN SIZE DISTRIBUTION

CLAYEY SILT to SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014	FILE 0911116014_T4521_C.GPJ	
DRAWN	TB	May 2013	SCALE N/A REV.
CHECK	SEMC	May 2013	FIGURE B3
APPR	JMAC	May 2013	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C401-1	10	25.9	16.0	9.9
■	C401-2	9	22.0	17.8	4.2
▲	C401-8	8	20.6	15.1	5.5

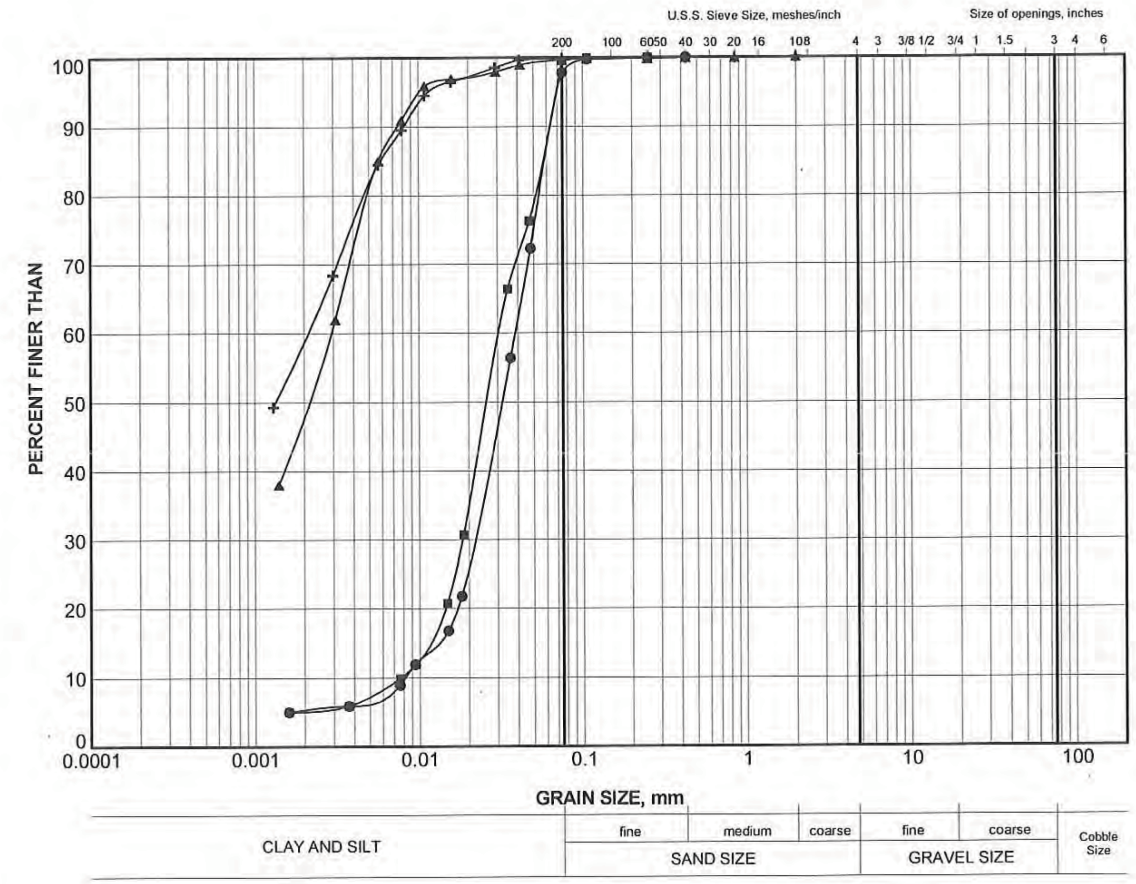
PROJECT
HIGHWAY 69/522 I/C
CULVERTS - CONTRACT 4

TITLE
PLASTICITY CHART
CLAYEY SILT to SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014		FILE No.0911116014_T4521_C.GPJ	
DRAWN	TB	May 2013	SCALE N/A	REV.
CHECK	SEMC	May 2013	FIGURE B4	
APPR	JMAC	May 2013		

SUD-MTO PL (NEW) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C401-2	13	164.6
■	C401-3	14	164.4
▲	C401-5	14	161.7
+	C401-6	14	162.8

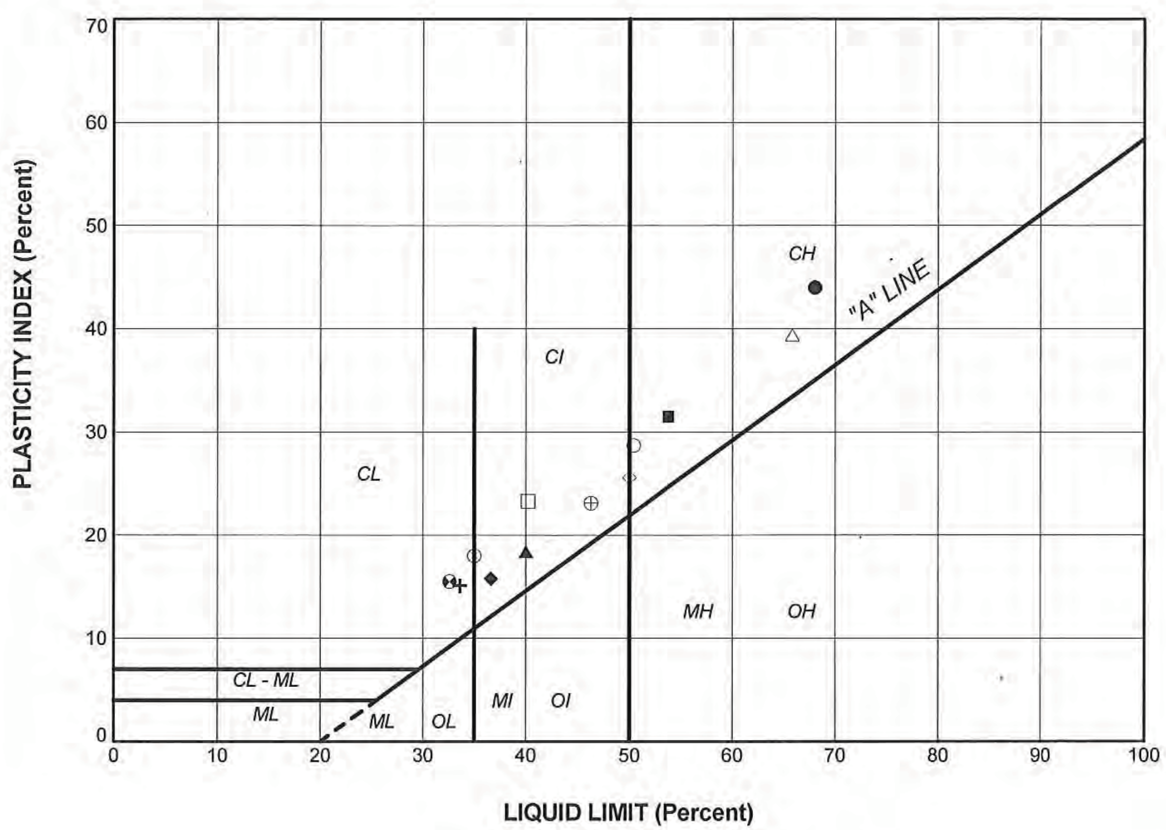
PROJECT
HIGHWAY 69/522 I/C
CULVERTS - CONTRACT 4

TITLE
GRAIN SIZE DISTRIBUTION
SILTY CLAY to CLAY

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014		FILE 0911116014_T4521_C.GPJ	
DRAWN	TB	May 2013	SCALE N/A	REV
CHECK	SEMC	May 2013	FIGURE B5	
APPR	JMAC	May 2013		

SUD-MTO GSD (NEW) GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C401-1	12	68.0	24.0	44.0
■	C401-2	11	53.8	22.3	31.5
▲	C401-2	15	40.0	21.6	18.4
✚	C401-3	13	33.6	18.5	15.1
◆	C401-5	13	36.6	20.8	15.8
◇	C401-5	14	50.0	24.4	25.6
○	C401-6	11	50.4	21.7	28.7
△	C401-6	14	65.8	26.4	39.4
⊗	C401-7	11	35.0	17.0	18.0
⊕	C401-7	15	46.3	23.2	23.1
□	C401-8	10	40.2	16.9	23.3
⊖	C401-8	13	32.6	17.1	15.5

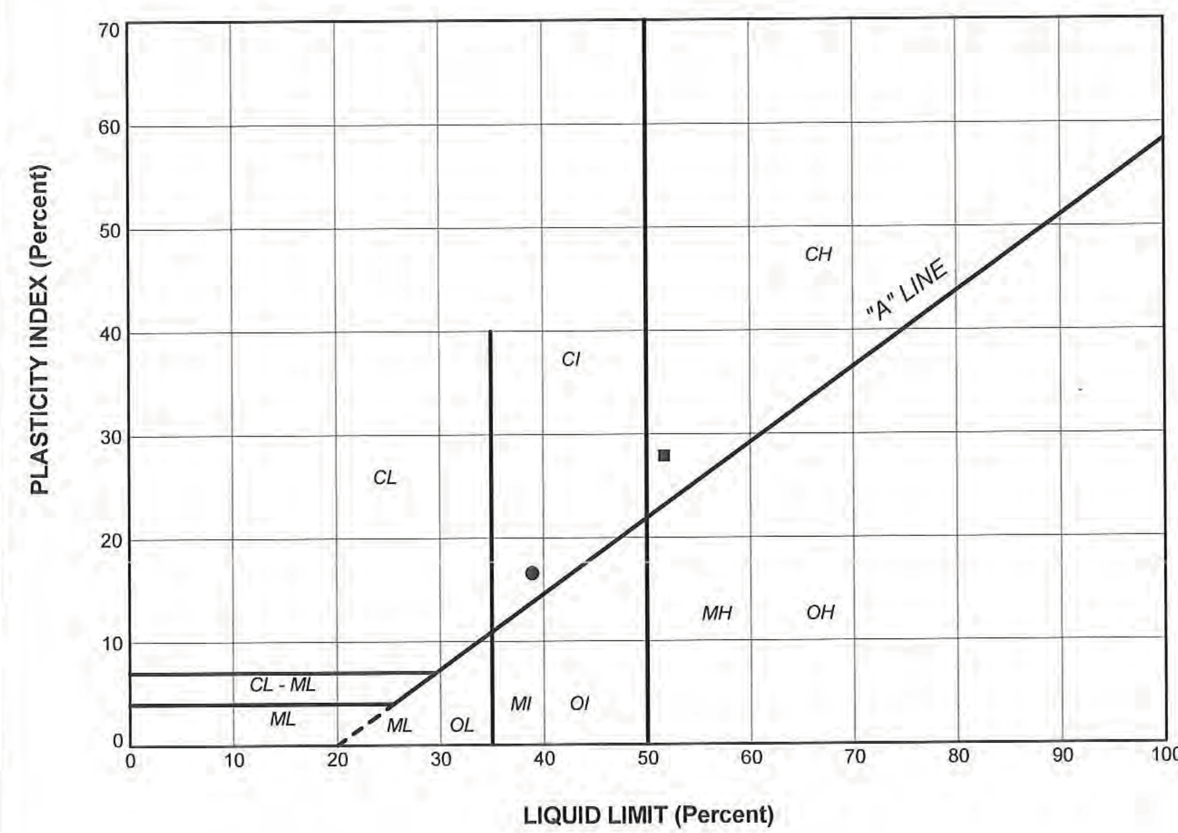
PROJECT
HIGHWAY 69/522 I/C
CULVERTS - CONTRACT 4

TITLE
PLASTICITY CHART
CLAYEY SILT to SILTY CLAY to CLAY

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014		FILE No.0911116014_T4521_C.GPJ
DRAWN	TB	May 2013	SCALE N/A REV.
CHECK	SEMC	May 2013	FIGURE B6.1
APPR	JMAC	May 2013	

SUD-MTO PL (NEW) GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C401-8	15	38.9	22.3	16.6
■	S401-17	13	51.7	23.8	27.9

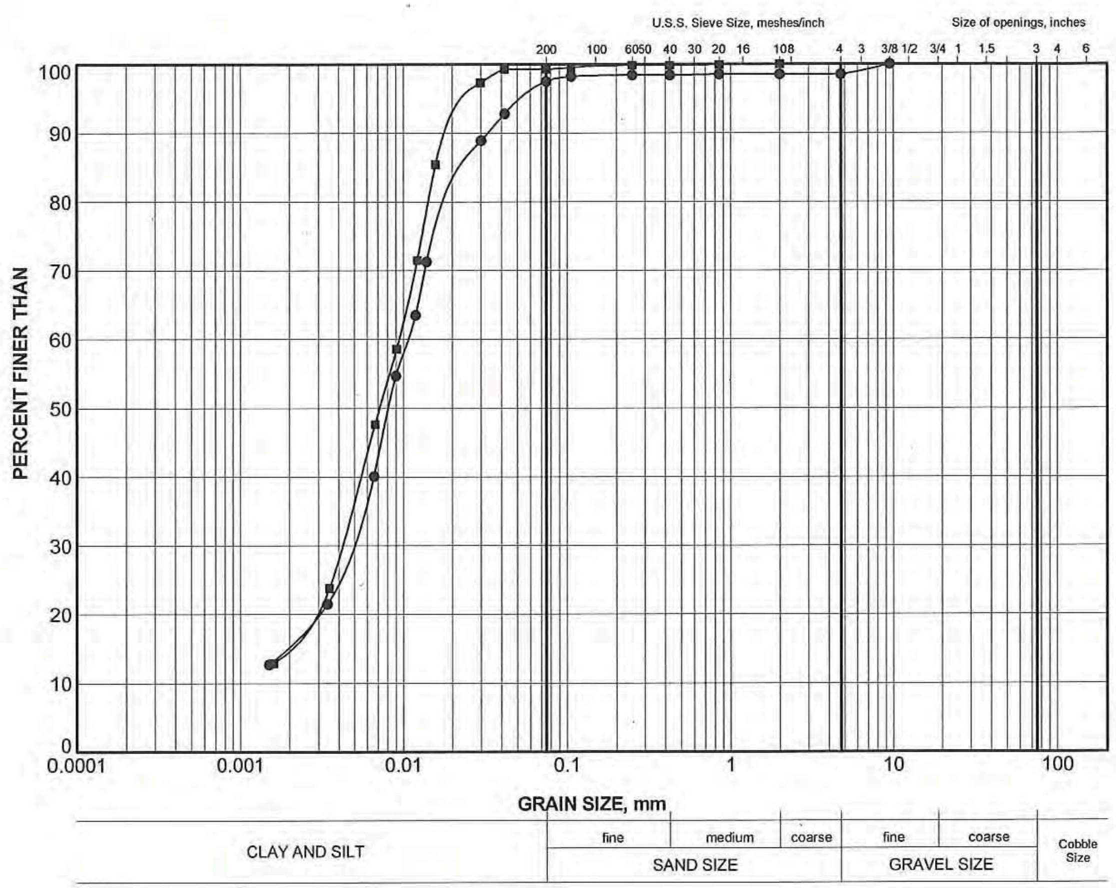
PROJECT
HIGHWAY 69
CULVERTS - CONTRACT 4

TITLE
PLASTICITY CHART
SILTY CLAY to CLAY

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014		FILE No.0911116014_T4521_C.GPJ
DRAWN	TB	May 2013	SCALE N/A REV.
CHECK	SEMC	May 2013	FIGURE B6.2
APPR	JMAC	May 2013	

SUD-MTO PL (NEW) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C401-1	16	159.9
■	C401-6	16	159.8

PROJECT

HIGHWAY 69/522 I/C
CULVERTS - CONTRACT 4

TITLE

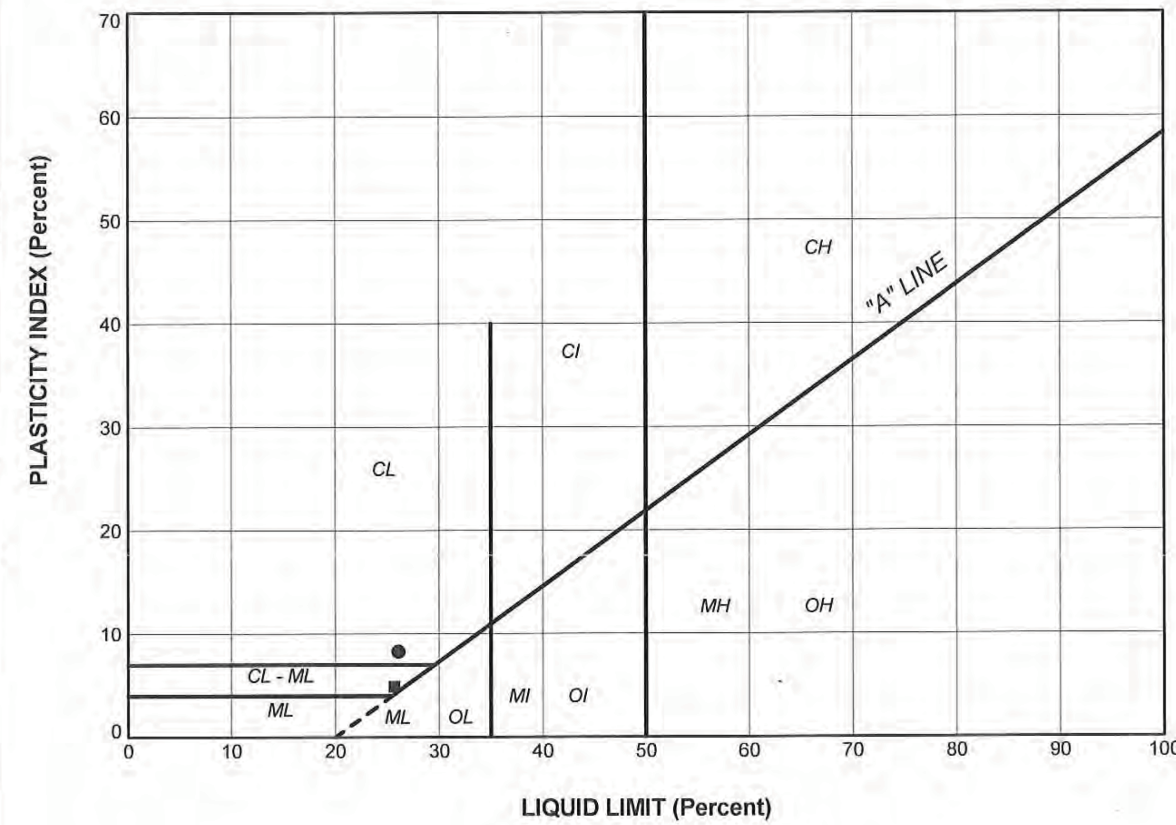
GRAIN SIZE DISTRIBUTION

CLAYEY SILT to SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014	FILE 0911116014_T4521_C.GPJ	
DRAWN	TB	May 2013	SCALE N/A	REV.
CHECK	SEMC	May 2013	
APPR	JMAC	May 2013	FIGURE B7

SUD-MTO GSD (NEW) GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C401-1	16	26.1	17.8	8.3
■	C401-6	16	25.7	20.8	4.9

PROJECT

HIGHWAY 69/522 I/C
CULVERTS - CONTRACT 4

TITLE

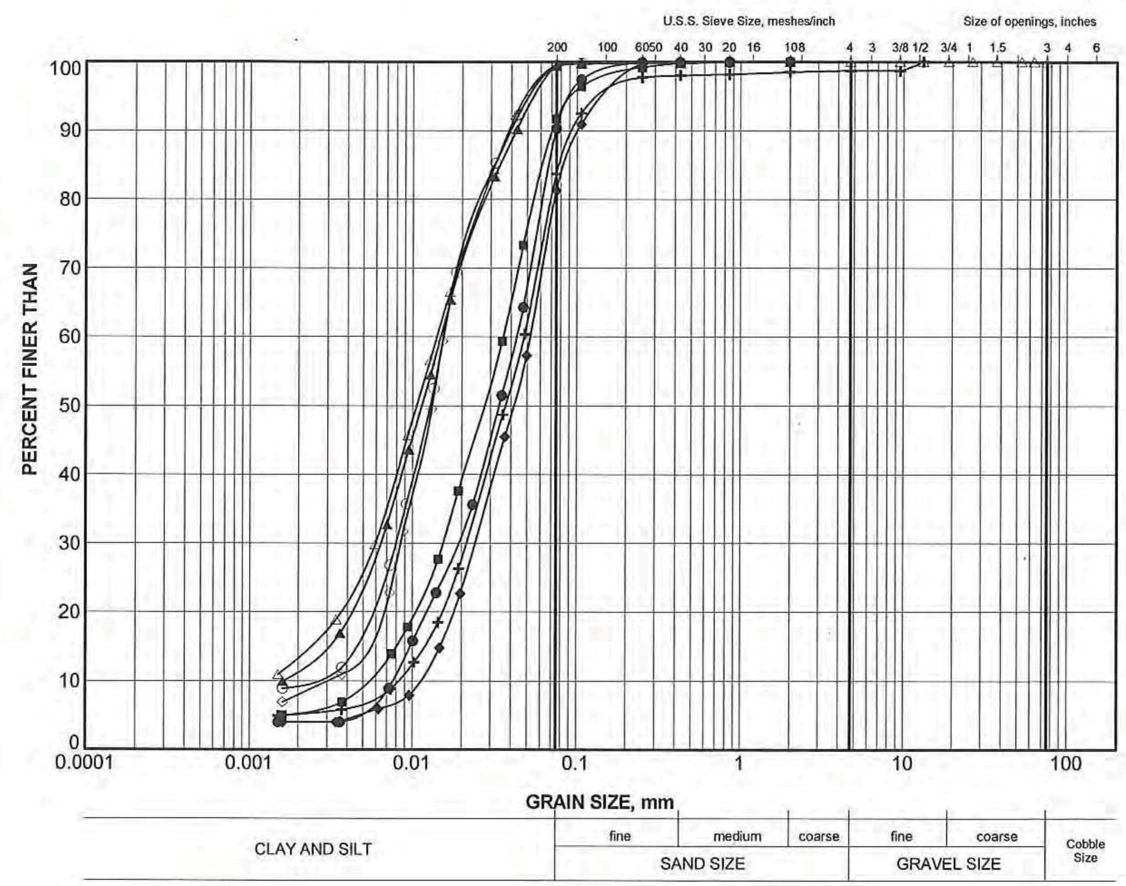
PLASTICITY CHART

CLAYEY SILT TO SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014	FILE No. 0911116014_T4521_C.GPJ	
DRAWN	TB	May 2013	SCALE N/A	REV.
CHECK	SEMC	May 2013	
APPR	JMAC	May 2013	FIGURE B8

SUD-MTO PL (NEW) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C401-1	18	156.8
■	C401-2	18	156.9
▲	C401-3	18	158.3
+	C401-5	18	155.6
◆	C401-6	19	155.2
◇	C401-7	17	158.4
○	C401-8	17	158.4
△	S401-17	17	158.5

PROJECT

HIGHWAY 69
CULVERTS - CONTRACT 4

TITLE

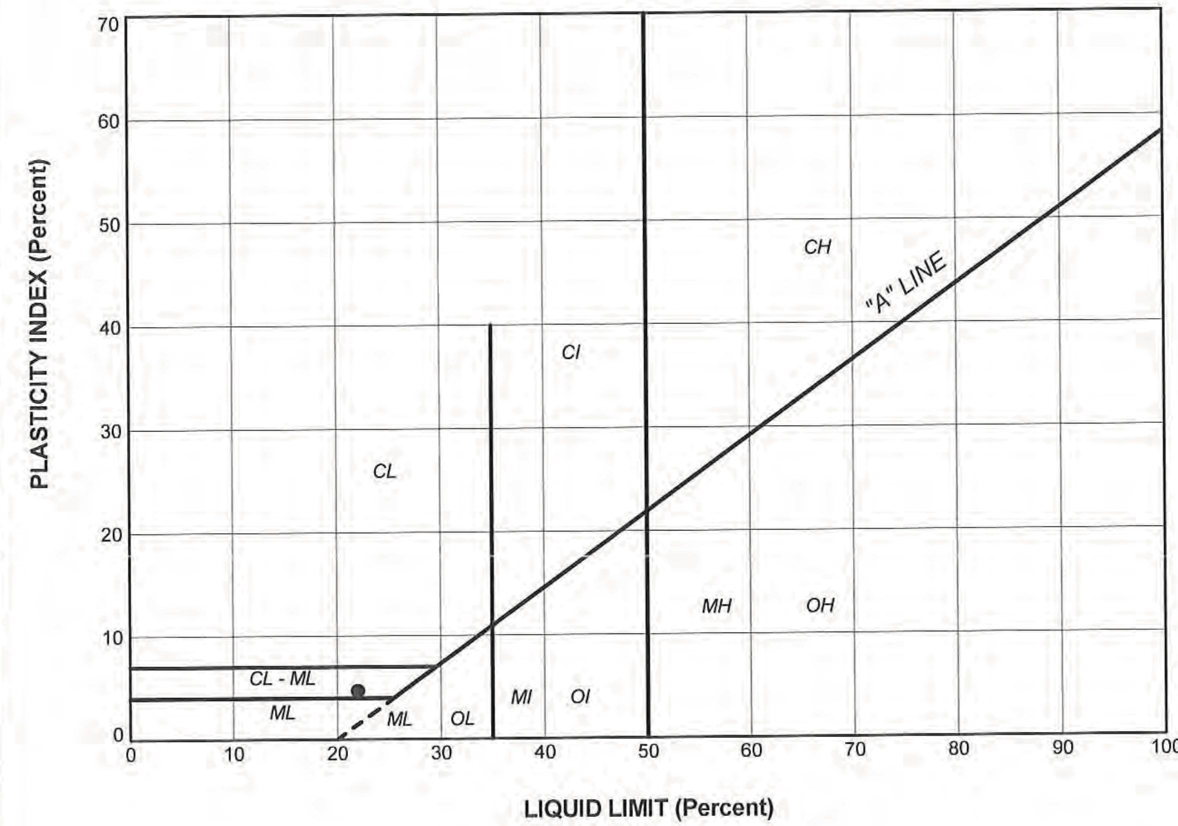
GRAIN SIZE DISTRIBUTION

SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014		FILE 0911116014_T4521_C.GPJ	
DRAWN	TB	May 2013	SCALE N/A	REV.
CHECK	SEMC	May 2013	FIGURE B9	
APPR	JMAC	May 2013		

SUD-MTO GSD (NEW) GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	S401-17	17	22.0	17.3	4.7

PROJECT

HIGHWAY 69
CULVERTS - CONTRACT 4

TITLE

PLASTICITY CHART

SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No	09-1111-6014		FILE No 0911116014_T4521_C.GPJ	
DRAWN	TB	May 2013	SCALE N/A	REV
CHECK	SEMC	May 2013	FIGURE B10	
APPR	JMAC	May 2013		

SUD-MTO PL (NEW) GLDR_LDN.GDT

SHEET T – CVM-13 – Fisheries/Wildlife Culvert (Station: ± 9+805 Hwy 522 – Mowat)

- Borehole Location Plan (PML)
- Record of Borehole Logs (PML)
- Laboratory Test Results (PML)

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field work for Culvert CVM-13 at Station 9+805, in the Township of Mowat (Site Nos. 044-0656/00 under the proposed Highway 522 alignment) was carried out on March 9, July 5 and 6, 2023.

2. Borehole Information

A total of three (3) boreholes were advanced along the alignment of the proposed culvert (Site No. 044-0656/00). Due to existing overhead and underground utility lines, the boreholes had to be relocated where field investigation could be carried out safely. The borehole locations were approved by the on-site CN personnel during site reconnaissance on March 2 and July 4, 2023. Flagging was provided by CN during the field investigation.

Refer to
- Structure and borehole location plan, and subsurface stratigraphy (Drawing T-1).
- Table T-1 for details of borehole origin, borehole location coordinates and borehole elevations/depths.
- Appendices B and C for Record of Borehole sheets and lab results showing details of the subsurface conditions at the borehole locations from current investigation.

Table T-1 Structural Culvert Borehole Information

Borehole ID	Borehole Location	MTM ON10 NAD 83 Coordinates		Ground Surface Elevation (m)	Borehole Depth (m)
		Northing (m)	Easting (m)		
CVM13-1	East End (Inlet)	5 086 239.5	221 668.9	180.7	15.8
CVM13-2	Median	5 086 254.1	221 628.6	180.7	15.8
CVM13-3	West End (Outlet)	5 086 275.0	221 595.1	182.4	12.8

2.1. Subsurface Conditions

The stratigraphy conceptually consists of alternating layers of cohesive and cohesionless soils to depths of 9.0 m to 10.0 m below ground surface. Below the alternating layers, firm to stiff cohesive soil deposits were encountered, which extended to the termination depths of the boreholes. Refer to the Record of Boreholes for details.

2.1.1. Alternating Layers

In Borehole CVM13-1, a 2.3 m thick silty clay was encountered at the ground surface, followed by 1.5 m thick very loose silty sand. A 2.3 m thick very soft silty clay to clay deposit was encountered below the silty sand, which extended to 6.1 m depth below ground surface. A 3.0 m thick loose silt layer was encountered below the very soft cohesive layer, which extended to 9.1 m depth below ground surface.

In Borehole CVM13-2, a 0.8 m thick very loose silty sand layer was encountered at the ground surface, overlying a 1.5 m thick stiff silty clay layer. A 0.7 m thick very loose sand was encountered immediately below the silty sand, followed by a 4.6 m thick soft to firm cohesive layer, which extended to a depth of 7.6 m below the ground surface. The cohesive layer was underlain by a 2.8 m thick sandy silt to silt deposit, extending to a depth of 10.4 m below the ground surface.

In Borehole CVM13-3, a 0.8 m thick organic clayey sand was encountered at the ground surface, followed by 1.5 m thick very loose sandy silt. A 4.6 m thick very stiff clayey silt to silty clay deposit was encountered below the sandy silt, which extended to a depth of 6.1 m depth below ground surface. at a depth of 3.0 m below the ground surface, this cohesive layer was intercepted by a 0.8 m very loose sand seam. A 3.0 m thick very loose silty sand layer was encountered below the very soft cohesive layer, which extended to 9.1 m depth below ground surface.

The SPT N values recorded from the non-cohesive layers ranged from as low as none (WH – penetration due to the weight of the hammer and rods) to 5 blows per 0.3 m penetration, indicating very loose to loose compactness. The moisture content determinations of samples tested from this layer ranged from 8.9% to 35.9%, with an average value of 26.9%. The grain size distribution results of the selected samples are provided in Figure GS-T-1.

The SPT N values recorded from the cohesive layers ranged from as low as none (WH – penetration due to the weight of the hammer and rods) to 7 blows per 0.3 m penetration, indicating very soft to firm consistency. In-situ vane shear test results were 41 kPa, 70 kPa, and 153 kPa, indicating a firm to very stiff consistency up to a depth of 3.0 m below the ground surface. Below 3.0 m depth, the values of the test results ranged from 12 kPa to 35 kPa, indicating very soft to firm consistency. The moisture content determinations of samples tested from this layer ranged from 24.5% to 88.2%, with an average value of 48.6%. The grain size distribution results of the selected samples are provided in Figure GS-T-2 and the Atterberg limits are presented in Figure PC-T-1.

2.1.1.1. Clayey Silt to Silty Clay

A 0.9 m thick deposit of clayey silt to silty clay was encountered below the alternating layer in all investigated boreholes at a depth of 9.1m to 10.4 m below the ground surface. This deposit was intercepted by a 0.6 m to 1.5 m thick firm to stiff clay layer at a depth of 11.9 m to 12.2 m below the surface. This deposit was not fully penetrated and extended to the borehole termination depths of 12.8 m to 15.8 m below the ground surface. The SPT N value recorded from this layer was 5 blows per 0.3 m penetration, indicating firm consistency. The moisture content determination of one (1) sample from this layer was 48.7%.

The SPT N values recorded from this deposit was none (WH – penetration due to the weight of the hammer and rods) per 0.3 m penetration, indicating very soft consistency. In-situ vane shear tests results ranged from 29 kPa to 94 kPa, indicating a firm to stiff consistency. The moisture content determinations of samples tested from this layer ranged from 24.5% to 88.2%, with an average value of 51.5%. The grain size distribution results of the selected sample are provided in Figure GS-T-3 and the Atterberg limits are presented in Figure PC-T-2.

2.2. Groundwater Conditions

Groundwater was not encountered inside any of the boreholes during drilling. Upon completion of drilling, groundwater levels were measured at depths 2.4 m (EL. 178.3), 2.4 m (EL. 178.3), and 2.1 m (EL. 180.3) below the existing ground surface in Boreholes CVM13-1, CVM13-2, and CVM13-3, respectively. The creek water level at the inlet of the existing culvert was measured at about EL. 178 m on July 6, 2023.

Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) are based on the following references:

1. Culvert Sections Drawings, provided by Parsons via email dated November 25, 2020

2. Highway 69 Profile Drawings, provided by Parson via email dated November 25, 2020

3. PROJECT DESCRIPTION

3.1. General

The proposed Fisheries/Wildlife (SAR) Culvert (Site No. 044-0656/00) will be installed under the new Highway 522 alignment and will replace the existing two CSP culverts along the existing creek alignment. The proposed culvert will cross the new Highway 522 alignment at Station 9+805, located in Mowat Township.

3.2. Proposed Structures

It is proposed that the culvert will have an opening size of 3.0 m in span, 2.4 m in height, will be approximately 144.5 m long, and will be on a skew of approximately 47 degrees from the new Highway 522 centreline alignment.

The existing ground surface elevation in the vicinity of the culvert alignments varies from approximately EL. 180.7 to EL. 182.4 m. The existing creek is generally flowing from east to west direction.

Based on the reference drawing, the proposed invert levels of the proposed culvert and inferred founding levels are summarized in Table T-2.

Table T-2: Box Culvert Founding Elevations at Station 9+805 (Site No. 44-0656/00)

FOUNDATION LOCATION	PROPOSED CULVERT INVERT ELEVATION	BOTTOM OF BOX CULVERT ELEVATION	SUBGRADE ELEVATION FOR GRANULAR BEDDING	FOUNDING STRATUM
West End (Inlet)	180.1 m	179.8 m	179.2 m	Firm Silty Clay
Middle Area (CVM13-2)	180.1 m	179.8 m	179.2 m	Stiff Silty Clay
East End (Outlet)	180.1 m	179.8 m	179.2 m	Very Loose Sand

Note(s): 1: The bottom thickness of the precast concrete box culvert is assumed 0.25 m (minimum).

The height of embankment fill required above the culvert to the proposed grades of Highway 522 at Station 9+805 will range approximately from 2.6 m to 11.0 m, including the pavement structure, above the existing ground surface. The proposed height of the new embankment will reach about EL. 192.9 at the highest point of the new embankment.

