Peto MacCallum Ltd.
CONSULTING ENGINEERS

SUPPLEMENTARY FOUNDATION INVESTIGATION AND DESIGN REPORT
for
STRAIGHT LAKE BRIDGE SOUTHBOUND LANES, SITE NO. 44-461/2 REVISED PIER LOCATIONS HIGHWAY 69 FOUR-LANING, STATION 20+850 FROM 1.7 KM NORTH OF HIGHWAY 529 (NORTH JUNCTION) TO 3.9 KM NORTH OF HIGHWAY 522 OWNER'S ENGINEER SERVICES GWP 5404-05-00

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PML Ref.: 14TF034E-2
Index No.: 064FIR and 065FDR
Geocres No.: 41H-171
February 21, 2018

Peto MacCallum Ltd.
CONSULTING ENGINEERS

PART A SUPPLEMENTARY FOUNDATION INVESTIGATION REPORT
for
STRAIGHT LAKE BRIDGE SOUTHBOUND LANES, SITE NO. 44-461/2
REVISED PIER LOCATIONS
HIGHWAY 69 FOUR-LANING, STATION 20+850
FROM 1.7 KM NORTH OF HIGHWAY 529 (NORTH JUNCTION)
TO 3.9 KM NORTH OF HIGHWAY 522
OWNER'S ENGINEER SERVICES
GWP 5404-05-00

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Peto MacCallum Ltd.
CONSULTING ENGINEERS

PART A - SUPPLEMENTARY FOUNDATION INVESTIGATION REPORT
for
Straight Lake Bridge Southbound Lanes, Site No. 44-461/2
Revised Pier Locations
Highway 69 Four-Laning, Station 20+850
Owner's Engineer Services
GWP 5404-05-00

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1. INTRODUCTION

Peto MacCallum Ltd. (PML) has been retained by Parsons on behalf of the Ministry of Transportation Ontario (MTO), to provide foundation engineering services for the revised locations of piers of the Straight Lake Southbound Lane (SBL) Bridge on the new alignment of Highway 69, as part of the four-laning project. The services were requested as part of the Owner's Engineer services for a Design-Build project delivery. PML understands that Golder Associate Ltd. (Golder) carried out the investigation at the previously planned location for SBL Bridge and submitted a Foundation Investigation and Design Report (FIDR), dated April 2017.

Golder was retained by URS Canada Inc. (URS) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the design and construction of the bridge that was proposed along the new southbound lanes (SBL) alignment of Highway 69 over Straight Lake (Site No. 44-461/2). The foundation investigations was carried out, as outlined in the MTO Terms of Reference dated December 2008 and in accordance with the Supplementary Specialty Plan dated April 19, 2010, prepared by Golder. Golder completed the investigation for the SBL Bridge and the High Fill area in two Phases:

Phase1: Two boreholes and one (DCPT) were advanced at two potential pier locations within Straight Lake along the proposed centerline of SBL. Following this, the investigation for the high fill area immediately north of Straight Lake was carried out and a report titled High Fill Swamp 502 was submitted under a separate cover. The fieldwork for Phase 1 was carried out in February, 2013.

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Phase 2: Remaining boreholes, reported in the Golder report dated April 25, 2017, for the bridge and approach embankments were advanced after establishing the bridge configuration by URS, i.e., lengths of spans, locations of piers and abutments, based on the preliminary data provided by Golder from their Phase 1 investigation. The fieldwork for Phase 2 was carried out in February and March, 2014.

Eighteen boreholes and two dynamic cone penetration tests (DCPTs) were advanced in Phase 1 and Phase 2 for proposed bridge foundation investigation, which was supplemented with eight boreholes and one DCPT advanced along the proposed SBL bridge centerline and near proposed toe of the embankment in the High Fill area (502) at north approach of the bridge.

Subsequent to the completion of Phase 2 investigations and detail assessment of the subsoil conditions, the layout of the proposed piers was revised and decided to extend the length of the structure to the north. This General Arrangement (GA) of the proposed bridge was finalized in February 2016 by URS and Golder, in consultations with MTO. Golder reported their findings and provided recommendations for the design and construction of the proposed SBL Bridge and associated embankments in a Foundation Investigation and Design Report (FIDR) dated April 25, 2017 (MTO Geocres No. 41H-166).

Subsequent to the Phase 2 investigation by Golder, the locations of all four piers were further revised by URS/AECOM (designer) in consultation with MTO. Peto MacCallum Ltd. (PML) has been retained by Parsons on behalf of MTO to investigate and report the subsoil conditions at the revised locations of the piers. PML advanced three boreholes to depths ranging from 33.4 m to 56.8 m below the lake water level, to establish the bedrock elevation. This supplementary Foundation Investigation and Design Report presents the results of the foundation investigations carried out by PML in May and June 2017.

2. SOURCES OF INFORMATION FOR DESKTOP STUDY

The subsurface information used in this report to assess the subsoil conditions and to plan the field investigation was obtained from the Foundation Investigation and Design Report (FIDR) available from the MTO Pavement and Foundation Section's GEOCRES database and the reference is as follows:

Reference 1. Foundation Investigation and Design Report – "Straight Lake SBL Bridge Structure, Site No. 44-461/2, Highway 69 Four-Laning From 1.7 km North of Highway 529 Northerly to 3.9 km North of Highway 522, Ministry of transportation Ontario, GWP 5347-08-00; GWP 5145-08-01. Prepared by Golder Associates and submitted to URS Canada, dated April 25, 2017. GEOCRES No. 41H-166.

2.1 Summarized Subsurface Conditions From Previous Investigations

In total, twenty six (26) boreholes and three (3) Dynamic Cone Penetration Tests were advanced along the previously proposed SBL bridge and approach embankments during both phases of the investigations by Golder.

The stratigraphical profile from the report by Golder indicated that generally, the site is underlain by localised peat and soft organic silt deposits below the lake floor, followed by very soft to very stiff cohesive layer varied from clayey silt to silty clay and clay, interlayered with sandy silt to silty sand, sand and gravel lenses. The clayey silt to silty clay layer is underlain by loose to compact silt deposit in boreholes that were drilled closer to the deepest part of the lake. The silt deposit is underlain by a thick deposit of compact sand to silty sand, which is followed by cobbles and boulders. The subsoils in all of the boreholes are followed by granitic gneiss bedrock with variable rock core recovery.

3. SITE DESCRIPTION AND GEOLOGY

The proposed new alignment of Highway 69 at the Straight Lake site is located at about 1.2 km west of existing Highway 69 alignment. The proposed site within the overall project limits is located in the Henvey Inlet Reserve 2 and the Township of Mowat.

Generally, the topography of the site consists of flat to rolling terrain. Site photographs are included in Appendix A. North side of the proposed bridge location is covered with bushes, trees with several rock outcrops followed by swampy area. The proposed south abutment of the bridge is located on a rock outcrop protrude from the lake and extends toward south, which is followed by

heavily wooded area. The Canadian Pacific Railway track (CPR) is located approximately 200 m to the south side of the bridge site and oriented in the east – west direction.

3.1 Background on Access to Site

The site was visited by a PML engineer on October 28, 2016 to assess the site accessibility and to decide on the schedule to start the drilling work. The drilling subcontractor recommended to schedule the field work to start in winter time, i.e., late January or early February, 2017.

The site was again visited by PML staff and representative of drilling subcontractor on February 17, 2017, to verify the thickness of ice on the lake. There was only 100 mm of solid black ice and 200 mm of soft white ice, which was not enough to support the drilling equipment. Therefore, the field work was postponed to the spring.

PML representative and MTO Project Manager had a meeting with the Chief of the Henvey Inlet First Nation at the Band Office on March 28, 2017 to coordinate the field work. The Chief agreed at the meeting to permit access to the site from the existing aggregate pit owned by the First Nation that is located on the north side of the lake. Barge equipment and drill rig were mobilized and demobilized to the proposed site from the aggregate pit under the field review of a representative of Henvey Inlet First Nation.

4. INVESTIGATION PROCEDURES

The fieldwork included advancing three (3) boreholes at the proposed locations of piers 1 to 3 within the lake using a barge. The drilling was carried out from May 3 to June 12, 2017. The location of boreholes in the field was established by D.S. Dorland Limited (DSL), Land Surveyors of Sudbury, Ontario under contract to PML and carried out the survey of the borehole locations and elevations. DSL provided the borehole elevations and co-ordinates for locations in MTM NAD 83 northings and eastings. PML used the survey data provided by DSL for preparation of this report. All elevations reported in this report are referred to Geodetic datum and expressed in meters.

A skid mounted drill rig floated on a barge was used for drilling the boreholes located within the lake. The drilling equipment used for the investigation was owned and operated by Landcore Drilling of Chelmsford, Ontario, who is a specialist drilling contractor. The fieldwork was carried out under the full-time supervision of a PML field supervisor.

Three (3) boreholes numbered SLB-1 to SLB-3 were advanced to depths ranging from 33.9 m (El. 145.5) to 57.3 m (El. 122.0). Depths of Boreholes SBL-1 to SBL-3 were measured from the top of barge that was elevated 500 mm above lake water level. These boreholes were advanced using the wash boring method and NQ size coring equipment, powered by a Skid Mounted Diedrich D-25 drill rig. Representative soil samples were recovered from these three boreholes using a conventional 51 mm O.D split spoon sampler in accordance with the Standard Penetration Test (SPT) procedure. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata. In addition, in-situ vane shear test was carried out using N-size (MTO) vane to measure the undrained shear strength of clayey soils.

Upon completion of drilling, the boreholes were backfilled with bentonite/cement grout in accordance with the MTO guidelines and MOE Regulation 903 for borehole abandonment procedures.

The recovered soil samples were returned to PML Toronto laboratory for detailed visual examination, and index tests.

5. SUBSURFACE CONDITION

The subsurface conditions presented in this report are based on findings from the three boreholes advanced during the investigation by PML and supplemented with the subsoil data obtained through a review of the Foundation Investigation and Design Reports referenced in Section 2. Record of Borehole Sheets and relevant figures from the current investigations are provided in Appendix B, rock core discerptions are provided in Appendix C and photographs of rock cores are provided in Appendix D of this report. Borehole data from previous investigations is included in Appendix E.

As summarized in Section 2.1 of this report, the boreholes advanced during the previous investigations within the lake along the SBL centreline revealed that the subsoil consisted of a thin deposit of peat underlain by organic silt, silt and sand over very soft to very stiff cohesive deposits, which is interlayered with thin lenses of sandy silt to silt. The clayey silt to silty clay deposit is underlain by loose to compact silt followed by compact sand to silty sand layer. A layer of cobbles and boulders was encountered below sandy layer in the deepest borehole advanced. All of the boreholes advanced during the previous investigations were terminated at or within granitic gneiss bedrock with rock core recovery ranging from 83% to 100%.

