# FOUNDATION INVESTIGATION AND DESIGN REPORT

**for**

# WILLOW CREEK BRIDGE REPLACEMENT
# GWP NO. 2360-10-00; SITE NO. 30-139/1&2
# HIGHWAY 400
# BARRIE, ONTARIO

PETO MacCALLUM LTD.
165 CARTWRIGHT AVENUE
TORONTO, ONTARIO
M6A 1V5
Phone: (416) 785-5110
Fax: (416) 785-5120
Email: toronto@petomaccallum.com

Distribution:
3 cc: MMM Group Limited for distribution to MTO, Project Manager, + 1 digital copy (pdf)
1 cc: MMM Group Limited for distribution to MTO, Pavements and Foundations Section + 1 digital copy (pdf)
2 cc: MMM Group Limited + 1 digital copy (pdf)
1 cc: PML Kitchener
1 cc: PML Toronto

PML Ref.: 12KF037A
Index No.: 119FIR and 120FDR
Geocres No.: 31D-602
April 1, 2015
(Revised April 21, 2015)

Peto MacCallum Ltd.
CONSULTING ENGINEERS

**FOUNDATION INVESTIGATION REPORT**

**for**

**WILLOW CREEK BRIDGE REPLACEMENT**
**GWP NO. 2360-10-00; SITE NO. 30-139/1&2**
**HIGHWAY 400**
**BARRIE, ONTARIO**

PETO MacCALLUM LTD.
165 CARTWRIGHT AVENUE
TORONTO, ONTARIO
M6A 1V5
Phone: (416) 785-5110
Fax: (416) 785-5120
Email: toronto@petomaccallum.com

Distribution:
3 cc: MMM Group Limited for distribution to MTO, Project Manager, + 1 digital copy (pdf)
1 cc: MMM Group Limited for distribution to MTO, Pavements and Foundations Section + 1 digital copy (pdf)
2 cc: MMM Group Limited + 1 digital copy (pdf)
1 cc: PML Kitchener
1 cc: PML Toronto

PML Ref.: 12KF037A
Index No.: 119FIR
Geocres No.: 31D-602
April 1, 2015
(Revised April 21, 2015)

# TABLE OF CONTENTS

1. INTRODUCTION ........ 1
2. SITE DESCRIPTION, GEOLOGY AND BACKGROUND ........ 1
3. INVESTIGATION PROCEDURES ........ 2
4. SUMMARISED SUBSURFACE CONDITIONS ........ 4
   4.1 Topsoil ........ 5
   4.2 Asphalt ........ 5
   4.3 Fill ........ 6
   4.4 Organic Sand / Silty Sand ........ 6
   4.5 Upper Clayey Silt ........ 6
   4.6 Upper Silty Sand ........ 7
   4.7 Lower Clayey Silt to Silty Clay ........ 7
   4.8 Lower Silty Sand ........ 8
   4.9 Groundwater ........ 8
5. CLOSURE ........ 9

Figures WC-GS-1 to WC-GS-3 – Grain Size Distribution Charts

Figures WC-PC-1 to WC-PC-3 – Plasticity Charts

Explanation of Terms Used in Report

Record of Borehole Sheets

Drawings WC-1 to WC-3 – Borehole Locations and Soil Strata

Appendix FIR-A – Contract Drawing 55-12

Appendix FIR-B – Previous Borehole Logs 1 to 4

Peto MacCallum Ltd.
CONSULTING ENGINEERS

**FOUNDATION INVESTIGATION REPORT**

**for**

Willow Creek Bridge Replacement
Highway 400
GWP No. 2360-10-00
Barrie, Ontario

## 1. INTRODUCTION

This report summarizes the results of a foundation investigation carried out for the proposed replacement of the existing Willow Creek Bridge. This investigation was carried out by Peto MacCallum Ltd. (PML) for MMM Group Limited on behalf of the Ministry of Transportation of Ontario (MTO).

## 2. SITE DESCRIPTION, GEOLOGY AND BACKGROUND

Willow Creek Bridge is located about 500 m south of the Highway 400/Highway 11 interchange, at the north end of the City of Barrie.

The bridge carries the Highway 400 NB and SB lanes over Willow Creek. At the bridge location, the Willow Creek flows from east to west, its channel is about 15 m wide and 2 m deep, and its invert at about elevation 229.0 m.

The site is located within the physiographic region known as the Simcoe Uplands, which includes pervious soil areas with sand and gravel deposits. The overburden at the project site is primarily sand and silt deposits with occasional clayey zones. The vegetation cover consists of grass, bushes and trees.

The existing three-span bridge was constructed in 1955, and widened in 1977. The bridge deck was replaced in 1992. The bridge deck is about 48.1 to 50.7 m wide with an approximate total length of 41.0 m between abutments. Span lengths of the existing bridge are 10.33 m – 19.28 m – 10.33 m. The deck area of this concrete slab on steel girder bridge is about 1982 $m^2$.

*165 Cartwright Avenue, Toronto, Ontario M6A 1V5*
*Tel: (416) 785-5110 Fax: (416) 785-5120*
*E-mail: toronto@petomaccallum.com*
*BARRIE, HAMILTON, KITCHENER, TORONTO*

The existing structure is founded on steel H-piles driven to depths ranging from 36 to 42 m. The underside elevation of the existing abutment and pier pile caps ranges from 228.0 to 230.0 m. The existing piers are surrounded by steel sheet piles extending to about elevation 222.0 m.

The existing approach embankments are about 2 m high (elevation 232.0 m) at the bridge site and original ground level is at approximately elevation 230.0 m.

According to Contract Drawing 55-12 dated November 23, 1954 (refer to Appendix FIR-A), the original single-span bridge (pre-1940's) that was located along the existing SB alignment, was abandoned and dropped into the creek between the piers of the existing three-span bridge.

## 3. INVESTIGATION PROCEDURES

Subsurface information for this project was acquired from previous investigations as well as from new investigations for this project.

Previous investigations were performed by DHO for the Extension to the Structure at the Crossing of Highway 400 and Willow Creek - Township of Vespra - County of Simcoe (GEOCRES File No. 3ID-166)", dated January 1971. A total of four boreholes were carried out for this study; boreholes 1 and 2 were located near the south abutment and pier, respectively; boreholes 3 and 4 were located near the north pier and abutment, respectively. The boreholes were advanced to depths ranging from about 14.3 to 34.0 m. Locations of these boreholes are indicated on Drawing WC-1 of this report. Refer to Appendix FIR-B for Records of Boreholes No. 1 to No. 4.

A previous Preliminary Foundation Investigation and Design Report for MTO project GWP 30-95-00 dated January 2002, prepared by Golder Associates and based on the above-referenced DHO boreholes was also reviewed to obtain site information.

Additional field work for the replacement bridge was carried out during the period of November 3 to November 26, 2014 and consisted of 10 boreholes. A summary including borehole depths and locations is included in the Table 3 below.

**Table 3(a) – Summary of Borehole and Cone Test Depths**

| Borehole No. | Borehole Location | Depth (m) | |
|---|---|---|---|
| | | Auger | Dynamic Cone |
| 14-1 | South Approach | 5.3 | – |
| 14-2 | South Approach | 8.0 | – |
| 14-3 | New South Abutment | 40.2 | 1.6 |
| 14-4 | New South Abutment | 9.8 | 24.4 |
| 14-5 | New South Pier | 9.8 | 21.9 |
| 14-6 | New North Pier | 41.4 | – |
| 14-7 | New North Abutment | 9.8 | 23.5 |
| 14-8 | New North Abutment | 16.0 | 17.5 |
| 14-9 | North Approach | 9.8 | – |
| 14-10 | North Approach | 9.8 | – |

The locations of the new boreholes for this project were established in the field by PML. The ground surface elevations at the borehole locations were surveyed by MMM Group Limited. Locations of the boreholes from previous and current investigations are shown in the attached Drawing WC-1. All elevations in this report are geodetic and expressed in metres.