In the absence of any structural details of the culverts, it is assumed that concrete culvert and fill would impose a dead load of up to 180 kPa on the founding subgrade along the proposed culvert alignment.

4. Estimated Settlement

For this preliminary FDR, the compression index (Cc) value was estimated using the empirical formulae suggested by Koppula (1981)[1] and Rendon-Herrero (1980)[2]. Based on the estimate, an average Cc value ranging from 0.28 to 0.65, an average Cr value ranging from 0.028 to 0.065 ($1/10^{th}$ of Cc value), and the estimated void ratio (e_o) of 0.7 to 1.5 were used to estimate the magnitude of total settlement expected under the imposed load of up to 180 kPa. Preconsolidation pressure was estimated using the empirical formula suggested by Naval Facilities Engineering Command – Soil Mechanics Design Manual 7.01[3].

The estimated settlement due to primary consolidation is estimated 325 mm to 475 mm and the differential settlement is estimated 115 mm to 140 mm. It should be noted that the extent of the cohesive soil could surpass the termination depth of the investigated boreholes and could result in additional settlements than described above.

4.1. Evaluation of Foundation Alternatives

The foundation alternatives listed below are considered for the replacement culvert.

1. Precast concrete box culvert placed without Settlement Mitigation
2. Precast concrete box culvert after Surcharging
3. Corrugated Steel Plate (CSP) Arch Culvert

Option 1: Precast concrete box culvert placed without Settlement Mitigation

Such relatively large total and differential settlements are not acceptable, considering that the magnitudes are in excess of the tolerable settlement limits for a precast concrete box culvert, and can cause damage to the joints, leading to deterioration of the culvert. Therefore, factored geotechnical resistances at ULS and at SLS for 100 mm of differential settlement are not applicable since the option of placing the proposed culvert at ±EL. 179.2 m without settlement mitigation measures is not considered to be feasible.

[1] Koppula, S. (1981). "Statistical Estimation of Compression Index," Geotechnical Testing Journal, Vol. 4, No. 2, pp. 68-73.

[2] Rendon-Herrero, O. (1980). "Universal Compression Index Equation," Journal of the Geotechnical Engineering Division, ASCE, Vol. 106, No. GT11, pp.1179-1200.

[3] Naval Facilities Engineering Command. (1986). Soil Mechanics Design Manual 7.01, pp.141.

Option 2: Precast Concrete Box Culvert after Surcharging

Based on the estimated settlement, it is recommended to surcharge the culvert area prior to culvert installation. It is estimated that it may take up to 3.0 years for 90% consolidation. A coefficient of consolidation (C_v) of 0.0025 cm^2/s was assumed.

Since there is no existing road or proposed structure where the culvert is proposed, it is recommended that the construction of precast concrete box culvert be coordinated with the construction of the embankment fill. Wick drains and surcharge may be carried out simultaneously along the footprint of the culvert to accelerate the settlement. The scheme may require the placement of temporary CSP pipes under the embankment fill to allow for the local drainage of the creek, if required. At the appropriate time, the fill used for the surcharge and the temporary CSPs would be removed and the precast box culverts would be installed.

The details and design of the wick drain installation and surcharge fill should be carried out during the detail design phase.

Unsuitable/organic materials at the culvert locations should be excavated from the areas under and within the zone of influence of the culverts (minimum of 2 m beyond the culvert walls) and care should be exercised when preparing the subgrade for the embankment construction to minimize excavation concerns when installing the culvert. Following the wick drain/surcharging period, the exposed subgrade should be inspected and approved before placement of compacted granular materials as specified in OPSS 422.07.06.

The granular material to backfill the precast concrete box culvert should be placed in accordance with OPSS 422.07.07. Granular material should be as specified in accordance with OPSS 422.05.13 and may consist of either Granular ‘A’ or Granular ‘B’ Type II, including a 75 mm levelling course for bedding purposes as required by OPSS 422.07.08.

Option 3: Corrugated Steel Plate (CSP) Arch Culvert on NBL and SBL

Refer to the General Report for preliminary general recommendations for the use of Corrugated Steel Plate (CSP) arch culverts.

5. APPROACH EMBANKMENT

The maximum fill height of 11.0 m will be placed on compressible soils. The slopes of the embankment should not be steeper than 2H:1V for earth embankment and 1.25H:1V for rock-fill embankment. A minimum 2.0 m wide mid-height berms shall be provided for embankments that are 8.0 m high or more. The stability of the embankment should be verified during the detail design phase.

6. CULVERT BEDDING AND COVER MATERIALS

Refer to the General Report for preliminary recommendations for materials to be used for culvert bedding and cover purposes.

7. TEMPORARY FLOW DIVERSION AND TEMPORARY ROADWAY PROTECTION

Temporary flow diversion or channel will be required to replace the existing culvert in accordance with OPSS.PROV 517, amended by SSP 517F07. It is anticipated that open-cut method will be utilized to replace the existing culvert. Temporary roadway protection will be required in accordance with OPSS.PROV 539, amended by SSP 105S09. The Contractor is responsible for the selection, design, construction and performances of temporary flow channel, cofferdams, if utilized, and temporary roadway protection. Parameters and recommendations for design of temporary flow channel, cofferdam and roadway protection should be determined during the detail design phase of the project. The geotechnical parameters provided in Table T-3 may be used for the preliminary evaluation of temporary protection system.

Table T-3 Preliminary Geotechnical Design Parameters

SOIL TYPE	DESIGN PARAMETERS		UNIT WEIGHT, kN/m^3
	EFFECTIVE FRICTION ANGLE (θ)	UNDRAINED SHEAR STRENGTH, kPa (c_u)	
Sand (Fill)	30	-	19.0
Sand (Very loose)	26	-	17.5
Sand (Loose)	28	-	18
Sandy Silt (Very Loose)	25	-	17.5
Silty Sand (Very loose)	26	-	17.5
Silt (Very loose)	25	-	17.0
Silt (Compact)	28	-	18.5
Silty Clay/Clay (Soft)	-	25	17.5
Silty Clay/Clay (Firm)	-	35	17.5
Silty Clay/Clay (Stiff)	-	65	17.5

8. CONSTRUCTION CONSIDERATIONS

4.1. Excavation

The Contractor should consider the type of surcharge material over the culvert area to facilitate excavation and disposal or reuse of the temporary fill materials.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

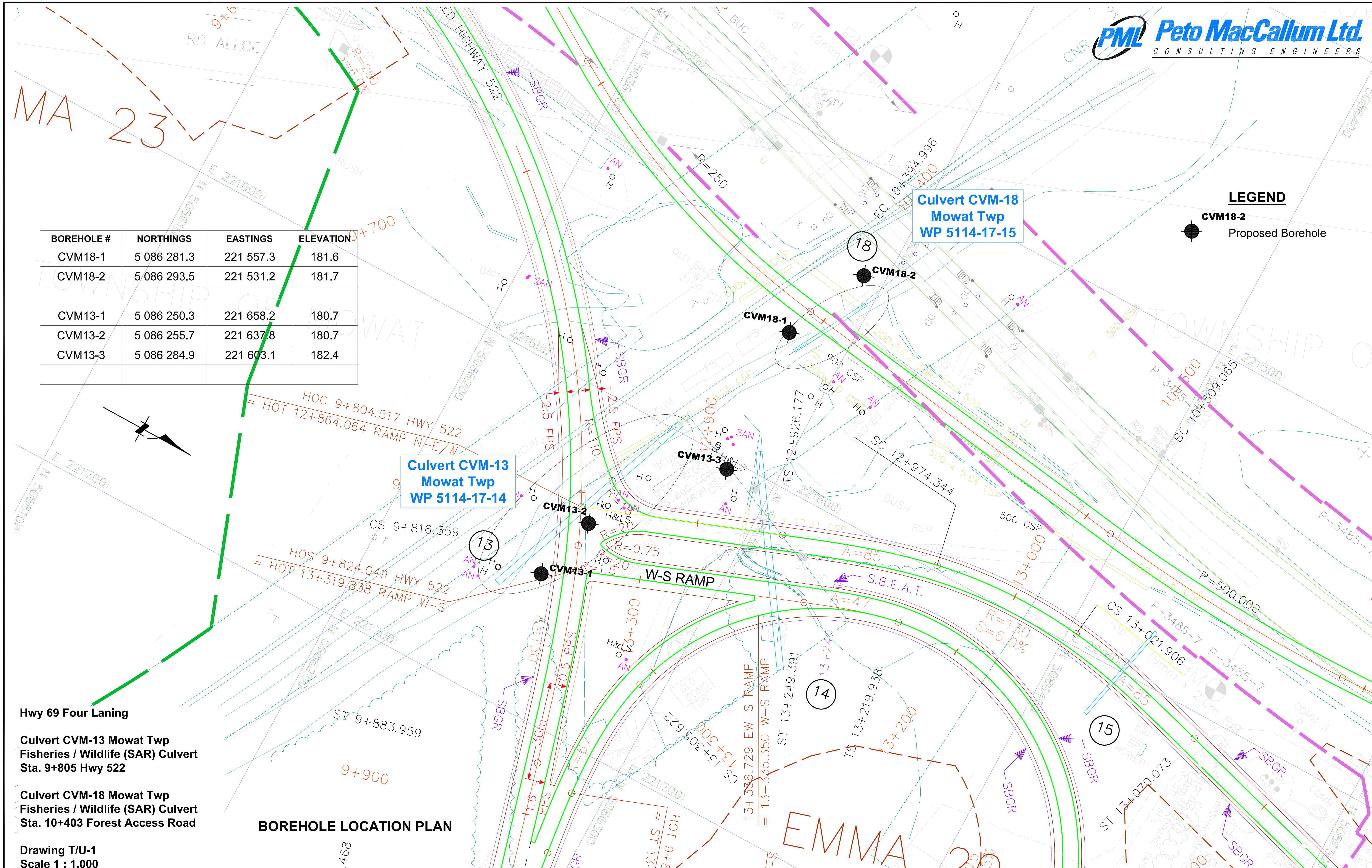
In accordance with OHSA, the fill and loose/stiff to firm soils are considered as Type 3 soils and very loose/very soft soils are considered as Type 4 soils. Soils that run or flow easily unless completely supported, and soils under groundwater are considered as Type 4 soils. The slope of excavation walls should conform to as described in Ont. Reg. 213/92, S. 234. Workers should not enter an unprotected excavation if there is evidence of ongoing groundwater seepage in the pits. Temporary shoring will be required if slopes as described in Ont. Reg. 213/92, S. 234 cannot be provided. Temporary shoring should be in accordance with OPSS.PROV 539, as amended.

Preliminary recommendations for backfilling to the culvert are provided in the General Report.

4.2. Groundwater and Surface Water Control

Dewatering may have to be carried out from wells installed along the interior periphery of the excavation to maintain the groundwater level a minimum 0.5 m depth below the base of the excavations. Surface water flow should be directed away from the excavation areas to mitigate disturbance of the native subgrade. For construction in-the-dry, the watercourse will have to be temporarily diverted.

Refer to the General Report for further groundwater control recommendations and requirements for water taking.



BOREHOLE #	NORTHINGS	EASTINGS	ELEVATION
CVM18-1	5 086 281.3	221 557.3	181.6
CVM18-2	5 086 293.5	221 531.2	181.7
CVM13-1	5 086 250.3	221 658.2	180.7
CVM13-2	5 086 255.7	221 637.8	180.7
CVM13-3	5 086 284.9	221 603.1	182.4

Hwy 69 Four Laning

Culvert CVM-13 Mowat Twp
Fisheries / Wildlife (SAR) Culvert
Sta. 9+805 Hwy 522

Culvert CVM-18 Mowat Twp
Fisheries / Wildlife (SAR) Culvert
Sta. 10+403 Forest Access Road

Drawing T/U-1
Scale 1 : 1,000

BOREHOLE LOCATION PLAN

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No CVM13-1

METRIC

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 086 239.5 N; 221 668.9 E | ORIGINATED BY H.C.

DIST ____ HWY 69 | BOREHOLE TYPE Continuous Flight Hollow Stem Augers | COMPILED BY N.L.

DATUM Geodetic | DATE 2023.07.06 | LATITUDE 45.911062 | LONGITUDE -80.571699 | CHECKED BY N.R.

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DCP / SHEAR STRENGTH kPa	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
180.7	Ground Surface							
0.0	SILTY CLAY, trace sand, organic inclusions Stiff to firm, mottled brown/grey, moist	1	SS	10				
		2	SS	2				
		FV	VANE			+ 4		
178.4 2.3	SILTY SAND, some silt Very loose, Grey, Wet	3	SS	2	▼			
		4	SS	WH				
176.9 3.8	SILTY CLAY to CLAY, some sand to sandy Very soft to soft, Grey, Wet	5	SS	WH			88	
		TW1	TW	PH				0 30 35 35
		6	SS	3				0 10 47 43
174.6 6.1	SILT, some sand Loose to very loose, Grey, Wet	7	SS	5				
		8	SS	2				
171.6 9.1	CLAYEY SILT to SILTY CLAY, trace sand Stiff, Grey, Wet	9	SS	WH				0 5 81 14
		FV	VANE			+ 2		
		10	SS	WH				
168.8 11.9	CLAY, trace sand Firm, Grey, Wet	FV	VANE			+ 2		
		11	SS	WH				0 1 40 59
167.3 13.4	SILTY CLAY/CLAYEY SILT, trace sand Stiff, Grey, Wet	FV	VANE			+ 2		
		12	SS	WH				
165.7								

Continued Next Page

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

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 23-7-25

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No CVM13-1

METRIC

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 086 239.5 N; 221 668.9 E | ORIGINATED BY H.C.

DIST ____ HWY 69 | BOREHOLE TYPE Continuous Flight Hollow Stem Augers | COMPILED BY N.L.

DATUM Geodetic | DATE 2023.07.06 | LATITUDE 45.911062 | LONGITUDE -80.571699 | CHECKED BY N.R.

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DCP / SHEAR STRENGTH kPa	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
165.7 15.0	CLAYEY SILT, trace sand Stiff, Grey, Wet	FV	VANE			+ 3		
		13	SS	WH				0 1 79 20
164.9 15.8	End of borehole ▼ Groundwater level measured upon completion of drilling WH Penetration due to weight of hammer and rods							

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

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 23-7-25

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No CVM13-2

METRIC

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 086 254.1 N; 221 628.6 E | ORIGINATED BY H.C.

DIST ____ HWY 69 | BOREHOLE TYPE Continuous Flight Hollow Stem Augers | COMPILED BY N.L.

DATUM Geodetic | DATE 2023.07.05 | LATITUDE 45.911108 | LONGITUDE -80.571963 | CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
180.7	Ground Surface							
0.0	SILTY SAND, organic inclusions Very loose, Brown, Moist	1	SS	4				
179.9 / 0.8	SILTY CLAY, trace sand, organic inclusions Stiff, Brown, Moist	2	SS	3				
		FV	VANE					
178.4 / 2.3	SILTY SAND Very loose, Grey, Wet	3	SS	2				
177.7 / 3.0	SILTY CLAY to CLAYEY SILT, trace sand Soft to firm, Grey, Wet	4	SS	WH				
		FV	VANE					
		5/TW1	SS	WH/PH	0	1	31	68
		FV	VANE					
		6	SS	WH	0	27	55	18
		FV	VANE					
173.1 / 7.6	SANDY SILT to SILT, trace clay Very loose, Grey, Wet	7	SS	1				
		8	SS	1	0	6	85	9
170.3 / 10.4	CLAYEY SILT to SILTY CLAY, trace sand Stiff, Grey, Wet	FV	VANE					
		9	SS	WH				
168.8 / 11.9	CLAY, trace sand Stiff, Grey, Wet	FV	VANE					
		10	SS	WH	0	2	39	59
167.3 / 13.4	SILTY CLAY, Stiff, Grey, Wet	FV	VANE					
		11	SS	WH				
165.7								

Continued Next Page

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT/GAS READING γ kN/m^3 / ppm/%; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Elevation scale: 180, 179, 178, 177, 176, 175, 174, 173, 172, 171, 170, 169, 168, 167, 166

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

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 23-7-25

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No CVM13-2

METRIC

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 086 254.1 N; 221 628.6 E | ORIGINATED BY H.C.

DIST ____ HWY 69 | BOREHOLE TYPE Continuous Flight Hollow Stem Augers | COMPILED BY N.L.

DATUM Geodetic | DATE 2023.07.05 | LATITUDE 45.911108 | LONGITUDE -80.571963 | CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES
165.7 / 15.0	SILTY CLAY, Stiff, Grey, Wet	FV	VANE	
		12	SS	WH
164.9 / 15.8	End of borehole			

Elevation scale: 165

▼ Groundwater level measured upon completion of drilling

WH Penetration due to weight of hammer and rods

NOTE: Thinwall Shelby Tube sample was extracted from a seperate borehole, immediately adjacent to CVM13-2 at a depth of 4.6 m below the existing ground surface.

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

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 23-7-25

RECORD OF BOREHOLE No CVM13-3

METRIC

PROJECT: Hwy 69 Structural Culvert	COORDINATES: Coords: 5 086 275.0 N; 221 595.1 E		ORIGINATED BY: H.C.
DIST:	HWY: 69	BOREHOLE TYPE: Continuous Flight Hollow Stem Augers	COMPILED BY: N.L.
DATUM: Geodetic	DATE: 2023.03.09	LATITUDE: 45.911366 LONGITUDE: -80.572415	CHECKED BY: N.R.

Column headings: SOIL PROFILE (ELEV / DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60); UNIT WEIGHT/ GAS READING (γ kN/m^3 / ppm/%); REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	Shear strength / water content notes	GR	SA	SI	CL
182.4	Ground Surface								
0.0	Organic CLAYEY SAND, trace gravel; Firm, Black, Wet	1	SS	7					
181.6 / 0.8	SANDY SILT, some clay, trace gravel; Very loose, Grey, Wet	2	SS	3					
180.9 / 1.5	CLAYEY SILT, trace sand; Very stiff, Grey, Wet	3	SS	3					
		FV	VANE		143				
179.4 / 3.0	SAND, some silt; Very loose, Grey, Wet	4	SS	2	non-plastic	0	83	11	6
178.6 / 3.8	SILTY CLAY, some sand; Very soft, Grey, Wet	5	SS	WH					
		FV	VANE						
		6	SS	2					
176.3 / 6.1	SILTY SAND; Very loose, Grey, Wet	7	SS	2					
		8	SS	4	non-plastic	0	66	31	3
173.3 / 9.1	SILTY CLAY, trace sand; Firm, Grey, Wet	9	SS	WH					
		FV	VANE		2				
		10	SS	WH					
		FV	VANE		3				
170.2 / 12.2	CLAY, trace silt; Firm, Grey, Wet	11	SS	WH		0	1	23	76
169.6 / 12.8	End of borehole								

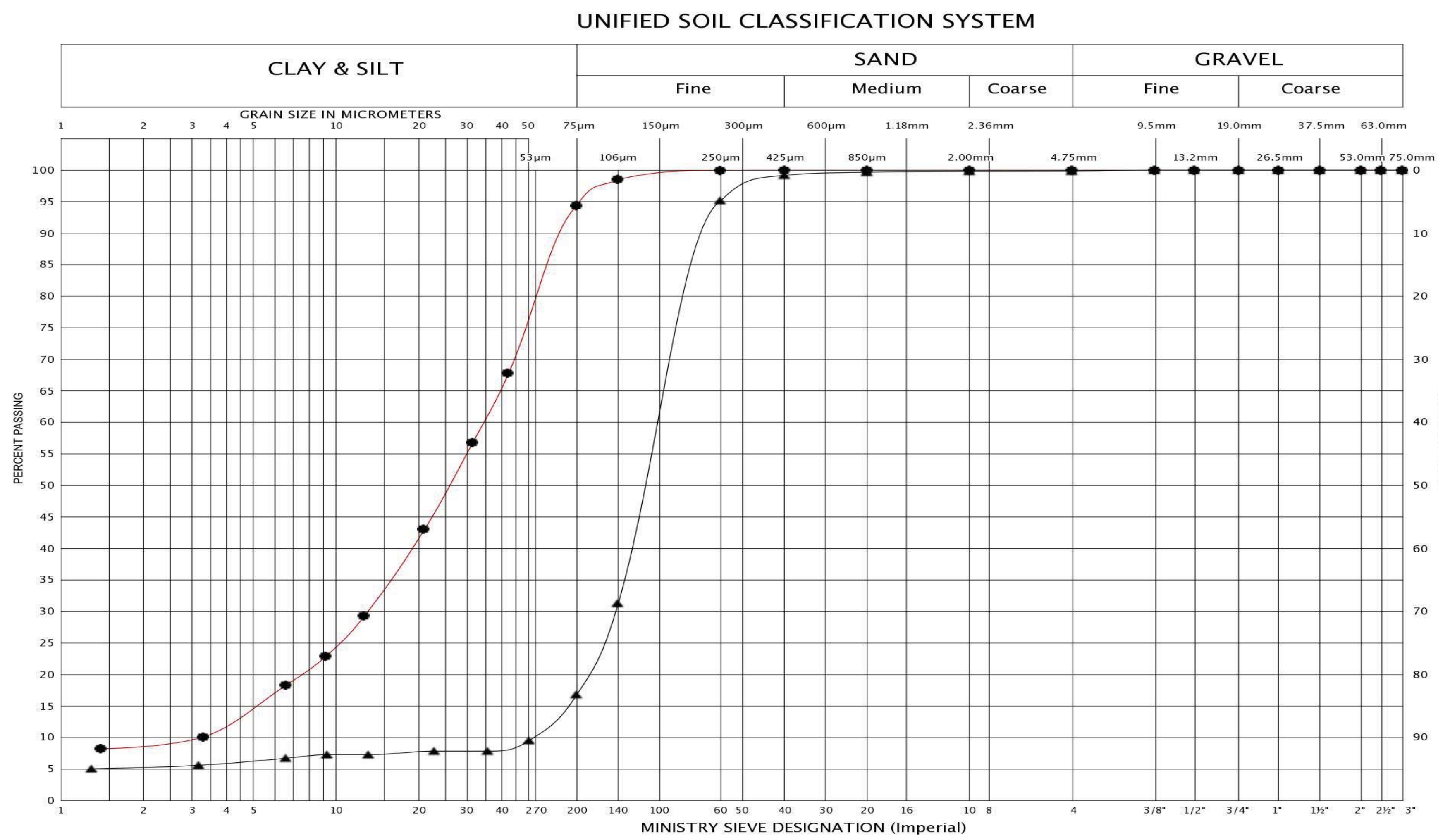
Elevation scale: 182, 181, 180, 179, 178, 177, 176, 175, 174, 173, 172, 171, 170

▼ Groundwater level measured upon completion of drilling

WH Penetration due to weight of hammer and rods

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE



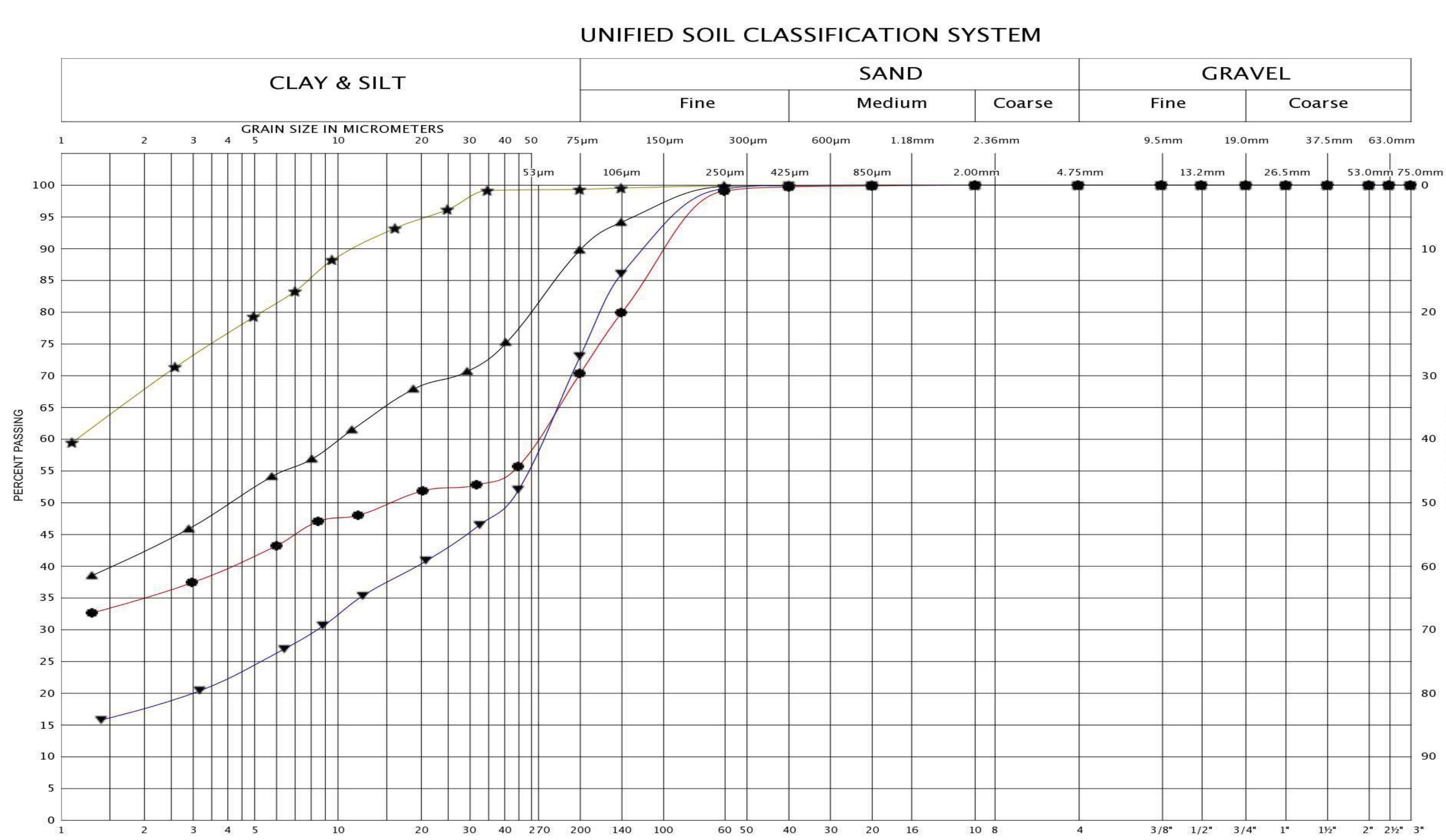
	BH	CVM13-2	CVM13-3
LEGEND	SAMPLE	8	4
	SYMBOL	●	▲

GRAIN SIZE DISTRIBUTION

SAND/SILTY SAND/SANDY SILT/SILT

Ontario

FIG No.: GS-T-1
HWY : 69
Project No.: 14TF034G



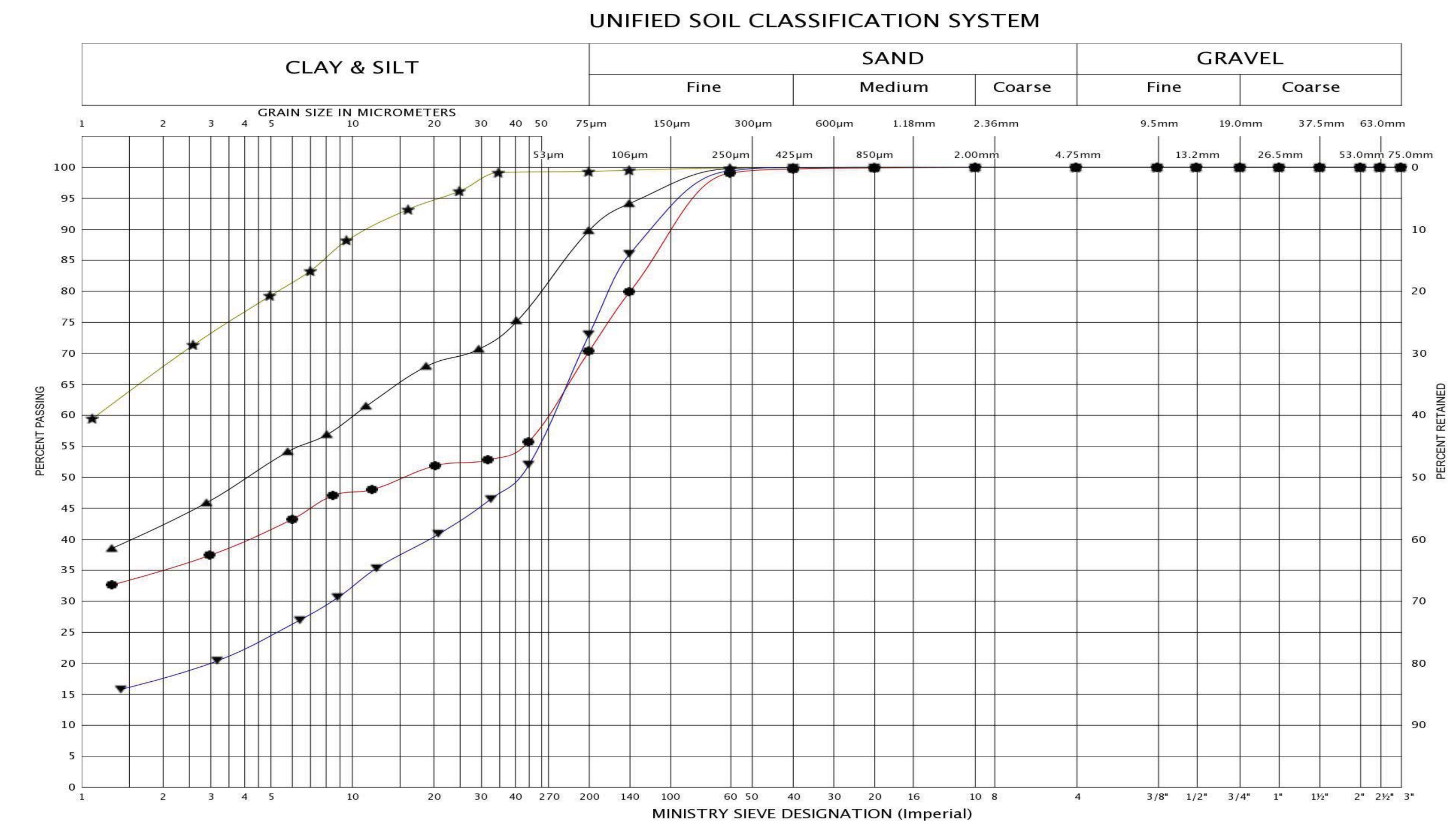
	BH	CVM13-1	CVM13-1	CVM13-2	CVM13-2
LEGEND	SAMPLE	TW1	6	TW1	6
	SYMBOL	●	▲	★	▼

GRAIN SIZE DISTRIBUTION

CLAY/SILTY CLAY/CLAYEY SILT

Ontario

FIG No.: GS-T-2
HWY : 69
Project No.: 14TF034G



LEGEND	BH	CVM13-1	CVM13-1	CVM13-1	CVM13-2	CVM13-3
	SAMPLE	9	11	13	10	11
	SYMBOL	●	▲	★	▼	■

Ontario

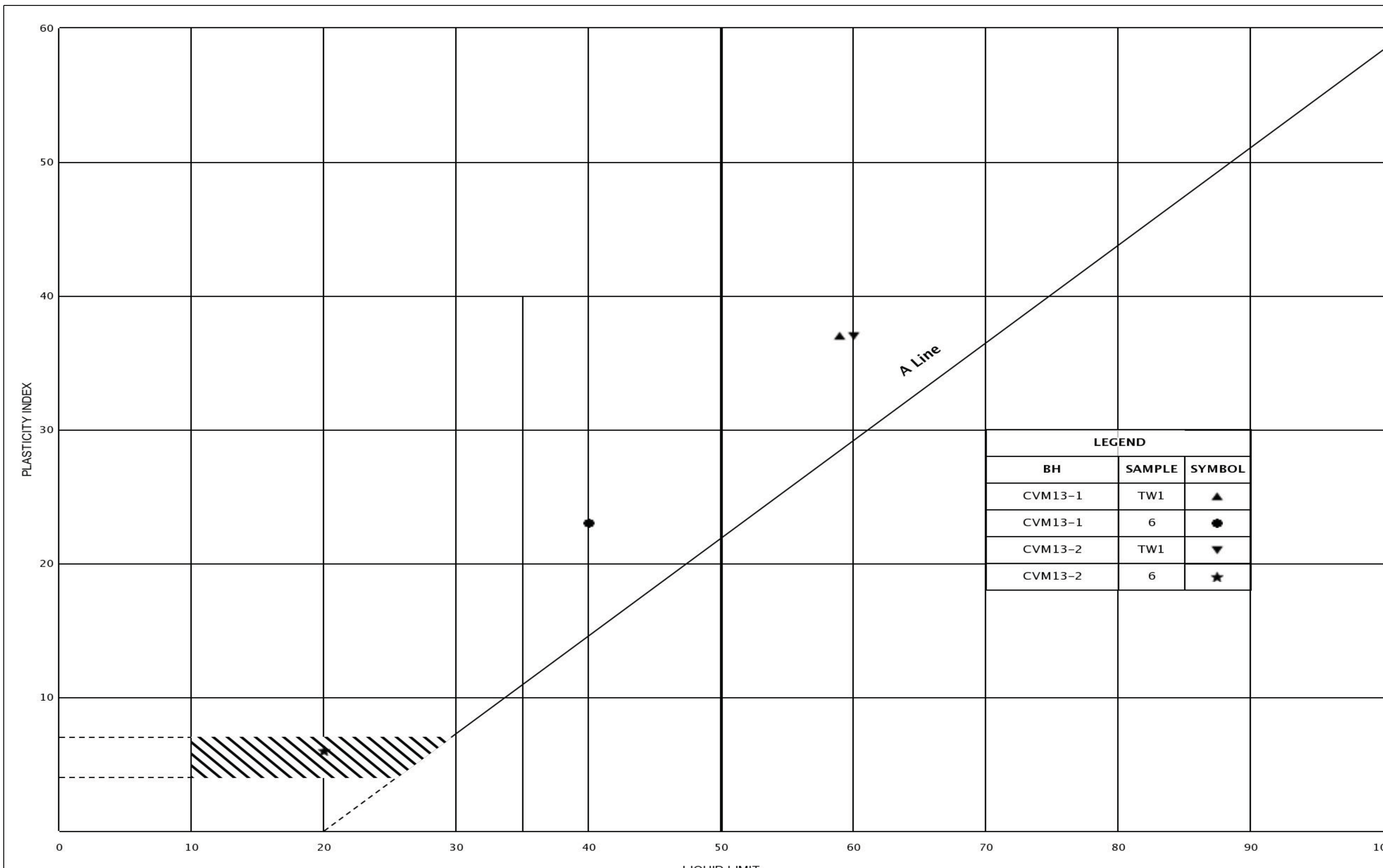
GRAIN SIZE DISTRIBUTION

CLAY/SILTY CLAY/CLAYEY SILT

FIG No.: GS-T-3

HWY : 69

Project No.: 14TF034G



Ontario

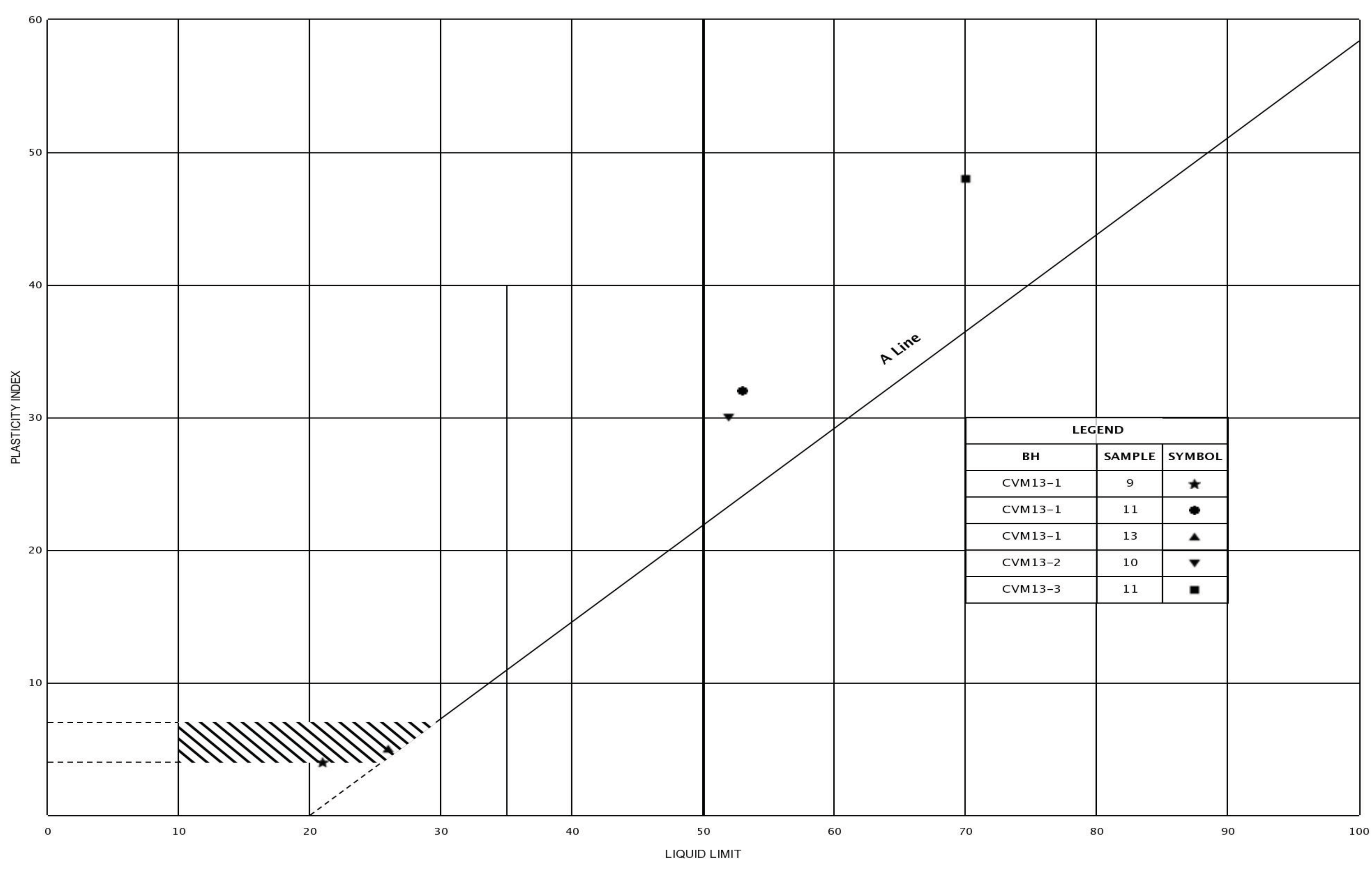
PLASTICITY CHART

CLAY/SILTY CLAY/CLAYEY SILT

FIG No.: PC-T-1

HWY.: 69

Proj No. 14TF034G



Ontario	PLASTICITY CHART CLAY/SILTY CLAY/CLAYEY SILT	FIG No.:	PC-T-2
		HWY.:	69
		Proj No.	14TF034G

SHEET U – CVM-18 – Fisheries/Wildlife Culvert (Station: ± 10+403 Forest Access Road – Mowat)

- Borehole Location Plan (PML)
- Record of Borehole Logs (PML)
- Laboratory Test Results (PML)

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field work for Culvert CVM-18 at Station 10+403, in the Township of Henvey (Site Nos. 044-0657/00under the NBL and SBL) was carried out on March 8 and 9, 2022.