The subsoil conditions encountered at the supplementary borehole locations are consistent, in terms of soil type and consistency, with that of the findings from the previous investigations. The water level in Straight Lake varied from elevation 178.7 to 179.3 during the time of the current field investigation.

The subsurface conditions encountered during the course of the investigation, together with the field and laboratory test results are shown on the attached Record of Borehole Sheets. The borehole locations and stratigraphic profile sections are shown on Drawings SBL-1. The boundaries between soil strata have been established at the borehole locations only. Between and beyond the boreholes, the boundaries are assumed and may vary from location to location.

5.1 Subsoil conditions at Pier Locations

Description of the soil strata encountered are summarised below. For classification purposes, the soils encountered at the locations of piers can be divided into eight distinct zones:

a) Peat
b) Organic Silt, Trace Clay
c) Sand and Gravel
d) Clayey Silt to Silty Clay
e) Silt to Sandy Silt
f) Silty Clay to Clay, Trace Sand
g) Sandy silt to Silty Sand
h) Granitic Gneiss Bedrock

5.1.1 Peat

Peat layer ranging in thickness from 1.6 m to 2.4 m was encountered in boreholes SBL-1 and SBL-2 below the Lake Floor (El. 173.7 to El. 176.2) and extends to depths varying from 4.2 m to 7.6 m below the water level (El. 174.6 to El. 171.3). The SPT N-values in this layer were zero (penetration under the weight of the rods), indicating a very soft consistency.

Two samples from this deposit tested indicate moisture content values of 256.0% and 314.0%.

5.1.2 Organic Silt, Trace Clay

The peat layer in Boreholes SBL-1 and SBL-2 is underlain by this organic silt deposit, which extends to depths ranging from 10.7 m to 11.5 m below the lake water level (El.168.2 to El. 167.3). However, in Borehole SBL-3, this organic silt deposit was encountered immediately below the Lake Floor and extends to a depth of 6.1 m below the water level (El. 172.6). The SPT values in this deposit were zero (under the weight of the rods or weight of the rods and hammer), indicating very soft consistency.

The moisture content of samples from this deposit tested varied from 127.0% to as high as 205.0%. The organic content of one sample tested from this deposit was about 6.9 %.

5.1.3 Sand and Gravel

A localised deposit of sand and gravel was encountered in borehole SBL-1 immediately below the organic silt and extend to a depth of 12.3 m below the water level (El. 166.6).

The SPT values in this deposit were 6 blows/300 mm, indicating loose state of compaction.

5.1.4 Clayey Silt to Silty Clay

The localised sand and gravel deposit in SBL-1 and organic silt deposit in borehole SBL-3 are followed by 2.9 m to 9.1 m thick clayey silt to silty clay deposit that extends to a depth of 15.2 m below water level (El. 163.7 to El. 163.5).

The SPT values in this deposit range from 1 blows/300 mm to 8 blows/300 mm, indicating very soft to firm consistency. Only one vane shear test conducted in Borehole SBL-1 indicate a shear strength value of 20 kPa, which indicates soft consistency.

The moisture content of samples from this deposit tested varied from 22.2% to 55.2%. The results of the sieve analysis test performed on two representative samples from this deposit are provided on Figure GS-SBL-01. The test results indicate that this deposit consists of 0% gravel, 0% to 15% sand, 49% to 61% silt and 36% to 39% clay. Atterberg limit test was performed on two samples and the results are provided on Figure PC-SBL-01. Based on the Atterberg limit values, the soil may be classified as clay of low to medium plasticity (CL to CI) in the Unified Soil Classification System (USCS).

5.1.5 Silt to Sandy Silt

The silty clay to clayey silt in borehole SBL-1 and SBL-3, and the organic silt in SBL-2 are immediately followed by this silt to sandy silt layer. The thickness of this layer range from 3.1 m to 5.9 m and extends to depths ranging from 17.4 m to 18.3 m (El. 161.4 to El. 160.6), below the lake water level. The SPT values in this deposit range from 4 blows/300 mm to as high as 25 blows/300 mm, indicating loose to compact state of compaction.

The moisture content of samples from this layer tested varied from 18.0% to 41.0%, with an average value of 22%. The results of the grain size analysis test performed on a representative sample from this layer are provided on Figure GS-SBL-02. The test results indicate that this deposit consists of 0% gravel, 46% sand, 47% silt and 7% clay-size particles.

5.1.6 Silty Clay to Clay, Trace Sand

The silt to sandy silt layer in all three boreholes is immediately followed by 6.1 m to 12.1 m thick silty clay to clay deposit that extends to depths ranging from 24.4 m to 29.5 m below water level (El. 154.5 to El. 149.3).

The SPT values in this deposit range from 1 blows/300 mm to 19 blows/300 mm, indicating very soft to stiff consistency. However, vane shear tests conducted in Borehole SBL-1 indicate shear strength values of 52 kPa and 62 kPa, indicating stiff consistency.

The moisture content of samples tested varied from 38.0% to 58.0%. The results of the sieve analysis test performed on three representative samples from this deposit are provided on Figure GS-SBL-03. The test results indicate that this deposit consists of 0% gravel, 1% sand, 32% to 52% silt and 47% to 67% clay. Atterberg limit test was performed on three samples and the results are provided on Figure PC-SBL-02. Based on the Atterberg limit values, the soil may be classified as clay of medium to high plasticity (CI to CH) in the Unified Soil Classification System (USCS).

5.1.7 Sandy Silt to Silty Sand

The silty clay to clay deposit in all three boreholes is followed by 5.9 m to 24.9 m of sandy silt to silty sand deposit. This deposit extends to depths ranging from 30.3 m to 54.4 m below the water level (El. 148.6 to El. 124.4). Occasional layers of cobbles were encountered in Boreholes SBL-2 and SBL-3 between El. 148.2 and El. 129.1.

The SPT values in this deposit range from 7 blows/300 mm to 50 blows/30 mm, indicating loose to very dense state of compaction. The moisture content of samples from this deposit tested varied from 20.0% to 22.0%, with an average value of 20%. The results of the gradation test performed on two representative samples are provided in figure GS-SBL-04. The gradation test results indicate that this deposit consists of 0% to 2% gravel, 33% to 55% sand, 41% to 60% silt and 2% to 7% clay-size particles.

5.1.8 Bedrock

The bedrock was encountered in all three boreholes, at depths ranging from 30.3 m to 54.4 m (El. 148.6 to El. 124.4) below the lake water level, following sandy silt to silty sand deposit. The bedrock comprises a multicolored slightly weathered medium to hard strength granitic gneiss.

The recovery and RQD of the rock cores retrieved from the boreholes are provided on the corresponding borehole logs. A detailed description of the retrieved rock cores is provided in Appendix C. Photographs of the rock cores are provided in Appendix D.

In general, the bedrock encountered is unweathered and the measured rock core recovery ranges from 53% to 100%. The RQD values of rock cores from Boreholes SBL-2 and SBL-3 range from 53% to 81%, indicating fair to good quality rock. However, the RQD values of rock cores from SBL-1 indicates excellent quality rock (91% and 100%).

5.1.9 Lake Water Level

The water level in the Straight Lake during the fieldwork was observed to vary from El. 178.9 to El. 178.7. The depth of Lake Floor from the surface of water ranged from 1.8 m to 5.2 m (El. 176.9 to El. 173.7).

A stabilized groundwater level during field investigation could not be established at this site due to the wash boring technique that was utilized for drilling the boreholes.

Artesian water condition was not encountered in any of the three boreholes. However, the report dated April 25, 2017 prepared by Golder (Reference 1) indicates that artesian conditions were encountered in boreholes B501-10 and B501-12. One of the two boreholes was located within the lake and the other was located near the North shoreline.

6. CLOSURE

Mr. S. Aziz carried out the field investigation under the supervision of Mr. M. Khorsand, BSc, P.Eng., and Mr. C. M. P. Nascimento, P. Eng., Project Manager.

Landcore Drilling supplied the drill rig and barge for the subsurface exploration. The laboratory testing of the selected samples was carried out in the PML laboratory in Toronto.

This report was prepared by Mr. M. Khorsand, BSc, P.Eng., and reviewed by Mr. M. Vasavithasan, M.Sc.Eng., P.Eng., Senior Engineer, Geotechnical Services, Mr. C. M. P. Nascimento, P. Eng., MTO Designated Principal Contact, conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

Mark Vasavithasan, M.Sc.Eng., P.Eng.
Senior Engineer, Geotechnical Services

Carlos M.P. Nascimento, P.Eng
Project Manager and
MTO Designated Principal Contact

MV/CN:nk

APPENDIX A

Site Photographs

Photograph 1: Due to soft and swampy condition of the access route, plywood was used to facilitate access to the lake (May 2017).

Photograph 2: The barge launching deck was built at site to facilitate access for barge and drill rig (May 2017).

Photograph 3: The Skid Mounted Diedrich D-25 drill rig loaded on barge to mobilize drill rig to borehole locations (June 2017).