The new boreholes were advanced using continuous flight solid stem augers, powered by a track-mounted CME-55 and truck-mounted CME-75 drill rigs, supplied and operated by a specialist drilling contractor, working under the full-time supervision of a member of our engineering staff.

Representative samples of the soils were recovered at 0.75 m and 1.5 m depth intervals using a conventional split spoon sampler during drilling. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata.

Dynamic cone penetration tests (cone) were also carried out in boreholes 14-3, 14-4, 14-5, 14-7 and 14-8 extending from the termination of augering to the depth indicated for Dynamic Cone. In situ vane shear testing was performed at selected locations to assess the shear strength of the cohesive soils.

Groundwater conditions at the borehole locations were assessed during and immediately after drilling by visual examination of soil, the sampler and drill rods as the samples were retrieved and, when appropriate, by measurement of the water level in open boreholes. Piezometers, consisting of 19 mm diameter PVC pipes with slotted screens walled in sand, were installed in each of boreholes 14-4, 14-5 and 14-6 for longer term monitoring of the ground water levels.

The boreholes and piezometers were backfilled with a bentonite/cement mixture in accordance with the MTO guidelines and MOE Reg. 903 for borehole abandonment procedures.

The recovered samples were returned to the PML laboratory for detailed visual examination, classification and routine moisture content determination. Lab testing consisting of Atterberg Limits tests, grain size distribution analyses and organic content tests were conducted on selected samples.

## 4. SUMMARISED SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets for details of the subsurface conditions including soil classification, inferred stratigraphy, boundary elevations, standard and dynamic cone penetration test data, in situ vane shear strength values and groundwater observations. The results of laboratory Atterberg limits testing, grain size distribution analyses and moisture content determination are also shown on the Record of Borehole sheets. Borehole locations and stratigraphic profiles are shown on Drawing WC-1. Stratigraphic profiles along the centreline of Highway 400 and cross-sections at the abutments and piers of the bridge are presented on Drawings WC-2 and WC-3. 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.

Generally, underlying roadway fill materials, embankment fill consists of silty sand to clayey silt extending up to 3.7 m in thickness. Underlying the fill, a deposit of very loose to dense silty sand extends for thicknesses in the order of 14 to 20 m. Underlying this noncohesive deposit is a cohesive deposit of soft to firm clayey silt to silty clay with a thickness ranging from 10 to 20 m.

The cohesive deposit is underlain by a deposit of generally compact to very dense silty sand in which the boreholes were terminated. The groundwater level is controlled by the level of Willow Creek, which is within 2 m of the natural ground level.

Debris, composed of the deck of the original single span bridge, is located between the piers of the southbound lanes of the existing three-span bridge. Geophysical investigations indicated that the plan extent of the debris extends from approximately Station 18+280 to Station 18+300. The actual plan extent of the debris may be larger. The elevation and vertical extent of the debris was not determined but is expected to consist of a reinforced concrete deck in the order of 0.5 m thick, located within the few metres below ground level. Details of the foundation type for the abandoned bridge were not available. The abandoned bridge could have been founded on spread footings or on timber piles, which may still be connected to the deck.

The following sections include detailed description of the recent subsurface conditions encountered at PML borehole locations.

### 4.1 Topsoil

Surficial topsoil was encountered in boreholes 14-2, 14-3, 14-4, 14-5, 14-6 and 14-8. The topsoil had a thickness of 300 to 330 mm. The topsoil was encountered at elevations ranging 229.7 to 231.2. Topsoil was silty sand in all boreholes except borehole 14-6 where it was sandy silt. A low amount of organic materials was encountered within the topsoil at some boreholes.

A thin layer of topsoil was encountered in borehole 14-4 at a depth of approximately 2.1 m below ground surface, (elevation 229.1). A 200 mm thick topsoil layer was also encountered in borehole 14-10 at a depth of approximately 2.0 m below ground surface (elevation 229.9).

### 4.2 Asphalt

Boreholes 14-7, 14-9 and 14-10 were drilled through the paved areas of the north and south bridge approaches and shoulders of Highway 400. An approximately 140 mm thick layer of asphalt was encountered from the ground surface at elevations ranging 231.6 to 231.9.

## 4.3 Fill

Fill was encountered in all boreholes underlying the topsoil / asphalt pavement except for boreholes 14-3 and 14-5. A summary of the thickness and elevations are summarized in Table 4.3.

**Table 4.3(a) – Summary of Thickness and Elevations of Fill at BH Locations**

| Borehole No. | Top of Fill Elevation (m) | Fill Thickness (m) | Base of Fill Elevation (m) |
|---|---|---|---|
| 14-1 | 231.7 | 0.8 | 230.9 |
| 14-2 | 230.8 | 0.6 | 230.2 |
| 14-4 | 231.2 | 3.7 | 227.5 |
| 14-6 | 230.1 | 2.0 | 228.1 |
| 14-7 | 231.6 | 2.6 | 229.0 |
| 14-8 | 230.3 | 0.9 | 229.4 |
| 14-9 | 231.9 | 1.8 | 230.1 |
| 14-10 | 231.9 | 2.0 | 229.9 |

The fill was very loose to compact (SPT-‘N’ values of 2 to 23) and moist to wet (moisture content of 6 to 77%).

Refer to the appended Record of Borehole sheets for details of encountered fill material in the boreholes.

## 4.4 Organic Sand / Silty Sand

Underlying the topsoil / fill material a 0.3 to 1.8 m thick deposit of cohesionless organic sand / silty sand material was encountered at elevations ranging from 229.0 to 230.1 in boreholes 14-3, 14-5, 14-8 and 14-9. This deposit extended to a depths varying from 1.4 to 3.7 m (elevation 227.3 to 228.0).

This material was very loose to compact (SPT-“N’ values of 1 to 11) and was moist to wet (moisture contents of 21 to 45%). The material had an organic content ranged between 2.1% to 2.6%.

## 4.5 Upper Clayey Silt

Zones of very soft to stiff clayey silt (SPT-‘N’ values of 1 blow to 14 blows) underlies the organic sand to silty sand in boreholes 14-1, 14-2, 14-3, 14-4 and 14-6 and underlies the silty sand deposit in borehole 14-10. The thickness of the deposit ranges from 1.4 to 3.3 m at the borehole locations. The deposit is moist to wet (moisture content of 22 to 37%). The results of in situ vane testing carried out in the clayey soils yielded undisturbed shear strength values in a range of 8 to 96 kPa (soil sensitivity of 2 to 9). The results of Atterberg limit testing on the Upper Clayey Silt layer are presented in the appended Figure WC-PC-1. The result of Atterberg limit testing of a silt layer encountered within the Upper Clayey Silt layer is illustrated in Figure WC-PC-2. The results of grain size distribution analysis are illustrated in Figure WC-GS-1.

### 4.6 Upper Silty Sand

A cohesionless soil stratum of silty sand was encountered in all boreholes at a depth ranging from 0.9 to 7.0 m (elevation 230.2 to 224.2). The silty sand contained occasional layers of silty clay / clayey silt. This stratum extended to depths ranging from 5.3 to 21.7 m (elevation 208.5 to 226.4). Dynamic cone penetration testing extended below this stratum in boreholes 14-4, 14-5, 14-7 and 14-8 to depths varying between 31.7 to 34.2 m (elevation 196.8 to 198.3). The soil within the dynamic cone penetration tests was not categorized and may extend to lower deposits.