2. Borehole Information

A total of two (2) boreholes were advanced along the alignment of the proposed replacement of the existing CSP culverts (Site No. 044-0657/00). Due to existing railway equipment and materials, and pile of snow placed along the bank of the creek, the boreholes had to be relocated 1.0 m south from the railway equipment and materials, and the snow pile. The borehole locations were approved by the on-site CN personnel during site reconnaissance on March 2, 2023. Flagging was provided by CN during the field investigation.

Refer to
- Structure and borehole location plan, and subsurface stratigraphy (Drawing U-1).
- Table U-1 for details of borehole origin, borehole location coordinates and borehole elevations/depths.
- Appendices B and C for Record of Borehole sheets and lab results showing details of the subsurface conditions at the borehole locations from current investigation.

Table U-1 Structural Culvert Borehole Information

Borehole ID	Borehole Location	UTM17 NAD 83 Coordinates		Ground Surface Elevation (m)	Borehole Depth (m)
		Northing (m)	Easting (m)		
CVM18-1	East	5086289.2	221562.5	181.6	12.0
CVM18-2	West	5086304.1	221536.6	181.7	10.7

2.1. Subsurface Conditions

The stratigraphy conceptually consists of approximately 0.8 m to 1.5 m of sand fill, followed by 2.3 m to 3.0 m of loose to very loose sand. Below the sand layer, the subsurface conditions varied widely between the two (2) investigated boreholes. In Borehole CVM18-1, the sand layer was followed by 6.1 m sandy silt to silty sand layer, underlain by silty clay to clay to the termination depth of drilling. In Borehole CVM18-2, the sand layer was followed by a 4.6 m layer of sandy clayey silt, underlain by silt to the termination depth of drilling. Refer to the Record of Boreholes for details.

The subsurface conditions at this site can be categorized into six (6) general layers as presented below from surface downwards.

2.1.1. Sand, Some Gravel, Trace Silt Fill

Immediately below the ground surface in Boreholes CVM18-1 and CVM18-2, a 0.8 m to 1.5 m thick sand layer was encountered. The SPT N values varied from 18 blows to 69 blows per 0.3 m penetration for this fill layer, indicating a compact to very dense state of compaction. Moisture content determinations performed on samples from this layer ranged between 4.0% and 14.0%, with an average value of 9.6%.

2.1.2. Sand, Some Silt, Trace Gravel

A 2.3 m to 3.0 m thick layer of sand was encountered below the fill in Boreholes CVM18-1 and CVM18-2, respectively. The SPT N values in this layer ranged from as low as 1 blow to 10 blows per 0.3 m penetration, indicating a very loose to loose state of compactness. The moisture content determinations performed on samples from this layer ranged from 21.6% to 27.7%, with the exception of one (1) sample from which was 73.7%. The grain size distribution results of the selected sample are provided in Figure GS-U-1.

2.1.3. Sandy Silt to Silty Sand, Trace Gravel

This 6.1 m thick sandy silt to silty sand deposit was encountered below the sand layer in Borehole CVM18-1. The SPT N value recorded in this layer ranged from as low as none (WH – penetration due to the weight of the hammer and rods) to 1 blow per 0.3 m penetration, indicating a very loose state of compactness. Moisture content determinations of two (2) samples tested from this layer were 20.0% and 23.0%. The moisture content determination of one (1) sample was 73.4%. The grain size distribution results of the selected sample are provided in Figure GS-U-2 and the Atterberg limits are presented in Figure PC-U-1.

2.1.4. Sandy clayey silt

A 4.6 m thick layer of sandy clayey silt was encountered below the sand layer in Borehole CVM18-2. The SPT N value recorded in this layer ranged from none (WH – penetration due to the weight of the hammer and rods) to 1 blow per 0.3 m penetration, indicating very soft consistency. In-situ vane shear test results for this layer ranged from 18 kPa to 35 kPa, indicating soft to firm consistency. The moisture content determinations of samples tested from this layer ranged from 28.7% to 78.1%, with an average value of 46.4%. The grain size distribution results of the selected sample are provided in Figure GS-U-3 and the Atterberg limits are presented in Figure PC-U-2.

2.1.5. Silt

This silt layer was encountered below the sandy clayey silt deposit in Borehole CVM18-2, and extended to the borehole termination depth of 10.7 m (EL. 171.0), below the ground surface. The SPT N values recorded in this layer were none (WH – penetration due to the weight of the hammer and rods) per 0.3 m penetration, indicating very loose compactness. The moisture content determinations of two (2) samples tested from this layer were 34.3% and 34.7%. The grain size distribution results of the selected sample are provided in Figure GS-U-4.

2.1.6. Clay

This clay deposit was encountered immediately below the sandy silt layer in Borehole CVM18-1, extending to the borehole termination depth of 12.0 m below the existing ground surface. The SPT N value recorded was 2 blows per 0.3 m penetration, indicating very soft consistency. An in-situ vane shear test performed obtained a test result of 29 kPa for this layer, indicating firm consistency. Moisture content determinations of one (1) sample tested from this layer was 64.7%. The grain size distribution result of a selected clay sample is provided in Figure GS-U-5 and the Atterberg limits are presented in Figure PC-U-3.

2.2. Groundwater Conditions

Groundwater was not encountered inside any of the boreholes during drilling. Upon completion of drilling, groundwater levels were measured at depths 1.5m (EL. 180.0), 2.1m (EL. 179.6) below the existing ground surface in Boreholes C18-1 and C18-2, respectively. The creek water level at the time of the investigation was approximately at EL. 179 on March 10, 2023.

Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) are based on the following references:

1. Culvert Sections Drawings, provided by Parsons via email dated November 25, 2020
2. Highway 69 Profile Drawings, provided by Parson via email dated November 25, 2020

3. PROJECT DESCRIPTION

3.1. General

The proposed Fisheries/Wildlife (SAR) Culvert (Site No. 044-0657/00) will replace the existing two (2) CSP culverts under the existing gravel roadway. The proposed culvert will cross the new Forest Access Road alignment at Station 10+403, located in Mowat Township.

3.2. Proposed Structures

It is proposed that the culvert will have an opening size of 3.0 m in span, 2.4 m in height, will be approximately 26.0 m long, and will be on a skew of approximately 110 degrees from the new Forrest Access Road centreline alignment.

The existing ground surface elevation in the vicinity of the culvert alignments varies from approximately EL. 181.6 to EL. 182.2 m. The existing creek is generally flowing from east to west direction.

Based on the reference drawing, the proposed invert level of the proposed culvert and inferred founding levels are summarized in Table U-2.

Table U-2: Box Culvert Founding Elevations at Station 10+403 (Site No. 044-0657/00)

FOUNDATION LOCATION	PROPOSED CULVERT INVERT ELEVATION	BOTTOM OF BOX CULVERT ELEVATION	SUBGRADE ELEVATION FOR GRANULAR BEDDING	FOUNDING STRATUM
West End (Inlet) (CVM18-2)	180.1 m	179.8 m	179.2 m	Loose Sand
East End (Outlet) (CVM 18-1)	180.1 m	179.8 m	179.2 m	Very Loose Sand

Note(s): 1: The bottom thickness of the precast concrete box culvert is assumed 0.25 m (minimum).

The height of embankment fill required above the culvert to the proposed grades of Forest Access Road at Station 10+403 is not expected to exceed 1.5 m, including the pavement structure. The height of the existing embankment is about EL. 182.2 and the proposed height of the new embankment will reach about EL. 183.2 at the highest point of the new embankment.

In the absence of any structural details of the culvert, it is assumed that the concrete culvert and fill would impose a dead load of 35 kPa to 55 kPa on the founding subgrade along the proposed culvert alignment.

4. EVALUATION OF FOUNDATION ALTERNATIVES

The foundation alternatives listed below are considered for the replacement culvert.

1. Precast concrete box culvert
2. Cast-in-place concrete culvert

For both options, assuming that the culvert is placed at the proposed subgrade level of EL. 179.2 m, loose to very loose cohesionless soils are expected underneath the base of the culvert. It is recommended to excavate the existing loose to very loose cohesionless soils to elevations 177.8 m to 177.9 m along the length of the proposed culvert, and replace with compacted granular material ‘A’ or ‘B’ Type. For design purposes, factored geotechnical resistances of 150 kPa and 100 kPa at ULS and SLS, respectively, may be considered for the 1.3 m to 1.4 m thick granular material. No major settlement issue is expected under the imposed load of up to 55 kPa at the culvert location following the subgrade treatment as discussed above.

To limit the degradation of the founding soil, it is recommended that 100 mm thick concrete working slab (lean concrete) be placed on subgrade within four hours after preparation, inspection and approval of the foundation subgrade for both options.

From a geotechnical perspective, both options are feasible. However, precast box culvert construction can be carried out faster than cast-in-place open footing culvert construction resulting in shorter durations for dewatering. Furthermore, the precast box culvert will be more tolerant to the total and differential settlement.

5. CULVERT BEDDING AND COVER MATERIALS

Refer to the General Report for preliminary recommendations for materials to be used for culvert bedding and cover purposes.

6. TEMPORARY FLOW DIVERSION AND TEMPORARY ROADWAY PROTECTION

For both options, temporary flow diversion or channel will be required to replace the existing culvert in accordance with OPSS.PROV 517, amended by SSP 517F07. It is anticipated that open-cut method will be utilized to replace the existing culvert. Temporary roadway protection will be required in accordance with OPSS.PROV 539, amended by SSP 105S09. The Contractor is responsible for the selection, design, construction and performances of temporary flow channel, cofferdams, if utilized, and temporary roadway protection. Parameters and recommendations for design of temporary flow channel, cofferdam and roadway protection should be determined during the detail design phase of the project. The geotechnical parameters provided in Table U-3 may be used for the preliminary evaluation of temporary protection system.

Table U-3 Preliminary Geotechnical Design Parameters

SOIL TYPE	DESIGN PARAMETERS		UNIT WEIGHT, kN/m³
	EFFECTIVE FRICTION ANGLE (θ)	UNDRAINED SHEAR STRENGTH, kPa (c_u)	
Sand (Fill)	30	-	19.0
Sand (Very loose)	26	-	17.5
Sand (Loose)	28	-	18
Sandy Silt (Very Loose)	25	-	17.5
Silty Sand (Very loose)	26	-	17.5
Silt (Very loose)	25	-	17.0
Silt (Compact)	28	-	18.5
Silty Clay/Clay (Soft)	-	25	17.5

7. APPROACH EMBANKMENT

No instability problems are anticipated for the approach embankment as the height of the maximum fill to be placed is approximately 1.5 m. Any soft or compressible zones observed should be removed prior to placing the fill.

8. CONSTRUCTION CONSIDERATIONS

8.1. Staged Construction

The removal of the existing culvert and construction of the new culvert is expected to be carried out in stages. The details of the staged construction should be finalized during the detail design phase of the project.

8.2. Excavation

Considering the existing ground level (EL. 181.6 m to EL. 182.2 m) and the subgrade treatment depth as discussed in Section 4 of this Sheet, 3.8 m to 4.4 m deep excavations into existing soils are required for subgrade preparation and culvert installation.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

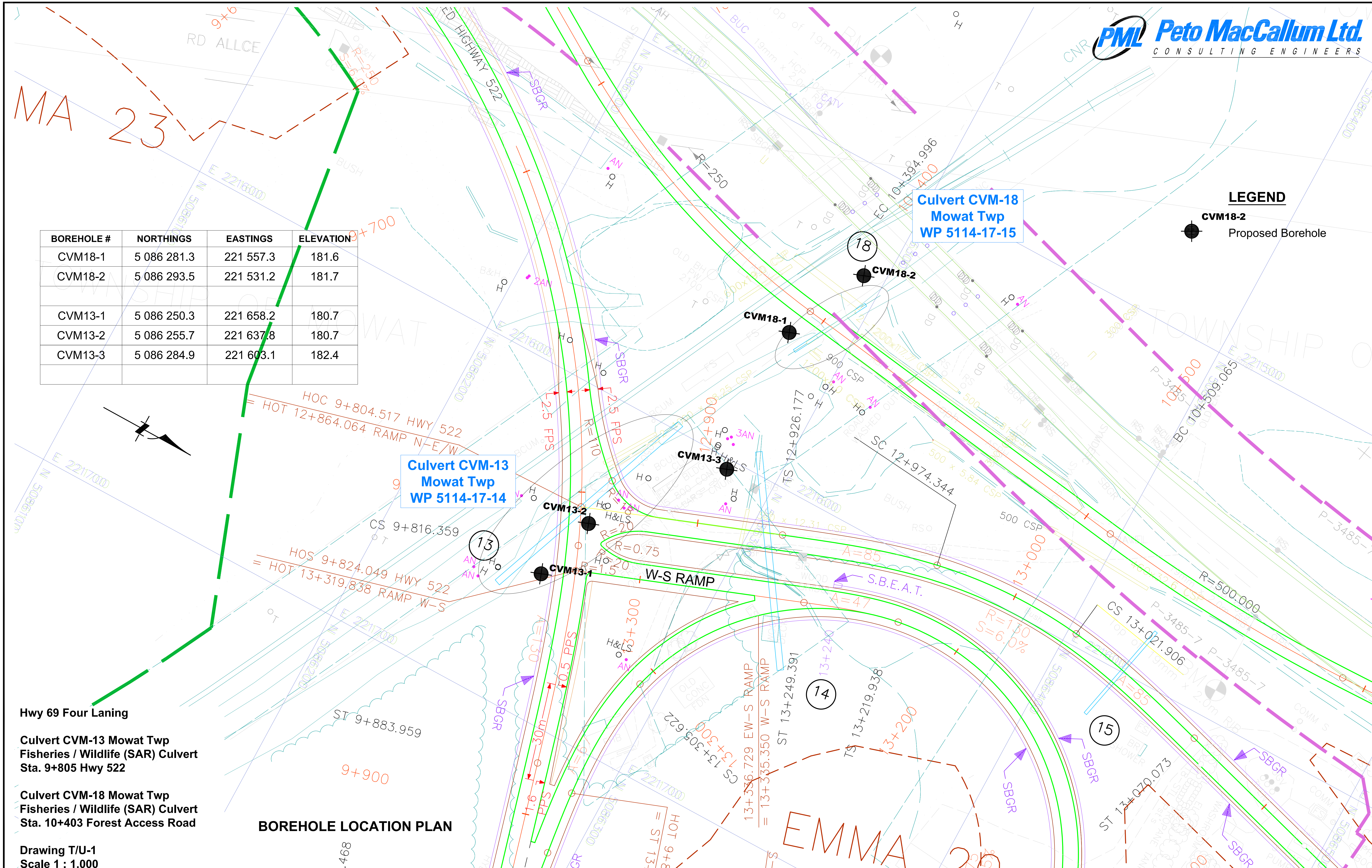
It is anticipated that the excavation will extend through the existing fill into very loose to loose cohesionless cohesionless soils. In accordance with OHSA, the fill and loose soils are considered as Type 3 soils and very loose soils are considered as Type 4 soils. Soils that run or flow easily unless completely supported, and soils under groundwater are considered as Type 4 soils. The slope of excavation walls should conform to as described in Ont. Reg. 213/92, S. 234. Workers should not enter an unprotected excavation if there is evidence of ongoing groundwater seepage in the pits. Temporary shoring will be required if slopes as described in Ont. Reg. 213/92, S. 234 cannot be provided. Temporary shoring should be in accordance with OPSS.PROV 539, as amended.

Preliminary recommendations for backfilling to the culvert are provided in the General Report.

8.3. Groundwater and Surface Water Control

To prevent basal heave, if any, dewatering may have to be carried out from wells installed along the interior periphery of the excavation to maintain the groundwater level a minimum 0.5 m depth below the base of the excavations. Surface water flow should be directed away from the excavation areas to mitigate disturbance of the native subgrade. For construction in-the-dry, the watercourse will have to be temporarily diverted.

Refer to the General Report for further groundwater control recommendations and requirements for water taking.



Peto MacCallum Ltd.
CONSULTING ENGINEERS

LEGEND

CVM18-2 Proposed Borehole

BOREHOLE #	NORTHINGS	EASTINGS	ELEVATION
CVM18-1	5 086 281.3	221 557.3	181.6
CVM18-2	5 086 293.5	221 531.2	181.7
CVM13-1	5 086 250.3	221 658.2	180.7
CVM13-2	5 086 255.7	221 637.8	180.7
CVM13-3	5 086 284.9	221 603.1	182.4

Hwy 69 Four Laning

Culvert CVM-13 Mowat Twp
Fisheries / Wildlife (SAR) Culvert
Sta. 9+805 Hwy 522

Culvert CVM-18 Mowat Twp
Fisheries / Wildlife (SAR) Culvert
Sta. 10+403 Forest Access Road

Drawing T/U-1
Scale 1 : 1,000

BOREHOLE LOCATION PLAN

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No CVM18-1

METRIC

PROJECT Hwy 69 Structural Culvert
COORDINATES Coords: 5 086 281.8 N; 221 557.3 E
ORIGINATED BY H.C.
DIST
HWY 69
BOREHOLE TYPE Continuous Flight Solid Stem Augers
COMPILED BY N.L.
DATUM Geodetic
DATE 2023.03.08
LATITUDE 45.911282
LONGITUDE -80.572982
CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS (GR SA SI CL)
181.6	Ground Surface				
0.0	SAND, some gravel, trace silt Dense to compact, Brown, Moist (FILL)	1	SS	40	
		2	SS	18	
180.1 / 1.5	SAND, some silt, trace gravel Loose, Brown, Wet	3	SS	4	
		4	SS	10	0 83 13 4
177.8 / 3.8	SANDY SILT Very loose, Grey, Wet	5	SS	WH	
		6	SS	WH	
		7	SS	3	5 40 43 12
173.2 / 8.4	SILTY SAND Very loose, Grey, Wet	8	SS	1	2 71 23 4
171.7 / 9.9	SILTY CLAY to CLAY, some sand Firm, Grey, Wet	9	SS	1	
		FV	VANE		
		10	SS	2	0 2 23 75
169.6 / 12.0	End of borehole				

Plot annotations: non-plastic (sample 4); non-plastic (sample 8); field vane sensitivity 1.

Groundwater level measured upon completion of drilling

WH Penetration due to weight of hammer and rods

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT/GAS READING γ kN/m^3 / ppm/%; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No CVM18-2

METRIC

PROJECT Hwy 69 Structural Culvert
COORDINATES Coords: 5 086 304.1 N; 221 536.6 E
ORIGINATED BY H.C.
DIST
HWY 69
BOREHOLE TYPE Continuous Flight Solid Stem Augers
COMPILED BY N.L.
DATUM Geodetic
DATE 2023.03.09
LATITUDE 45.911435
LONGITUDE -80.573343
CHECKED BY N.R.

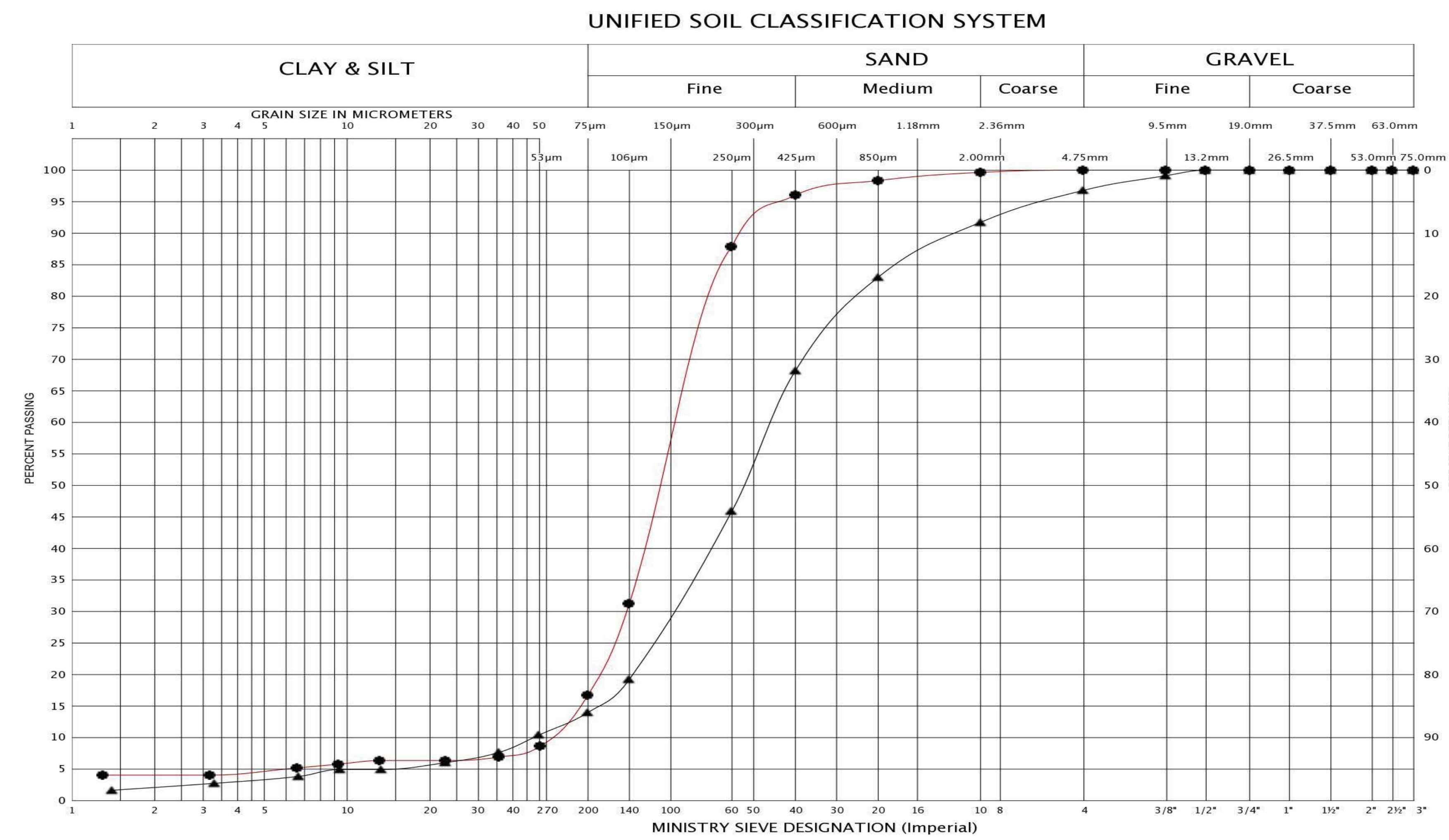
ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS (GR SA SI CL)
181.7	Ground Surface				
0.0	SAND, some gravel, trace silt Very dense, Brown, Moist (FILL)	1	SS	69	
180.9 / 0.8	SAND, trace to some silt, trace gravel Loose to very loose, Brown to grey, Moist to wet	2	SS	5	
		3	SS	2	3 83 11 3
		4	SS	1	
		5	SS	3	
177.9 / 3.8	Sandy CLAYEY SILT, Soft to firm, Grey, Wet	6	SS	WH	
		FV	VANE		
		7	SS	WH	0 33 38 29
		FV	VANE		
		8	SS	1	
		FV	VANE		
173.3 / 8.4	SILT, trace sand Very loose, Grey, Wet	9	SS	WH	0 5 84 11
		10	SS	WH	
171.0 / 10.7	End of borehole				

Plot annotations: non-plastic (sample 3); non-plastic (sample 9); field vane sensitivity 2; field vane sensitivity 2.

Groundwater level measured upon completion of drilling

WH Penetration due to weight of hammer and rods

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



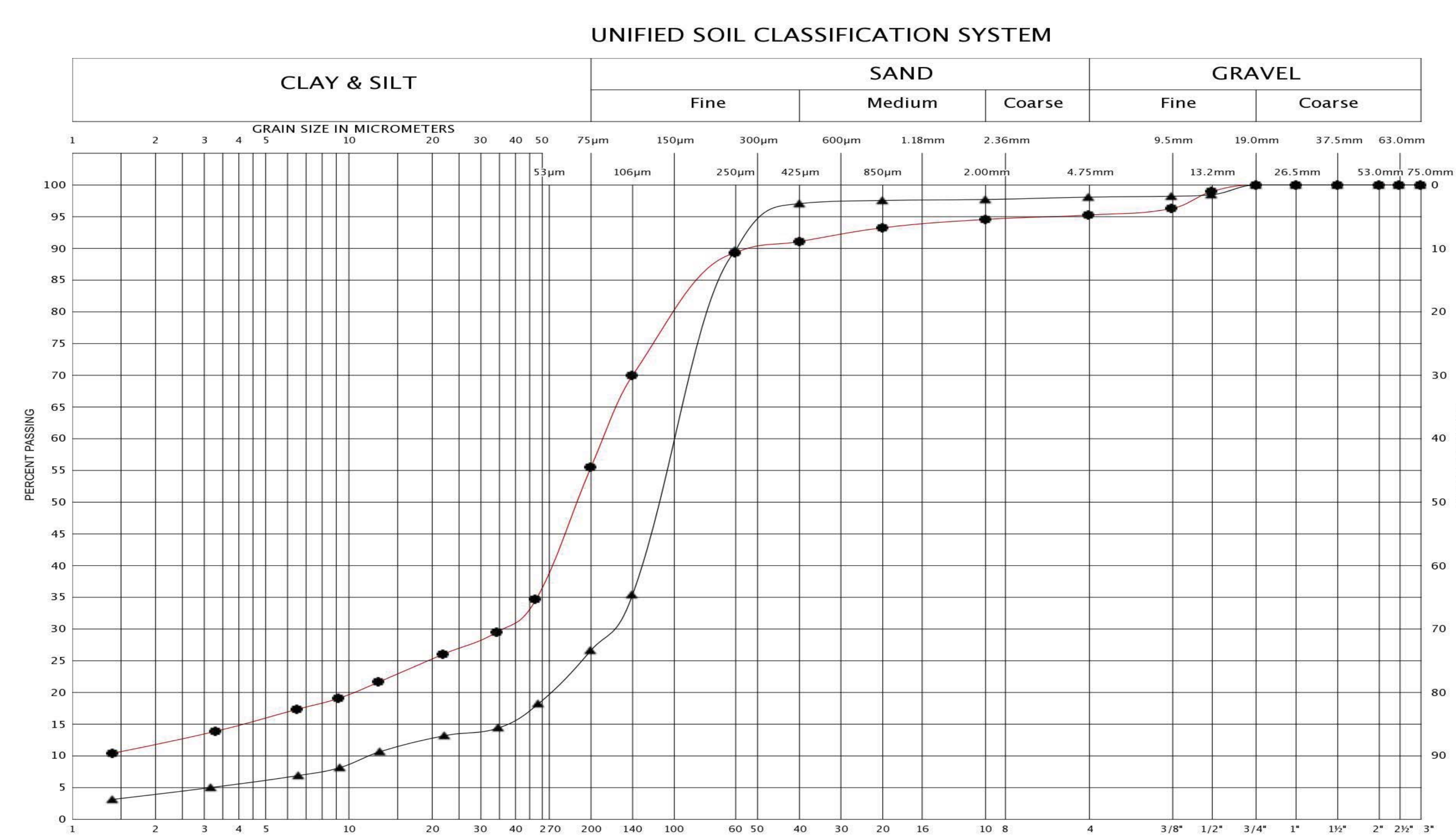
LEGEND	BH	CVM18-1	CVM18-2
	SAMPLE	4	3
	SYMBOL	●	▲

Ontario

GRAIN SIZE DISTRIBUTION

SAND

FIG No.: GS-U-1
HWY : 69
Project No.: 14TF034G



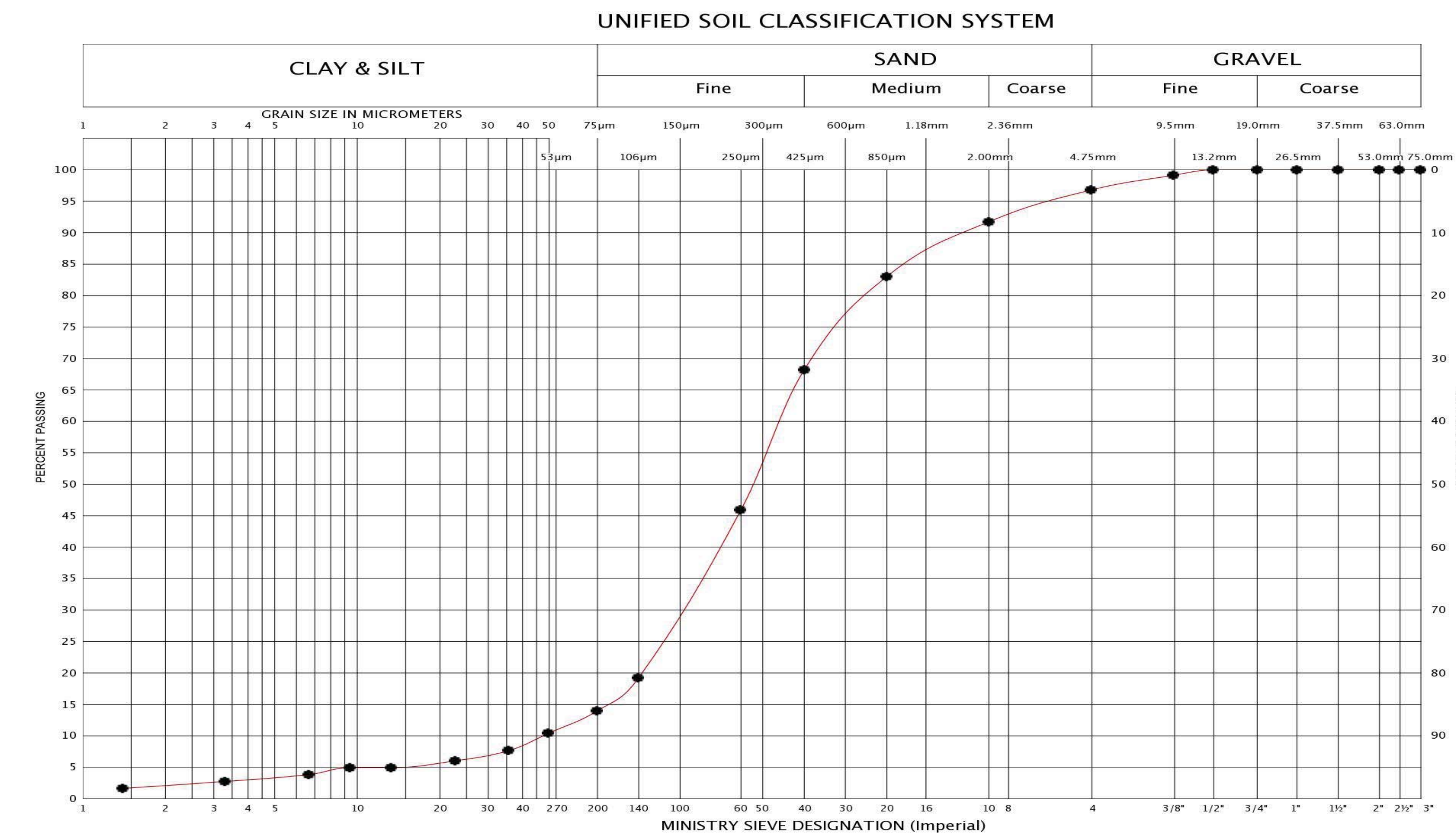
LEGEND	BH	CVM18-1	CVM18-1
	SAMPLE	7	8
	SYMBOL	●	▲