APPENDIX B

Borehole Locations Plan and Soil Strata at Straight Lake

Explanation of Terms Used in Report

Record of Borehole Sheets

Results of Grain Size Distribution Analyses – Figures GS-SBL-01 to GS-SBL-04

Plasticity Chart – Figures PC-SBL-01 to PC-SBL-02

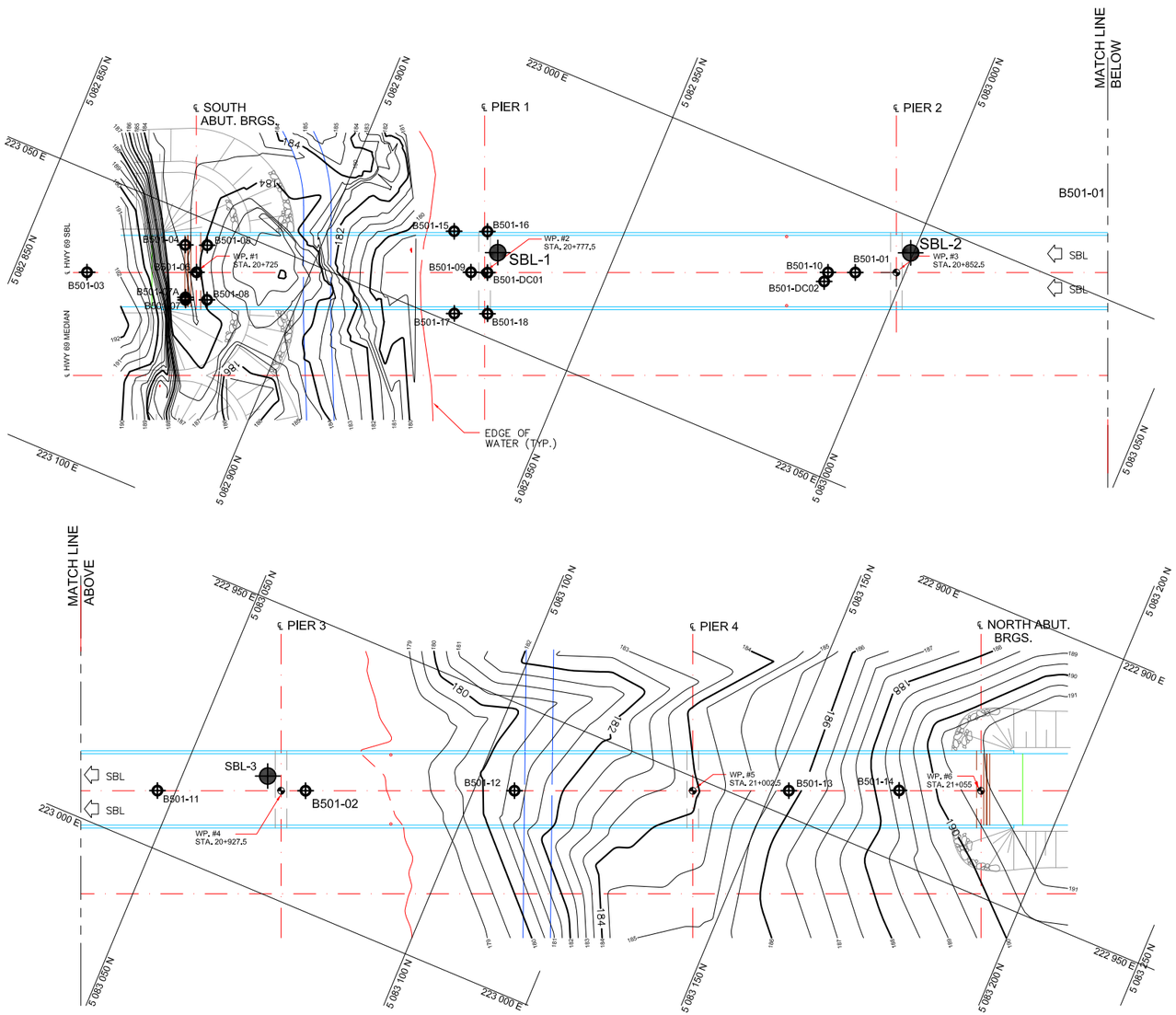
MINISTRY OF TRANSPORTATION, ONTARIO FR-D-707 88-05

G.W.P. No. 5404-05-00

STRAIGHT LAKE BRIDGE – SBL
HIGHWAY 69 FOUR-LANING
HENVEY INLET RESERVE 2 AND MOWAT TWP
BOREHOLE LOCATIONS

SHEET

Peto MacCallum Ltd.
CONSULTING ENGINEERS



PLAN
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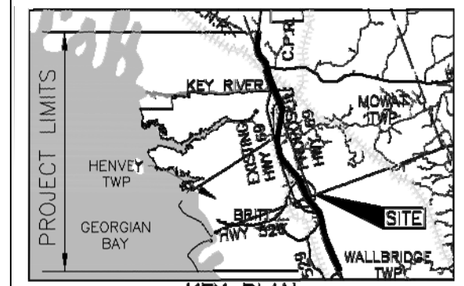


KEY PLAN
SCALE
6 0 6 12 km

LEGEND

- Borehole
- Cone
- Borehole and Cone
- Geocres Borehole (by Others)
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60 Cone, 475 J/blow)
- WL at time of investigation June 2016
- Head
- ARTESIAN WATER
- Encountered
- PIEZOMETER

BH No	ELEVATION	NORTHINGS	EASTINGS
SBL-1	178.9	5 082 929.6	223 032.6
SBL-2	179.3	5 083 000.7	223 002.2
SBL-3	178.7	5 083 064.8	222 979.9

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
2. REFER TO DRAWING SBL-2 FOR PROFILE ALONG C/L SBL.
3. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
4. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

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

LICENSED PROFESSIONAL ENGINEER M. YASAVITHASAH Feb. 21, 2018 PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER C.M.P. Nascimento Feb. 21, 2018 PROVINCE OF ONTARIO

REF. URS Drawing: Sheet 23, Contract No. 2015-5100 dated October 14, 2014

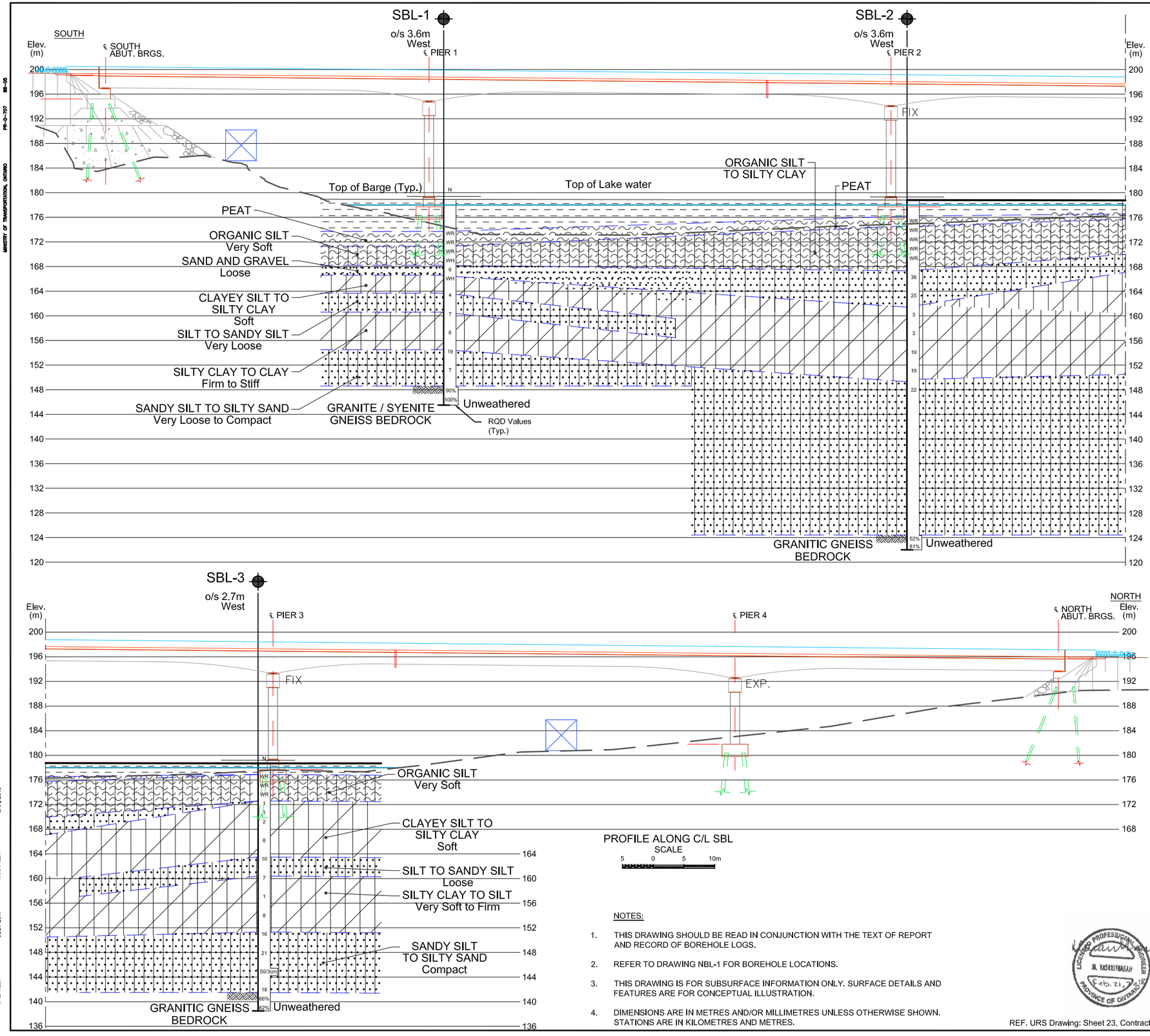
REVISIONS

DATE	BY	DESCRIPTION

Geocres No. 41H-171

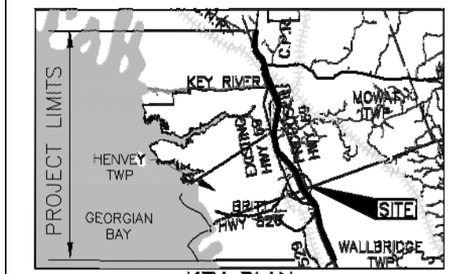
HWY No.					DIST
SUBM'D	N.A.	CHECKED	M.Kh.	DATE FEB. 21, 2018	SITE 44-461/2
DRAWN	N.A.	CHECKED	M.V.	APPROVED C.N.	DWG SBL-1

DRAWING NAME: 141F034E - HWY 69 n Starlight Lake Bridge.dwg
CREATED: JULY 2017
MODIFIED:



G.W.P. No. 5404-05-00	
STRAIGHT LAKE BRIDGE – SBL HIGHWAY 69 FOUR-LANING HENVEY INLET RESERVE 2 AND MOWAT TWP SOIL STRATA	SHEET

Peto MacCallum Ltd.
CONSULTING ENGINEERS



LEGEND

- Borehole
- Cone
- Borehole and Cone
- Geocres Borehole (by Others)
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60 Cone, 475 J/blow)
- WL at time of investigation June 2016
- Head ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	NORTHINGS	EASTINGS
SBL-1	178.9	5 082 929.6	223 032.6
SBL-2	179.3	5 083 000.7	223 002.2
SBL-3	178.7	5 083 064.8	222 979.9

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
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3. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
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– NOTE –
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LICENSED PROFESSIONAL ENGINEER M. YASKIV THASAH PROVINCE OF ONTARIO Feb. 21, 2018