The material was very loose to very dense (SPT-"N' values of 1 blow to 50 blows and was moist to wet (moisture contents of 17 to 52%). It is considered that the lower SPT values are disturbed measurements.

The results of grain size distribution analyses are illustrated in Figure WC-GS-2.

### 4.7 Lower Clayey Silt to Silty Clay

A deposit of cohesive clayey silt to silty clay was encountered in boreholes 14-3, 14-6 and 2 and 3 starting at a depth varied between 19.5 to 21.7 m (elevation 208.5 to 210.0). The cohesive layer extended to a depth varying between 29.9 to 40.5 m (elevation 189.6 to 199.6). Borehole 14-3 was terminated within this layer at a depth of 40.2 m (elevation 190.0). A dynamic cone penetration test extended below this stratum in borehole 14-3 to a depth of 41.8 m (elevation 188.4). The silty clay / clayey silt was very soft to hard in consistency (SPT-"N' values of 1 blow to 141) and was moist to wet (moisture contents ranging between 10 to 49%).

The results of grain size distribution analyses are illustrated in Figure WC-GS-3.

The results of Atterberg limit testing of clayey silt and silty clay components are presented in the appended Figures WC-PC-3.

### 4.8 Lower Silty Sand

A deposit of silty sand underlies the clayey silt in Boreholes 2, 3 and 14-6, the only locations at which boreholes were extended to depths where this layer was penetrated. This deposit was encountered at elevations 199.6 at Boreholes 2 and 3 and at elevation and 189.6 at borehole 14-6, which corresponds to depths in the order of 30 to 40 m below ground. From this information, it is inferred that the lower silty sand deposit underlies the lower clayey silt to silty clay across the entire site. The material is in a compact to very dense state of compaction (SPT-'N' values of 20 to 133) and is moist (moisture contents of 8 to 22%). Grain size analysis of one sample of Borehole 2 indicated that the sample contains 8% gravel, 61% sand and 31% silt and clay.

### 4.9 Groundwater

Water levels first observed in the boreholes during drilling and upon completion of drilling are summarized in Table 4.8 below.

**Table 4.8(a) – Summary of Groundwater Levels in Boreholes**

| Borehole No. | Drilling Date | Groundwater Level (m) | |
|---|---|---|---|
| | | Depth During Drilling / Elevation | Depth upon Completion of Drilling / Elevation |
| 14-1 | November 19, 2014 | 2.1 / 229.6 | 2.1 / 229.6 |
| 14-2 | November 26, 2014 | 2.3 / 228.8 | 2.1 / 229.0 |
| 14-3 | November 11, 2014 | 1.5 / 228.7 | – |
| 14-4 | November 25, 2014 | 3.7 / 227.5 | 3.7 / 227.5 |
| 14-5 | November 10, 2014 | 1.5 / 228.2 | 1.1 / 228.6 |
| 14-6 | November 17, 2014 | 2.3 / 227.8 | – |
| 14-7 | November 6 and 7, 2014 | 2.6 / 229.0 | – |
| 14-8 | November 24, 2014 | 0.9 / 229.4 | – |
| 14-9 | November 3 and 4, 2014 | 1.4 / 230.5 | 3.1 / 228.8 |
| 14-10 | November 4 and 5, 2014 | 0.8 / 231.1 | 2.1 / 229.8 |

It is anticipated that the groundwater levels at the site are subject to seasonal fluctuations and rainfall patterns and is controlled by the creek level.

## 5. CLOSURE

The field work was carried out under the supervision of Mr. F. Portela and direction of Mr. K. Daly, BEng, Project Supervisor, Geotechnical Services. The equipment was supplied by Canadian Soils Drilling.

This report was prepared by Ms. Souzan Dabbagh, MEng, P.Eng., Project Engineer, Geotechnical Services, and reviewed by Mr. David Dundas, P. Eng., Senior Engineer, Geotechnical Services. Mr. C.M.P. Nascimento, P.Eng., Project Manager and MTO Designated Principal Contact conducted an independent review of the report.

Yours very truly

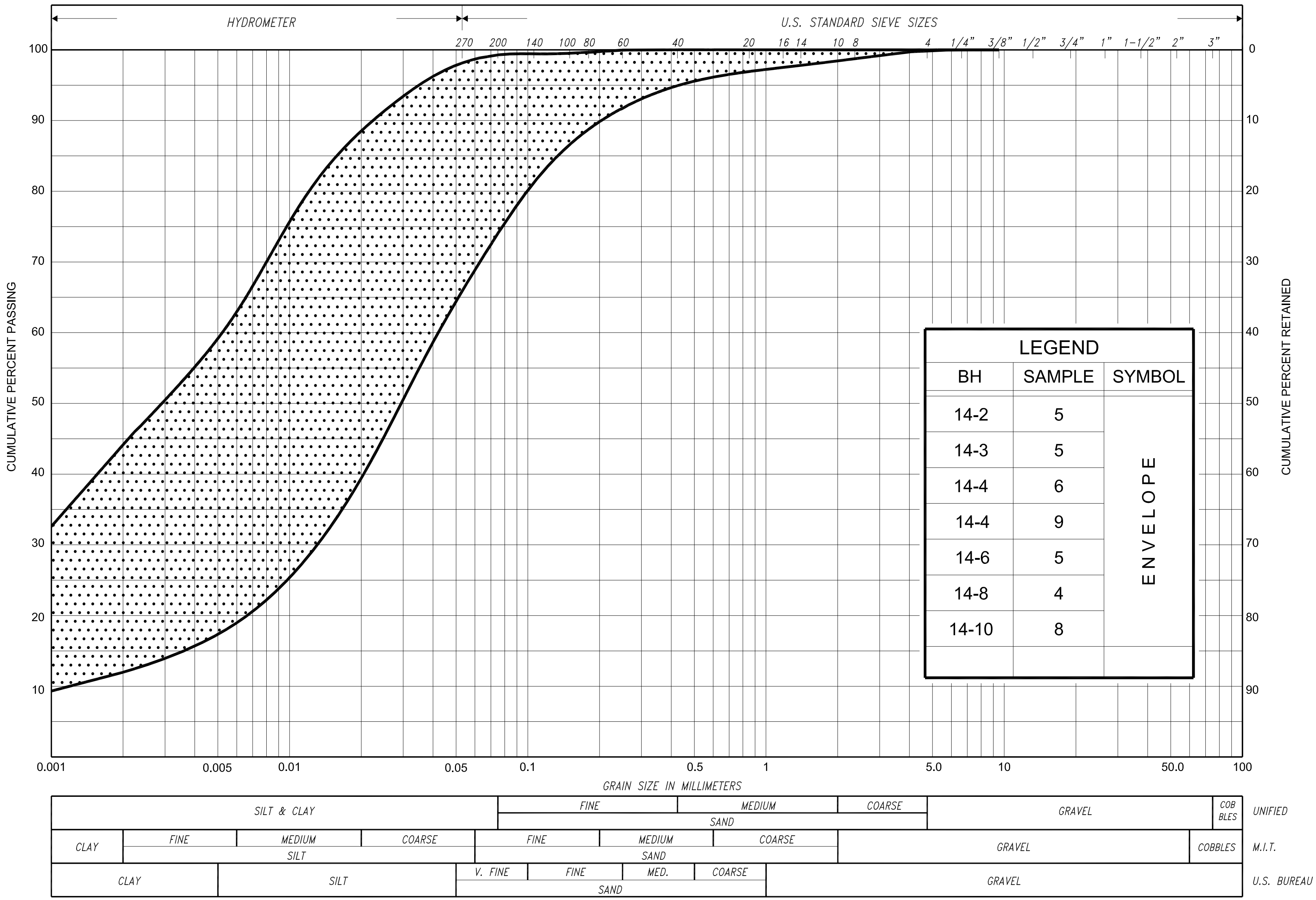
Peto MacCallum Ltd.