Ontario

GRAIN SIZE DISTRIBUTION

SANDY SILT/SILTY SAND

FIG No.: GS-U-2
HWY : 69
Project No.: 14TF034G



LEGEND		
	BH	CVM18-2
	SAMPLE	3
	SYMBOL	●

Ontario

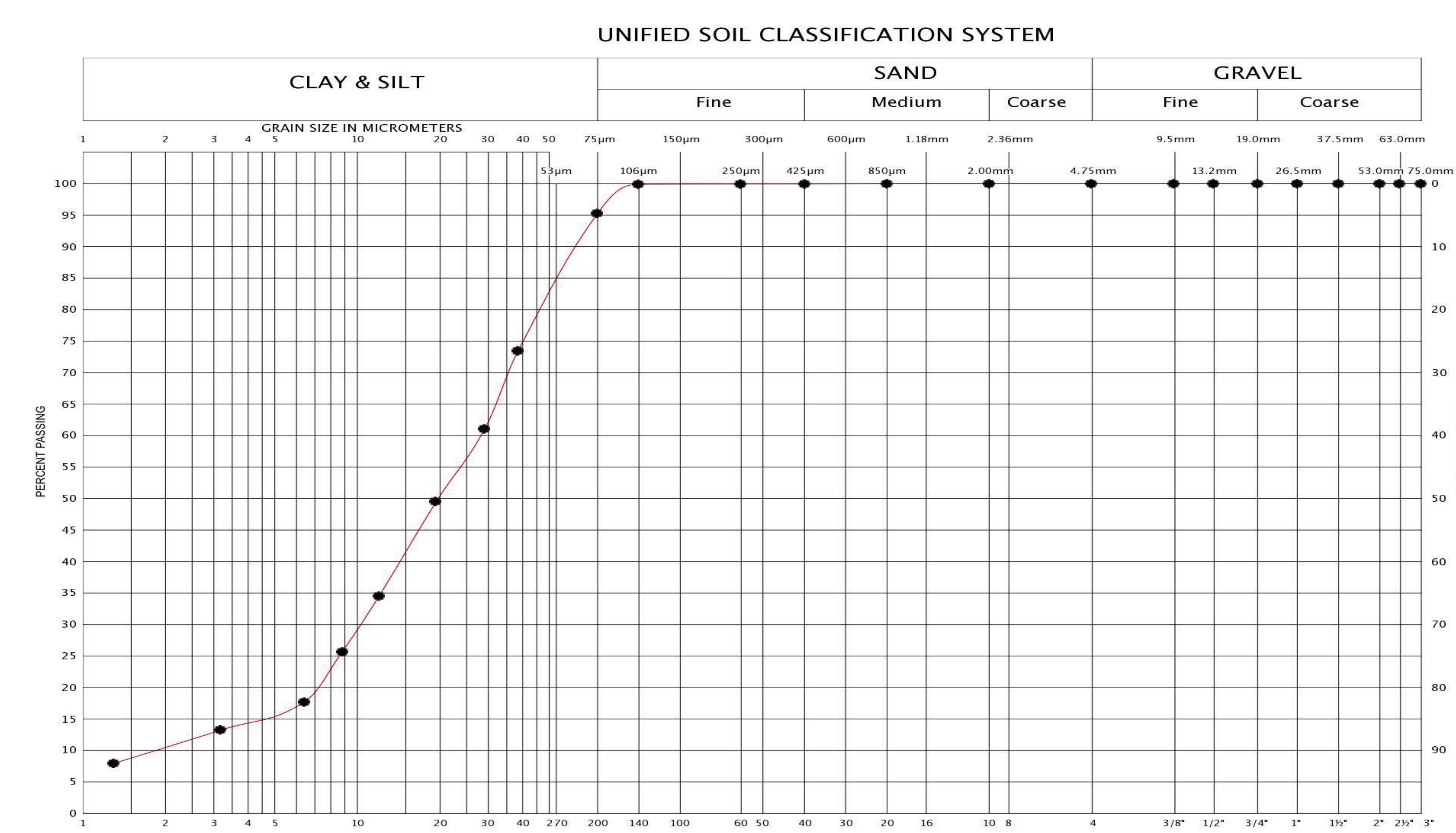
GRAIN SIZE DISTRIBUTION

Sandy CLAYEY SILT

FIG No.: GS-U-3

HWY : 69

Project No.: 14TF034G



LEGEND		
	BH	CVM18-2
	SAMPLE	9
	SYMBOL	●

Ontario

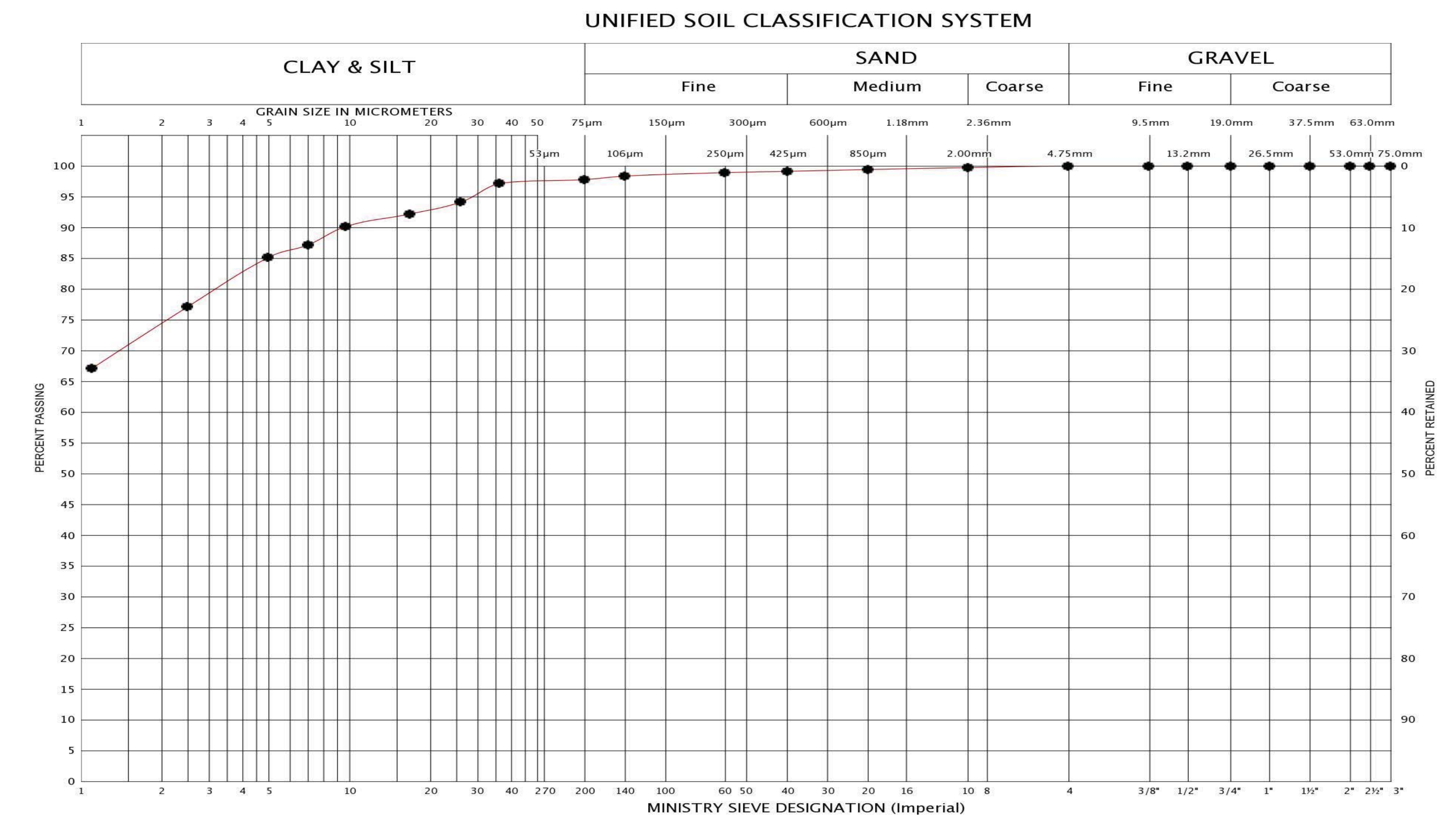
GRAIN SIZE DISTRIBUTION

SILT

FIG No.: GS-U-4

HWY : 69

Project No.: 14TF034G

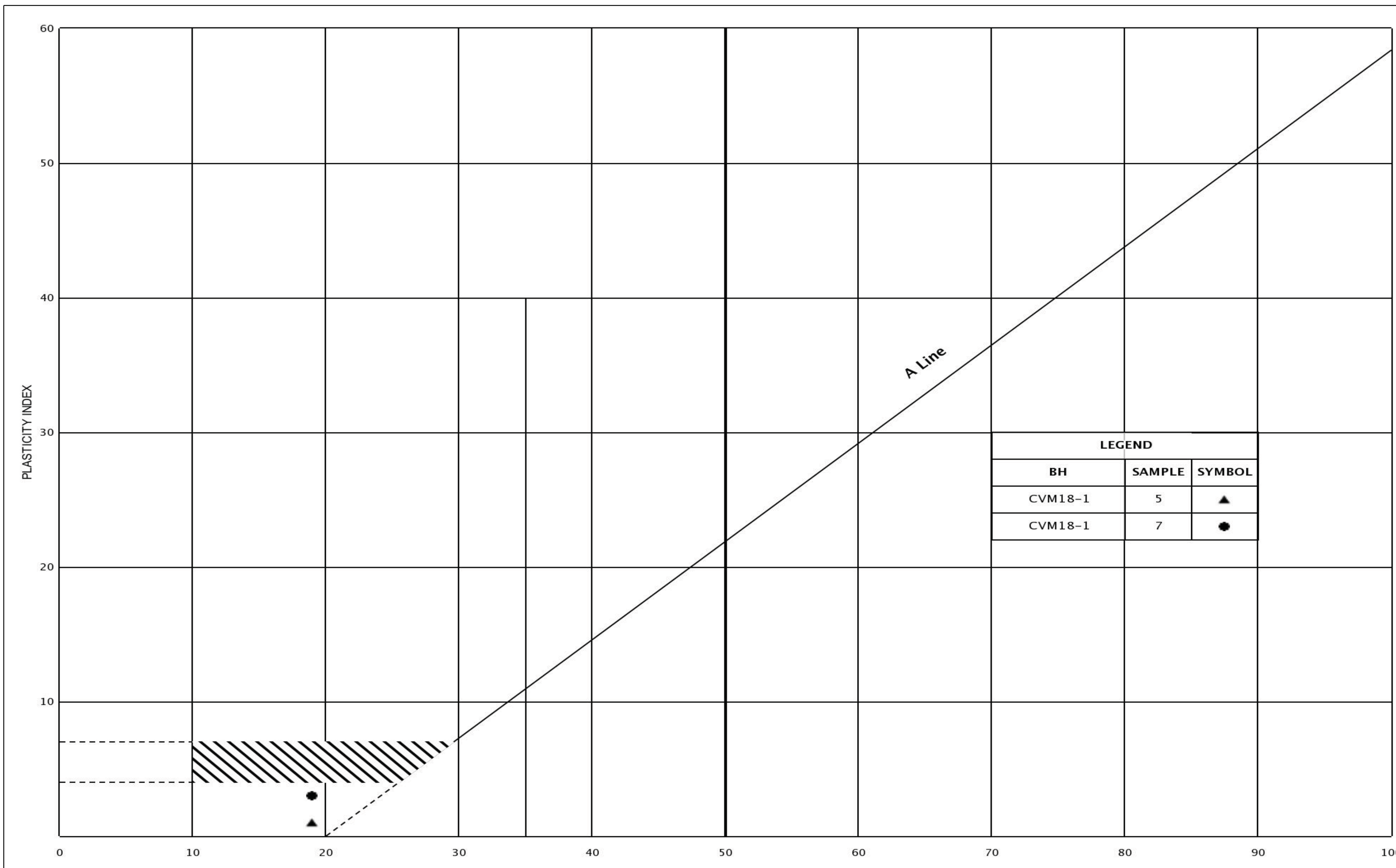


LEGEND		
	BH	CVM18-1
	SAMPLE	10
	SYMBOL	●

Ontario

GRAIN SIZE DISTRIBUTION
CLAY

FIG No.: GS-U-5
HWY : 69
Project No.: 14TF034G

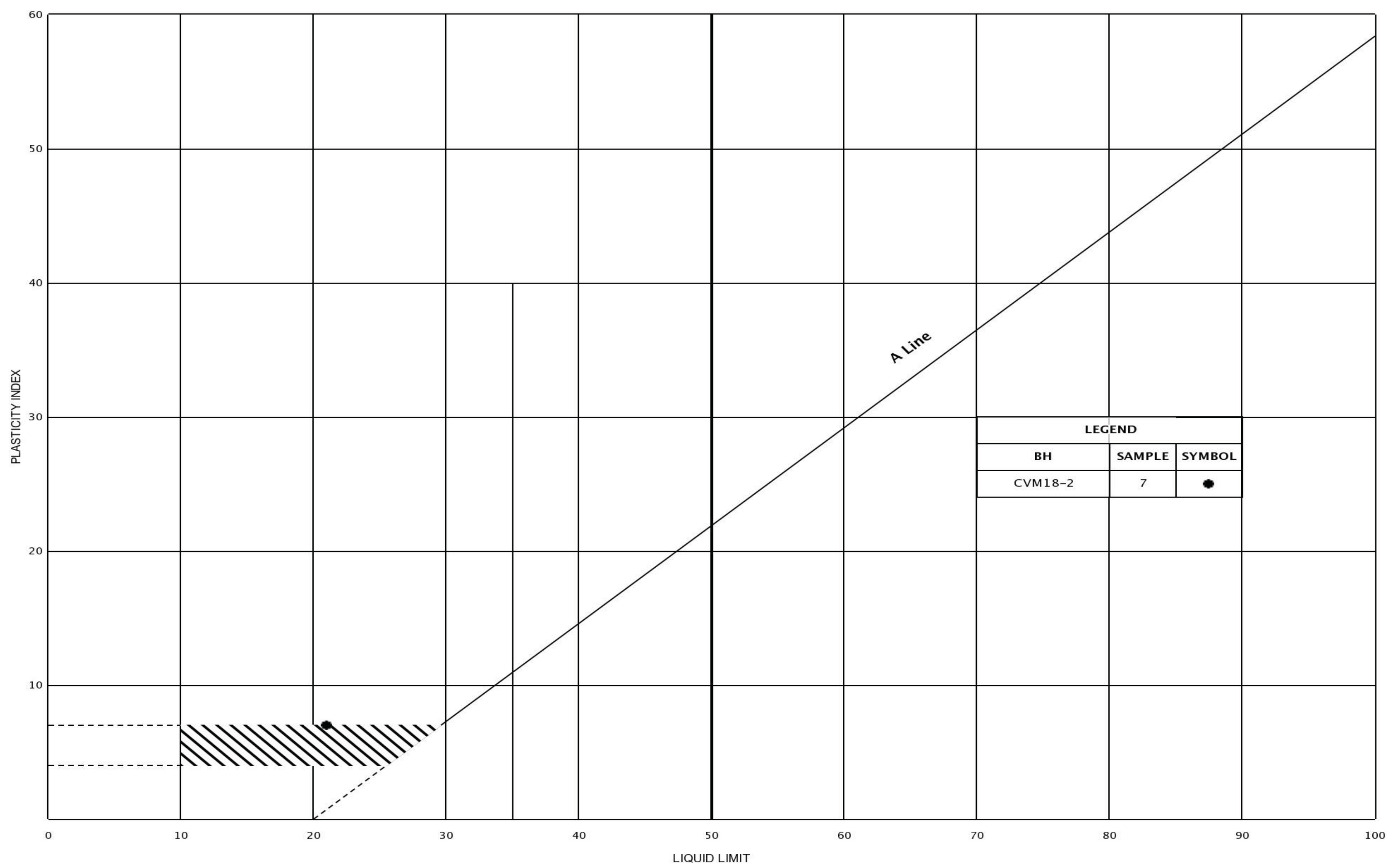


LEGEND		
BH	SAMPLE	SYMBOL
CVM18-1	5	▲
CVM18-1	7	●

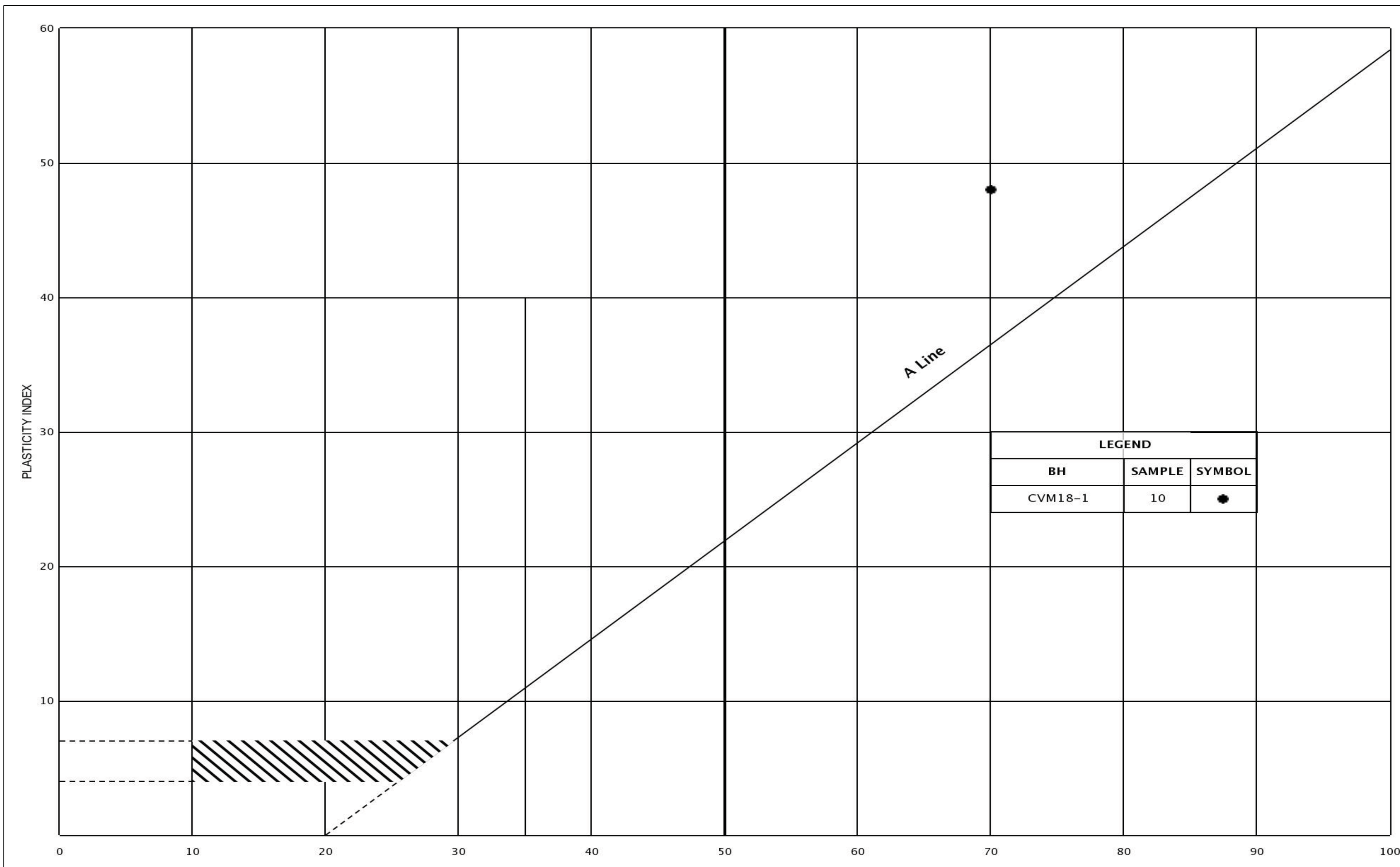
Ontario

PLASTICITY CHART
SANDY SILT

FIG No.: PC-U-1
HWY.: 69
Proj No. 14TF034G



Ontario	**PLASTICITY CHART** Sandy CLAYEY SILT	FIG No.:	PC-U-2
		HWY.:	69
		Proj No.	14TF034G



Ontario	PLASTICITY CHART CLAY	FIG No.:	PC-U-3
		HWY.:	69
		Proj No.	14TF034G

SHEET V – CVM-6 and CVM-7 - Fisheries/Wildlife Culverts (Station: ± 13+790 Hwy 69 NBL/SBL – Mowat)

- Borehole Location Plan (PML)
- Record of Borehole Logs (PML)
- Laboratory Test Results (PML)

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field investigation for Culverts CVM-6 and CVM-7 at Station 13+790, in the Township of Mowat (Site Nos. 044-0659/01&02 under the NBL and SBL) was carried out on April 19, 2022. Culvert CVM-6 is proposed under new Highway NBL and Culvert CVM-7 is proposed under new Highway SBL. The culverts are located in a marsh area, where surface water was encountered above the ground. Borehole CVM6-2 could not be accessed due to high water level and very soft ground. At the east end of Culvert CVM-6, a beaver dam is located. Rock face is located north of the marsh area. No access pathways were available for drill rig or portable tripod equipment to carry out the investigation. A manual Dynamic Cone Penetration Test (K-100 DCP) was carried out at each borehole location below ground surface to assess the subsoil conditions to limited depths. The depths of the DCPT ranged from 2.1 m to 3.6 m below ground surface, where refusal was met. In addition, hand auger, probe rod and Shelby (thin wall) tube samples, where possible, were carried out.

2. BOREHOLE INFORMATION

A total of four (4) boreholes were advanced along the alignments of the proposed culverts (Site Nos. 044-0659/01&02).

Refer to
- Drawing V-1 for the borehole location plan
- Table V-1 for details of borehole origin, borehole location coordinates and borehole elevations/depths
- Record of Borehole sheets and lab results showing details of the subsurface conditions at the borehole locations from current investigation

Table V-1 Borehole Information for Structural Culvert CVM-6

BOREHOLE ID	BOREHOLE LOCATION	MTM ON10 NAD 83 COORDINATES		GROUND SURFACE ELEVATION (m)	DCPT DEPTH (m)
		NORTHING (m)	EASTING (m)		
CVM6-1	West End (Outlet)	5 087 124.2	221 489.7	185.2	3.6
CVM6-2	Median	Could not access due to high water level and very soft ground			
CVM6-3	East End (Intel)	5 087 146.4	221 521.1	185.3	3.6

Table V-2 Borehole Information for Structural Culvert CVM-7

BOREHOLE ID	BOREHOLE LOCATION	MTM ON10 NAD 83 COORDINATES		GROUND SURFACE ELEVATION (m)	DCPT DEPTH (m)
		NORTHING (m)	EASTING (m)		
CVM7-1	West End (Outlet)	5 087 101.6	221 457.4	185.1	2.1
CVM7-2	East End (Inlet)	5 087 113.1	221 474.4	184.9	2.6

3. CVM-6 SUBSURFACE CONDITIONS

The stratigraphy conceptually consists probably of peat, clayey silt/silty clay and bedrock, below the existing water surface, to the termination depth of DCP. Refer to the Record of Boreholes for details.

The subsurface conditions at this site can be categorized into three (3) general layers as presented below from surface downwards.

3.1. Peat

Based on manual investigation with hand auger and probe rod, and DCPT in boreholes CVM6-1 and CVM6-3, peat was encountered immediately at the surface, extending approximately to 1.4 m and 1.3 m, respectively, below the ground surface.

3.2. Probable Clayey Silt/Silty Clay

Below peat, a cohesive layer was encountered at the two borehole locations, which extended to the DCPT termination depth of 3.6 m, where refusal was met and the hammer on the DCPT was bouncing.

3.3. Probable Bedrock

Based on the DCPT, it is inferred that probable bedrock was encountered at 3.6 m depth below ground surface at borehole CVM6-1, EL. 181.6, and at borehole CVM6-2, EL. 181.7.

3.4. Groundwater Conditions

Groundwater was encountered at the ground surface at the borehole locations. At the time of investigation, the water level in the marsh area at the location of Borehole CVM6-2 was approximately 0.4 m above the ground surface. At boreholes CVM6-1 and CVM6-3, the surface water was measured to 0.1 m above the ground surface.

Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

4. CVM-7 Subsurface Conditions

The stratigraphy conceptually consists peat, clayey silt and bedrock, below or at the existing water surface, to the termination depth of DCP. Refer to the Record of Boreholes for details.

The subsurface conditions at this site can be categorized into three (3) general layers as presented below from surface downwards.

4.1. Peat

Based on manual investigation with hand auger, probe rod, Shelby tube sample, and DCPT in boreholes CVM7-1 and CVM7-2, peat was encountered immediately at the surface, extending approximately to 0.1 m and 0.4 m, respectively, below the ground surface.

4.2. Probable Clayey Silt/Silty Clay

Below peat, a cohesive layer was encountered at the two borehole locations, which extended to the DCPT termination depth of 2.1 m and 2.6 m, where refusal was met and the hammer on the DCPT was bouncing.

4.3. Probable Bedrock

Based on the DCPT, it is inferred that probable bedrock was encountered at 3.6 m depth below ground surface at borehole CVM6-1, EL. 181.6 m, and at borehole CVM6-2, EL. 181.7 m. In boreholes CVM7-1 and CVM7-2, it is inferred that the bedrock was encountered at 2.1 m, EL. 183.0 m, and 2.6 m, EL. 182.3 m, below ground surface, respectively.

4.4. Groundwater Conditions

Groundwater was encountered at the ground surface at borehole CVM7-1 at EL. 185.1 m, and above ground surface at borehole CVM7-2 at EL. 185.1 m.

Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) are based on the following references:

1. Highway 69 Profile Drawings, provided by Parson via email dated November 25, 2020
2. Culvert Sections Drawings, provided by Parsons via email dated November 25, 2020

5. PROJECT DESCRIPTION

5.1. General

The proposed Fisheries/Wildlife Culverts (Site No. 044-0659/01&02) are new structures across the new alignments of Highway 69 NBL/SBL.

5.2. Proposed Structures

It is proposed that both culverts will have an opening size of 3.0 m in span, 2.4 m in height, will be approximately 34.0 m long and will be approximately perpendicular to the new alignment of the new Highway 69 NBL/SBL alignment.

The existing ground surface in the vicinity of the culvert alignments varies from approximate EL. 184.9 m to EL. 185.3 m. The proposed maximum height of the proposed Highway 69 NBL and SBL embankments, including the pavement structure, will be approximately 2.9 m and 3.3 m, respectively, above the proposed culverts CVM-6 and CVM-7.

Based on Reference 1, the proposed invert levels of the culverts are provided in the Tables V-1 and V-4.

Table V-3: Box Culvert Founding Elevations at Station 13+790 NBL CVM-6 Culvert (Site No. 044-0658/1)

PROPOSED CULVERT INVERT ELEVATION	BOTTOM OF BOX CULVERT ELEVATION	SUBGRADE ELEVATION FOR GRANULAR BEDDING	FOUNDING STRATUM
184.7 m	184.4 m	184.1 m	Granular or Rockfill

Note(s): 1: The bottom thickness of the precast concrete box culvert is assumed 0.25 m (minimum).

Table V-4: Box Culvert Founding Elevations at Station 13+790 SBL CVM-7 Culvert (Site No. 044-0658/2)

PROPOSED CULVERT INVERT ELEVATION	BOTTOM OF BOX CULVERT ELEVATION	SUBGRADE ELEVATION FOR GRANULAR BEDDING	FOUNDING STRATUM
184.3 m	184.0 m	183.7 m	Clayey Silt

Note(s): 1: The bottom thickness of the precast concrete box culvert is assumed 0.25 m (minimum).

The height of embankment fill of new Highway 69 NBL and SBL required above the culverts to the proposed grades of at Station 13+790 is not expected to exceed 2.9 m and 3.3 m including the pavement structure, respectively.

In the absence of any structural details of the culverts, it is assumed that the concrete culvert and fill would impose a dead load of approximately 118 kPa and 120 kPa on the founding subgrade at the proposed CVM-6 and CVM-7 culvert locations, respectively.

6. EVALUATION OF FOUNDATION ALTERNATIVES

The foundation alternatives listed below were based on the available information in Reference 1 and also considered the proposed embankments in Reference 2, including the assumed embankment fill required above the culverts that is not expected to exceed as stated above.

1. Precast concrete box culverts placed without settlement mitigation
2. Precast concrete box culverts placed after preloading or surcharging

6.1. Option 1: Precast Concrete Box Culverts Placed without Settlement Mitigation

For the proposed CVM-6 culvert, based on the DCPT results, it is assessed that a bearing capacity at SLS of approximately 50 kPa may be realized at the subgrade level as shown in Table V-3 for the CVM-6 culvert site. A dead load of approximately 118 kPa is anticipated at this site location. The settlement magnitudes of the cohesive soil could be in excess of the tolerable settlement limits for a precast concrete box culvert, and can cause damage to the joints, leading to deterioration of the culvert. It is recommended that the existing peat and soil be excavated to 3.6 m below ground surface to mitigate large total and differential settlements. Based on the investigation, the presence of bedrock is inferred at 3.6 m below ground surface at this proposed culvert location. With proper dewatering system in place, granular material or rockfill could be placed from the bedrock surface to the subgrade level of the culvert. Factored geotechnical resistances at ULS and at SLS of 225 kPa and 150 kPa may be used for the design of the culvert placed on granular material or rockfill. The existing beaver dam should be taken into consideration during the construction of the proposed culvert and Highway 69 NBL embankment.

For the proposed CVM-7 culvert, based on the DCPT, it is assessed that factored geotechnical resistances at ULS and SLS of approximately 225 kPa and 150 kPa, respectively, may be realized at the subgrade level as shown in Table V-4 for the CVM-7 culvert site. A dead load of approximately 120 kPa is anticipated at this site location. The peat and the upper cohesive soil down to the subgrade level need to be excavated. Based on the assessed factored geotechnical resistances at the subgrade level, it is considered that the total settlement will be less than 25 mm, and the differential settlement will be between15 mm and 20 mm.

6.2. Option 2: Precast Concrete Box Culverts after Preloading or Surcharging

No previous investigation for the marsh/swamp area is reported at this site location.

In this Option 2 scenario, since there is no existing road or proposed structure where culvert CVM-6 is proposed, it is recommended that the construction of precast concrete box culverts be coordinated with the construction of the embankment fill across the marsh/swamp and the footprint of the culverts preloaded and surcharged simultaneously with the embankments. The scheme may require the placement of temporary CSP pipe under the embankment fill to allow for the local drainage of the creek, if required. At the appropriate time, the fill used for the preload, the surcharge material and the temporary CSP would be removed and the precast box culvert would be installed. The existing beaver dam near the vicinity of the proposed culvert CVM-6 need to be considered when constructing the embankment.

For the proposed culvert CVM-6 under the proposed Highway 69 NBL, the footprint of the culvert needs to be surcharged for Option 2. Prior to surcharging, the existing peat/organic material up to 1.4 m will need to be excavated at the footprint of the culvert. The estimated average height from 1.4 m below the existing ground including the surcharge will include some 6.3 m of granular soils for ease of excavation after surcharging the footprint of the culvert following excavation of the existing peat/organic material. These materials would impose an estimated preload and surcharge load of 118 kPa, assuming an average unit weight of 21.0 kN/m^3. For this material placed on the footprint of the culvert CVM-6 site, it is estimated that the primary consolidation would be in range from 450 mm to 570 mm. It is estimated that 90% of the consolidation of the cohesive soil will take approximately 3 months to 4 months to complete. For the cohesive soil, a void ratio of 2, a compression index (c_c) of 0.7 and a coefficient of consolidation (c_v) of 5 x 10^{-3} cm^2/s were assumed.

Unsuitable/organic materials at the culvert locations should be excavated from the areas under and within the zone of influence of the culverts (minimum of 2 m beyond the culvert walls) and care should be exercised when preparing the subgrade for the embankment construction to minimize excavation concerns when installing the culvert. Following the preloading/surcharging period, the exposed subgrade should be inspected and approved before placement of compacted granular materials as specified in OPSS 422.07.06.

The granular material to backfill the precast concrete box culvert should be placed in accordance with OPSS 422.07.07. Granular material should be as specified in accordance with OPSS 422.05.13 and may consist of either Granular 'A' or Granular 'B' Type II, including a 75 mm levelling course for bedding purposes as required by OPSS 422.07.08.

The precast concrete box culverts after preloading or surcharging period may be designed assuming a factored geotechnical resistance of 180 kPa at ULS and 120 kPa at SLS. Following placement of the precast concrete box culvert as recommended and the estimated 2.9 m of fill above the culvert CVM-6, it is estimated that the total settlements would be less than 50 mm and the differential settlement between 20 mm and 25 mm.

For culvert CVM-7, Option 2 is not considered since it is assessed that the required factored geotechnical resistances at ULS and SLS are available at the subgrade level.

7. <u>CULVERT BEDDING AND COVER MATERIALS</u>

Refer to the General Report for preliminary recommendations for materials to be used for culvert bedding and cover purposes.

8. <u>APPROACH EMBANKMENT</u>

Based on References 1 and 2, the proposed embankment will be constructed approximately up to EL. 190.0.

In general, construction of embankments shall be in accordance with OPSS.PROV 206. Where construction of embankments over swamps is anticipated, the construction shall be in accordance with OPSS.PROV 209.