REGISTERED PROFESSIONAL ENGINEER C M P Nascimento PROVINCE OF ONTARIO Feb. 21, 2018

REVISIONS			
	DATE	BY	DESCRIPTION

Geocres No. 41H-171

HWY No						DIST	
SUBM'D	NA	CHECKED	M.Kh.	DATE	FEB. 21, 2018	SITE	44-461/2
DRAWN	NA	CHECKED	M.V.	APPROVED	C.N.	DWG	SBL-2

REF. URS Drawing: Sheet 23, Contract No. 2015-5100 dated October 14, 2014

MINISTRY OF TRANSPORTATION, ONTARIO RR-D-707 88-05

DRAWING NAME: 141T034E - HWY 69 in Straight Lake Bridge.dwg
CREATED: JULY 2017 MODIFIED: JAN. 2018

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m 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 (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

PERCENT BY MASS	0 – 10	10 – 20	20 – 30	30 – 40	> 40
	TRACE	*SOME*	*WITH*	*ADJECTIVE (SILTY)*	*AND (AND SILT)*

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*

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

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

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

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	>3m
JOINTING	*VERY CLOSE*	*CLOSE*	*MOD. CLOSE*	*WIDE*	*VERY WIDE*
BEDDING	*VERY THIN*	*THIN*	*MEDIUM*	*THICK*	*VERY THICK*

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE
F V	FIELD VANE		

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL
e	1,%	VOID RATIO
n	1,%	POROSITY
w	1,%	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX = $w_L - w_P$
I_L	1	LIQUIDITY INDEX = $\frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_P}$
DTPL		DRIER THAN PLASTIC LIMIT
APL		ABOUT PLASTIC LIMIT
WTPL		WETTER THAN PLASTIC LIMIT
e_{max}	1,%	VOID RATIO IN LOOSEST STATE
e_{min}	1,%	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

RECORD OF BOREHOLE No SBL-1

1 OF 3

METRIC

G.W.P. 5404-05-00 LOCATION Co-ords: 5 082 929.6 N ; 223 032.6 E ORIGINATED BY S.A.

DIST Sudbury HWY 69 BOREHOLE TYPE Hollow Stem Augers and NQ Rock Coring COMPILED BY M.Kh.

DATUM Geodetic DATE 2017.05.10 - 2017.05.11 LATITUDE 45.881352 LONGITUDE -80.553421 CHECKED BY M.V.

ELEV / DEPTH	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 ● QUICK TRIAXIAL + FIELD VANE × 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
179.4	TOP OF BARGE										
0.0	Barge										
178.9						▽▼	179				
0.5	Lake Water						178				
							177				
							176				
							175				
173.7							174				
5.7	PEAT		1	SS	WR**						
							173			314	
			2	SS	WR					256	
171.3							172				
8.1	ORGANIC SILT, trace clay Very soft		3	SS	WR		171			128	
			4	SS	WH***		170			143	
168.2							169				
11.2	SAND AND GRAVEL Loose, Grey to black, Wet		5	SS	6		168				
166.6							167				
12.8	CLAYEY SILT TO SILTY CLAY Soft, Grey to brown, Wet		6	SS	WH						0 0 61 39
				VANE			166	+5			
							165				

Continued Next Page

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

RECORD OF BOREHOLE No SBL-1

2 OF 3

METRIC

G.W.P. 5404-05-00 LOCATION Co-ords: 5 082 929.6 N ; 223 032.6 E ORIGINATED BY S.A.

DIST Sudbury HWY 69 BOREHOLE TYPE Hollow Stem Augers and NQ Rock Coring COMPILED BY M.Kh.

DATUM Geodetic DATE 2017.05.10 - 2017.05.11 LATITUDE 45.881352 LONGITUDE -80.553421 CHECKED BY M.V.

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 ● QUICK TRIAXIAL + FIELD VANE × 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
164.4	CLAYEY SILT TO SILTY CLAY Soft, Grey to brown, Wet *(Cont.d)*						164				
163.7							163				
15.7	SILT TO SANDY SILT Very loose, Grey, Wet		7	SS	4		162		○		
							161				
160.6							160	+ 6			
18.8	SILTY CLAY TO CLAY, trace sand Firm to stiff, Grey to brown, Moist		8	SS	7		159		○		
				VANE			158				
			9	SS	6		157	+ 6	⊢○⊣		0 1 52 47
				VANE			156				
154.5							155				
24.9	SANDY SILT TO SILTY SAND Very loose to compact, Grey, Wet		10	SS	19		154		○		
							153				
							152				
			11	SS	7		151		○		
							150				

Continued Next Page

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

RECORD OF BOREHOLE No SBL-1

3 OF 3 **METRIC**

G.W.P. 5404-05-00 LOCATION Co-ords: 5 082 929.6 N ; 223 032.6 E ORIGINATED BY S.A.

DIST Sudbury HWY 69 BOREHOLE TYPE Hollow Stem Augers and NQ Rock Coring COMPILED BY M.Kh.

DATUM Geodetic DATE 2017.05.10 - 2017.05.11 LATITUDE 45.881352 LONGITUDE -80.553421 CHECKED BY M.V.

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 γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
149.4											
	SANDY SILT TO SILTY SAND Very loose to compact, Grey, Wet *(Cont.d)*						149				
148.6											
30.8	GRANITE / SYENITE GNEISS BEDROCK Unweathered		12	RC NQ	REC 99%		148				RQD 91%
			13	RC NQ	REC 100%		147				RQD 100%
145.5							146				
33.9	End of borehole										

▼ Water level measured after drilling

WR** denotes penetration under weight of rods only

WH** denotes penetration under weight of rods and hammer

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No SBL-2

1 OF 4

METRIC

G.W.P. 5404-05-00 LOCATION Co-ords: 5 083 000.7 N ; 223 002.2 E ORIGINATED BY S.A.

DIST Sudbury HWY 69 BOREHOLE TYPE Wash Boring and NQ Rock Coring COMPILED BY M.Kh.

DATUM Geodetic DATE 2017.06.01 - 2017.06.12 LATITUDE 45.881988 LONGITUDE -80.553825 CHECKED BY M.V.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
179.3	TOP OF BARGE										
0.0 / 178.8	Barge					▽▼	179				
0.5 / 176.2	Lake Water						178				
							177				
3.1 / 174.6	PEAT, amorphous Dark brown / black		1	SS	WR**		176				
4.7 / 167.3	ORGANIC SILT Very soft, Dark brown to grey, Wet		2	SS	WR		175		127 Org. 6.9%		
			3	SS	WR		174				
			4	SS	WR		173		138		
			5	SS	WR		172		131		
12.0	SILT TO SANDY SILT Dense to loose, Grey, Moist		6	SS	36		171		160		
							170				
							169				
							168				
							167		○		
							166				
							165				

Continued Next Page

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

RECORD OF BOREHOLE No SBL-2

2 OF 4

METRIC

G.W.P. 5404-05-00 LOCATION Co-ords: 5 083 000.7 N ; 223 002.2 E ORIGINATED BY S.A.

DIST Sudbury HWY 69 BOREHOLE TYPE Wash Boring and NQ Rock Coring COMPILED BY M.Kh.

DATUM Geodetic DATE 2017.06.01 - 2017.06.12 LATITUDE 45.881988 LONGITUDE -80.553825 CHECKED BY M.V.

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 ● QUICK TRIAXIAL + FIELD VANE × 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
164.3	SILT TO SANDY SILT Dense to loose, Grey, Moist *(Cont.d)*		7	SS	25		164				0 46 47 7
161.4							163				
17.9	SILTY CLAY TO CLAY, trace sand Very loose, Grey, Moist		8	SS	3		162				
							161				
			9	SS	3		160				0 1 37 62
							159				
			10	SS	19		158				
							157				
			11	SS	19		156				
149.3							155				
							154				
							153				
							152				
							151				
							150				

Continued Next Page

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

RECORD OF BOREHOLE No SBL-2

3 OF 4

METRIC

G.W.P. 5404-05-00 LOCATION Co-ords: 5 083 000.7 N ; 223 002.2 E ORIGINATED BY S.A.

DIST Sudbury HWY 69 BOREHOLE TYPE Wash Boring and NQ Rock Coring COMPILED BY M.Kh.

DATUM Geodetic DATE 2017.06.01 - 2017.06.12 LATITUDE 45.881988 LONGITUDE -80.553825 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × 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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
149.3 / 30.0	SANDY SILT TO SILTY SAND Compact to very dense, Grey Wet						149				
			12	SS	22				○		1 35 60 4
							148				
							147				
							146				
							145				
							144				
							143				
							142				
							141				
							140				
							139				
							138				
							137				
							136				
							135				

Continued Next Page

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

RECORD OF BOREHOLE No SBL-2

4 OF 4

METRIC

G.W.P. 5404-05-00 LOCATION Co-ords: 5 083 000.7 N ; 223 002.2 E ORIGINATED BY S.A.

DIST Sudbury HWY 69 BOREHOLE TYPE Wash Boring and NQ Rock Coring COMPILED BY M.Kh.

DATUM Geodetic DATE 2017.06.01 - 2017.06.12 LATITUDE 45.881988 LONGITUDE -80.553825 CHECKED BY M.V.

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 γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
134.3	SANDY SILT TO SILTY SAND Compact to very dense, Grey Wet *(Cont.d)*						134				
	cobbles and boulders						133				
							132				
							131				
	cobbles and boulders						130				
							129				
							128				
							127				
							126				
							125				
124.4 54.9	GRANITE GNEISS BEDROCK Unweathered		13	RC NQ	REC 92%		124				RQD 53%
			14	RC NQ	REC 89%		123				RQD 81%
122.0 57.3	End of borehole						122				

▼ Water level measured after drilling

WR** denotes penetration under weight of rods only

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

RECORD OF BOREHOLE No SBL-3

1 OF 3

METRIC

G.W.P. 5404-05-00 LOCATION Co-ords: 5 083 064.8 N ; 222 979.9 E ORIGINATED BY S.A.

DIST Sudbury HWY 69 BOREHOLE TYPE Hollow Stem Augers and NQ Rock Coring COMPILED BY M.Kh.

DATUM Geodetic DATE 2017.05.03 - 2017.05.04 LATITUDE 45.882562 LONGITUDE -80.554123 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × 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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
179.2	TOP OF BARGE										
0.0	Barge						179				
178.7						▽▼					
0.5	Lake Water						178				
176.9							177				
2.3	ORGANIC SILT Soft		1	SS	WR**				175		
			2	SS	WR		176		176		
			3	SS	WR		175		205		7 5 52 36
172.6							174				
6.6	CLAYEY SILT TO SILTY CLAY Very soft to firm, Grey to brown, Wet		4	SS	1		173				
			5	SS	1		172				
			6	SS	2		171				0 15 49 36
			7	SS	8		170				
							169				
							168				
							167				
							166				
							165				

Continued Next Page

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

RECORD OF BOREHOLE No SBL-3 2 OF 3 METRIC

G.W.P. 5404-05-00 LOCATION Co-ords: 5 083 064.8 N ; 222 979.9 E ORIGINATED BY S.A.