Souzan Dabbagh, MEng, P.Eng.
Project Engineer, Geotechnical Services

David Dundas, P. Eng.
Senior Engineer, Geotechnical Services

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

SD/DD/CN:dd-jk




**LEGEND**

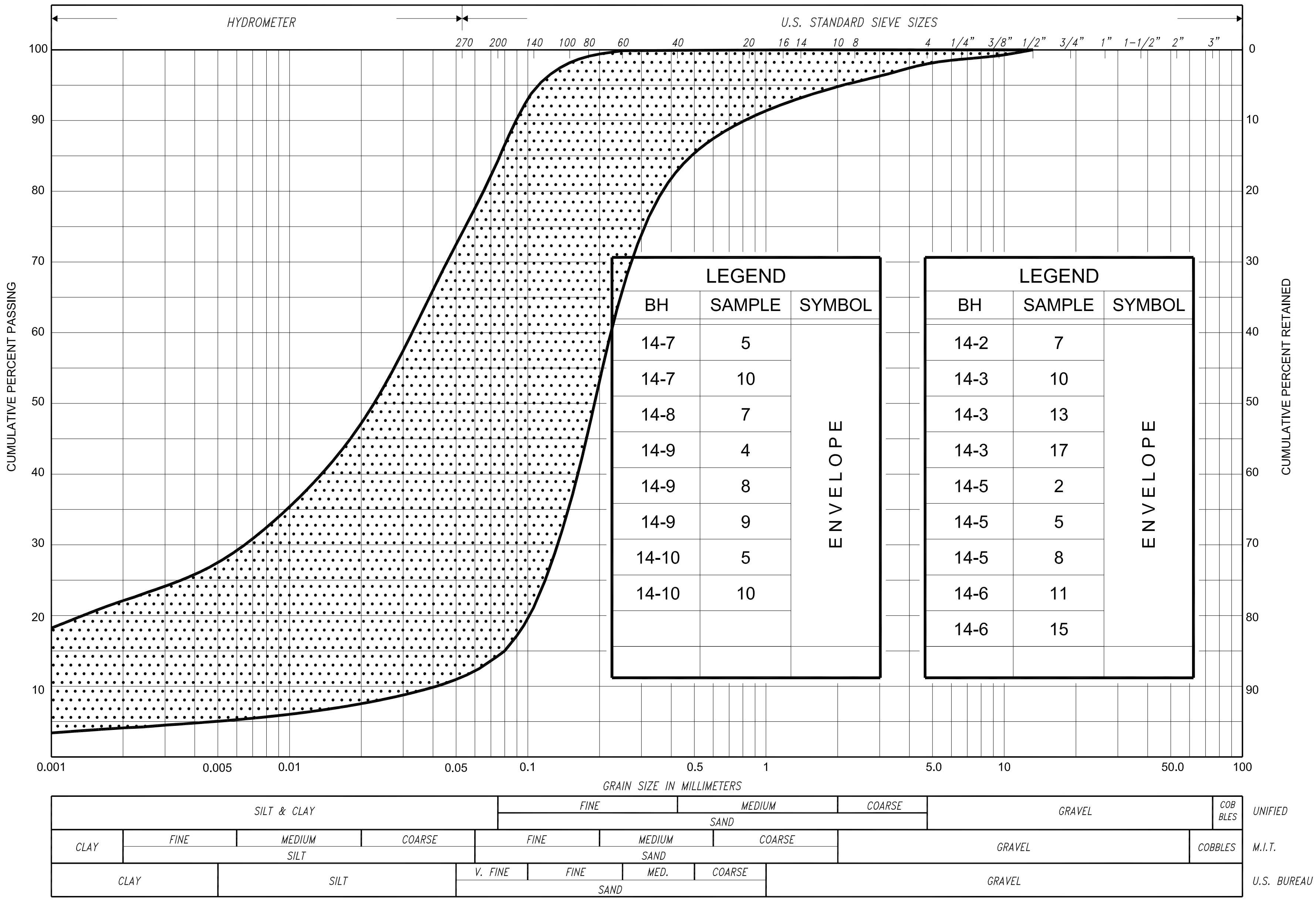
| BH | SAMPLE | SYMBOL |
|---|---|---|
| 14-2 | 5 | ENVELOPE |
| 14-3 | 5 | |
| 14-4 | 6 | |
| 14-4 | 9 | |
| 14-6 | 5 | |
| 14-8 | 4 | |
| 14-10 | 8 | |

Ontario

# GRAIN SIZE DISTRIBUTION

## UPPER CLAYEY SILT

| | |
|---|---|
| FIG No. | WC-GS-1 |
| HWY: | 400 / 11 |
| G.W.P. No. | 2360-10-00 |




| LEGEND | | |
|---|---|---|
| BH | SAMPLE | SYMBOL |
| 14-7 | 5 | ENVELOPE |
| 14-7 | 10 | |
| 14-8 | 7 | |
| 14-9 | 4 | |
| 14-9 | 8 | |
| 14-9 | 9 | |
| 14-10 | 5 | |
| 14-10 | 10 | |