All organic materials and cohesive soils shall be removed from the proposed footprint of the embankment and replaced with compacted granular material. Backfill should be placed in accordance with OPSS.PROV 206. Where water bodies are within the footprint of the embankment, backfill material other than rock may be placed up to 600 mm above water level without compaction in accordance with OPSS.PROV 209 (209.07.03.01). It should also be noted that vibratory compaction equipment should not be used within 1.0 m of the original surface of the swamp (OPSS.PROV 209 – 209.07.04.2).

The proposed embankment can be construct with granular materials, earth borrow or rockfill. The side slopes of the proposed embankment are to be sloped at a minimum 2H:1V if granular material or earth borrow is used to construct the embankment. The side slopes of the embankment should be a minimum 1.25H:1V if rockfill is used to construct the embankment.

Granular materials shall be in accordance with OPSS.PROV 1010, amended by SSP 110S06. If earth borrow is utilized to construct the embankment, the earth borrow should be in accordance with OPSS.PROV 212, amended by SSP 112S07 and SSP 212F01. If rockfill is utilized to construct the new embankment, the material should be in accordance with OPSS.PROV 1004, amended by SS 110S16. Compaction shall be carried out in accordance with OPSS.PROV 501, amended by SSP 105S22. It should be noted that frost susceptible material shall not be placed within the zone between the frost penetration depth and the final grade of the roadway.

No stability and settlement issues are anticipated following construction of the embankments as discussed above. It is anticipated that 20 mm to 35 mm of settlement of the embankment fill due to self weight will be completed following construction of the embankment.

9. CONSTRUCTION CONSIDERATIONS

9.1. Excavation

Considering the existing ground level and the culvert invert level for the proposed culvert CVM-7, approximately 1.2 to 1.4 m deep excavations into native soils are needed for subgrade preparation and slope instability issues are not anticipated. For Option 2, some 6.3 m of cut into the embankment fill would be excavated and the stability of the temporary slope excavation should be assessed at the design-build stage for culvert CVM-6.

The Contractor should consider the type of preloaded and/or surcharge material over the culvert area to facilitate excavation and disposal or reuse of the temporary fill materials.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

Preliminary recommendations for backfilling to the culvert are provided in the General Report.

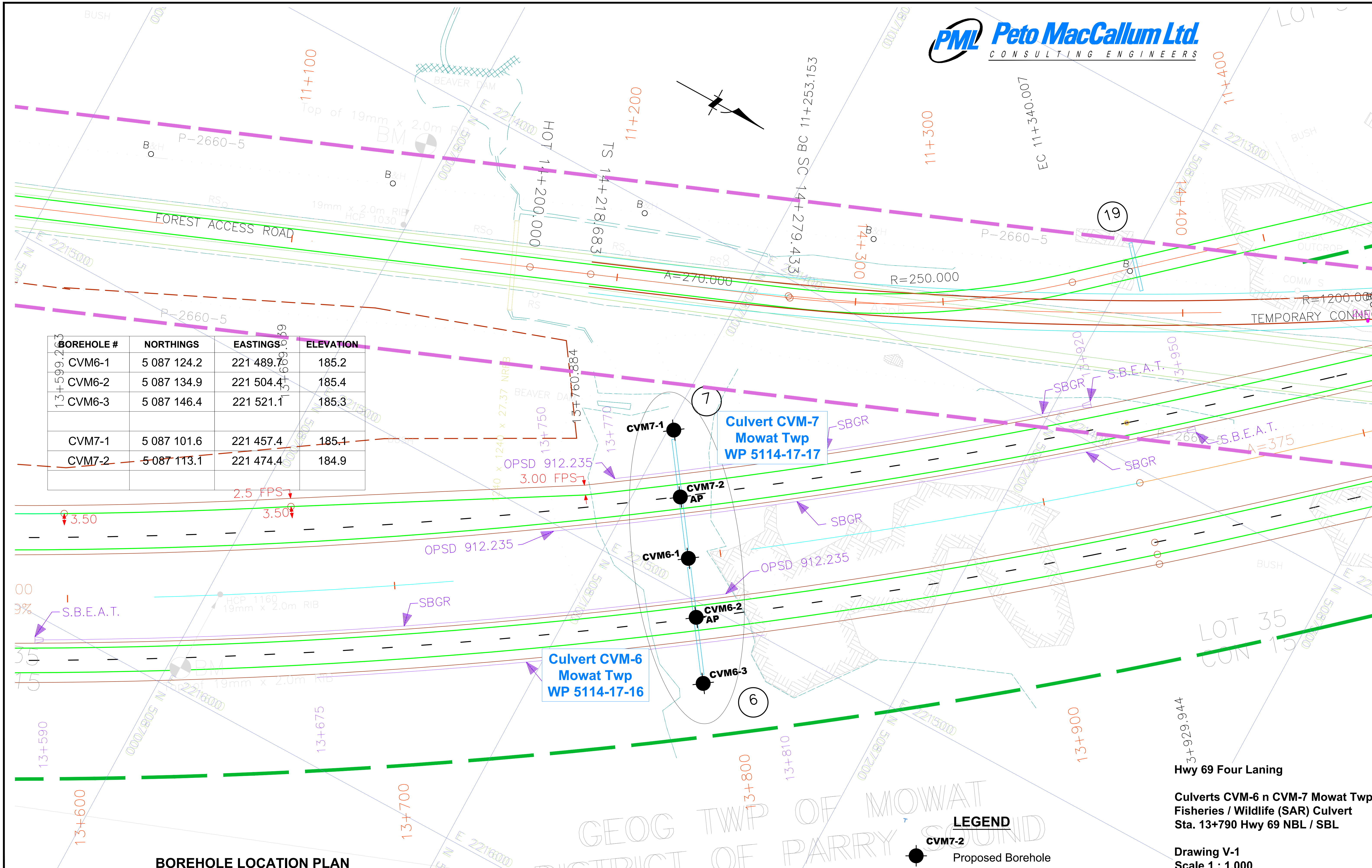
9.2. Groundwater and Surface Water Control

For construction in-the-dry, proper dewatering system, including temporary flow channel, would be required at the culvert locations. The existing beaver dam may need to be dismantled during the construction of the proposed Highway 69 NBL embankment and installation of culvert CVM-6.

Refer to the General Report for further groundwater control recommendations and requirements for water taking.

9.3. Additional Investigation

It is suggested that additional investigation to 3.0 m below the depth of the proposed subgrade level be carried out during the detail design within 2.0 m north or south of the proposed culverts along the centreline of Highway 69 NBL and at the ends of the culvert to confirm the presence of bedrock, and groundwater conditions. Based on the data, the recommendations provided in this report may have to be revised.



BOREHOLE #	NORTHINGS	EASTINGS	ELEVATION
CVM6-1	5 087 124.2	221 489.7	185.2
CVM6-2	5 087 134.9	221 504.4	185.4
CVM6-3	5 087 146.4	221 521.1	185.3
CVM7-1	5 087 101.6	221 457.4	185.1
CVM7-2	5 087 113.1	221 474.4	184.9

BOREHOLE LOCATION PLAN

LEGEND

CVM7-2 Proposed Borehole

Hwy 69 Four Laning

Culverts CVM-6 n CVM-7 Mowat Twp
Fisheries / Wildlife (SAR) Culvert
Sta. 13+790 Hwy 69 NBL / SBL

Drawing V-1
Scale 1 : 1,000

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No CVM6-1

METRIC

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 087 124.2 N; 221 489.7 E | ORIGINATED BY M.M.

DIST | HWY 69 | BOREHOLE TYPE Manual Probe | COMPILED BY N.L.

DATUM Geodetic | DATE 2022.04.19 | LATITUDE 45.918903 | LONGITUDE -80.574022 | CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT/GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
185.2	Ground Surface Below Water										
0.0	PEAT						185				
183.8 / 1.4	Probable CLAYEY SILTY to SILTY CLAY						184, 183, 182				
181.6 / 3.6	Borehole terminated on inferred bedrock										

Legend: SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE. PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L.

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

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No CVM6-3

METRIC

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 087 146.4 N; 221 521.1 E | ORIGINATED BY M.M.

DIST | HWY 69 | BOREHOLE TYPE Manual Probe | COMPILED BY N.L.

DATUM Geodetic | DATE 2022.04.19 | LATITUDE 45.919107 | LONGITUDE -80.573622 | CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT/GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
185.3	Ground Surface Below Water										
0.0	PEAT						185				
184.0 / 1.3	Probable CLAYEY SILTY to SILTY CLAY						184, 183, 182				
181.7 / 3.6	Borehole terminated on inferred bedrock										

Legend: SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE. PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L.

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

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 22-10-26

RECORD OF BOREHOLE No CVM7-1

METRIC

PROJECT: Hwy 69 Structural Culvert	COORDINATES: Coords: 5 087 101.6 N; 221 457.4 E		ORIGINATED BY: M.M.
DIST:	HWY: 69	BOREHOLE TYPE: Manual Probe	COMPILED BY: N.L.
DATUM: Geodetic	DATE: 2022.04.19	LATITUDE: 45.918696 LONGITUDE: -80.574435	CHECKED BY: N.R.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
185.1	Ground Surface									
	PEAT	1	GRAB			185				
185.0 / 0.1	CLAYEY SILTY to SILTY CLAY	2	GRAB							
		3	TW	PM			0	5	63	32
						184				
183.0 / 2.1	Borehole terminated on inferred bedrock					183				

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60 113; UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%

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

RECORD OF BOREHOLE No CVM7-2

METRIC

PROJECT: Hwy 69 Structural Culvert	COORDINATES: Coords: 5 087 113.1 N; 221 474.4 E		ORIGINATED BY: M.M.
DIST:	HWY: 69	BOREHOLE TYPE: Manual Probe	COMPILED BY: N.L.
DATUM: Geodetic	DATE: 2022.04.19	LATITUDE: 45.918801 LONGITUDE: -80.574218	CHECKED BY: N.R.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
184.9	Ground Surface Below Water									
0.0	PEAT									
184.5 / 0.4	Probable CLAYEY SILTY to SILTY CLAY									
						184				
						183				
182.3 / 2.6	Borehole terminated on inferred bedrock									

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%

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

ONTARIO MTO - W/GAS READING_REV 14TF034G.GPJ ONTARIO MTO.GDT 23-7-25

SHEET W – CVM-8 - Fisheries/Wildlife Culvert (Station: ± 15+340 Hwy 69 NBL – Mowat)

- Borehole Location Plan (PML)
- Record of Borehole Logs (PML)

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field work for Culvert CVM-8 at Station 15+340, in the Township of Mowat (Site Nos. 044-0659/01 under the NBL) was carried out on July 19, 20, and November 9, 2021.

2. BOREHOLE INFORMATION

A total of three (3) boreholes were advanced along the alignment of the proposed replacement of the existing culvert (Site No. 044-0659/01) along the same horizontal and vertical alignment. Due to lack of access, steep embankment slope and soft ground at the toe of the embankment for track/truck mounted drill rig and portable tripod, borehole CVM8-3 was advanced by means of manual hand auger/probe. In addition, a manual DCPT, with K-100 DCP, was carried out at the borehole location. Refusal was met at approximately 0.4 m below ground surface on probable boulder/blasted rock.

Refer to
- Drawing W-1 for the borehole location plan
- Table W-1 for details of borehole origin, borehole location coordinates and borehole elevations/depths
- Record of Borehole sheets and lab results showing details of the subsurface conditions at the borehole locations from current investigation

Table W-1 Structural Culvert Borehole Information

BOREHOLE ID	BOREHOLE LOCATION	MTM ON10 NAD 83 COORDINATES		GROUND SURFACE ELEVATION (m)	BOREHOLE DEPTH (m)
		NORTHING (m)	EASTING (m)		
CVM8-1	West End (Outlet)	5 088 467.3	220 743.8	193.0	0.5
CVM8-2	Median	5 088 455.9	220 772.7	195.6	3.0
CVM8-3	East End (Inlet)	5 088 449.3	220 809.5	190.2	1.5

2.1. Subsurface Conditions

The stratigraphy generally consists of a silty sand, some gravel to gravelly deposit to the termination depth of drilling in Boreholes CVM8-1 and CVM8-2. In Borehole CVM8-3, fibrous peat was encountered immediately below the ground surface, extending to the borehole termination depth. Boreholes were terminated due to refusal on probable bedrock/blast rock. Refer to the Record of Boreholes for details.

The subsurface conditions at this site can be categorized into three (3) general layers as presented below from surface downwards.

2.1.1. Silty Sand, some gravel to gravelly

This silty sand layer was encountered immediately below the ground surface in Boreholes CVM8-1 and CVM8-2, extending to the borehole termination depths of 0.5 m and 3.0 m, respectively. The SPT N values of this layer varied from 17 blows to over 100 blows per 0.3 m penetration, indicating a compact to very dense state of compaction. Moisture content determinations of two (2) samples tested from this layer were 3.5% and 5.8%.

2.1.2. Peat

Fibrous peat was encountered immediately below the water surface in Boreholes CVM8-3, extending to the borehole termination depth of 0.7 m. Moisture content determinations of one (1) sample tested from this layer was 78.1%.

2.1.3. Probable Boulder/Blast Rock

Boreholes CVM8-2 and CVM8-3 were terminated at depths 3.0 m (EL. 192.6) and 1.5 m (EL. 188.7), respectively, below the ground surface due to refusal on probable boulder. Borehole CVH8-1 was terminated at 0.5 m (EL. 192.5) below the existing ground surface due to refusal on probable blast rock.

2.2. Groundwater Conditions

Surface water was encountered at the ground surface at borehole CVM8-3 location (at the toe of the embankment). Groundwater was not encountered during and after augering at borehole CVM8-1 location. In borehole CVM8-2, groundwater was only encountered at 0.6 m (EL. 195.0) below ground surface upon completed of drilling.

Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) are based on the following references:

1. Highway 69 Profile Drawings, provided by Parson via email dated November 25, 2020
2. Culvert Sections Drawings, provided by Parsons via email dated November 25, 2020

3. PROJECT DESCRIPTION

3.1. General

The proposed Fisheries Culvert (Site No. 044-0659/01) is a new structure across the new alignment of Highway 69 NBL. The culvert is located within the Township of Mowat.

3.2. Proposed Structure

It is proposed that the culvert will have an opening size of 3.0 m in span, 2.4 m in height, will be approximately 64.0 m long and will be approximately perpendicular to the new alignment of the new Highway 69 NBL alignment.

The existing ground surface in the vicinity of the culvert alignments varies from approximate EL. 190.2 m to EL. 193.0 m, with the exception of the existing Highway 69 embankment; where there top of grade elevation is approximately EL. 195.6 m.

Based on Reference 1, the proposed invert level of the culvert is approximately at EL. 190.4 m. Silty sand/sandy silt/sandy clayey silt is anticipated at the invert level of the culvert.

Table H: Box Culvert Founding Elevations at Station 16+868 NBL CVH-26 Culvert (Site No. 044-0649/01)

PROPOSED CULVERT INVERT ELEVATION	BOTTOM OF BOX CULVERT ELEVATION	SUBGRADE ELEVATION FOR GRANULAR BEDDING	FOUNDING STRATUM
190.4 m	190.1 m	189.8 m	Probable Bedrock

Note(s): 1: The bottom thickness of the precast concrete box culvert is assumed 0.25 m (minimum).

Based on Reference 2, the height of embankment fill required above the culvert to the proposed grade of Highway 69 NBL at Station 15+345.84 is not expected to exceed 6.8 m, including the pavement structure.

All three (3) boreholes were terminated either on probable boulder or blasted rock. Based on Reference 1, it is anticipated that the culvert will be placed on bedrock. To found the subgrade level, excavation has to extend through the probable boulder or blasted rock to bedrock to construct the proposed culvert.

4. EVALUATION OF FOUNDATION ALTERNATIVES

The foundation alternatives listed below were based on the available information in References 1, and 2, including the assumed embankment fill required above the culvert that is not expected to exceed 6.8 m.

1. Precast concrete box culverts placed without settlement mitigation
2. Precast concrete box culverts placed after preloading or surcharging

For both options, assuming that the culvert is placed at the proposed subgrade level of EL. ±189.8 m, probable bedrock is expected underneath the base of the culvert at the subgrade level (based on Reference 1). No major settlement issues are expected.

The existing subgrade material, including boulders/blasted rocks, at the culvert location should be excavated from within the zone of influence of the culvert (minimum of 2.0 m beyond the culvert walls) and the area under the culvert when preparing the subgrade for the culvert. The exposed subgrade should be inspected and approved before placement of compacted granular materials as specified in OPSS 422.07.06.

The granular material to backfill the precast concrete box culvert should be placed in accordance with OPSS 422.07.07. Granular material should be as specified in accordance with OPSS 422.05.13 and may consist of either Granular 'A' or Granular 'B' Type II, including a 75 mm levelling course for bedding purposes as required by OPSS 422.07.08.

The precast concrete box culvert may be designed assuming a factored geotechnical resistance of 350 kPa at ULS placed on probable bedrock. For bedrock surface, SLS will not govern because the loads required to produce detrimental deformation is anticipated to be larger than the factored resistance at ULS. Following placement of the precast concrete box culvert as recommended and the estimated fill of 6.8 m above the culvert, it is estimated that the total settlement would be less than 25 mm and the differential settlement between 15 mm and 20 mm. Generally, for precast concrete box culvert, a tolerable limit of 100 mm of differential settlement is assumed.

5. CULVERT BEDDING AND COVER MATERIALS

Refer to the General Report for preliminary recommendations for materials to be used for culvert bedding and cover purposes.

6. APPROACH EMBANKMENT

Based on References 1 and 2, the proposed culvert will be constructed under the existing Highway 69 embankment, where the new Highway 69 NBL alignment will coincide with the existing alignment. The existing embankment has to be excavated to construct the proposed culvert. Based on Reference 2, the existing embankment will be raised approximately 0.3 m for the new Highway 69 NBL alignment at the proposed culvert location. Furthermore, the existing embankment slopes will be maintained following construction of the new Highway 69 NBL at the culvert location.

In general, construction of embankments shall be in accordance with OPSS.PROV 206. Where construction of embankments over swamps are anticipated, the construction shall be in accordance with OPSS.PROV 209.

All organic materials and cohesive soils shall be removed from the proposed footprint of the embankment. Backfill should be placed in accordance with OPSS.PROV 206. Where water bodies are within the footprint of the embankment, backfill material other than rock may be placed up to 600 mm above water level without compaction in accordance with OPSS.PROV 209 (209.07.03.01). It should also be noted that vibratory compaction equipment should not be used within 1.0 m of the original surface of the swamp (OPSS.PROV 209 – 209.07.04.2).

The proposed embankment can be construct with granular materials, earth borrow or rockfill. The side slopes of the proposed embankment are to be sloped at a minimum 2H:1V if granular material or earth borrow is used to construct the embankment. The side slopes of the embankment should be a minimum 1.25H:1V if rockfill is used to construct the embankment.

Granular materials shall be in accordance with OPSS.PROV 1010, amended by SSP 110S06. If earth borrow is utilized to construct the embankment, the earth borrow should be in accordance with OPSS.PROV 212, amended by SSP 112S07 and SSP 212F01. If rockfill is utilized to construct the new embankment, the material should be in accordance with OPSS.PROV 1004, amended by SS 110S16. Compaction shall be carried out in accordance with OPSS.PROV 501, amended by SSP 105S22. It should be noted that frost susceptible material shall not be placed within the zone between the frost penetration depth and the final grade of the roadway.

No stability and settlement issues are anticipated following construction of the embankment as discussed above. It is anticipated that 20 mm to 30 mm of settlement of the embankment fill due to self weight will be completed following construction of the embankment.

7. CONSTRUCTION CONSIDERATIONS

7.1. Excavation

Considering the existing ground level (EL. 190.2 m to EL. 195.6 m) and the culvert subgrade level (EL. ±189.8 m), 0.4 m to 5.8 m deep excavation into existing subsoil/boulder/blasted rock is required for subgrade preparation. It is anticipated that temporary protection system will be required at this culvert location. A performance level of 2 should be adopted in accordance with OPSS.PROV 539, as amended. The contractor shall be responsible for the design, installation and performance of the temporary protection system.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

Preliminary recommendations for backfilling to the culvert are provided in the General Report.

7.2. Groundwater and Surface Water Control

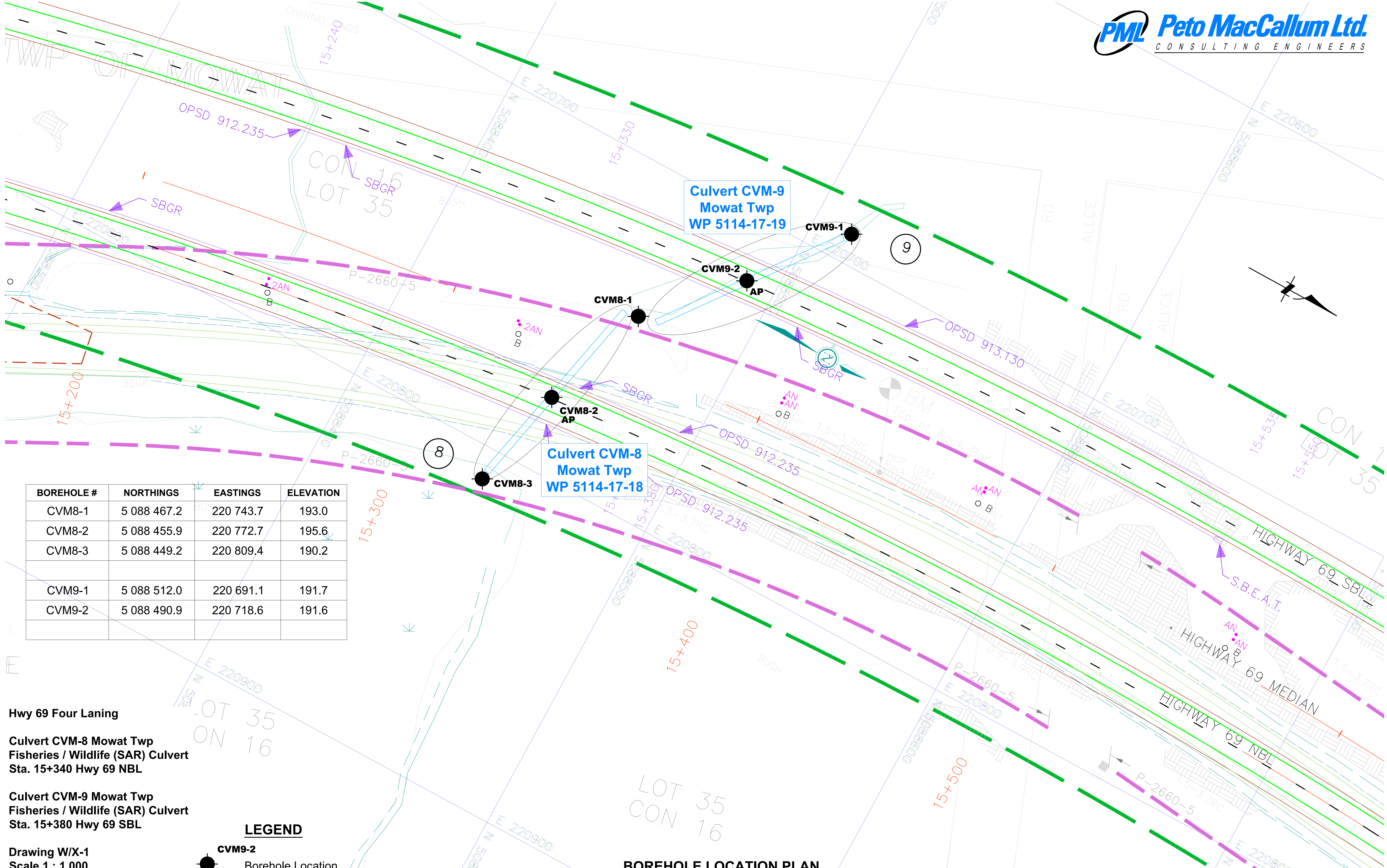
For construction in-the-dry, dewatering system, including cofferdam, and temporary flow system will be required at this culvert location in accordance with OPSS.PROV 517, as amended. The contractor shall be responsible for the design, installation and performance of the dewatering system and temporary flow system.

Refer to the General Report for further groundwater control recommendations and requirements for water taking.

7.3. Additional Investigation

It is suggested that additional investigation to 3.0 m below the depth of the proposed subgrade level be carried out during the detail design within 2.0 m north or south of the proposed culvert along the centreline of Highway 69 NBL and at the ends of the culvert to confirm the presence of bedrock, and groundwater conditions. Based on the data, the recommendations provided in this report may have to be revised.

Peto MacCallum Ltd.
CONSULTING ENGINEERS



BOREHOLE #	NORTHINGS	EASTINGS	ELEVATION
CVM8-1	5 088 467.2	220 743.7	193.0
CVM8-2	5 088 455.9	220 772.7	195.6
CVM8-3	5 088 449.2	220 809.4	190.2
CVM9-1	5 088 512.0	220 691.1	191.7
CVM9-2	5 088 490.9	220 718.6	191.6

Hwy 69 Four Laning

Culvert CVM-8 Mowat Twp
Fisheries / Wildlife (SAR) Culvert
Sta. 15+340 Hwy 69 NBL

Culvert CVM-9 Mowat Twp
Fisheries / Wildlife (SAR) Culvert
Sta. 15+380 Hwy 69 SBL

Drawing W/X-1
Scale 1 : 1,000

LEGEND

CVM9-2 Borehole Location

BOREHOLE LOCATION PLAN

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No CVM8-1

METRIC

PROJECT Hwy 69 Structural Culvert
COORDINATES Coords: 5 088 467.3 N; 220 743.8 E
ORIGINATED BY M.M.
DIST
HWY 69
BOREHOLE TYPE CFHSA
COMPILED BY N.L.
DATUM Geodetic
DATE 2021.07.20
LATITUDE 45.930898
LONGITUDE -80.583876
CHECKED BY N.R.

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
195.0	Ground Surface										
0.0	SILTY SAND, some gravel		1	SS	64						
194.5	Very dense, Brown, Moist										
0.5	Borehole terminated due to auger refusal on probable blast rock										

NOTES:
1. Groundwater level was not encountered during or upon completion of augering.
2. Borehole was too shallow to set up rock core casing, thus the borehole was terminated.

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

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No CVM8-2

METRIC

PROJECT Hwy 69 Structural Culvert
COORDINATES Coords: 5 088 455.9 N; 220 772.7 E
ORIGINATED BY M.M.
DIST
HWY 69
BOREHOLE TYPE CFHSA
COMPILED BY N.L.
DATUM Geodetic
DATE 2021.07.19
LATITUDE 45.930796
LONGITUDE -80.583497
CHECKED BY N.R.

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
195.6	Ground Surface										
0.0	SILTY SAND, with gravel/gravelly Compact to very dense, Brown/grey, Moist		1	SS	27	▼	195		○		
			2	SS	17				○		
			3	SS	72		194				
			4	SS	50/3cm		193				
192.6 / 3.0	Borehole terminated due to auger refusal on probable boulder										

▼ Groundwater level measured upon completion of drilling

NOTE: Borehole caved-in at a depth of 1.5 m (EL. xxx) below the ground surface, upon extraction of hollow stem augers.

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

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No CVM8-3

METRIC

PROJECT Hwy 69 Structural Culvert	COORDINATES Coords: 5 088 449.3 N; 220 809.5 E		ORIGINATED BY M.M.
DIST ___ HWY 69	BOREHOLE TYPE Manual Probe		COMPILED BY N.L.
DATUM Geodetic	DATE 2021.11.09	LATITUDE 45.93074 LONGITUDE -80.583023	CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
190.2	Ground Surface Below Water										
0.0	Fibrous PEAT, with sand Very soft, Black, Wet		1	TW			190				
189.1 1.1	End of borehole										

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

SHEET X – CVM-9 - Fisheries/Wildlife Culvert (Station: ± 15+380 Hwy 69 SBL – Mowat)

- Borehole Location Plan (PML)
- Record of Borehole Logs (PML)
- Laboratory Test Results (PML)

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field work for Culvert CVM-9 at Station 15+380, in the Township of Mowat (Site No. 044-0659/02 under the SBL) was carried out on November 9, 2021. The site is located within a swamp area. There were no accessible roadway/pathway for track/truck mounted drill rig or portable tripod equipment to the proposed culvert site. In addition, a manual Dynamic Cone Penetration Test (DCPT) was carried out at each borehole location to 3.1 m below ground surface to assess the bearing capacity at the depth of the subgrade.

2. BOREHOLE INFORMATION

A total of two (2) boreholes were advanced by manual methods, including hand auger, probe rod, Shelby (thin wall) sample tubes and DCPT at the inlet and outlet of the proposed culvert (Site No. 044-0659/02).

Refer to
- Drawing X-1 for the borehole location plan
- Table X-1 for details of borehole origin, borehole location coordinates and borehole elevations/depths
- Record of Borehole sheets and lab results showing details of the subsurface conditions at the borehole locations from current investigation

Table X-1 Structural Culvert Borehole Information

BOREHOLE ID	BOREHOLE LOCATION	MTM ON10 NAD 83 COORDINATES		GROUND SURFACE ELEVATION (m)	BOREHOLE DEPTH (m)
		NORTHING (m)	EASTING (m)		
CVM9-1	East End (Outlet)	5 088 512.0	220 691.2	191.7	1.0
CVM9-2	West End (Inlet)	5 088 490.9	220 718.6	191.6	1.3

2.1. Subsurface Conditions

The stratigraphy conceptually consists of clayey silt, trace/some sand, below the existing water surface, to the termination depth of drilling. Refer to the Record of Boreholes for details.

The subsurface conditions at this site can be categorized into one (1) general layer as presented below from surface downwards.

2.1.1. Clayey Silt, Trace/Some Sand

This clayey silt, trace/some sand deposit was encountered immediately below the water surface in Boreholes CVM9-1 and CVM9-2, extending to the borehole termination depths of 1.0 m and 1.3 m below the existing ground surface, respectively. The boreholes were refused on probable boulders. Moisture content determinations of two (2) samples tested from this layer were 24.5% and 25.0%.

The grain size distribution test results of the representative samples selected from this layer are provided in Figure GS-X-2 and the Atterberg limits are presented in Figure PC-X-2.

2.2. Groundwater Conditions

The borehole locations were located underwater. The surface water level was measured at Elevation 191.8 m, on November 9, 2021.

Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) are based on the following references:

1. Highway 69 Profile Drawings, provided by Parson via email dated November 25, 2020
2. Culvert Sections Drawings, provided by Parsons via email dated November 25, 2020

3. PROJECT DESCRIPTION

3.1. General

The proposed Fisheries Culvert (Site No. 044-0659/02) is a new structure across the new alignment of Highway 69 SBL. The culvert is located within the Township of Mowat.

3.2. Proposed Structure

It is proposed that the culvert will have an opening size of 3.0 m in span, 2.4 m in height, will be approximately 62.0 m long and will be approximately perpendicular to the new alignment of the new Highway 69 SBL alignment.

The existing ground surface in the vicinity of the culvert alignments varies from approximate EL. 191.6 m to EL. 191.7 m.

Based on Reference 1, the proposed invert level of the culvert is approximately at EL. 190.9 m. Silty sand/sandy silt/sandy clayey silt is anticipated at the invert level of the culvert.

Table H: Box Culvert Founding Elevations at Station 15+380 SBL CVM-9 Culvert (Site No. 044-0659/02)

PROPOSED CULVERT INVERT ELEVATION	BOTTOM OF BOX CULVERT ELEVATION	SUBGRADE ELEVATION FOR GRANULAR BEDDING	FOUNDING STRATUM
190.9 m	190.6 m	190.3 m	Clayey Silt

Note(s): 1: The bottom thickness of the precast concrete box culvert is assumed 0.25 m (minimum).

Based on Reference 2, the height of embankment fill required above the culvert to the proposed grade of Highway 69 SBL at Station 15+347.39 is not expected to exceed 6.7 m, including the pavement structure.

In the absence of any structural details of the culverts, at the time of writing this report, it is assumed that concrete culverts and fill would impose a dead load of 160 kPa on the founding subgrade.

4. EVALUATION OF FOUNDATION ALTERNATIVES

The foundation alternatives listed below were based on the available information in References 1, and 2, including the assumed embankment fill required above the culvert that is not expected to exceed 6.7 m.

1. Precast concrete box culverts placed without settlement mitigation
2. Precast concrete box culverts placed after preloading or surcharging

For both options, assuming that the culvert is placed at the proposed subgrade level of EL. ±190.3 m, clayey silt is expected underneath the base of the culvert.

Unsuitable/organic materials at the culvert location should be excavated from within the zone of influence of the culvert (minimum of 2.0 m beyond the culvert walls) and the area under the culvert when preparing the subgrade for the culvert. The exposed subgrade should be inspected and approved before placement of compacted granular materials as specified in OPSS 422.07.06.

The granular material to backfill the precast concrete box culvert should be placed in accordance with OPSS 422.07.07. Granular material should be as specified in accordance with OPSS 422.05.13 and may consist of either Granular ‘A’ or Granular ‘B’ Type II, including a 75 mm levelling course for bedding purposes as required by OPSS 422.07.08.

Based on the DCP test, at about 1.5 m below the existing ground surface at both borehole locations, it is assessed that the precast concrete box culvert may be designed assuming a factored geotechnical resistance of 250 kPa at ULS and 165 kPa at SLS placed on clayey silt. Bedrock is expected 2.0 m to 2.5 m below the culvert invert level based on Reference 1. Following placement of the precast concrete box culvert as recommended and the estimated fill of 6.7 m above the culvert, it is estimated that the total settlement would be less than 25 mm and the differential settlement between 15 mm and 20 mm. Generally, for precast concrete box culvert, a tolerable limit of 100 mm of differential settlement is assumed.

5. CULVERT BEDDING AND COVER MATERIALS

Refer to the General Report for preliminary recommendations for materials to be used for culvert bedding and cover purposes.

6. APPROACH EMBANKMENT

Based on References 1 and 2, the proposed embankment will be constructed approximately up to EL. 200.0.

In general, construction of embankments shall be in accordance with OPSS.PROV 206. Where construction of embankments over swamps is anticipated, the construction shall be in accordance with OPSS.PROV 209.

All organic materials and cohesive soils shall be removed from the proposed footprint of the embankment and replaced with compacted granular material. Backfill should be placed in accordance with OPSS.PROV 206. Where water bodies are within the footprint of the embankment, backfill material other than rock may be placed up to 600 mm above water level without compaction in accordance with OPSS.PROV 209 (209.07.03.01). It should also be noted that vibratory compaction equipment should not be used within 1.0 m of the original surface of the swamp (OPSS.PROV 209 – 209.07.04.2).

The proposed embankment can be construct with granular materials, earth borrow or rockfill. The side slopes of the proposed embankment are to be sloped at a minimum 2H:1V if granular material or earth borrow is used to construct the embankment. The side slopes of the embankment should be a minimum 1.25H:1V if rockfill is used to construct the embankment.