DIST Sudbury HWY 69 BOREHOLE TYPE Hollow Stem Augers and NQ Rock Coring COMPILED BY M.Kh.

DATUM Geodetic DATE 2017.05.03 - 2017.05.04 LATITUDE 45.882562 LONGITUDE -80.554123 CHECKED BY M.V.

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 ● QUICK TRIAXIAL + FIELD VANE × 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
164.2	CLAYEY SILT TO SILTY CLAY Very soft to firm, Grey to brown, Wet *(Cont.d)*						164				
163.5											
15.7	SILT TO SANDY SILT Loose Grey Wet		8	SS	10		163				
160.4							162				
18.8	SILTY CLAY TO CLAY, trace sand Very soft to firm, Grey to reddish brown, Wet to moist		9	SS	7		161				0 1 32 67
			10	SS	1		160				
			11	SS	8		159				
							158				
							157				
							156				
							155				
							154				
							153				
							152				
151.3											
27.9	SANDY SILT TO SILTY SAND Compact, Grey, Wet		12	SS	16		151				0 33 60 7
							150				

Continued Next Page

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

RECORD OF BOREHOLE No SBL-3

3 OF 3 **METRIC**

G.W.P. 5404-05-00 LOCATION Co-ords: 5 083 064.8 N ; 222 979.9 E ORIGINATED BY S.A.

DIST Sudbury HWY 69 BOREHOLE TYPE Hollow Stem Augers and NQ Rock Coring COMPILED BY M.Kh.

DATUM Geodetic DATE 2017.05.03 - 2017.05.04 LATITUDE 45.882562 LONGITUDE -80.554123 CHECKED BY M.V.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
149.2	SANDY SILT TO SILTY SAND Compact, Grey, Wet *(Cont.d)* Cobbles						149				
			13	SS	21		148				
							147				
							146				
			14	SS	50/3cm		145				
							144				
							143				
141.5			15	SS	18		142				2 55 41 2
37.7	GRANITE GNEISS BEDROCK Unweathered		16	RC NQ	REC 88%		141				RQD 61%
			17	RC NQ	REC 100%		140				RQD 67%
138.5							139				
40.7	End of borehole										

▼ Water level measured after drilling

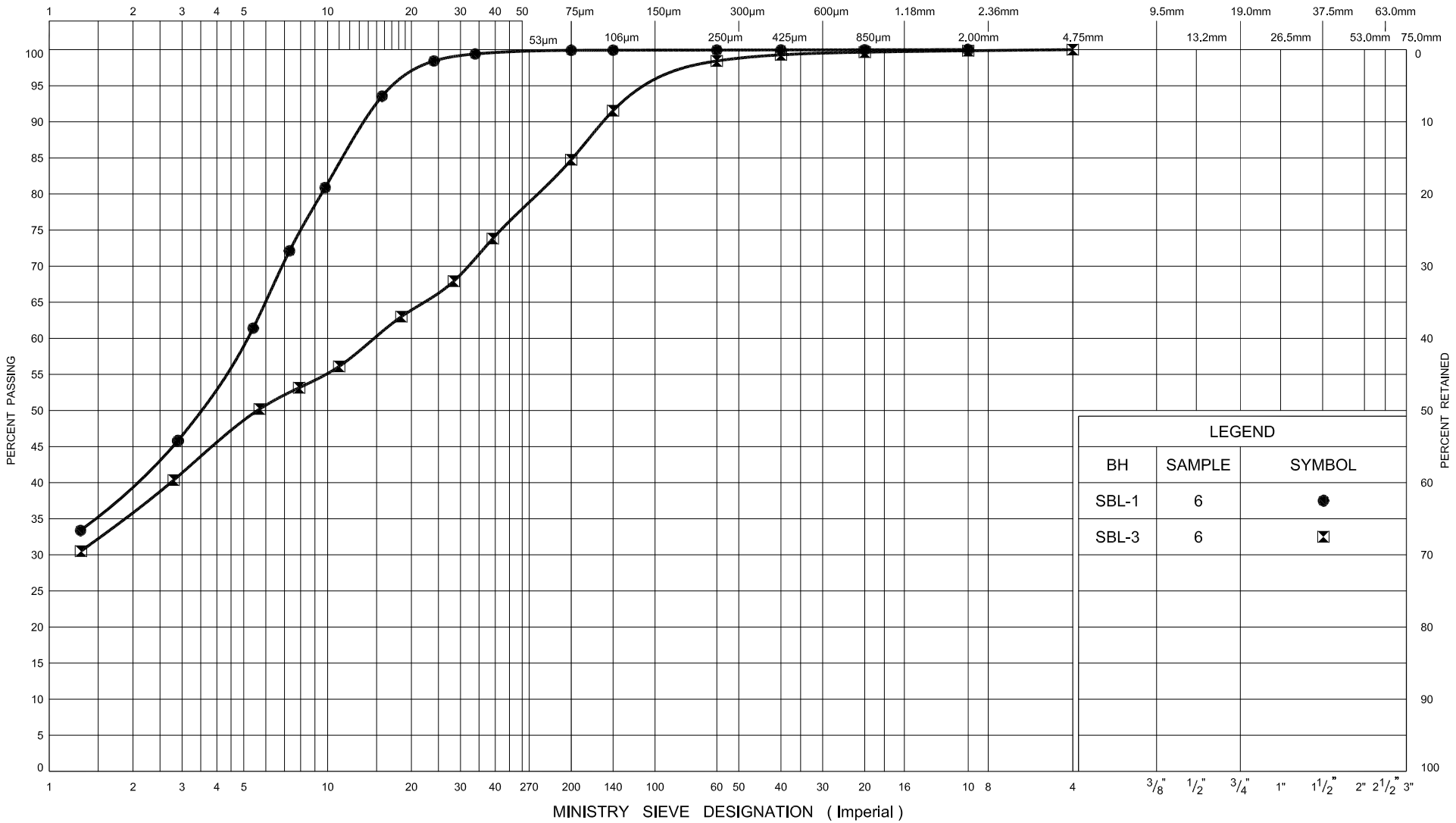
WR** denotes penetration under weight of rods only