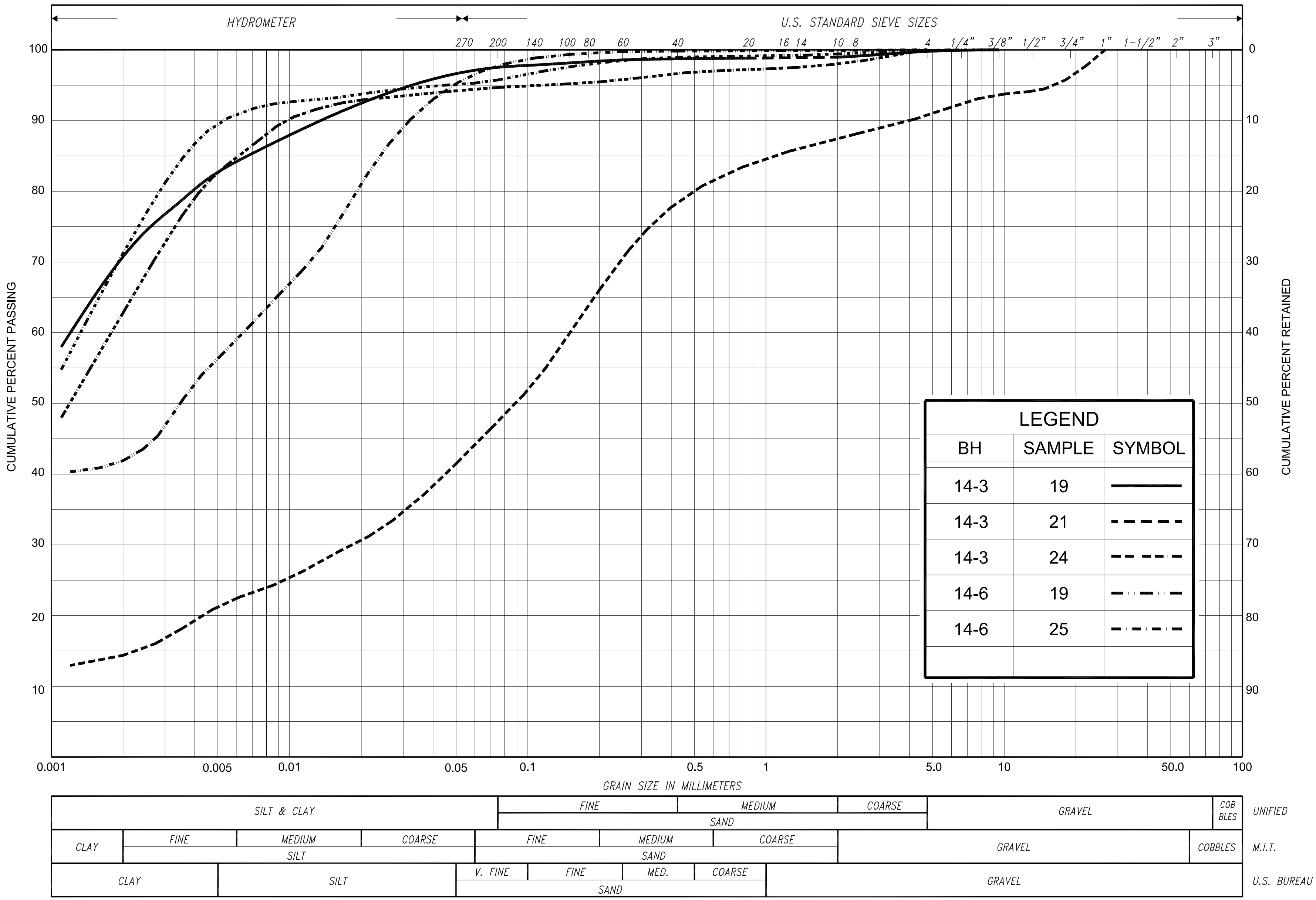
| LEGEND | | |
|---|---|---|
| BH | SAMPLE | SYMBOL |
| 14-2 | 7 | ENVELOPE |
| 14-3 | 10 | |
| 14-3 | 13 | |
| 14-3 | 17 | |
| 14-5 | 2 | |
| 14-5 | 5 | |
| 14-5 | 8 | |
| 14-6 | 11 | |
| 14-6 | 15 | |

Ontario

# GRAIN SIZE DISTRIBUTION

UPPER SILTY SAND

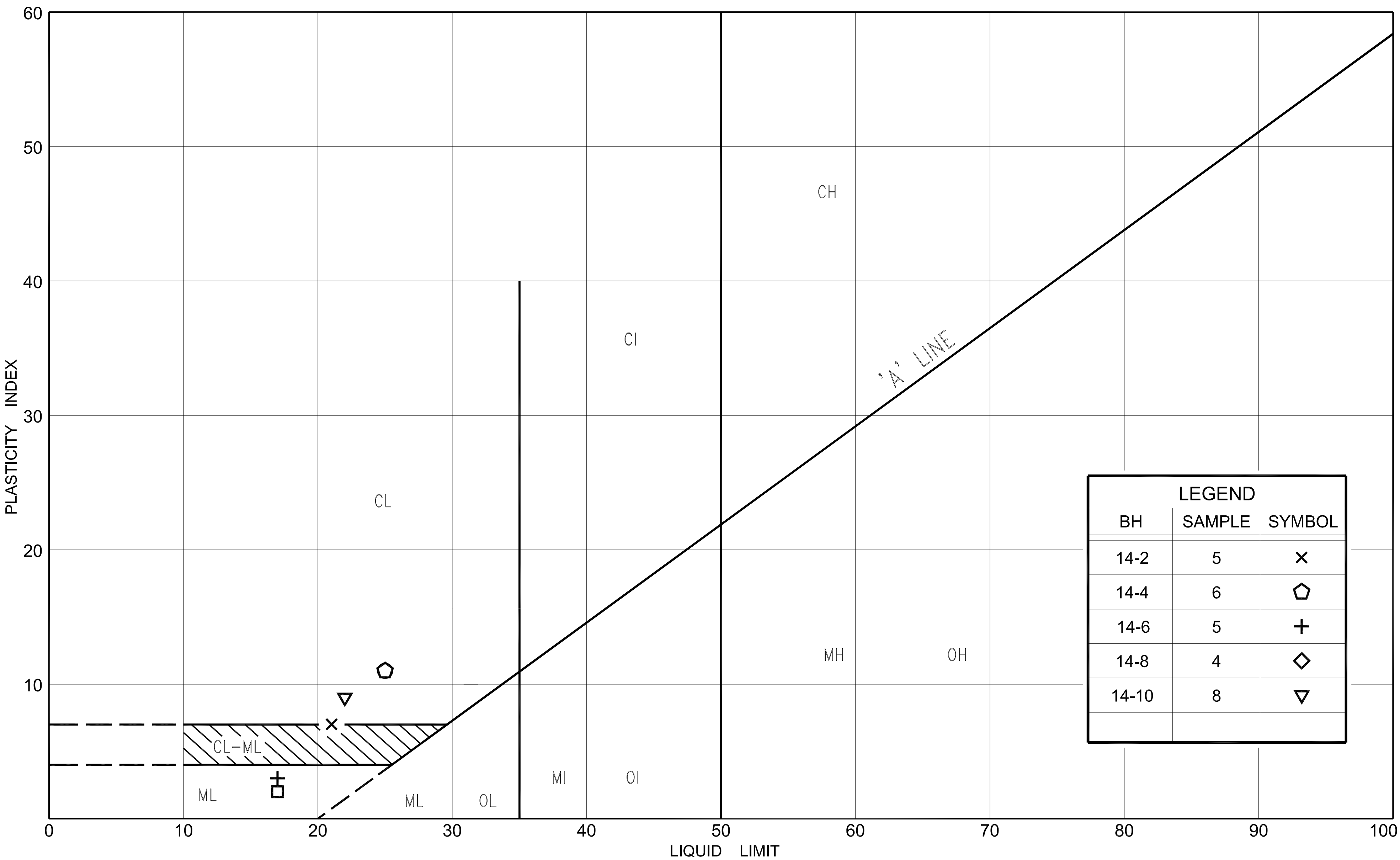
| | |
|---|---|
| FIG No. | WC-GS-2 |
| HWY: | 400 / 11 |
| G.W.P. No. | 2360-10-00 |