Granular materials shall be in accordance with OPSS.PROV 1010, amended by SSP 110S06. If earth borrow is utilized to construct the embankment, the earth borrow should be in accordance with OPSS.PROV 212, amended by SSP 112S07 and SSP 212F01. If rockfill is utilized to construct the new embankment, the material should be in accordance with OPSS.PROV 1004, amended by SS 110S16. Compaction shall be carried out in accordance with OPSS.PROV 501, amended by SSP 105S22. It should be noted that frost susceptible material shall not be placed within the zone between the frost penetration depth and the final grade of the roadway.

No stability and settlement issues are anticipated following construction of the embankments as discussed above. It is anticipated that 20 mm to 35 mm of settlement of the embankment fill due to self weight will be completed following construction of the embankment.

7. <u>CONSTRUCTION CONSIDERATIONS</u>

7.1. Excavation

Considering the existing ground level (EL. 191.6 m to EL. 191.7 m) and the culvert subgrade level (EL. ±190.3 m), 1.3 m to 1.4 m deep excavation into native soils is needed for subgrade preparation. Slope instability issues are not anticipated.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

Preliminary recommendations for backfilling to the culvert are provided in the General Report.

7.2. Groundwater and Surface Water Control

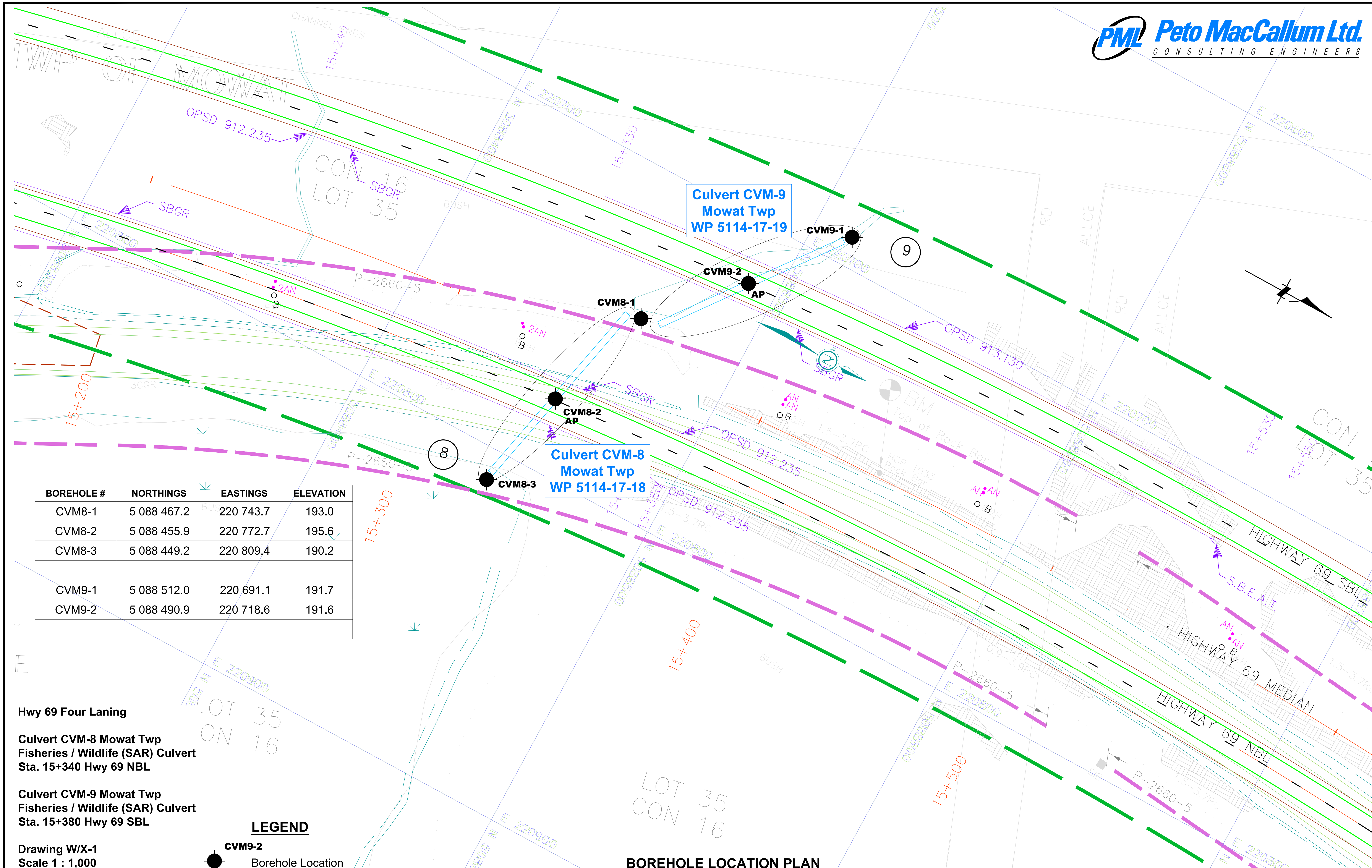
Surface water flow should be directed away from the excavation areas to mitigate disturbance of the native subgrade by means of temporary pipe. Dewatering may be carried out from sumps along the interior periphery of the excavation to maintain the groundwater level a minimum of depth of 0.5 m below the base of excavations. For construction in-the-dry, the flowing water will have to be temporary diverted.

Refer to the General Report for further groundwater control recommendations and requirements for water taking.

Refer to the General Report for further groundwater control recommendations and requirements for water taking.

7.3. Additional Investigation

It is suggested that additional investigation below the depth of the proposed subgrade level be carried out during the detail design within 2.0 m north or south of the proposed culvert along the centreline of Highway 69 SBL and at the ends of the culvert to confirm the subsurface soil and groundwater conditions. Based on the data, the recommendations provided in this report may have to be revised.



BOREHOLE #	NORTHINGS	EASTINGS	ELEVATION
CVM8-1	5 088 467.2	220 743.7	193.0
CVM8-2	5 088 455.9	220 772.7	195.6
CVM8-3	5 088 449.2	220 809.4	190.2
CVM9-1	5 088 512.0	220 691.1	191.7
CVM9-2	5 088 490.9	220 718.6	191.6

Hwy 69 Four Laning

Culvert CVM-8 Mowat Twp
Fisheries / Wildlife (SAR) Culvert
Sta. 15+340 Hwy 69 NBL

Culvert CVM-9 Mowat Twp
Fisheries / Wildlife (SAR) Culvert
Sta. 15+380 Hwy 69 SBL

Drawing W/X-1
Scale 1 : 1,000

LEGEND

CVM9-2
Borehole Location

BOREHOLE LOCATION PLAN

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No CVM9-1

METRIC

PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 088 512.0 N; 220 691.2 E | ORIGINATED BY M.M.

DIST | HWY 69 | BOREHOLE TYPE Manual Probe | COMPILED BY N.L.

DATUM Geodetic | DATE 2021.11.09 | LATITUDE 45.931291 | LONGITUDE -80.584559 | CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
191.7	Ground Surface Below Water										
0.0	organics; CLAYEY SILT, trace sand; Grey, Moist		1	TW							0 2 81 17
191.1 / 0.6	End of borehole										

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

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No CVM9-2

METRIC

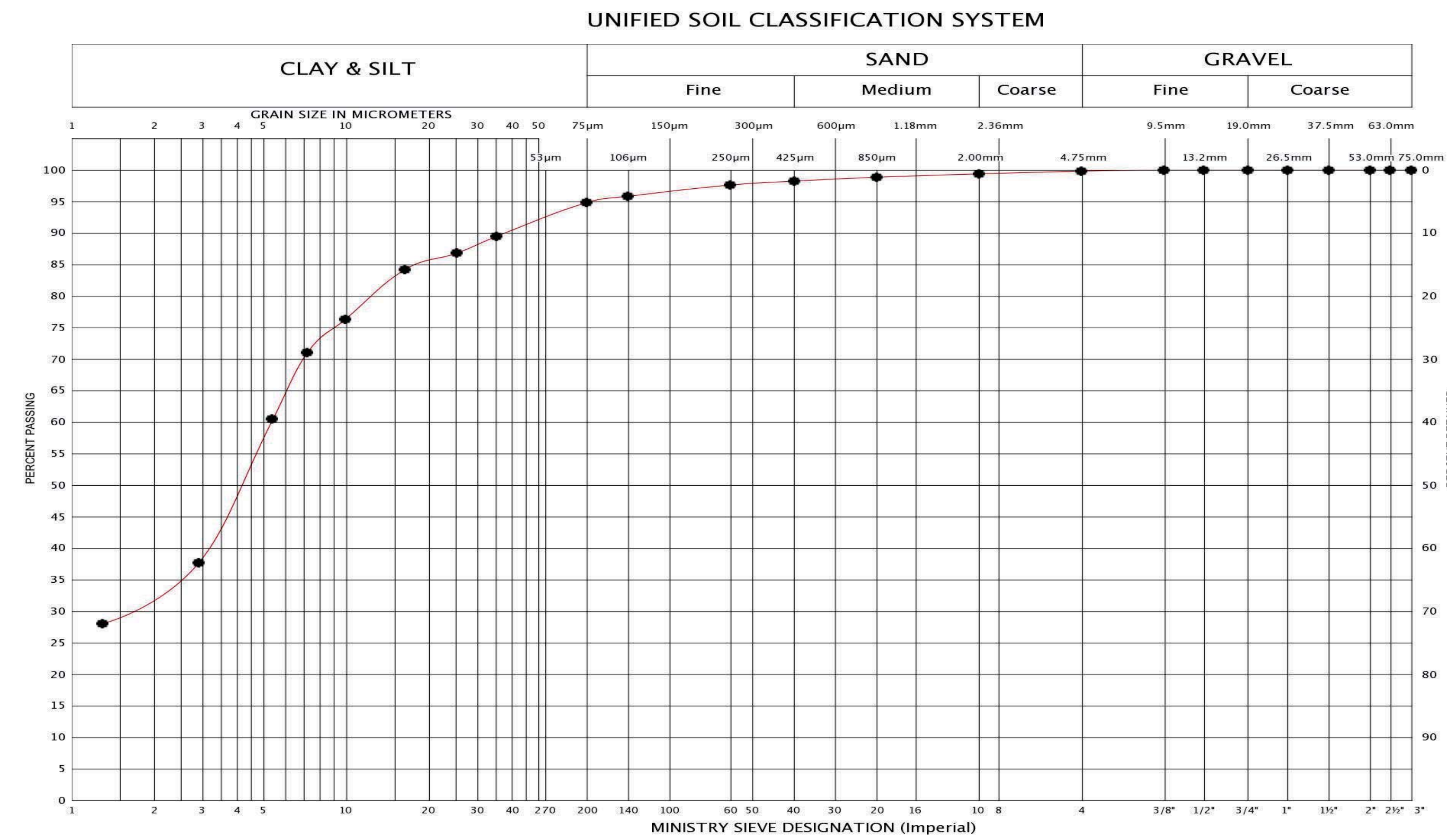
PROJECT Hwy 69 Structural Culvert | COORDINATES Coords: 5 088 490.9 N; 220 718.6 E | ORIGINATED BY M.M.

DIST | HWY 69 | BOREHOLE TYPE Manual Probe | COMPILED BY N.L.

DATUM Geodetic | DATE 2021.11.09 | LATITUDE 45.931104 | LONGITUDE -80.584201 | CHECKED BY N.R.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT/ GAS READING γ kN/m³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
191.6	Ground Surface Below Water										
0.0	organics; CLAYEY SILT, some sand; Grey, Moist		1	TW							0 12 76 12
191.0 / 0.6	End of borehole						191				

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



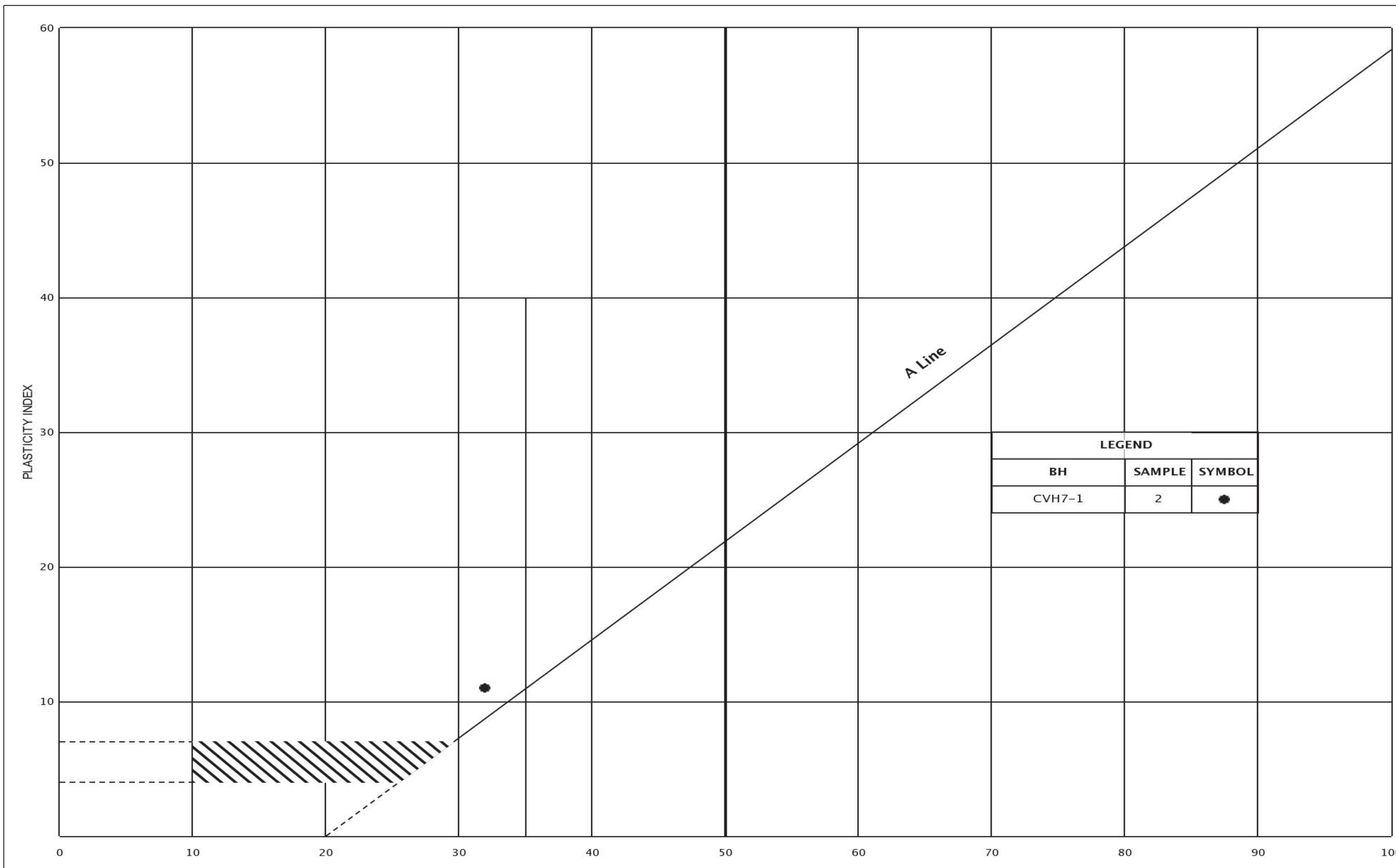
LEGEND		
	BH	CVH7-1
	SAMPLE	2
	SYMBOL	●

Ontario

GRAIN SIZE DISTRIBUTION

CLAYEY SILT

FIG No.: GS-V-1
HWY : 69
Project No.: 14TF034G

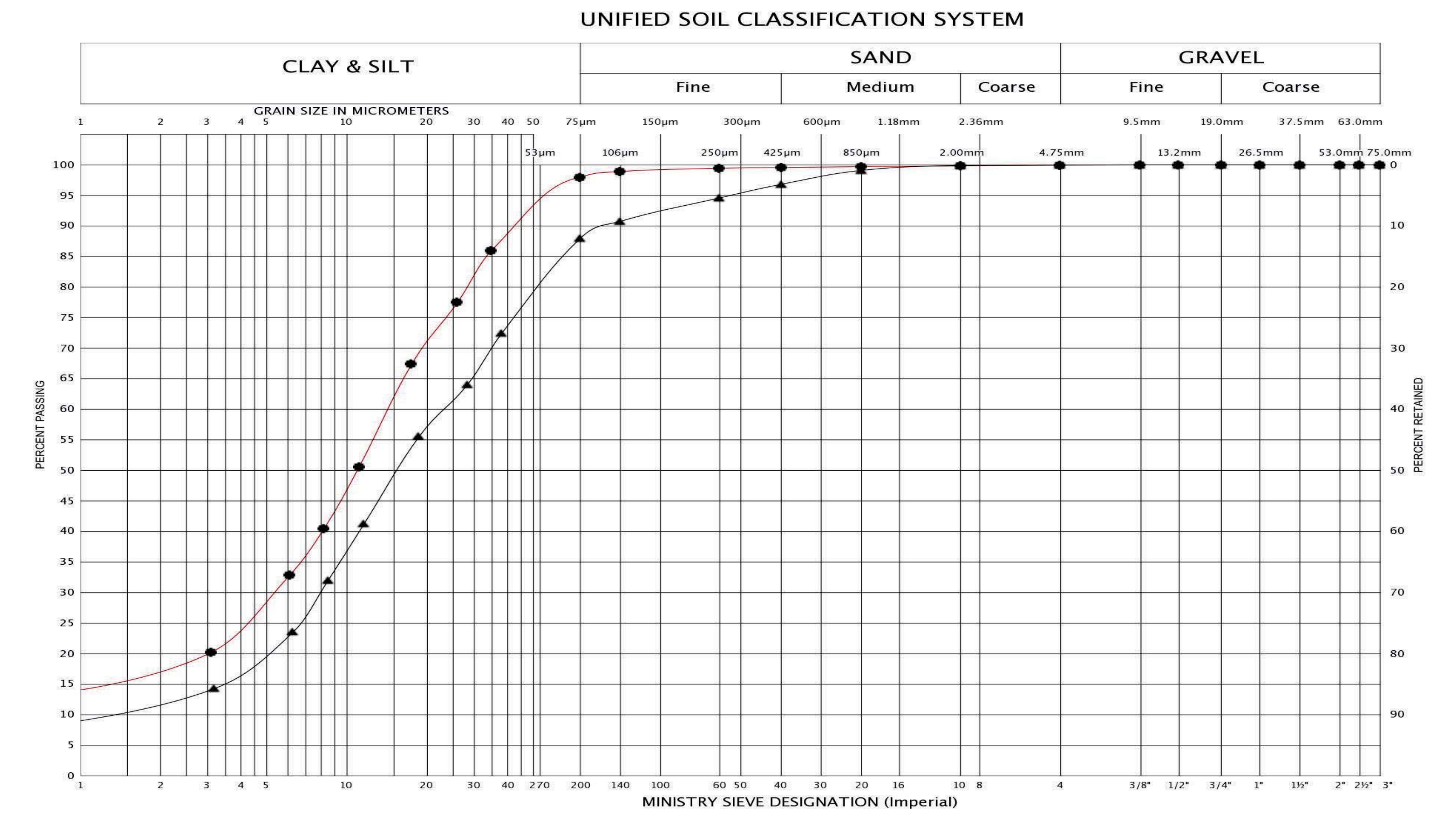


Ontario

PLASTICITY CHART

CLAYEY SILT

FIG No.: PC-V-1
HWY.: 69
Proj No. 14TF034G



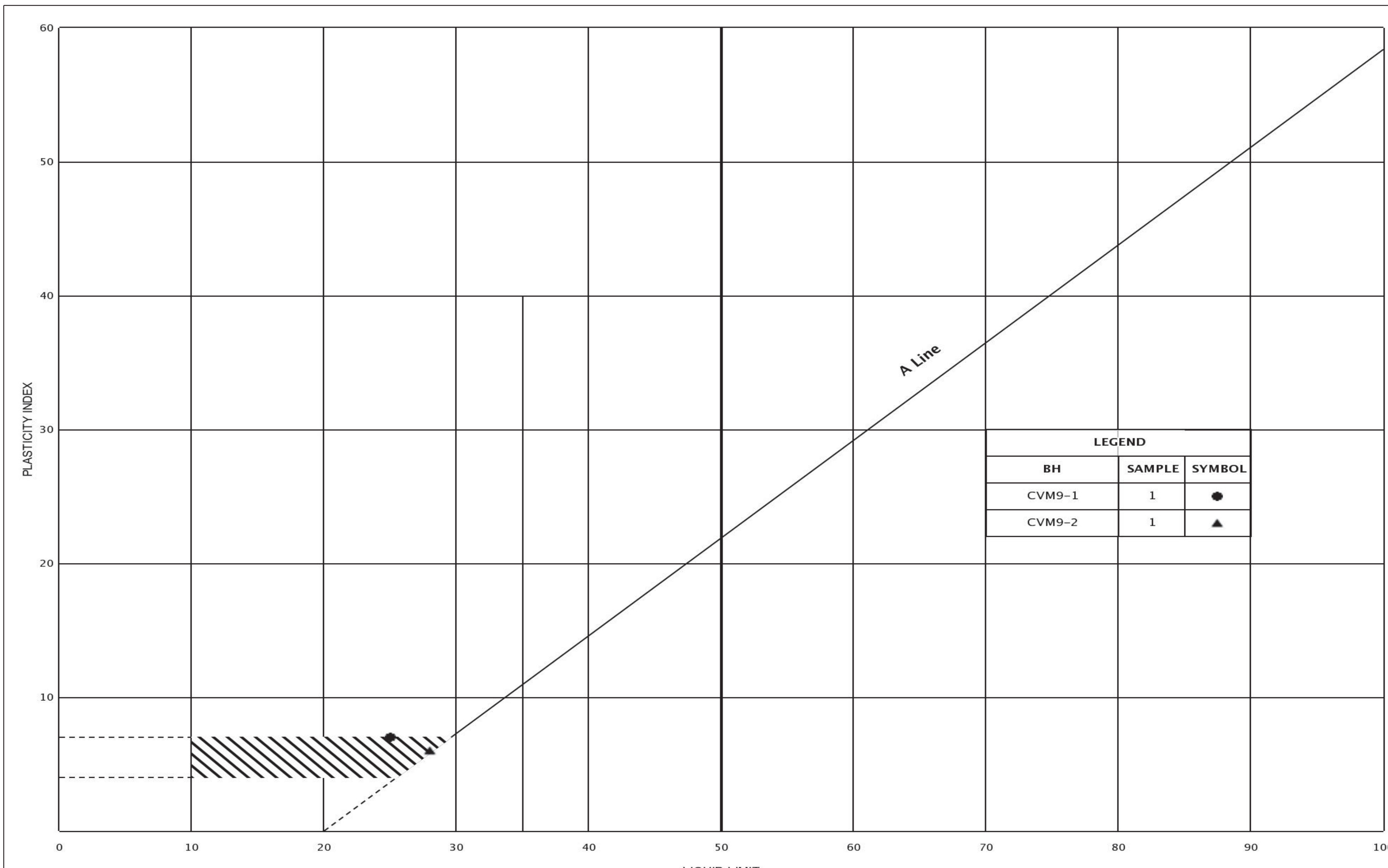
LEGEND			
	BH	CVM9-1	CVM9-2
	SAMPLE	1	1
	SYMBOL	●	▲

Ontario

GRAIN SIZE DISTRIBUTION

CLAYEY SILT

FIG No.:	GS-X-1
HWY :	69
Project No.:	14TF034G



LEGEND		
BH	SAMPLE	SYMBOL
CVM9-1	1	●
CVM9-2	1	▲

Ontario

PLASTICITY CHART

CLAYEY SILT

FIG No.:	PC-X-1
HWY.:	69
Proj No.	14TF034G

SHEET Y – CVM-10 - Fisheries/Wildlife Culvert (Station: ± 16+414 Hwy 69 NBL – Mowat)

- Borehole Locations and Soil Strata (Geocres 41H-132)
- Record of Borehole Logs (Geocres 41H-132)
- Laboratory Test Results (Geocres 41H-132)
- Rock Core Photograph (Geocres 41H-132)

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

The field work for the replacement of Culvert CVM-10 at Station 16+414 Mowat Township on the Northbound Lane (NBL) (Structure: ID C200) of the existing Highway 69 was carried out by Golder Associates Ltd. (Golder) on February 10, 12 and March 2, 2013, and a foundation investigation report (FIR) Reference 1 below was submitted to MTO.

Four (4) boreholes were advanced at this culvert site. Three (3) of the boreholes (CR-1, CR-2 and CR-3) were advanced by Golder and one (1) borehole (310-14) was advanced by Peto MacCallum Ltd. (PML) on October 12, 2006, for the preliminary report of the embankment over Swamp 310 (GEOCRES No. 41H-75). Refer to the FIR submitted by Golder for details of the borehole locations and subsurface conditions encountered at the culvert location.

The following document is referenced:

1. Foundation Investigation Report (FIR) – Culvert Replacement, Contract 4, Existing Highway 69 NBL – Station 16+414, Township of Mowat, Highway 69 Four-Laning from 1.7 km North of Highway 529 Northerly to 3.9 km North of Highway 522, Ministry of Transportation, Ontario, GWP 5347-08-00; WP 5347-08-01, (GEOCRES No. 41H-132), Submitted to URS Canada Inc. by Golder on October 9, 2013 (Report Number: 09-1111-6014-4550).
2. Foundation Investigation and Design Report (FIDR), Swamp Crossings and High Fill Areas - Contract 3, Highway 69 Four-Laning from 1.7 km North of Highway 529 Northerly to 3.9 km North of Highway 522, MTO, GWP 5404-05-00; WP 5404-05-01, (GEOCRES No. 41H-134, submitted to URS by Golder on February 11, 2014 (Report Number: 09-1111-6014-3520).

The culvert location is generally covered with sparse trees and various types of grasses and low vegetation, within a low-lying swamp area with open water. The local topography is that of a typical flat land swamp.

PRELIMINARY FOUNDATION DESIGN REPORT

The discussions and preliminary recommendations presented in this preliminary Foundation Design Report (FDR) are based on the information received by PML from Parsons on March 2 and September 13 and 24, 2018 and the sub-surface soil and groundwater conditions provided in the report Reference 1.

2. PROJECT DESCRIPTION

2.1 General

As part of the four-laning of Highway 69, the proposed Fisheries/Wildlife (SAR) Culvert CVM-10 at Station 16+414 on the existing Highway 69 will be the upgraded replacement structure across the future NBL of Highway 69. A new two-lane roadway will be constructed approximately 30 m west of the existing Highway 69 to carry the SBL traffic.

2.2 Existing Structure

The inspection report prepared by URS on September 19, 2012 that was provided by Parsons indicates that the existing structure is a 22.7 m long, cast-in-place concrete box culvert with an opening size of 1.22 m in span, and 1.22 mm in height. This report also indicated that there is no wingwall or headwall at the inlet or outlet of the culvert. It is a permanent watercourse with earthen bed surface and the flow is in the east to west direction. The depth of the standing water at the time of inspection was measured at 0.3 m. Based on the inspection report, the channel is stable and there is no potential hazard to the existing embankment.

The invert levels at the upstream and downstream ends are at EL. 193.83 and EL. 193.67 m, respectively. The borehole location plan and stratigraphic profile provided on Drawing No. 2 of the FIR indicates that the inlet and outlet of the existing culvert was covered with approximately 0.3 m of ice at the time of fieldwork.

2.3 Proposed Structure

Based on Drawing No. 2 included in the report Reference 1, the proposed replacement culvert will have an opening of 3.0 m in span, 2.4 m in height and will be approximately 25.0 m in length. The alignment of the proposed culvert will be on a slightly skewed angle to the existing alignment of Highway 69, as shown on Drawing No. 2.

This drawing also indicates that the invert of the proposed culvert will be placed at approximate EL. 193.75. The existing ground surface in the vicinity of the existing culvert alignment varies from approximately EL. 196.7 to 194.0 m and the ground profile is generally flat. The existing Highway 69 pavement is at approximate EL. 198.0 m.

The invert and founding levels of proposed replacement culvert across the NBL of existing alignment of Highway 69 are summarized in Table Y-1 below.

Table Y-1 Founding Elevations of Replacement Culvert at Sta. 16+414 NBL Existing Highway 69

FOUNDATION LOCATION	PROPOSED CULVERT INVERT ELEVATION, m	BOTTOM OF BOX CULVERT ELEVATION, m	SUBGRADE ELEVATION FOR GRANULAR BEDDING, m	EXISTING FOUNDING STRATUM
West End (Inlet)	193.8	193.5	193.2	Soft clayey silt, trace sand
East End (Outlet)	193.7	193.4	193.1	Gneiss bedrock

Note(s): 1. The bottom thickness of the precast concrete box culvert is assumed as minimum 0.25 m.

The estimated height of embankment, including the pavement structure, above the box culvert is approximately 2.0 m for estimation of the imposed load at the subgrade level. It is also assumed that the proposed replacement culvert, including the fill height of 2.0 m, would impose a load of about 85 kPa on the founding subsoil.

2.4 Structure Foundation Subsurface Conditions (Boreholes CR-1 to CR-3, and 310-14)

Refer to the subsurface and groundwater information reported in report Reference 1 which was summarized in the following paragraph:

In general, the stratigraphy encountered at this site consists of asphalt underlain by fill in the paved area and ice in the area of inlet and outlet, which are followed by peat to silty organics. The organic layer is followed by silty clay to clayey silt, which is underlain by sand and silt to silty sand in three of the boreholes that were terminated on probable bedrock. In the borehole located at the outlet, the clayey silt is underlain by gneiss bedrock, which was confirmed by coring.

In summary, the stratigraphy underlying the existing road consists of 260 mm of asphalt followed by fill to a depth of 1.8 to 2.2 m (EL. 194.5 m). The fill is underlain by firm to stiff silty clay to about 4.1 to 4.3 m (EL. 192.4 m), which is followed by 1.6 m of silty sand to the termination depth of the boreholes by refusal on probable bedrock at EL. 190.7 m. The borehole CR-3 located at the outlet reveals 300 mm of ice at the surface followed by silty organics and clayey silt to a depth of 0.6 m, where gneiss bedrock was encountered at EL. 194.4 m. The stratigraphy in borehole located at the inlet consisted of 300 mm of ice at the surface that is underlain by 300 mm of peat followed by 1.5 m of soft clayey silt. The clayey silt layer is underlain by compact silt and sand to the termination depth of the borehole where probable bedrock was encountered at EL. 191.3.

The surface of the probable bedrock in the drilled boreholes varies from EL. 194.4 to EL. 190.7. The bedrock level should be checked for detail design since the boreholes were drilled 3 to 5 m away from the centreline of the culvert.

In-situ vane shear strength (C_u) of clayey silt to silty clay between EL. 193.0 and EL. 192.0 m were reported in boreholes CR-1 and CR-2 are 23 kPa and 72 kPa.

Upon completion of augering, the groundwater levels measured in all four (4) boreholes ranged from 0.3 m, EL. 194.7 m, to 3.6 m, EL. 193.1 m depths below the existing ground or ice surface. The groundwater levels are subject to seasonal fluctuations and precipitation patterns. It is anticipated that the groundwater level in this area would be higher during wet periods of the year.

3. EVALUATION OF FOUNDATION ALTERNATIVES

The evaluation of foundation alternatives was based on the information provided on Drawing No. 2 in the report Reference 1 and the proposed box culvert invert will be as summarized in Table Y-1. This option will result on the inlet being placed on compressible 2.0 m thick firm to stiff silty clay over sand and the outlet being placed on a gneiss bedrock cut.

The settlement mitigation measures for the culvert should be coordinated with similar measures to be implemented for the construction of the highway embankment over Swamp 310 in report Reference 2. The preferred settlement mitigation measures for the embankment include the preloading and surcharging of the embankment. It is noted, however, that the preloading effect of the existing Highway 69 embankment on the subgrade at the culvert replacement location and the variation in thickness of clay layer underneath the culvert will result in total settlements of the inlet and centre of the culvert ranging from 50 to 60 mm. There will be only negligible settlements at the culvert outlet founded on bedrock. The associated differential settlements in relation to the outlet will be in the range of magnitude of 10 mm to 65 mm along the length of the culvert. The magnitude of total and differential settlements expected from replacing with Granular B Type II material under the estimated load of 85 kPa is assumed to be within the tolerable limit of 100 mm, generally acceptable for a precast concrete box culvert. However, the settlements will be excessive for a cast-in-place concrete culvert which should not be used at this site.

The foundation alternatives for this culvert are as follows.

1 Precast concrete box culvert placed on granular replacement fill

2 Corrugated Steel Plate (CSP) Arch Culvert on granular replacement fill

3.1 Option 1: Precast Concrete Box Culvert on Granular Replacement Fill

To place the precast concrete box culvert at the proposed invert level, it is recommended that peat, silty organics to clayey silt to silty clay layers to a depth of 1.8 m (EL. 192.2) to 3.90 m (EL. 192.8) below the existing ice or ground surface be removed and replaced with Granular B Type II backfill to the proposed founding level. The excavation includes removal of organic soils, spongy areas and soft or unsuitable materials observed within the footprint of the culvert, as outlined in OPSS 422.07.06.

Since the outlet end of the culvert will be placed on a bedrock cut, the foundation level at the outlet end should be excavated at least 300 mm deeper than the bottom of the culvert and the over excavation filled with compacted granular bedding material for uniformity and to avoid hard bearing points at the transition from soils to bedrock under the base of the culvert.

The precast concrete box culvert placed on replacement fill consisting of Granular B Type II may be designed assuming factored geotechnical resistances of 150 kPa at ULS and 100 kPa at SLS. The resistance of the bedrock part of the foundation will be higher but will not govern the design. The total settlement induced under the estimated load of 85 kPa is expected to be in the range of 50 to 60 mm and the associated differential settlement may be in the range of 10 to 60 mm.

The detail design of the culvert should consider to incorporate a camber of 60 mm at the inlet and 50 mm at the centre of the culvert to avoid potential ponding inside the culvert.

Refer to the General Report for details of the replacement fill materials and construction.

3.2 Option 2: Corrugated Steel Plate (CSP) Arch Culvert on Granular Replacement Fill

Refer to the General Report for preliminary general recommendations for the use of Corrugated Steel Plate (CSP) arch culverts. An allowance of 300 mm over excavation of the bedrock at the outlet end of the culvert should be incorporated in the design to avoid damage to the culvert over hard and/or unyielding points under the culvert.

4. CULVERT BEDDING AND COVER MATERIALS

Refer to the General Report for preliminary recommendations for materials to be used for culvert bedding and cover purposes.