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



Ministry of Transportation
Ontario

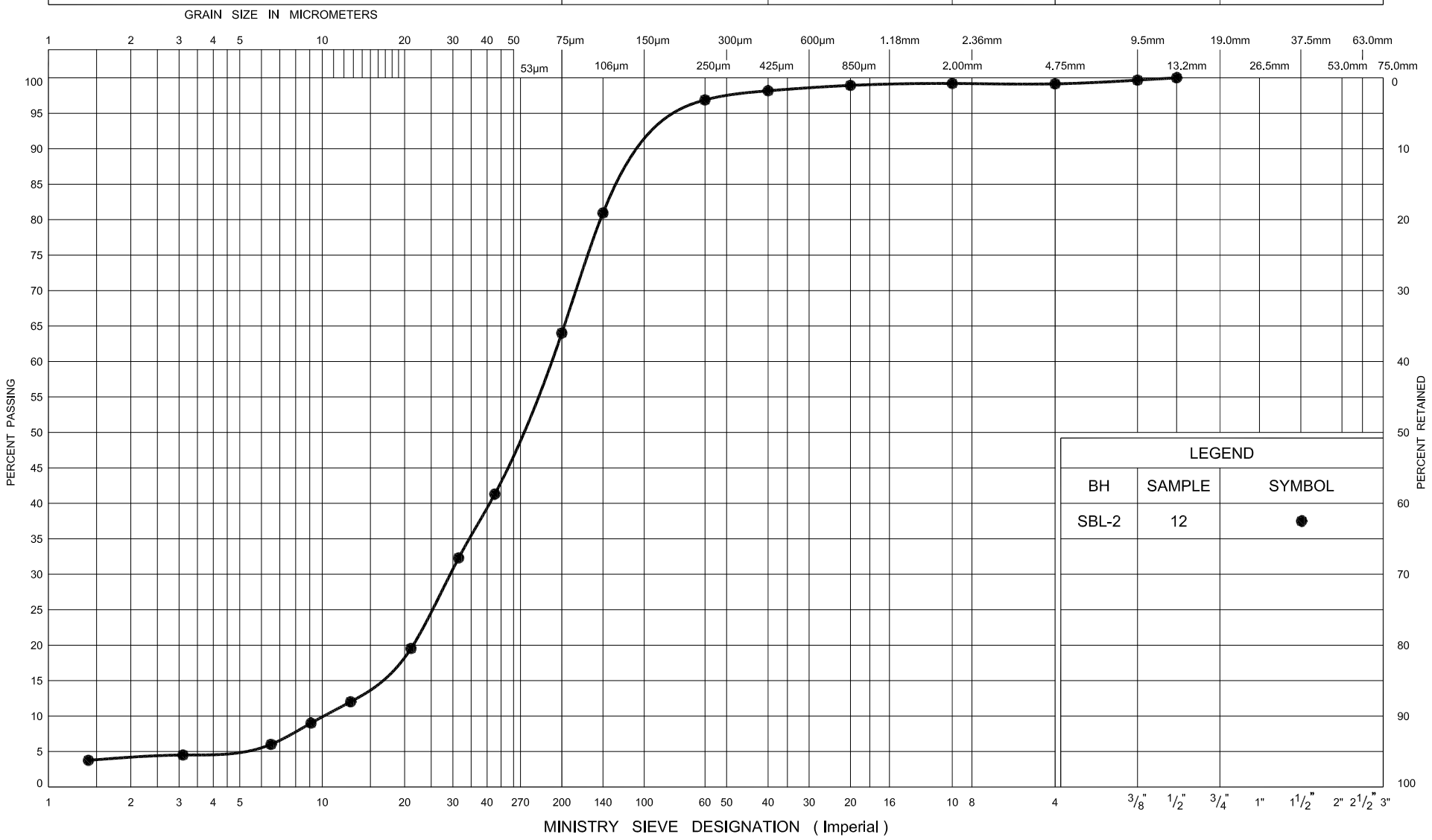
GRAIN SIZE DISTRIBUTION

CLAYEY SILT to SILTY CLAY

FIG No.	GS-SBL-01
HWY	69
G.W.P. No.	5404-05-00

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



Ministry of Transportation
Ontario

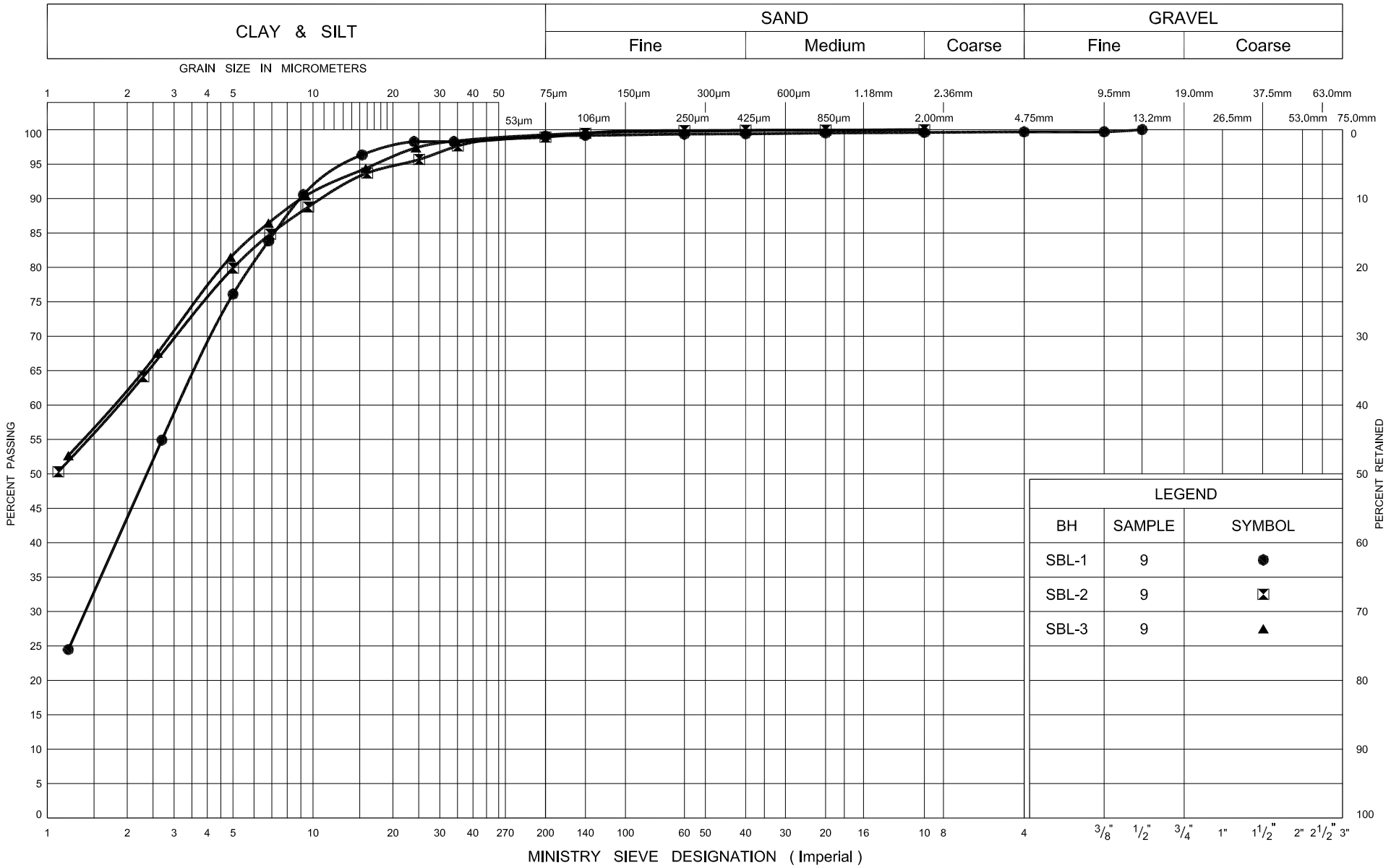
GRAIN SIZE DISTRIBUTION

SILT TO SANDY SILT

FIG No.	GS-SBL-02
HWY	69
G.W.P. No.	5404-05-00

ONTARIO MOT GRAIN SIZE 16TF028_LAB.GPJ ONTARIO MOT.GDT 23/5/17

UNIFIED SOIL CLASSIFICATION SYSTEM



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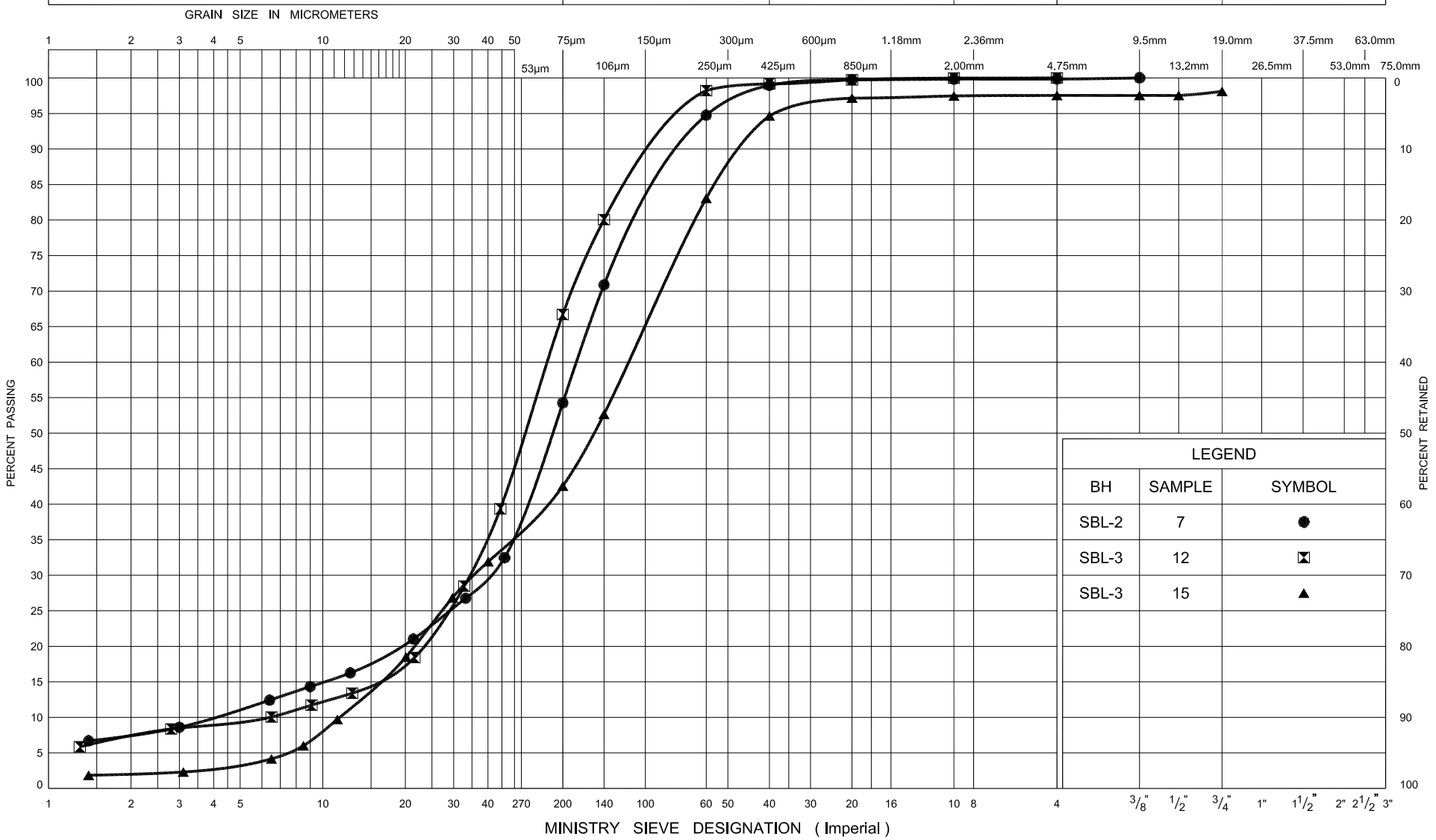
GRAIN SIZE DISTRIBUTION

SILTY CLAY to CLAY, trace sand

FIG No.	GS-SBL-03
HWY	69
G.W.P. No.	5404-05-00

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



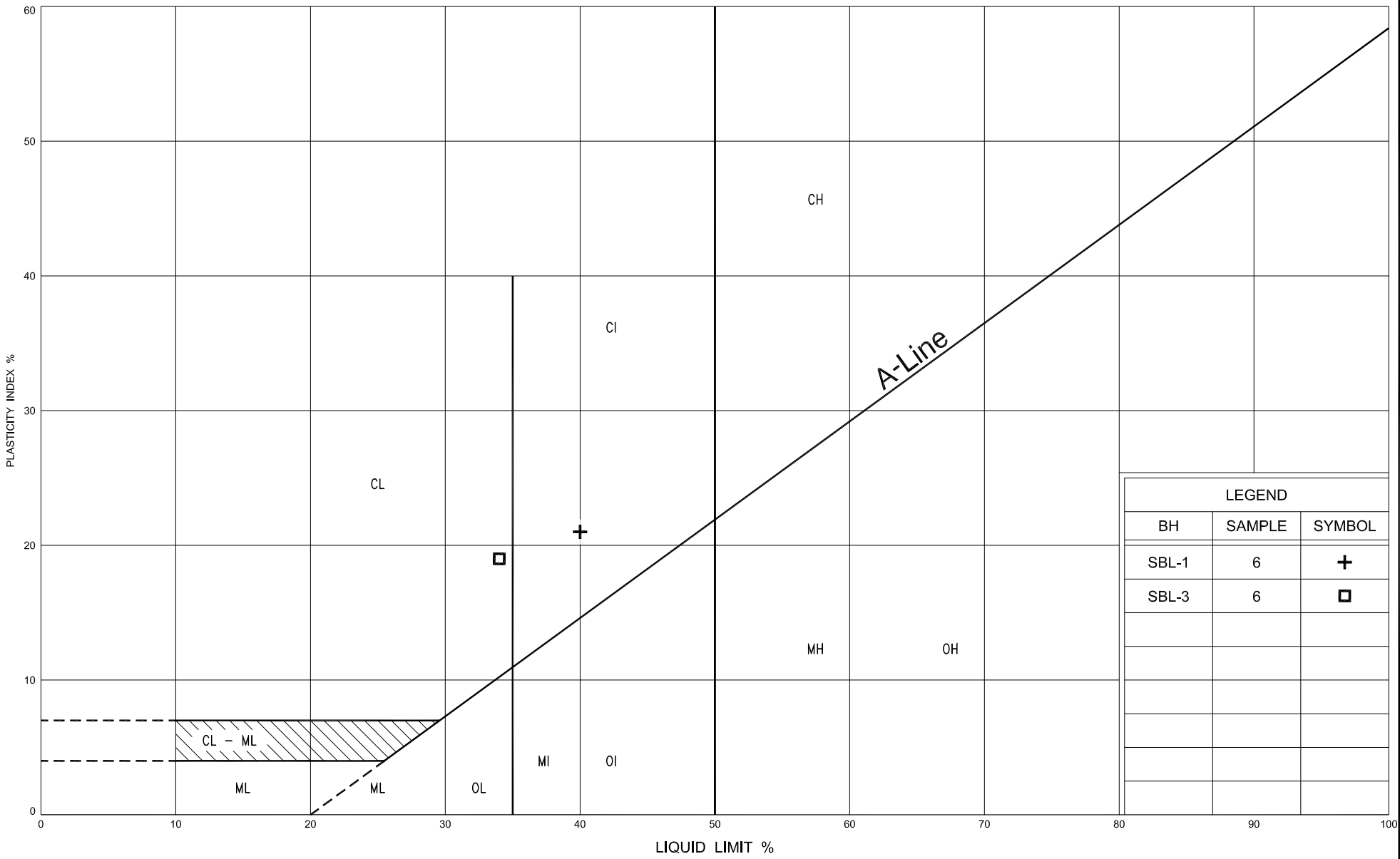
Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