# GRAIN SIZE DISTRIBUTION

## LOWER CLAYEY SILT TO SILTY CLAY

| | |
|---|---|
| FIG No. | WC-GS-3 |
| HWY: | 400 / 11 |
| G.W.P. No. | 2360-10-00 |




LEGEND

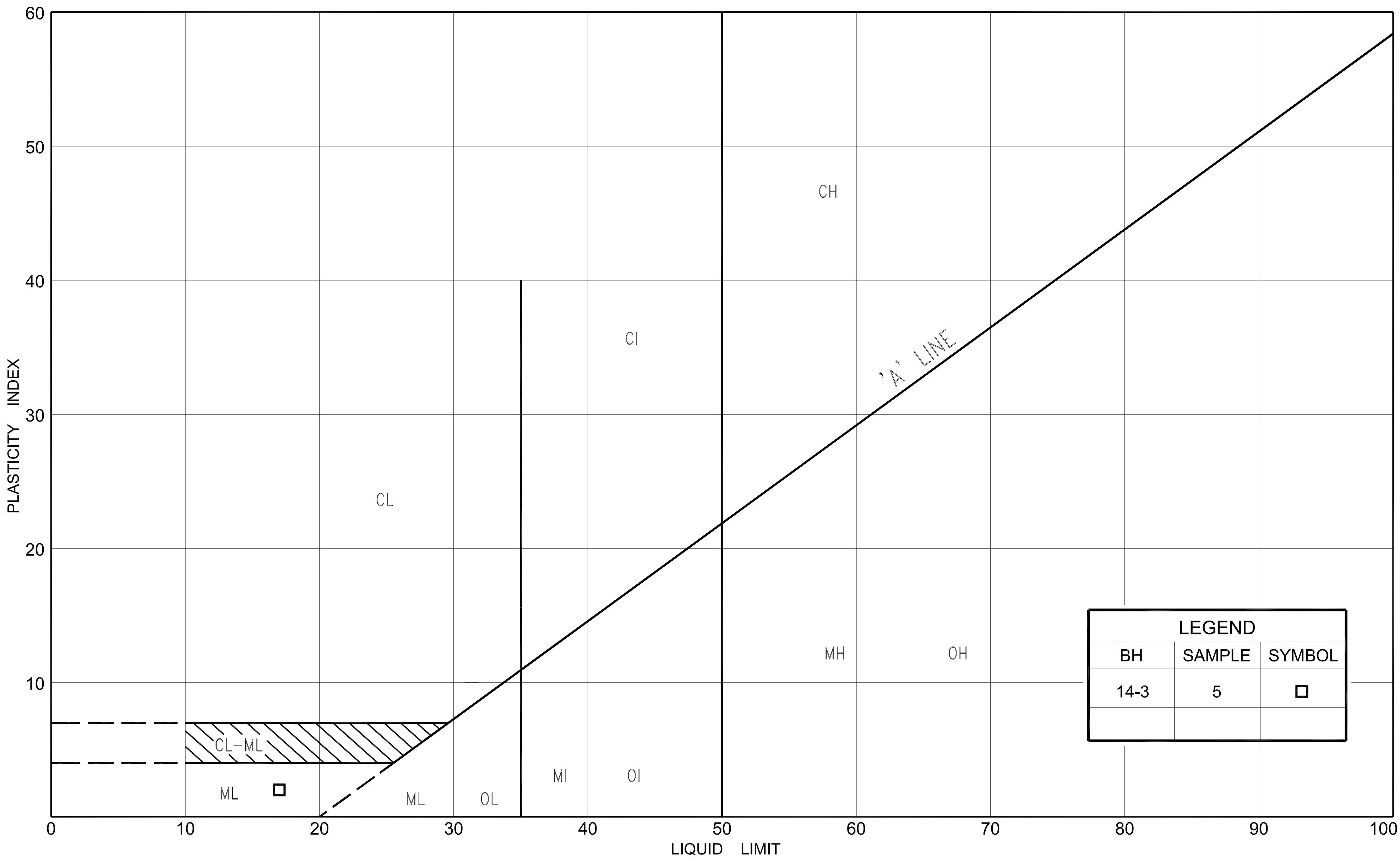
| BH | SAMPLE | SYMBOL |
|---|---|---|
| 14-2 | 5 | × |
| 14-4 | 6 | ⬠ |
| 14-6 | 5 | + |
| 14-8 | 4 | ◇ |
| 14-10 | 8 | ▽ |

Ontario

# PLASTICITY CHART

UPPER CLAYEY SILT

| | |
|---|---|
| FIG No. | WC-PC-1 |
| HWY: | 400 / 11 |
| G.W.P. No. | 2360-10-00 |

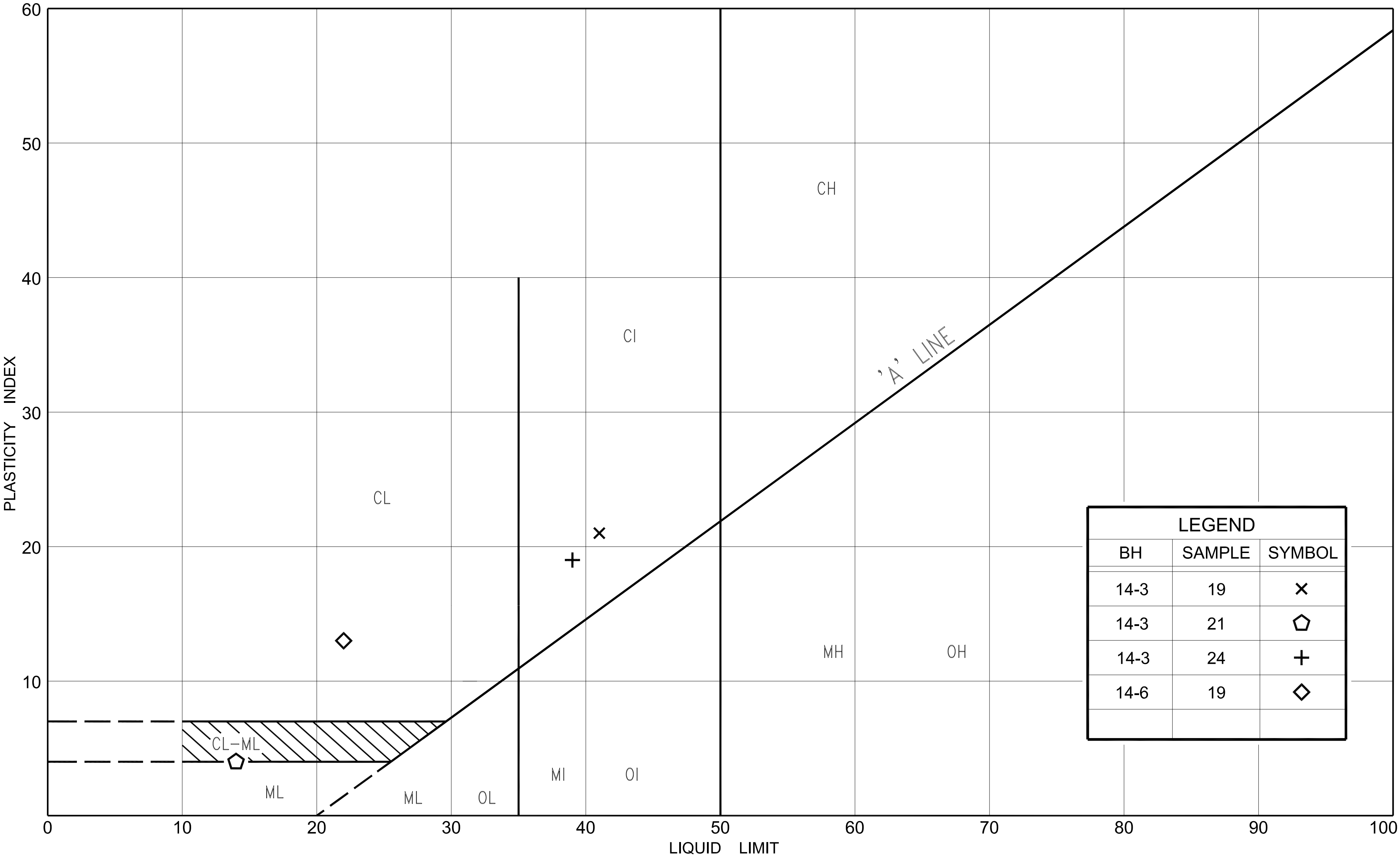



# PLASTICITY CHART

SILT layers

| | |
|---|---|
| FIG No. | WC-PC-2 |
| HWY: | 400 / 11 |
| G.W.P. No. | 2360-10-00 |

Ontario




| LEGEND | | |
|---|---|---|
| BH | SAMPLE | SYMBOL |
| 14-3 | 19 | × |
| 14-3 | 21 | ⬠ |
| 14-3 | 24 | + |
| 14-6 | 19 | ◇ |