5. APPROACH EMBANKMENTS

The details for design, construction, and mitigation procedures for the embankment through Swamp 310 are included in report Reference 2. This report should be consulted for placement of fill for the swamp crossing and no recommendation is provided in this report for new embankments. Subject to detail design considerations, if the replacement culvert was constructed at the same existing location and without grade changes, the reconstruction of the approach embankments would be straightforward.

6. CONSTRUCTION CONSIDERATIONS

6.1 Excavation

It is estimated that excavation to a depth of about 1.8 m to 3.9 m will be required to remove peat and silty organics, spongy areas and soft or unsuitable materials observed within the footprint of the culvert. In addition, about 1.3 m of bedrock excavation is required to place the precast concrete box culvert over a granular layer.

To avoid longitudinal shoring, this culvert could be replaced during the construction staging of the Highway 69 four-laning after the traffic has been temporarily moved to the new SBL embankment. If roadway protection is required, the Project Co designer should consider the presence of relatively shallow bedrock. Refer to the General Report for further notes for roadway protection requirements.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

Preliminary recommendations for culvert backfilling are provided in the General Report.

6.2 Groundwater and Surface Water Control

Refer to the General Report for further groundwater control recommendations and requirements for water taking.

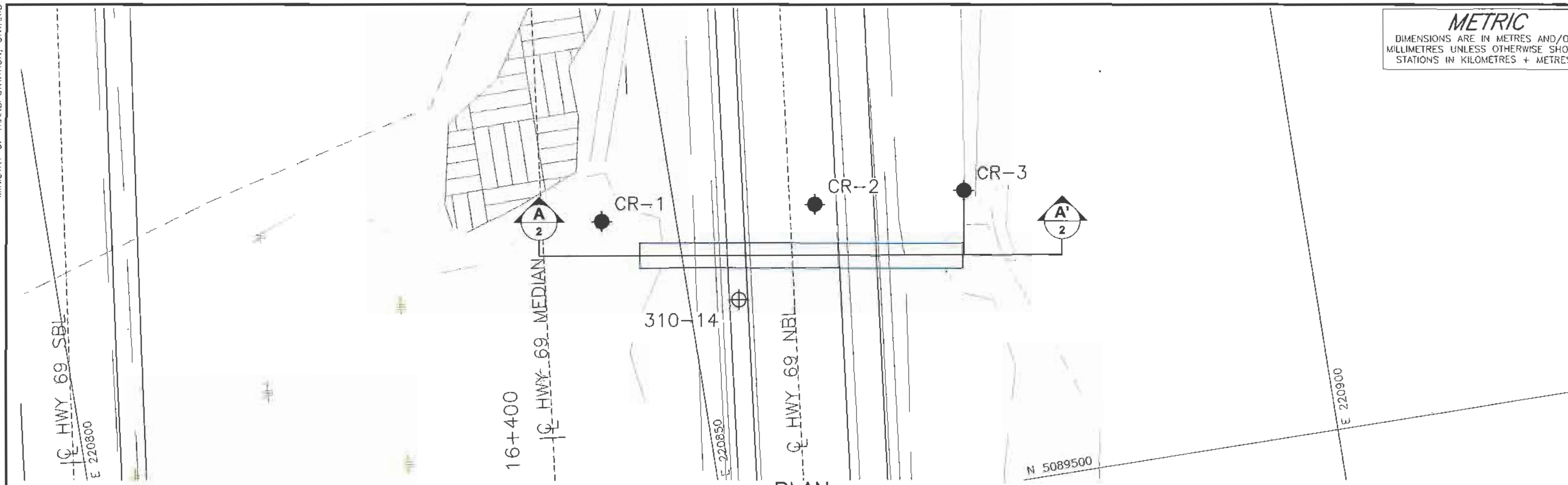
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No.5404-05-00

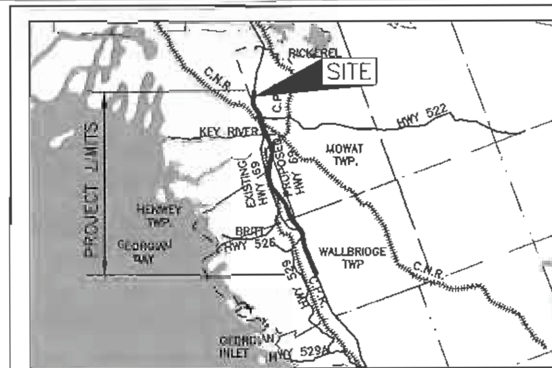
SHEET

HIGHWAY 69
NBL – STA 16+414 CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA

Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



PLAN
SCALE
4 0 4 8 m



KEY PLAN
SCALE
10 0 10 20 km

LEGEND

●	Borehole – Current Investigation
⊕	Borehole – Previous Investigation
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
100%	Rock Quality Designation (RQD)
R	Refusal
⊻	WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
CR-1	194.3	5089525.9	220844.1
CR-2	196.7	5089524.6	220861.3
CR-3	195.0	5089523.8	220873.2
310-14	196.4	5089518	220854

NOTES

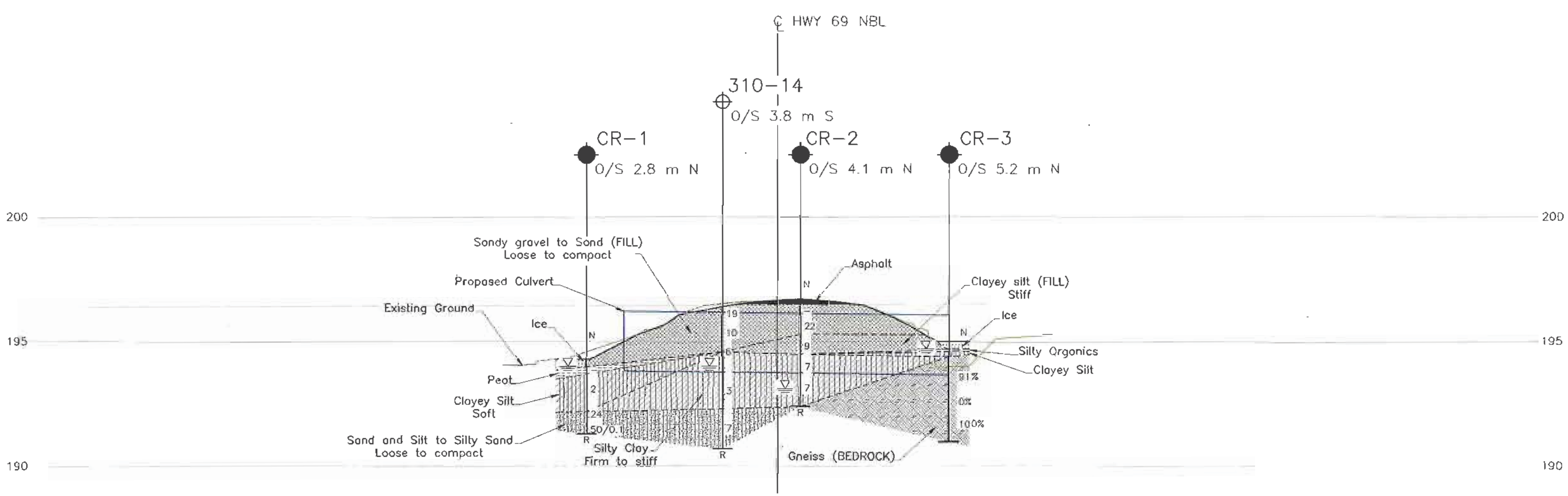
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

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

REFERENCE

Base plans provided in digital format by URS, drawing file Hwy69_XS_C4_CULVERT AT 16+414_for-GOLDER-APRIL-24-2013.dwg received April 24, 2013. Keyplan received APR 16, 2010.



A-A' 2 PROFILE ALONG CULVERT
HIGHWAY 69 (NBL–STA 16+414)
HORIZONTAL SCALE
4 0 4 8 m
2 0 2 4 m
VERTICAL SCALE

LICENSED PROFESSIONAL ENGINEER S.E.M. COYNE 90471921 OCT 9, 2013 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER J.M.A. COSTA OCT 9, 2013 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 41H-132			
HWY. 69		PROJECT NO. 09-1111-6014	DIST.
SUBM'D. AC	CHKD.	DATE: OCT 2013	SITE:
DRAWN: JJL	CHKD. SEMC	APPD. JMAC	DWG. 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
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:
The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

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

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

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

III. SOIL DESCRIPTION

(a) Cohesionless Soils

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

(b) Cohesive Soils
Consistency

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

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

Percent 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

Golder Associates

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

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
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_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 $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

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

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

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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		

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RECORD OF BOREHOLE No CR-1

1 OF 1 **METRIC**

PROJECT 09-1111-6014
W.P. 5347-08-01
DIST ______ HWY ______
DATUM GEODETIC
LOCATION N 5089525.9; E 220844.1
BOREHOLE TYPE Portable Equipment, B Casing and Wash Boring
DATE March 2, 2013
ORIGINATED BY EHS
COMPILED BY AC
CHECKED BY SEMC

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLES – NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED) 20 40 60 80 100	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L – WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.3	ICE SURFACE									
0.0 / 194.0	ICE	1	SS	-	∇	194				
193.7 / 0.6	PEAT (Fibrous) Black Wet									
	CLAYEY SILT, trace sand Soft Grey Wet	2	SS	2		193	+6			
192.2 / 2.1	SAND and SILT to Silty SAND, some gravel, trace clay Compact Grey Wet	3	SS	24		192				
191.3 / 3.0	END OF BOREHOLE SPOON REFUSAL	4	SS	50/0.1						

Note:

1. Water level at a depth of 0.3 m below ground surface (Elev. 194.0 m) upon completion of drilling.

SUD_MTO 003 09-1111-6014.GPJ GAL-MISS.GDT 31/05/13 DATA INPUT:

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

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RECORD OF BOREHOLE No CR-2

1 OF 1 **METRIC**

PROJECT 09-1111-6014
W.P. 5347-08-01
LOCATION N 5089524.6; E 220861.3
ORIGINATED BY EHS
DIST ____ HWY ____
BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers
COMPILED BY AC
DATUM GEODETIC
DATE February 12, 2013
CHECKED BY SEMC

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
196.7	GROUND SURFACE						
0.0	ASPHALT (260 mm)						
196.2	Sandy Gravel (FILL)						
0.5	Sand, trace silt (FILL) Compact Brown Moist	1	AS	-		196	
		2	SS	22			1 95 (4)
195.3 / 1.4	Clayey Silt, trace sand, trace organics (FILL) Stiff Grey to brown Wet	3	SS	9		195	
194.5 / 2.2	SILTY CLAY, trace sand Firm to stiff Grey to brown Wet	4	SS	7		194	0 1 73 26
		5	SS	7	∇	193	
192.4 / 4.3	END OF BOREHOLE AUGER REFUSAL Note: 1. Water level at a depth of 3.6 m below ground surface (Elev. 193.1 m) upon completion of drilling.						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL · REMOULDED: 20 40 60 80 100
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%): 20 40 60
UNIT WEIGHT γ kN/m³

5
+

SUD_MTO 003 09-1111-6014.GPJ GAL-MISS.GDT 31/05/13 DATA INPUT:

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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No CR-3

1 OF 1 **METRIC**

PROJECT 09-1111-6014
W.P. 5347-08-01
LOCATION N 5089523.8; E 220873.2
ORIGINATED BY EHS
DIST ____ HWY ____
BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers
COMPILED BY AC
DATUM GEODETIC
DATE February 10, 2013
CHECKED BY SEMC

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
195.0	ICE SURFACE						
0.0	ICE	1	AS	-	∇		
194.7	Silty Organics						
	CLAYEY SILT, trace to some sand						
0.6	GNEISS BEDROCK Bedrock cored from 0.6 m depth to 4.0 m depth. For coring details see Record of Drillhole CR-3.	1	RC	REC 100%		194	RQD = 91%
		2	RC	REC 100%		193	RQD = 0%
		3	RC	REC 100%		192	RQD = 100%
191.0 / 4.0	END OF BOREHOLE Note: 1. Water level at a depth of 0.3 m below ice surface (Elev. 194.7 m) upon completion of drilling.					191	

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED: 20 40 60 80 100
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%): 20 40 60
UNIT WEIGHT γ kN/m³

SUD_MTO 003 09-1111-6014.GPJ GAL-MISS.GDT 31/05/13 DATA INPUT:

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

RECORD OF DRILLHOLE: CR-3

PROJECT: 09-1111-6014
LOCATION: N 5089523.8 ;E 220873.2
INCLINATION: -90° AZIMUTH: —

DRILLING DATE: February 10, 2013
DRILL RIG: CME 55
DRILLING CONTRACTOR: Landcore Drilling Inc.

SHEET 1 OF 1
DATUM: GEODETIC

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	DISCONTINUITY DATA – TYPE AND SURFACE DESCRIPTION	NOTES WATER LEVELS INSTRUMENTATION
		REFER TO PREVIOUS PAGE	194.4				
	February 10, 2013 NQ Coring (NW)	GNEISS Medium Grained Dark grey to green Well foliated	0.6				
1				1	GREY 100%	JNIRRo JNIRRo JNFCRo JNIRRo JNIRRo JNFORo JNFORo JNFORo JNFORo	UCS=130 MPa
2						JNIRRo JNIRRo	
		Highly weathered schist from 2.2 m to 2.3 m depth and 2.4 m to 2.6 m depth. Sand seam from 2.3 m to 2.4 m depth.		2	GREY / BROWN 100%	BR	
3				3	GREY 100%	JNFORo JNFORo JNFORo	
4		END OF DRILLHOLE	191.0 4.0				

Other column headings: SYMBOLIC LOG; FLUSH; RECOVERY (TOTAL CORE %, SOLID CORE %); R.Q.D. %; FRACT. INDEX PER 0.3 METRES; DISCONTINUITY DATA (B Angle, DIP w.r.t. CORE AXIS, Jr, Ja, Jn); HYDRAULIC CONDUCTIVITY k, cm/s; Diametral Point Load Index (MPa); RMC -Q' AVG

Depth scale: 5, 6, 7, 8, 9, 10

DEPTH SCALE 1 : 50

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LOGGED: EHS
CHECKED: SEMC

SUD-ROCK 09-1111-6014.GPJ GAL-MISS.GDT 31/05/13 DATA INPUT:

Ministry of Transportation Ontario

Peto MacCallum Ltd.
Foundation Design

RECORD OF BOREHOLE No 310-14

1 of 1 METRIC

G.W.P. 5203-06-00	LOCATION Hwy 69(New), Sta. 13+450, o/s 12.9m Rt. CL Med.	ORIGINATED BY M.R.
DIST 54 HWY 69	BOREHOLE TYPE Continuous Flight Hollow Stem Augers	COMPILED BY G.D.
DATUM Geodetic	DATE October 12, 2006	CHECKED BY C.N.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
196.4	Ground Surface					
0.0	Gravelly sand, trace silt Compact Dark brown Wet (PAVEMENT FILL)	1	SS	19		196
195.4 1.0	Sand, trace silt Loose Brown Wet (FILL)	2	SS	10		195
194.6 1.8	Silty clay, trace sand Firm Brown Wet	3	SS	6	▼*	194
	thin layers of silt	4	SS	5		193
192.3 4.1	Silty sand Loose Grey Wet	5	SS	7		192 191
190.7 5.7	End of borehole Refusal on probable bedrock					

Other column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

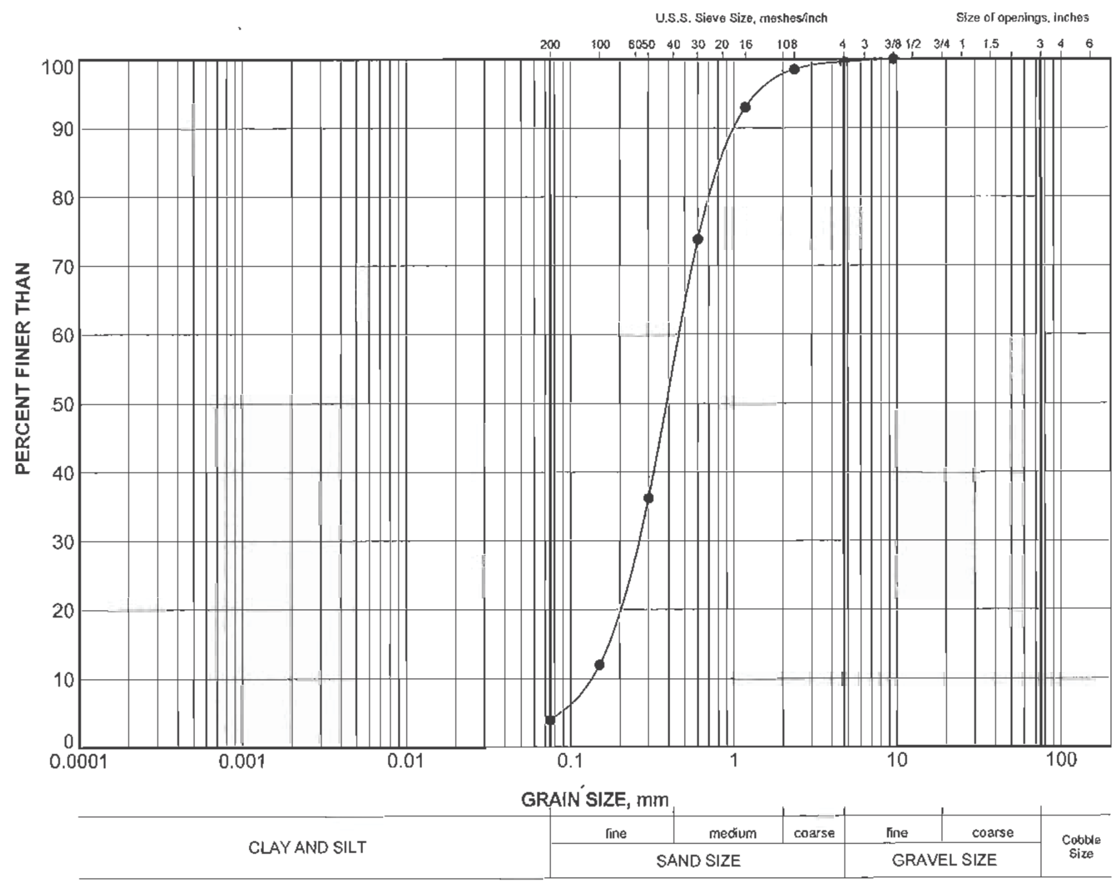
* 2006 10 12

▼ Water level measured after drilling

ON_MOT VER3 SWAMP 310-FINAL.GPJ ON_MOT.GDT 7/15/2009 10:56:56 AM

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15–○–5 / 10 (%) STRAIN AT FAILURE



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	CR-2	2	195.6

PROJECT

HIGHWAY 69
CULVERT AT STA 16+414

TITLE

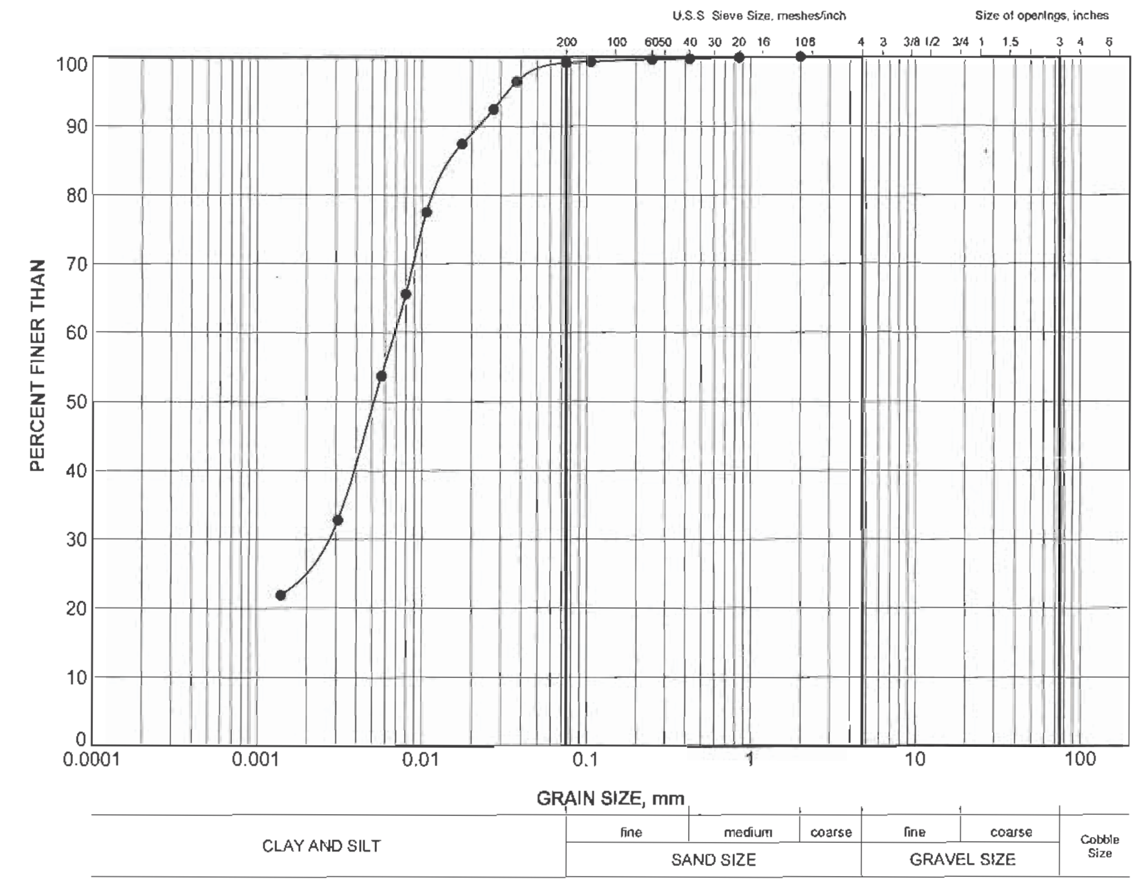
GRAIN SIZE DISTRIBUTION

SAND (FILL)

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014	FILE No.	09-1111-6014.GPJ
DRAWN	TB	May 2013	SCALE N/A REV.
CHECK	SEMC	May 2013	FIGURE B1
APPR	JMAC	May 2013	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	CR-2	4	194.1

PROJECT

HIGHWAY 69
CULVERT AT STA 16+414

TITLE

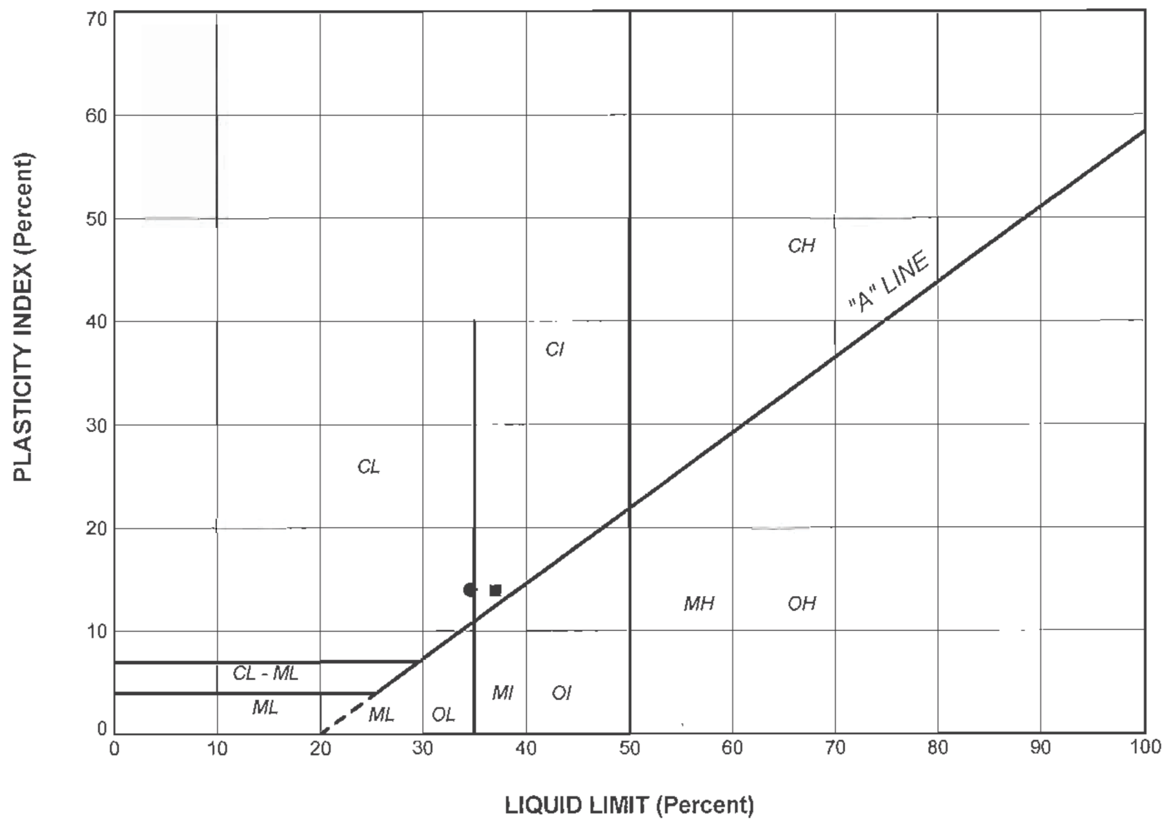
GRAIN SIZE DISTRIBUTION

SILTY CLAY

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014	FILE No.	09-1111-6014.GPJ
DRAWN	TB	May 2013	SCALE N/A REV.
CHECK	SEMC	May 2013	FIGURE B2
APPR	JMAC	May 2013	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	CR-1	2	34.6	20.6	14.0
■	CR-2	4	37.0	23.1	13.9

PROJECT
HIGHWAY 69
CULVERT AT STA 16+414

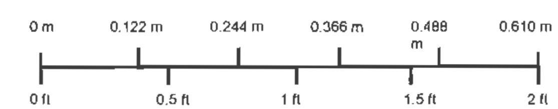
TITLE
PLASTICITY CHART
CLAYEY SILT to SILTY CLAY

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1111-6014		FILE No.	09-1111-6014.GPJ
DRAWN	TB	May 2013	SCALE N/A	REV.
CHECK	SEMC	May 2013	FIGURE B3	
APPR	JMAC	May 2013		

SUD-MTO PL (NEW) GLDR_LDN.GDT

Borehole CR-3
Elevation 194.4 m to 191.0 m



PROJECT
Highway 69
Culvert at STA 16+414

TITLE
BEDROCK CORE PHOTOGRAPH

Golder Associates

PROJECT No.	09-1111-6014		FILE No. —
DESIGN	AC	APR 2013	SCALE AS SHOWN REV.
CADD	--		FIGURE B4
CHECK	SEMC	APR 2013	
REVIEW			

APPENDIX A – SUBSURFACE INFORMATION

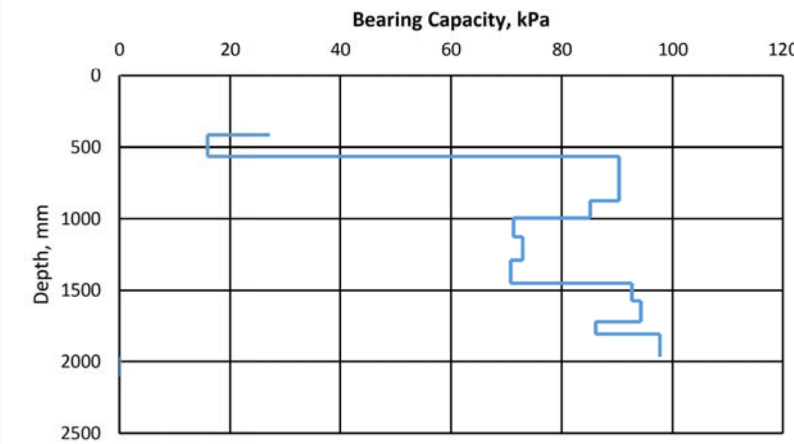
A-1 Kessler K-100 DCP Test Results

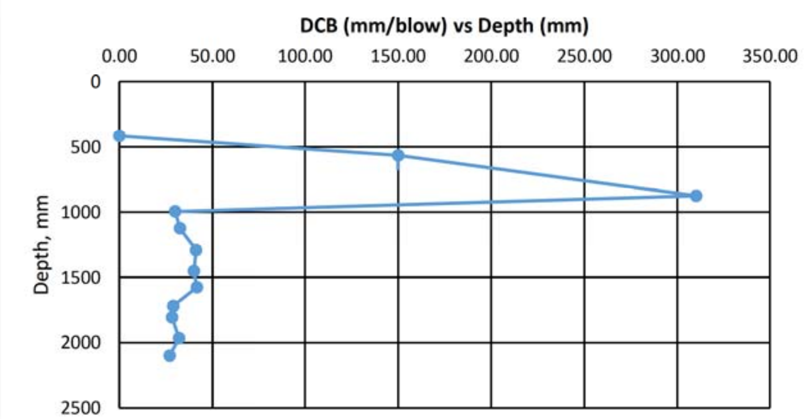
DCP TEST DATA CVH21-2

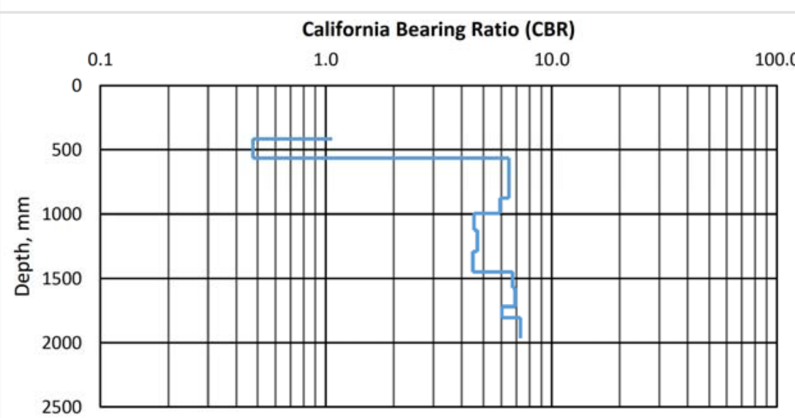
PROJECT: HWY 69 Structural Culverts
LOCATION: Britt, Ontario
HAMMER WEIGHT: 8.0 KG
PROJECT #: 14TF034G
DATE: 30-Sep-22
SOIL TYPE: All Soil Types

Blows	Accumilative (mm)	DCB (mm/blow)
0	415	0.00
1	565	150.00
1	875	310.00
4	995	30.00
4	1125	32.50
4	1290	41.25
4	1450	40.00
3	1575	41.67
5	1720	29.00
3	1805	28.33
5	1965	32.00
5	2100	27.00

Blows	CBR
0	0.0
1	1.1
1	0.5
4	6.5
4	5.9
4	4.5
4	4.7
3	4.5
5	6.7
3	6.9
5	6.0
5	7.3





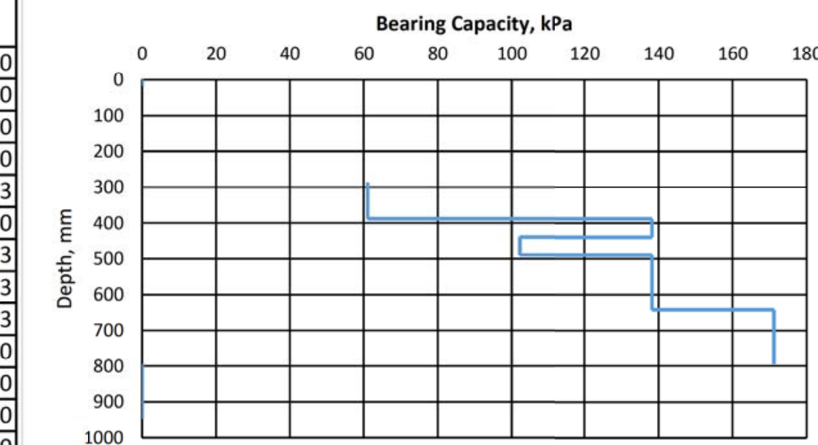


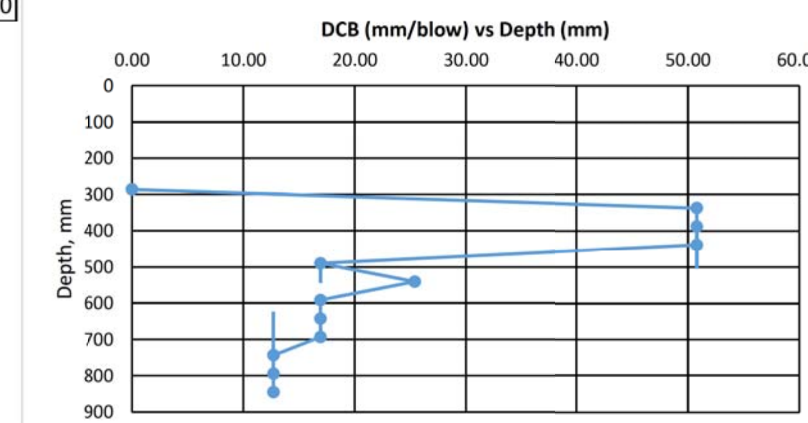
DCP TEST DATA CVH22-2

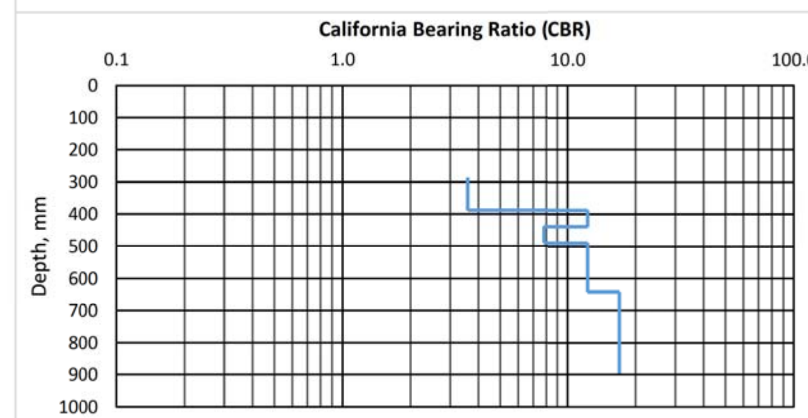
PROJECT: HWY - 69
LOCATION: Britt, Ontario
HAMMER WEIGHT: 8.0 KG
PROJECT #: 14TF034G
DATE: 10-Jul-23
SOIL TYPE: All Soil Types

Blows	Accumilative (mm)	DCB (mm/blow)
0	287	0.00
1	337	50.80
1	388	50.80
1	439	50.80
3	490	16.93
2	541	25.40
3	591	16.93
3	642	16.93
3	693	16.93
4	744	12.70
4	795	12.70
4	845	12.70
4	896	12.70
4	947	12.70