SANDY SILT TO SILTY SAND

FIG No.	GS-SBL-04
HWY	69
G.W.P. No.	5404-05-00

ONTARIO MOT GRAIN SIZE 161T028_LAB.GPJ ONTARIO MOT.GDT 23/5/17



LEGEND		
BH	SAMPLE	SYMBOL
SBL-1	6	+
SBL-3	6	□

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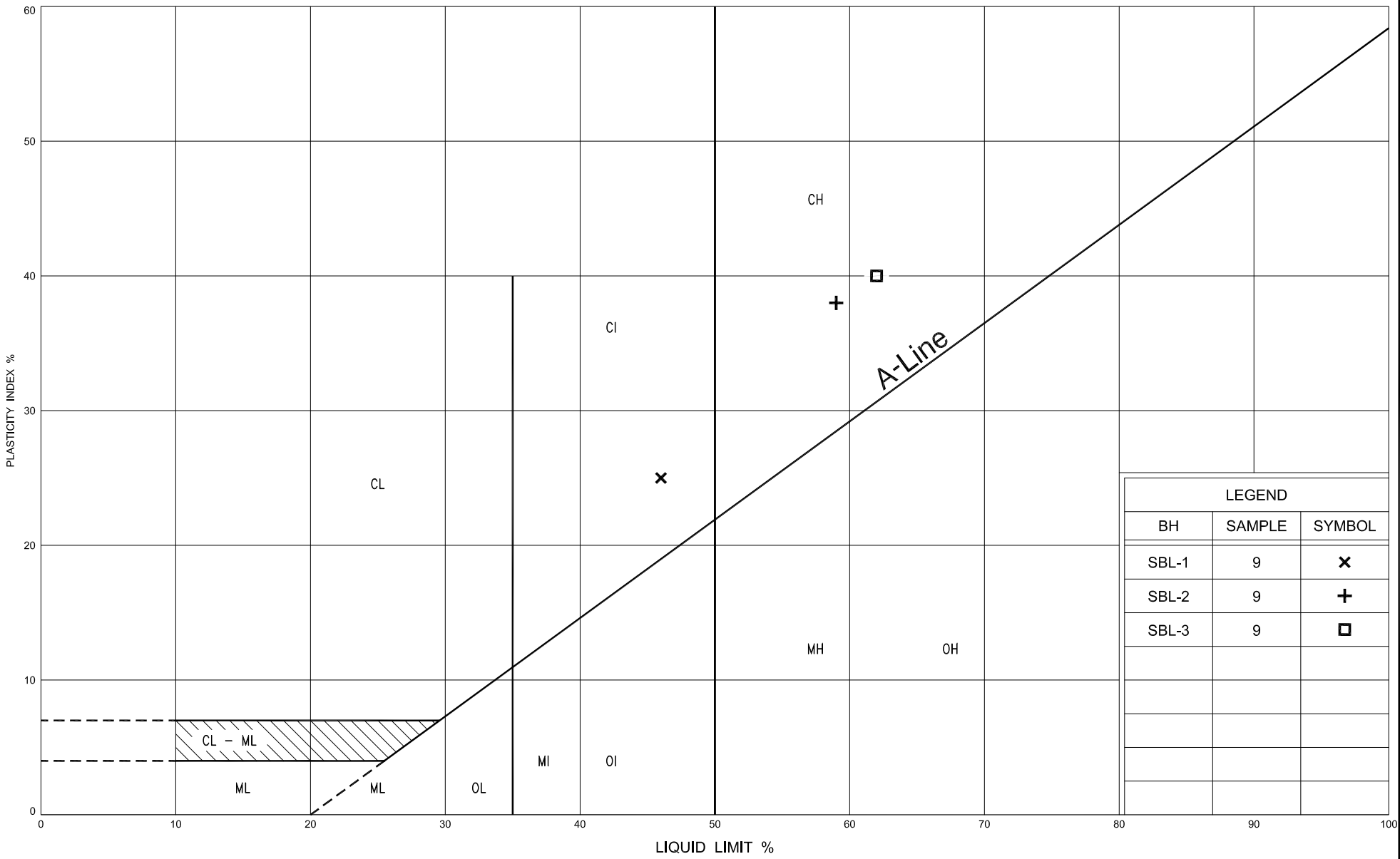
Ontario

PLASTICITY CHART

CLAYEY SILT to SILTY CLAY

FIG No.	PC-SBL-01
HWY	69
G.W.P. No.	5404-05-00

ONTARIO MOT PLASTICITY CHART 16TF028_LAB.GPJ ONTARIO MOT.GDT 23/5/17



LEGEND		
BH	SAMPLE	SYMBOL
SBL-1	9	×
SBL-2	9	+
SBL-3	9	□

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PLASTICITY CHART

SILTY CLAY to CLAY, trace sand

FIG No.	PC-SBL-02
HWY	69
G.W.P. No.	5404-05-00

ONTARIO MOT PLASTICITY CHART 16TF028_LAB.GPJ ONTARIO MOT.GDT 23/5/17

APPENDIX C

Detailed Description of the Rock Core

ROCK CORE DESCRIPTION

Location: Hwy 69, Sudbury, Ontario **Site Name:** Hwy 69 Four-Laning OE Services **Reference**: 5404-05-00 **Project Number:** 14TF034E

BH No.	CORE RECOVERY				CORE DESCRIPTION	
	RC No.	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
SBL-1	1	30.33	98.7 (1.50 m)	91.4 (1.39 m)	31.85	**GRENVILLE PROVINCE – CENTRAL GNEISS BELT** **GRANITE/SYENITE** – red/black/white; medium to coarse grained; banded; crystalline; hard; unweathered. Occasional features: white, translucent calcite veins (< 5.0 mm wide); coarse grained zone (4-12 cm in diameter; black, rounded clasts) between 31.14 – 31.67 m; slight iron staining along surface of natural fractures. Natural fractures: angles 45 - 65°; surface - rough/planar.
SBL-1	2	31.85	100.0 (1.52 m)	100.0 (1.52 m)	33.37	**GRENVILLE PROVINCE – CENTRAL GNEISS BELT** **GRANITE/SYENITE** – red/black/white; medium grained; banded; crystalline; hard; unweathered. Occasional features: white, translucent calcite veins (< 5.0 mm wide). Natural fractures: angles 45 - 65°; surface - rough/planar to curved.

CR* - Core Recovery

Logged by: Heather Racher, M.Sc.

RQD* - Rock Quality Designation

Note: Depths are approximated where core recovery is less than 100%. RQDs are calculated according to core recovery (less than designated 1.52 m runs).

ROCK CORE DESCRIPTION

Location: Hwy 69, Sudbury, Ontario **Site Name:** Hwy 69 Four-Laning OE Services **Reference**: 5404-05-00 **Project Number:** 14TF034E

BH No.	CORE RECOVERY				CORE DESCRIPTION	
	RC No.	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
SBL-2	1	54.86	91.8 (1.12 m)	52.5 (0.64 m)	56.08	**GRENVILLE PROVINCE – CENTRAL GNEISS BELT** **GNEISS** – black/pink/white; medium grained; banded; crystalline; hard; unweathered. Occasional features: vertical fractures at 55.73 – 55.78 m, 55.78 – 55.98 m; broken rock zone at 55.68 – 55.73 m. Natural fractures: angles 60 - 65°; surface - rough/planar.
SBL-2	2	56.08	89.3 (1.09 m)	81.1 (0.99 m)	57.30	**GRENVILLE PROVINCE – CENTRAL GNEISS BELT** **GNEISS** – black/red/pink/white; medium grained; banded; crystalline; hard; unweathered. Occasional features: vertical fracture at 56.08 – 56.21 m. Natural fractures: angles 60 - 65°; surface - rough/planar.

CR* - Core Recovery

Logged by: Heather Racher, M.Sc.

RQD* - Rock Quality Designation

Note: Depths are approximated where core recovery is less than 100%. RQDs are calculated according to core recovery (less than designated 1.52 m runs).

ROCK CORE DESCRIPTION

Location: Hwy 69, Sudbury, Ontario **Site Name:** Hwy 69 Four-Laning OE Services **Reference**: 5404-05-00 **Project Number:** 14TF034E

BH No.	CORE RECOVERY				CORE DESCRIPTION	
	RC No.	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
SBL-3	1	37.19	88.2 (1.34 m)	60.5 (0.92 m)	38.71	**GRENVILLE PROVINCE – CENTRAL GNEISS BELT** **GNEISS** – pink/black/white; medium grained; banded; crystalline; hard; unweathered. Occasional features: vertical fractures at 38.27 – 38.38 m, 38.34 – 38.48 m; broken rock zone at 38.20 -38.23 m. Natural fractures: angles 45-65°; surface - rough/planar.
SBL-3	2	38.71	100.0 (1.52 m)	67.1 (1.02 m)	40.23	**GRENVILLE PROVINCE – CENTRAL GNEISS BELT** **GNEISS** – pink/black/white; medium grained; banded; crystalline; hard; unweathered. Natural fractures: angles 45-65°; surface - rough/planar.