Ontario

# PLASTICITY CHART

## LOWER CLAYEY SILT to SILTY CLAY

| | |
|---|---|
| FIG No. | WC-PC-3 |
| HWY: | 400 / 11 |
| G.W.P. No. | 2360-10-00 |

# 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/0.3 m) | 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 |
| $\sigma$ | kPa | TOTAL NORMAL STRESS |
| $\sigma'$ | kPa | EFFECTIVE NORMAL STRESS |
| $\tau$ | kPa | SHEAR STRESS |
| $\sigma_1, \sigma_2, \sigma_3$ | kPa | PRINCIPAL STRESSES |
| $\epsilon$ | % | LINEAR STRAIN |
| $\epsilon_1, \epsilon_2, \epsilon_3$ | % | PRINCIPAL STRAINS |
| E | kPa | MODULUS OF LINEAR DEFORMATION |
| G | kPa | MODULUS OF SHEAR DEFORMATION |
| $\mu$ | 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 |
| $C_\alpha$ | 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 |
| $\sigma'_{vo}$ | kPa | EFFECTIVE OVERBURDEN PRESSURE |
| $\sigma'_p$ | kPa | PRECONSOLIDATION PRESSURE |
| $\tau_f$ | kPa | SHEAR STRENGTH |
| $c'$ | kPa | EFFECTIVE COHESION INTERCEPT |
| $\phi'$ | -° | EFFECTIVE ANGLE OF INTERNAL FRICTION |
| $c_u$ | kPa | APPARENT COHESION INTERCEPT |
| $\phi_u$ | -° | APPARENT ANGLE OF INTERNAL FRICTION |
| $\tau_R$ | kPa | RESIDUAL SHEAR STRENGTH |
| $\tau_r$ | kPa | REMOULDED SHEAR STRENGTH |
| $S_t$ | 1 | SENSITIVITY $= \frac{c_u}{\tau_r}$ |

### PHYSICAL PROPERTIES OF SOIL

| | | |
|---|---|---|
| $\rho_s$ | $kg/m^3$ | DENSITY OF SOLID PARTICLES |
| $\gamma_s$ | $kN/m^3$ | UNIT WEIGHT OF SOLID PARTICLES |
| $\rho_w$ | $kg/m^3$ | DENSITY OF WATER |
| $\gamma_w$ | $kN/m^3$ | UNIT WEIGHT OF WATER |
| $\rho$ | $kg/m^3$ | DENSITY OF SOIL |
| $\gamma$ | $kN/m^3$ | UNIT WEIGHT OF SOIL |
| $\rho_d$ | $kg/m^3$ | DENSITY OF DRY SOIL |
| $\gamma_d$ | $kN/m^3$ | UNIT WEIGHT OF DRY SOIL |
| $\rho_{sat}$ | $kg/m^3$ | DENSITY OF SATURATED SOIL |
| $\gamma_{sat}$ | $kN/m^3$ | UNIT WEIGHT OF SATURATED SOIL |
| $\rho'$ | $kg/m^3$ | DENSITY OF SUBMERGED SOIL |
| $\gamma'$ | $kN/m^3$ | 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 |

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

# RECORD OF BOREHOLE No 14-1



**METRIC**

**G.W.P.** 2360-10-00 **LOCATION** Coords: 4 920 488.7 N; 292 593.6 E **ORIGINATED BY** F.P.

**DIST** Central **HWY** 400 **BOREHOLE TYPE** Continuous Flight Solid Stem Augers **COMPILED BY** S.D.

**DATUM** Geodetic **DATE** November 12, 2014 **CHECKED BY** D.D.

| ELEV / DEPTH | DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | SHEAR STRENGTH kPa | WATER CONTENT (%) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|
| 231.7 | Ground Surface | | | | | | | | | |
| 0.0 | Sand and gravel; Sand, organic inclusions; Compact, Brown, Moist (FILL) | 1 | SS | 10 | | | | ~7 | | |
| 230.9 / 0.8 | Clayey silt, trace sand, organic inclusions; Stiff to firm, Dark brown, Moist | 2 | SS | 11 | | 231 | | ~17 | | |
| | trace gravel | 3 | SS | 6 | ▽* ▼* | 230 | | | | |
| 229.5 / 2.2 | Silty sand, layers of organic sandy silt; Very loose, Brown, Wet | 4 | SS | 3 | | 229 | | ~30 | | |
| | | 5 | SS | 3 | | 228 | | ~18 | | |
| | silty clay layer; Very soft to soft, Grey, Wet | 6 | SS | WH** | | | | ~16 | | |
| | | | FV | | | 227 | +3 (field vane ~ 24 kPa) | | | |
| | trace clay; Compact, Grey, Wet | 7 | SS | 18 | | | | ~13 | | |
| 226.4 / 5.3 | End of borehole | | | | | | | | | |

* 2014 11 12

▽ Water level observed during drilling

▼ Water level measured after drilling

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



+7, ×5 : Numbers refer to Sensitivity

20 / 15 — ○ — 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd.
CONSULTING ENGINEERS

Foundation Design

# RECORD OF BOREHOLE No 14-2



**METRIC**

| | | | |
|---|---|---|---|
| G.W.P. 2360-10-00 | LOCATION Coords: 4 920 466.6 N; 292 641.9 E | | ORIGINATED BY F.P. |
| DIST Central HWY 400 | BOREHOLE TYPE Continuous Flight Hollow Stem Augers | | COMPILED BY S.D. |
| DATUM Geodetic | DATE November 26, 2014 | | CHECKED BY D.D. |

| ELEV / DEPTH | DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | NATURAL MOISTURE CONTENT (%) | GR | SA | SI | CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 231.1 | Ground Surface | | | | | 231 | | | | | |
| 230.8 / 0.0 | Topsoil | | | | | | | | | | |
| 0.3 | Sand, trace silt layers<br>Loose Dark Grey Moist<br>(FILL) | 1 | SS | 3 | | | ~20 | | | | |
| 230.2 / 0.9 | Silty sand<br>topsoil inclusions<br>Very loose Grey Wet | 2 | SS | 6 | | 230 | ~45 | | | | |
| | | 3 | SS | 3 | ▽* (during drilling) ▼* (after drilling) ~229.2 | 229 | ~24 | | | | |
| | | 4 | SS | 2 | | | | | | | |
| 228.1 / 3.0 | Clayey silt, trace sand<br>Very soft Grey Wet to firm | 5 | SS | 1 | | 228 | ~25 (Wp ~18) | 0 | 2 | 70 | 28 |
| | | 6 | SS | 5 | | 227 | ~27 | | | | |
| 226.6 / 4.5 | Silty sand, some clay<br>occasional silt layers<br>Very loose Grey Wet to compact | 7 | SS | 1 | | 226 | | 0 | 16 | 67 | 17 |
| | | 8 | SS | 6 | | | ~24 | | | | |
| | | 9 | SS | 6 | | 225 | ~19 | | | | |
| | some gravel | | | | | 224 | | | | | |
| 222.9 / 8.2 | | 10 | SS | 13 | | 223 | ~19 | | | | |
| | End of borehole | | | | | | | | | | |

* 2014 11 26

▽ Water level observed during drilling

▼ Water level measured after drilling

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, × 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 (%)



+7, ×5: Numbers refer to Sensitivity

20 / 15 — 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

# RECORD OF BOREHOLE No 14-3



**METRIC**

**G.W.P.** 2360-10-00 **LOCATION** Coords: 4 920 507.4 N; 292 595.4 E **ORIGINATED BY** F.P.

**DIST** Central **HWY** 400 **BOREHOLE TYPE** C.F.S.S.A.and Mud Rotary + Dynamic Cone Penetration test **COMPILED BY** S.D.