Blows	CBR
0	0.0
1	3.6
1	3.6
4	3.6
4	12.3
4	7.8
4	12.3
3	12.3
5	12.3
3	16.9
5	16.9
5	16.9



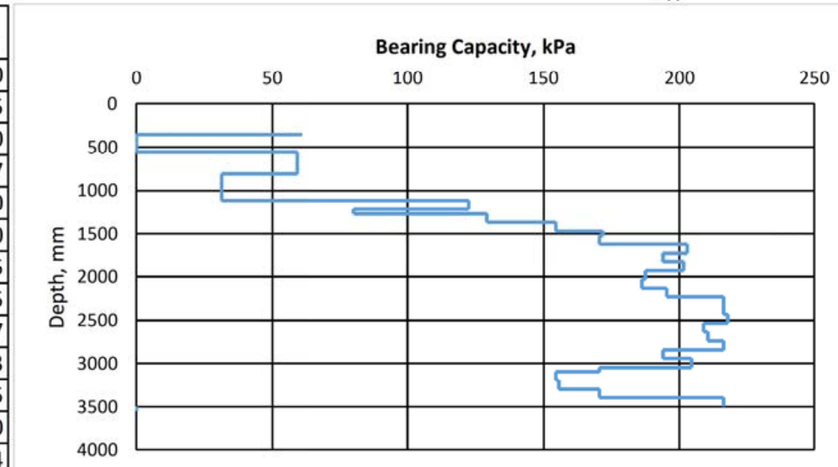


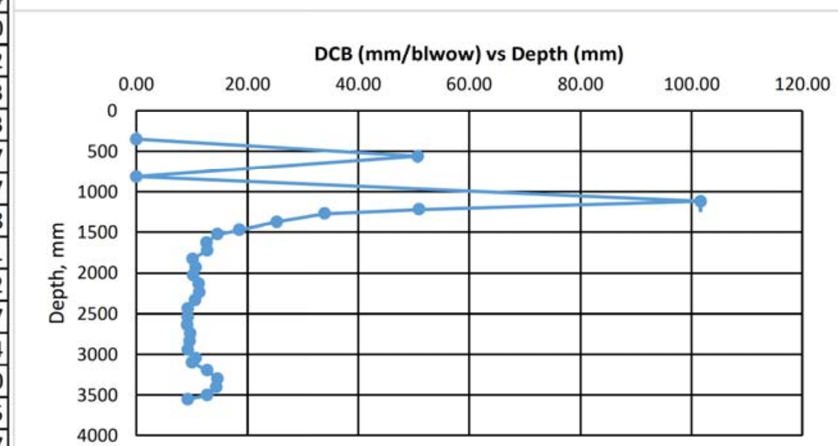


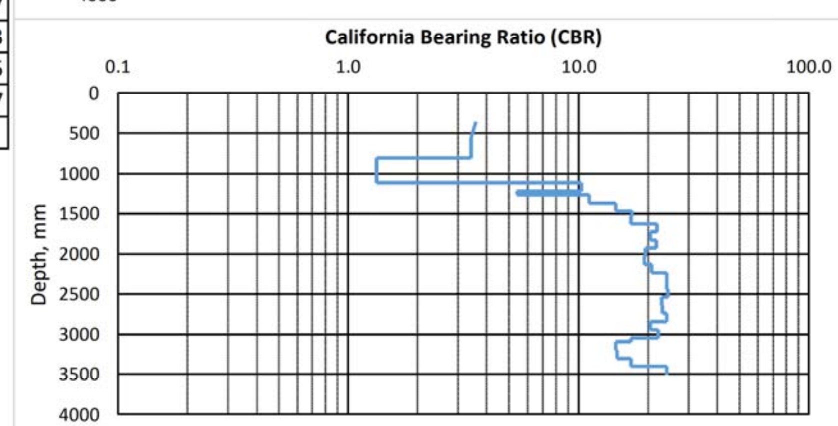
DCP TEST DATA — CVM6-1

PROJECT: HWY - 69
PROJECT #: 14TF034G
LOCATIO Britt, Ontario
DATE: 30-Sep-22
HAMMER WEIGHT: 4.6 KG
SOIL TYPE: All Soil Types

Blows	Accumilative (mm)	CBR	DCB (mm/blow)
0	355	0.0	0.00
8	558	3.6	50.75
0	812	0.0	0.00
6	1117	3.4	101.67
4	1219	1.3	51.00
3	1270	10.2	34.00
8	1371	5.4	25.25
11	1473	11.1	18.55
7	1524	14.5	14.57
16	1625	17.1	12.63
16	1727	16.9	12.75
20	1828	21.9	10.10
19	1930	20.5	10.74
20	2032	21.7	10.20
18	2133	19.5	11.22
18	2235	19.3	11.33
19	2336	20.7	10.63
22	2438	24.1	9.27
22	2540	24.1	9.27
22	2641	24.4	9.18
21	2743	22.9	9.71
21	2844	23.1	9.62
22	2946	24.1	9.27
19	3048	20.5	10.74
10	3098	22.2	10.00
16	3200	16.9	12.75
14	3302	14.5	14.57
14	3403	14.7	14.43
16	3505	16.9	12.75
11	3556	24.1	9.27



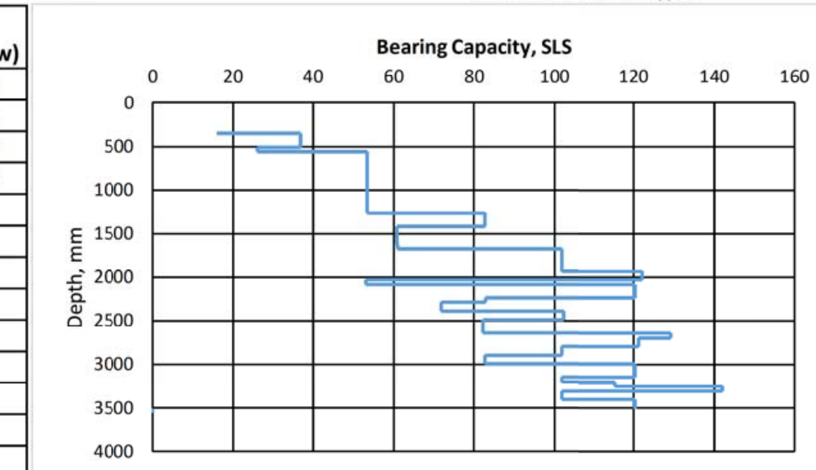


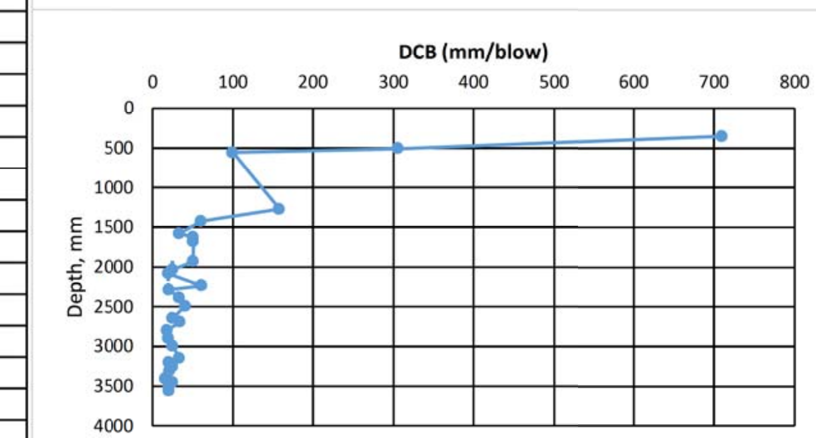


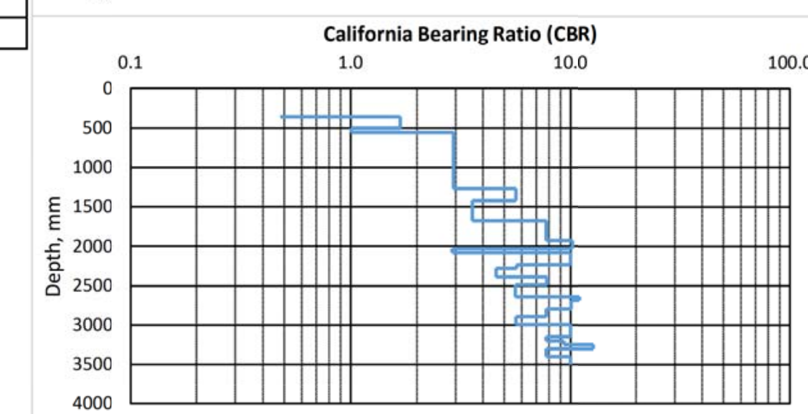
DCP TEST DATA — CVM6-3

PROJECT: HWY 69 Structural Culverts
PROJECT #: 14TF034G
LOCATION: Britt, Ontario
DATE: 30-Sep-22
HAMMER WEIGHT: 4.6 KG
SOIL TYPE: All Soil Types

Blows	Accumilative (mm)	CBR	DCB (mm/blow)
1	355	0.2	710.00
1	508	0.5	306.00
1	558	1.7	100.00
9	1270	1.0	158.22
5	1422	2.9	60.80
9	1574	5.7	33.78
2	1625	3.6	51.00
2	1676	3.6	51.00
10	1930	3.6	50.80
8	2032	7.8	25.50
5	2082	10.2	20.00
5	2235	2.9	61.20
5	2286	10.0	20.40
6	2387	5.7	33.67
5	2489	4.6	40.80
12	2641	7.8	25.33
3	2692	5.6	34.00
11	2794	11.1	18.55
10	2895	10.1	20.20
8	2997	7.8	25.50
9	3149	5.7	33.78
5	3200	10.0	20.40
4	3251	7.8	25.50
5	3305	9.3	21.60
12	3403	12.8	16.33
4	3454	7.8	25.50
5	3505	10.0	20.40
5	3556	10.0	20.40



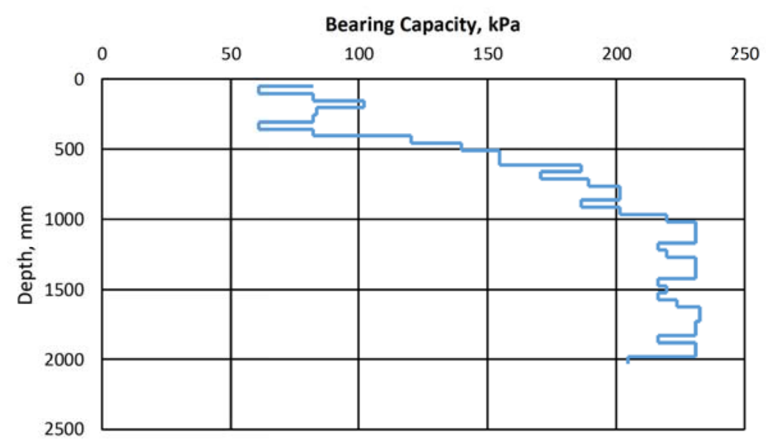


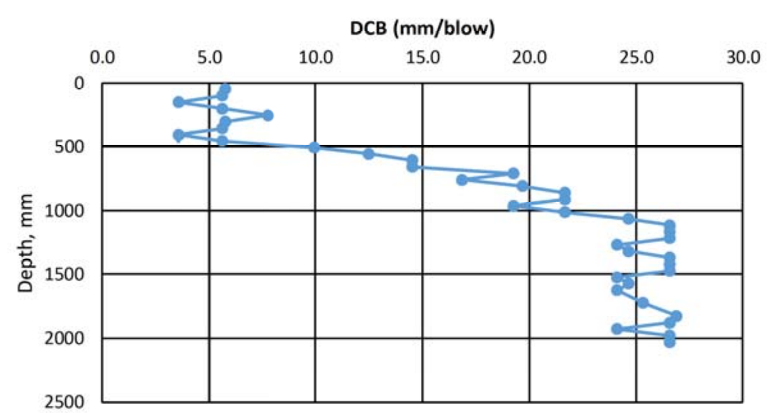


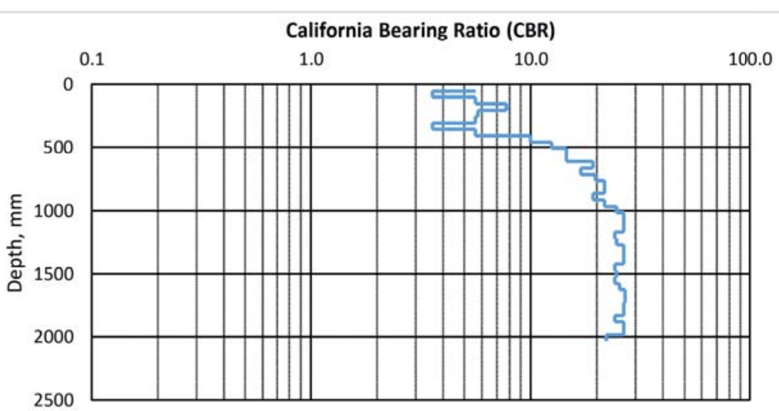
DCP TEST DATA — CVM7-1

PROJECT: HWY 69 Structural Culverts
LOCATION: Britt, Ontario
HAMMER WEIGHT: 4.6 KG
PROJECT #: 14TF034G
DATE: 29-Sep-22
SOIL TYPE: All Soil Types

Blows	Accumilative (mm)	CBR	DCB (mm/blow)
3	50	5.8	33.33
3	101	5.6	34.00
2	152	3.6	51.00
3	203	5.6	34.00
4	254	7.8	25.50
3	304	5.8	33.33
3	355	5.6	34.00
2	406	3.6	51.00
3	457	5.6	34.00
5	508	10.0	20.40
6	558	12.5	16.67
7	609	14.5	14.57
7	660	14.5	14.57
9	711	19.3	11.33
8	762	16.9	12.75
9	812	19.7	11.11
10	863	21.7	10.20
10	914	21.7	10.20
9	965	19.3	11.33
10	1016	21.7	10.20
11	1066	24.6	9.09
12	1117	26.6	8.50
12	1168	26.6	8.50
12	1219	26.6	8.50
11	1270	24.1	9.27
11	1320	24.6	9.09
12	1371	26.6	8.50
12	1422	26.6	8.50
12	1473	26.6	8.50
11	1524	24.1	9.27
11	1574	24.6	9.09
11	1625	24.1	9.27
23	1727	25.3	8.87
24	1828	26.9	8.42
12	1879	26.6	8.50
11	1930	24.1	9.27
12	1981	26.6	8.50
12	2032	26.6	8.50
5	2057	22.2	10.00



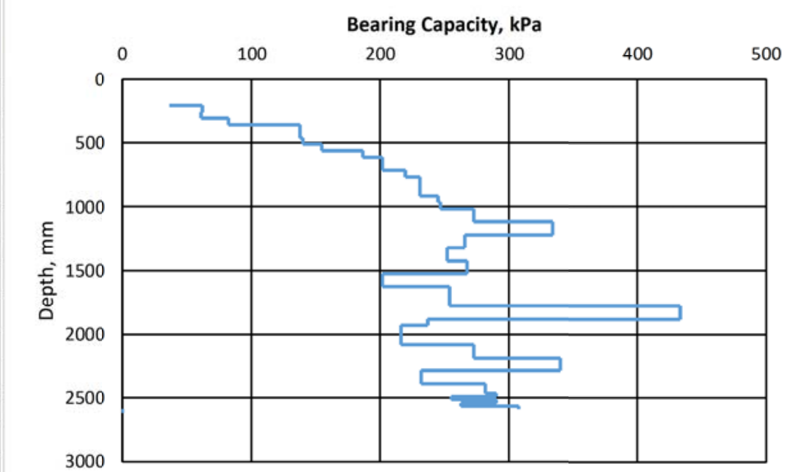


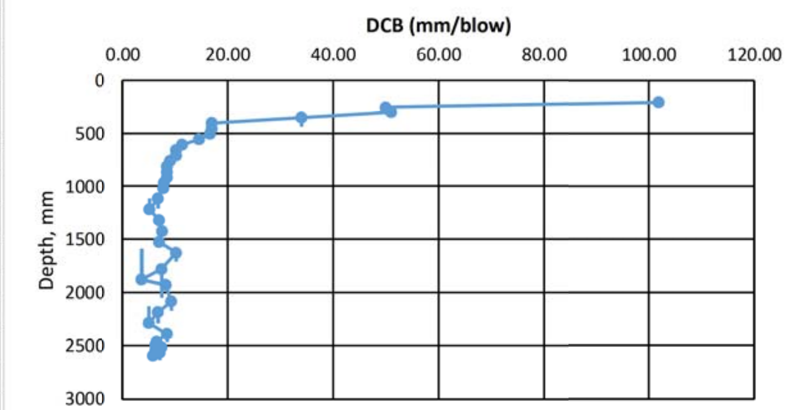


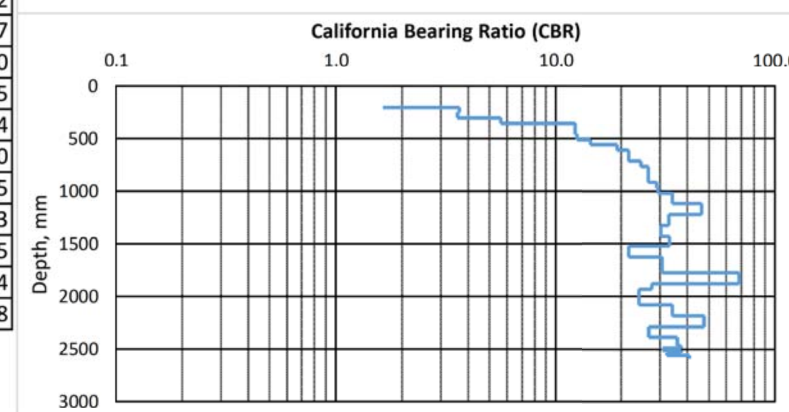
DCP TEST DATA — CVM7-2

PROJECT: HWY 69 Structural Culverts
LOCATION: Britt, Ontario
HAMMER WEIGHT: 4.6 KG
PROJECT #: 14TF034G
DATE: 19-Sep-22
SOIL TYPE: All Soil Types

Blows	Accumilative (mm)	CBR	DCB (mm/blow)
1	203	0.3	406.00
1	254	1.6	102.00
2	304	3.7	50.00
2	355	3.6	51.00
3	406	5.6	34.00
6	457	12.2	17.00
6	508	12.2	17.00
6	558	12.5	16.67
7	609	14.5	14.57
9	660	19.3	11.33
10	711	21.7	10.20
10	762	21.7	10.20
11	812	24.6	9.09
12	863	26.6	8.50
12	914	26.6	8.50
12	965	26.6	8.50
13	1016	29.1	7.85
26	1117	29.4	7.77
30	1219	34.1	6.80
39	1320	46.3	5.18
29	1422	32.8	7.03
27	1524	30.3	7.56
29	1625	33.2	6.97
30	1778	21.7	10.20
27	1879	30.7	7.48
28	1930	68.6	3.64
37	2082	27.6	8.22
22	2184	24.1	9.27
30	2286	34.1	6.80
40	2387	47.6	5.05
18	2463	26.8	8.44
8	2489	35.9	6.50
8	2514	37.5	6.25
7	2540	30.9	7.43
8	2565	37.5	6.25
7	2590	32.3	7.14
9	2616	40.9	5.78



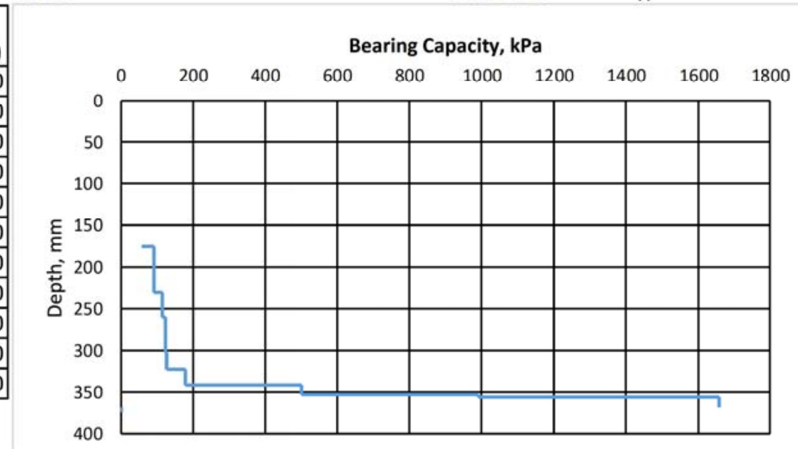


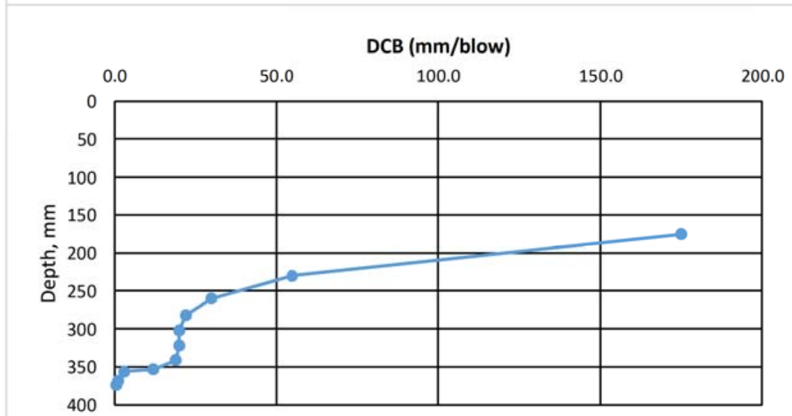


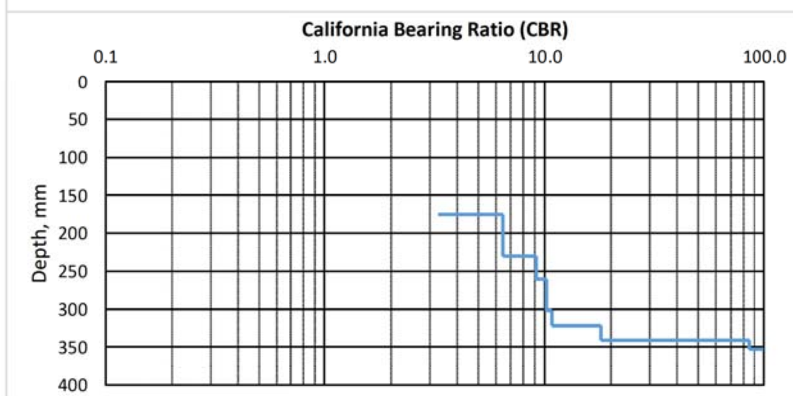
DCP TEST DATA CVM8-3

PROJECT: HWY 69 Structural Culverts
PROJECT #: 14TF034G
LOCATION: Britt, Ontario
DATE: 26-Aug-22
HAMMER WEIGHT: 8.0 KG
SOIL TYPE: All Soil Types

Blows	Accumilative (mm)	CBR	DCB (mm/blow)
1	175	0.9	175.00
1	230	3.3	55.00
1	260	6.5	30.00
1	282	9.2	22.00
1	302	10.2	20.00
1	322	10.2	20.00
1	341	10.8	19.00
1	353	18.1	12.00
1	356	85.3	3.00
10	368	238.1	1.20
10	374	517.4	0.60



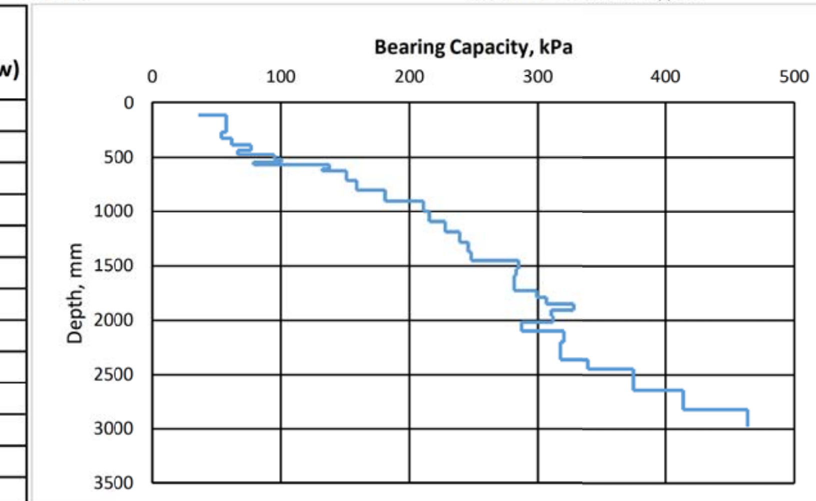


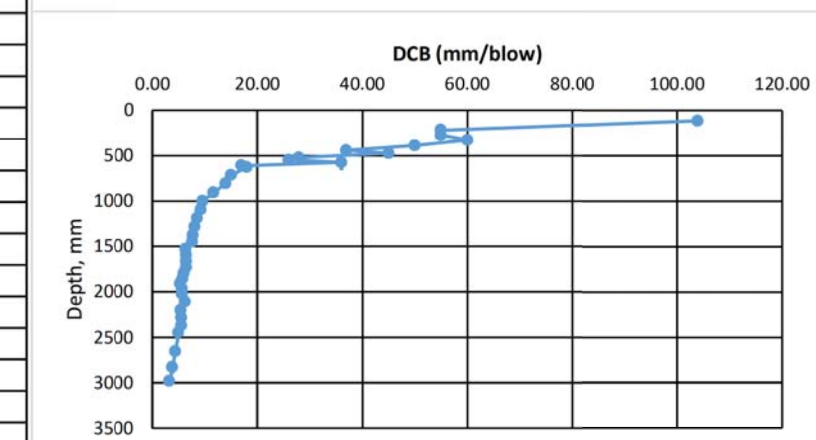


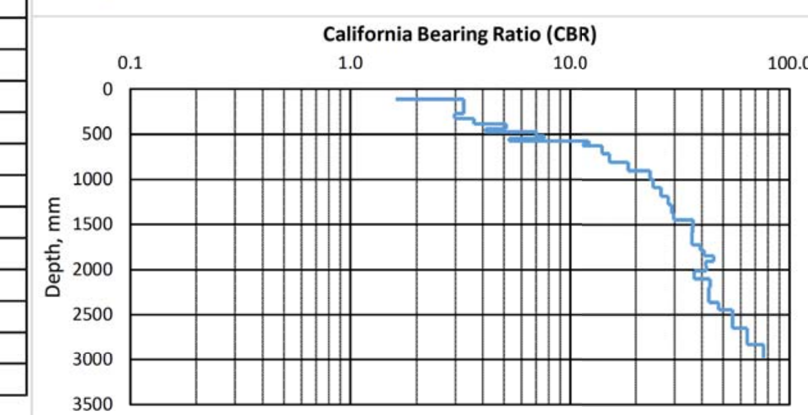
DCP TEST DATA CVM9-1

PROJECT: HWY 69 Structural Culverts
PROJECT #: 14TF034G
LOCATION: Britt, Ontario
DATE: 26-Aug-22
HAMMER WEIGHT: 8.0 KG
SOIL TYPE: All Soil Types

Blows	Accumilative (mm)	CBR	DCB (mm/blow)
0	114	0.0	0.00
1	218	1.6	104.00
1	273	3.3	55.00
1	328	3.3	55.00
1	388	3.0	60.00
1	438	3.7	50.00
1	475	5.1	37.00
1	520	4.1	45.00
1	548	7.0	28.00
1	574	7.6	26.00
1	610	5.3	36.00
1	627	12.2	17.00
5	717	11.5	18.00
6	807	14.1	15.00
7	905	15.2	14.00
8	999	18.5	11.75
10	1095	23.2	9.60
10	1188	24.0	9.30
11	1283	26.1	8.64
11	1372	28.1	8.09
10	1450	29.3	7.80
10	1527	29.7	7.70
10	1591	36.5	6.40
11	1662	36.2	6.45
10	1727	35.9	6.50
10	1792	35.9	6.50
10	1852	39.3	6.00
10	1910	40.8	5.80
10	1963	45.1	5.30
10	2020	41.6	5.70
15	2105	41.8	5.67
15	2200	36.9	6.33
15	2282	43.6	5.47
15	2365	43.0	5.53
15	2448	43.0	5.53
40	2650	47.6	5.05
40	2827	55.2	4.43
40	2982	64.0	3.88
37	3105	76.0	3.32







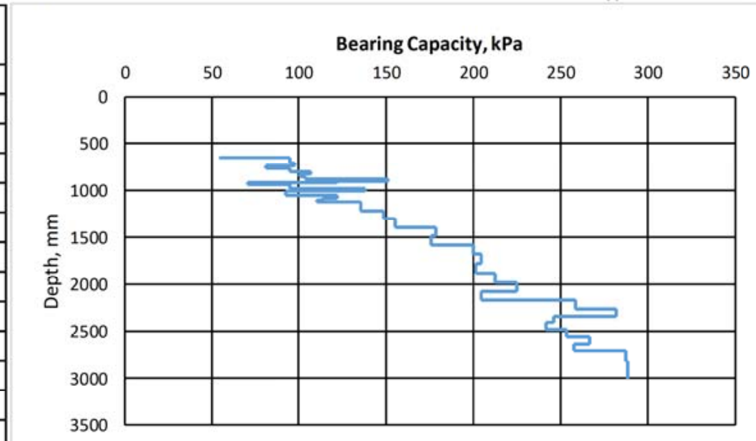
DCP TEST DATA **CVM9-2**

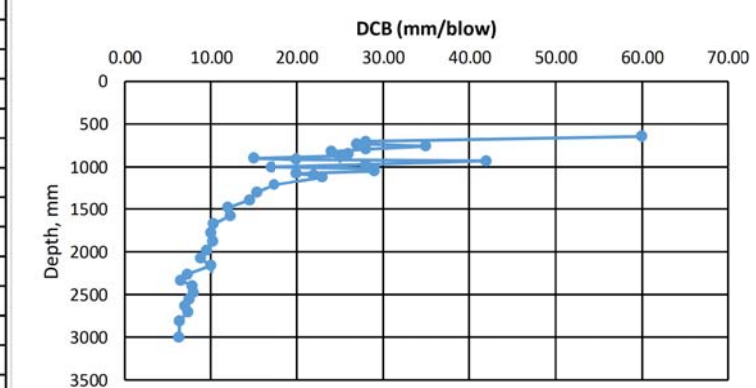
PROJECT: HWY 69 Structural Culverts **PROJECT #: 14TF034G**

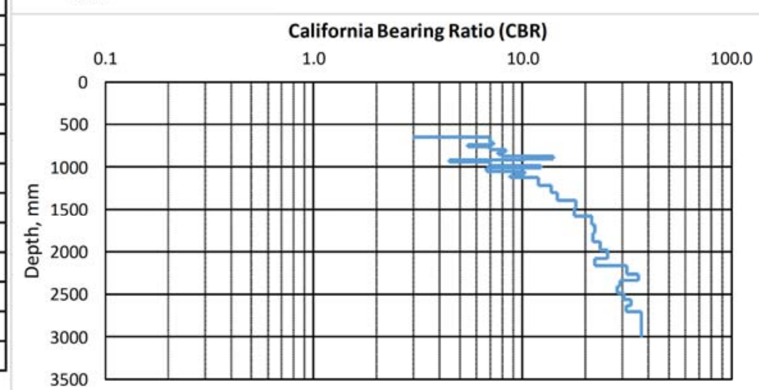
LOCATION: Britt, Ontario **DATE:** 26-Aug-22

HAMMER WEIGHT: **8.0 KG** **SOIL TYPE:** All Soil Types

Blows	Accumilative (mm)	CBR	DCB (mm/blow)
0	648	0.0	0.00
1	708	3.0	60.00
1	736	7.0	28.00
1	763	7.3	27.00
1	798	5.4	35.00
1	826	7.0	28.00
1	850	8.3	24.00
1	876	7.6	26.00
1	901	7.9	25.00
1	916	14.1	15.00
1	936	10.2	20.00
1	978	4.4	42.00
1	1006	7.0	28.00
1	1023	12.2	17.00
1	1052	6.7	29.00
1	1081	6.7	29.00
1	1101	10.2	20.00
1	1123	9.2	22.00
4	1215	8.7	23.00
5	1302	11.9	17.40
6	1394	13.7	15.33
6	1481	14.6	14.50
8	1577	18.1	12.00
8	1675	17.6	12.25
10	1778	21.4	10.30
10	1878	22.2	10.00
10	1980	21.7	10.20
10	2075	23.5	9.50
10	2163	25.6	8.80
10	2263	22.2	10.00
10	2336	31.5	7.30
10	2401	35.9	6.50
10	2479	29.3	7.80
10	2559	28.4	8.00
10	2634	30.6	7.50
10	2704	33.0	7.00
15	2814	31.4	7.33
30	3004	36.9	6.33
20	3130	37.2	6.30







B-1 LIST OF MTO SPECIFICATIONS

DOCUMENT	TITLE
OPSS.PROV 206	Construction Specification for Grading
OPSS 209	Construction Specification for embankments Over Swamps and Compressible Soils
OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts in Open Cut
OPSS.PROV 501	Construction Specification for Compacting
SP 105S22	Amendment to OPSS 501, November 2014 - Target Density Control Strip
OPSS 511	Construction Specification for Rip-Rap, Rock Protection, and Granular Sheeting
OPSS.PROV 517	Construction Specification for Dewatering
SP 517F01	Amendment to OPSS 517, November 2016 – Design Storm Return Period and Preconstruction Survey Distance
OPSS.PROV 539	Temporary Protection Systems
SP 105S09	Amendment to OPSS 539, November 2014
OPSS 802	Construction Specification for Topsoil
OPSS.PROV 803	Construction Specification for Sodding
OPSS.PROV 804	Construction Specification for Seed and Covert
OPSS 902	Construction Specification for Excavation and Backfilling - Structures
SP 109S12	Amendment to OPSS 902
NSSP FOUN0003	Dewatering Structure Excavations
OPSS.PROV 1004	Material Specification for Aggregates - Miscellaneous
OPSS.PROV 1010	Material Specification for Aggregates - Base, Subbase, Select Subgrade, and Backfill Material
SSP 110S06	Amendment to OPSS 1010
OPSD 202.010	Slopes Flattening Using Surplus Excavated Material on Earth or Rock Embankment
OPSD 208.010	Benching of Earth Slope
OPSD 221.010	Temporary Flow Passage System, Culvert in Watercourse
OPSD 221.020	Temporary Flow Passage System, Pumping and Piping
OPSD 221.030	Temporary Flow Passage System, Temporary Channel or Culvert Outside Watercourse
OPSD 810.010	General Rip-Rap Layout for Sewer and Culvert outlets
OPSD 812.010	Cut off Wall for Structural Plate Pipe Arch and Circular CSP
OPSD 3090.101	Foundation Frost Penetration Depths for Southern Ontario
OPSD 3101.150	Walls – Abutment, Backfill, Minimum Granular Requirement