CR* - Core Recovery

Logged by: Heather Racher, M.Sc.

RQD* - Rock Quality Designation

Note: Depths are approximated where core recovery is less than 100%. RQDs are calculated according to core recovery (less than designated 1.52 m runs).

APPENDIX D

Photos of Rock Cores Retrieved

SBL-1

SBL-2

SBL-3

PART B - SUPPLEMENTARY FOUNDATION DESIGN REPORT
For
STRAIGHT LAKE BRIDGE SOUTHBOUND LANES, SITE NO. 44-461/2
REVISED PIER LOCATIONS
HIGHWAY 69 FOUR-LANING, STATION 20+850
FROM 1.7 KM NORTH OF HIGHWAY 529 (NORTH JUNCTION)
TO 3.9 KM NORTH OF HIGHWAY 522
OWNER'S ENGINEER SERVICES
GWP 5404-05-00

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PML Ref.: 14TF034E-2
Index No.: 065FDR
GEOCRES No.: 41H-171
February 21, 2018

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PART B - SUPPLEMENTARY FOUNDATION DESIGN REPORT
for
Straight Lake Bridge Southbound Lanes, Site No. 44-461/2
Revised Pier Locations
Highway 69 Four-Lanning Station 20+850
Owner's Engineer Services, GWP 5404-05-00

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7. INTRODUCTION

The Ministry of Transportation of Ontario (MTO) has retained Parsons, as the Prime Consultant to carry out Owner's Engineer services for the four-laning of Highway 69. Parsons has retained Peto MacCallum Ltd. (PML) on behalf of the MTO to provide foundation engineering services for the revised locations of piers of the Straight Lake Southbound Lane (SBL) Bridge located on the new alignment of Highway 69 at Station 20+850, Township of Henvey, Parry Sound District, Ontario. PML conducted the geotechnical investigation under the Agreement No. 5013-E-0036, Work Order # 12. This foundation investigation work is part of an assignment to prepare the Design-Build ready package for the foundation design and construction of the Straight Lake SBL Bridge.

This supplementary Foundation Design Report presents the factual findings obtained from the geotechnical investigation carried out by PML in 2017, which are relevant to the revised location of foundation elements of the proposed bridge. The structure is to be located on the re-aligned Highway 69, 1.2 km west of the existing Highway 69 and approximately 4.0 km south of the existing Highway 522 and Highway 69 intersection.

This report should be read in conjunction with the subsoil conditions and recommendations provided in the previous investigation and design reports identified under the Sources of Information in Section 8.

The purpose of the investigation was to explore the subsurface conditions expected to influence the design of the piers of the SBL Bridge, and to aid the designer in selecting the suitable type of foundations to support the proposed structure.

This Supplementary Foundation Investigation and Design Report with the interpretation and recommendations are intended for the use of Parsons on behalf of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The design-build contractor must make their own interpretation based on the factual data in Supplementary Foundation Investigation Report. Where comments are made on construction, they are provided only to highlight those aspects, which could affect the design of the project. Contractors must make their own interpretation of the factual information provided in Part A of the report, as it may affect equipment selection, proposed construction methods, and scheduling.

8. SOURCES OF INFORMATION

PML reviewed the following Foundation Investigation and Design Reports to present the general conditions of the site, geological description and subsoil information of the proposed SBL Bridge site.

Reference 1. Foundation Investigation and Design Report – “Straight Lake SBL Bridge Structure, Site No. 44-461/2, Highway 69 Four-Laning From 1.7 km North of Highway 529 Northerly to 3.9 km North of Highway 522, Ministry of Transportation Ontario, GWP 5347-08-00; GWP 5145-08-01”. Prepared by Golder Associates (Golder) and submitted to URS Canada, dated April 25, 2017, GEOCRES No. 41H-166.

Reference 2. Straight Lake Crossing Highway 69 Preferred Alternative General Arrangement. G.W.P 54-05-00, prepared by AECOM Canada Ltd., dated January 2017.

The Foundation Investigation and Design Report (FIDR) referenced in Section 2 (Reference 1) reveals that Golder carried out the foundation investigations for the Straight Lake SBL Bridge in two phases as follows:

Phase 1: A preliminary foundation investigation consisting of advancing a total of four boreholes (two at the SBL structure and two at the NBL structure) at the potential locations of piers within the lake.

Phase 2: Detailed foundation investigation for the foundation elements of the bridges and approach embankments, after finalizing the bridge span arrangement and locations of piers.

It is noted that the report prepared by Golder and the recommendations provided are based on CHBDC 2006. The following table refers to relevant clauses of CHBDC 2014 that should be followed for the design of the proposed bridge:

Table 8: Canadian Highway Bridge Design Code and Commentary

CODE VERSIONS	CHBDC (2006)	CHBDC (2014)
Inclination Load on Shallow Footing	Clauses 6.7.2 and 6.7.4	Clause 6.10.2
Resistance to Lateral Load (Sliding)	Clause 6.7.5	Clause 6.10.5
Resistance to Lateral load (Deep Foundation)	Clause 6.8.7.2	Clause 6.11.2.2
Site Coefficient	Clause 4.4.6	Clause 4.4.3.3
Seismic loading	Clause 4.4.10	Clause 4.5.3
Seismic performance category	Clause 4.4.10	Clause 4.4.10
Lateral Earth Pressures	Clause 6.9.2.2	Clause 6.12.2.2

9. STRUCTURAL LAYOUT OF PROPOSED BRIDGE

The background information provided in the FIDR dated April 25, 2017 (reference 1) reveals that initially in January 2013, 264 m long twin bridges (NBL and SBL) were considered along the new alignment of Highway 69, for crossing the Straight Lake. Two structural layouts comprised of four-span and five-span bridges were considered at that time. The proposed structural layouts were as follows:

- Four-span bridges with two 57 m long end-spans and two 75 m long centre-spans
- Five-span bridges with two 45 m long end-spans and three 58 m long centre-spans

In January 2014, subsequent to the Phase 1 investigations and preliminary assessment of the alternatives, MTO agreed to extend the structures and move the location of the north abutments 30 m to the north. The revised General Arrangement layout was based on 295 m long twin bridges designed as five-span bridges with two 50 m long end-spans and three 65 m long centre-spans.

Based on the findings from the Phase 2 investigations the structural layouts of both NBL and SBL bridges were further revised in February 2016. The current layout of the five-span SBL Bridge has two 52.5 m long end-spans and three 75 m long centre-spans, to a total length of 330 m. Parsons provided the revised layout of the proposed SBL Bridge and the boreholes were located at the locations of piers shown on the GA Drawing prepared by AECOM dated January, 2017. PML carried out the foundation investigations to determine the subsoil conditions and the elevations of bedrock at the pier locations.

It is noted that PML concurs with the recommendations provided by Golder in their report dated April 25, 2017. Their recommendations for design and construction of the foundations are also applicable for the piers at the revised locations.

10. STRUCTURE FOUNDATIONS

The report by Golder dated April 25, 2017 (Reference 1) provided detailed evaluations of various options and alternatives, to be used for the design and construction of piers and abutment foundations. The ranking of the foundation alternatives provided in the reference report should be considered for the foundations of the proposed foundations.

The table below summarises the foundation conditions based on the new boreholes. The details include the elevation of the bedrock, approximate minimum founding depth below the lake floor at the piers 1, 2 and 3.

Table 10: Estimated Foundation Conditions at New Boreholes

FOUNDATION ELEMENT AND LOCATION	REFERENCE BOREHOLE	LAKE WATER LEVEL EL. (m)	LAKE FLOOR /SHORE EL.(m)	TOP OF BEDROCK SURFACE EL.(m)	MINIMUM DEEP FOUNDATION ELEMENT LENGTH FROM LAKE FLOOR
Pier # 1 South	SBL-1	178.9	173.7	148.6	25.1
Pier # 2 South-Central	SBL-2	178.8	176.2	124.4	51.8
Pier # 3 North-Central	SBL-3	178.7	176.9	141.5	35.4

The lengths of the deep foundation element provided in the table are based on the approximate location of the piers and the depth of bedrock from the Lake Floor. The lengths do not include the length of the required rock socket, if any.

Considering the very soft organic silt extending to about elevation 167.3, the foundation elements should be considered unsupported for calculation of slenderness or structural capacity. In addition, the lateral capacity of the foundation element may have to be derived from adequate length of rock socket and it should be taken into consideration during the Design-Build stage. In particular, the bedrock surface at the location of Pier #2 is about 51.8 m deep. Considering the

depth of bedrock and the soft subsoil conditions, it may be preferable to adjust the location of Pier #2 during the Design-Build stage. The revision may require additional investigations to establish the bedrock elevation.

The potential difficulties associated with setting the piles on the sloping rock surface at this site were discussed in the Report by Golder (Reference 1) and should be considered valid based on the results of the current boreholes.

11. CONSTRUCTION

Construction issues such as dewatering and settlement mitigation were discussed in the report by Golder (Reference 1).

11.1. Access to Piers Located in Water

Recommendations were also provided in the report by Golder (Reference 1) to access piers located in water. It is noted that the e-mail dated January 21, 2014 from URS and the memorandum of rationale from Environmental and Natural Science point of view attached to the e-mail indicate that a temporary rock fill platform constructed on geogrid would be acceptable to access the location of centre-north pier (Pier #3) provided that the mitigation measures and timing detailed in the memorandum are implemented during the construction of the rock fill platform. Alternatively, lake floor may be dredged as indicated in Golder report.

The memorandum cites projects on wetlands where rock fill platform was constructed on geogrid and successfully utilised in various infrastructure projects. As discussed in the report by Golder, settlement and stability of the rock fill platform will be a concern due to the soil conditions at the pier locations. The feasibility to access the pier locations utilising temporary rock fill platform(s) and the investigation for stable embankment geometry on the very soft lake bottom soils should be assessed at the design-build stage.

12. CLOSURE

This Supplementary Foundation Investigation and Design Report was prepared by Mr. M. Khorsand, P. Eng and reviewed by Mark Vasavithasan, M.Sc.Eng., P.Eng., Senior Engineer, Geotechnical Services. Mr. C. Nascimento, P.Eng., MTO Designated Principal Contact conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

Mark Vasavithasan, M.Sc.Eng., P.Eng.
Senior Engineer, Geotechnical Services

Carlos M.P. Nascimento, P.Eng
Project Manager and
MTO Designated Principal Contact

MV/CN:nk