**DATUM** Geodetic **DATE** November 10 & 11, 2014 **CHECKED BY** D.D.

## SOIL PROFILE

| ELEV / DEPTH | DESCRIPTION |
|---|---|
| 230.2 | Ground Surface |
| 0.0 / 229.9 | Topsoil |
| 0.3 | Silty sand, organics<br>Very loose Dark grey Moist<br>(ALLUVIUM) |
| 228.0 / 2.2 | Clayey silt to silty clay trace sand<br>Very soft to firm Grey Wet<br>layers of silt, with sand, some clay |
| 225.3 / 4.9 | Silty sand occasional clayey silt to silty clay layers<br>Very loose to compact Grey Wet<br>Sand, some silt trace clay, trace gravel |
| 215.2 | Cont'd |

## SAMPLES

| NUMBER | TYPE | "N" VALUES | Field vane sensitivity | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|
| 1 | SS | 6 | | |
| 2 | SS | 4 | | |
| 3 | SS | 2 | | |
| 4 | SS | WH** | | |
| | FV | | 3 | |
| 5 | TW | - | | 0 26 62 12 |
| | FV | | 9 | |
| 6 | SS | 5 | | |
| 7 | TW | - | | |
| 8 | SS | 18 | | |
| 9 | SS | 12 | | |
| 10 | SS | 5 | | 2 82 (16) |
| 11 | SS | 3 | | |
| 12 | SS | 5 | | |
| | FV | | 2 | |
| 13 | SS | 12 | | 0 80 16 4 |
| 14 | SS | 17 | | |

GROUND WATER CONDITIONS: ∇* (at approx. elev. 228.8)

ELEVATION SCALE: 230, 229, 228, 227, 226, 225, 224, 223, 222, 221, 220, 219, 218, 217, 216

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



+7 , ×5 : Numbers refer to Sensitivity

20 / 15 —○— 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

# RECORD OF BOREHOLE No 14-3



**METRIC**

**G.W.P.** 2360-10-00 **LOCATION** Coords: 4 920 507.4 N; 292 595.4 E **ORIGINATED BY** F.P.

**DIST** Central **HWY** 400 **BOREHOLE TYPE** C.F.S.S.A.and Mud Rotary + Dynamic Cone Penetration test **COMPILED BY** S.D.

**DATUM** Geodetic **DATE** November 10 & 11, 2014 **CHECKED BY** D.D.

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa | WATER CONTENT (%) ($w_P$ / w / $w_L$) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 215.2 / 15.0 | Silty sand, occasional clayey silt to silty clay layers. Compact to dense, Grey, Wet (Cont'd.) | | | | | | 215 | | | | |
| | | | 15 | SS | 5 | | | | ○ ≈ 27 | | |
| | | | | | | | 214 | | | | |
| | | | 16 | SS | 2 | | 213 | | ○ ≈ 29 | | |
| | | | | | | | 212 | | | | |
| | | | 17 | SS | WH | | | | ○ ≈ 20 | | 0 38 53 9 |
| | | | | | | | 211, 210, 209 | | | | |
| 208.5 / 21.7 | Clayey silt to silty clay, trace sand. Soft to hard, Grey, Wet | | 18 | SS | 40 | | | ■ | ○ ≈ 29 | | |
| | | | | | | | 208, 207, 206 | | | | |
| | trace gravel | | 19 | SS | 4 | | | ■ | ├─┤ ○ ≈ 39 | | 1 2 (97) |
| | | | | | | | 205, 204, 203 | | | | |
| | | | 20 | SS | WH | | | | ○ ≈ 36 | | |
| 200.2 | Cont'd | | | | | | 202, 201 | | | | |

ON MTO_VER3 NEW LOGO 12KF037A.GPJ ON_MOT.GDT 4/1/2015

Legend: ○ UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE. +7, ×5: Numbers refer to Sensitivity. 20 / 15—○—5 / 10: (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 14-3



**METRIC**

**G.W.P.** 2360-10-00 **LOCATION** Coords: 4 920 507.4 N; 292 595.4 E **ORIGINATED BY** F.P.

**DIST** Central **HWY** 400 **BOREHOLE TYPE** C.F.S.S.A.and Mud Rotary + Dynamic Cone Penetration test **COMPILED BY** S.D.

**DATUM** Geodetic **DATE** November 10 & 11, 2014 **CHECKED BY** D.D.

| ELEV / DEPTH | DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | ELEVATION SCALE | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|
| 200.2 / 30.0 | Clayey silt to silty clay trace sand, trace gravel. Soft to hard, Grey, Wet (Cont'd.) | 21 | SS | 12 | 200–199 | 9 44 33 14 |
| | | 22 | SS | 15 | 197–196 | |
| | | 23 | SS | 11/23cm | 194–193 | |
| | | 24 | SS | 141 | 192 | 0 5 32 63 |
| 190.0 / 40.2 | | 25 | SS | 51 | 191–190 | |
| | End of borehole. Switched to dynamic cone penetration test. Probable silty clay to clayery silt | | | | 190–189 | |
| 188.4 / 41.8 | End of dynamic cone penetration test | | | | | |

Dynamic cone penetration values: 141, 219, 381, 120/5cm

* 2014 11 10 & 11

Water level observed during drilling

■ Penetrometer test

C.F.S.S.A. denotes continuous flight soild stem augers

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; UNIT WEIGHT γ kN/m³

+7, ×5 : Numbers refer to Sensitivity

20 / 15—○—5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

# RECORD OF BOREHOLE No 14-4



**METRIC**

| | |
|---|---|
| G.W.P. | 2360-10-00 |
| LOCATION | Coords: 4 920 483.9 N; 292 649.1 E |
| ORIGINATED BY | F.P. |
| DIST | Central |
| HWY | 400 |
| BOREHOLE TYPE | Continuous Flight Hollow Stem Augers |
| COMPILED BY | S.D. |
| DATUM | Geodetic |
| DATE | November 25, 2014 |
| CHECKED BY | D.D. |

## Soil Profile

| ELEV / DEPTH | DESCRIPTION |
|---|---|
| 231.2 | Ground Surface |
| 0.0 | Topsoil<br>Silty sand<br>Loose to compact, Dark Brown, Moist<br>(FILL)<br>Organic silty sand<br>Loose, Dark brown, Moist<br>Topsoil<br>organic sand seams |
| 227.5 / 3.7 | Clayey silt, trace sand<br>Stiff to very soft, Grey, Moist |
| 224.2 / 7.0 | Silty sand<br>Very loose to loose, Grey, Wet |
| 221.4 / 9.8 | End of borehole<br>Switched to dynamic cone penetration test |
| 216.2 | Cont'd |

## Samples

| NUMBER | TYPE | "N" VALUES | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|
| 1 | SS | 3 | |
| 2 | SS | 19 | |
| 3 | SS | 8 | |
| 4 | SS | 2 | |
| 5 | SS | 2 | |
| 6 | SS | 9 | 0 11 52 37 |
| 7 | SS | 2 | |
| 8 | SS | WH** | |
| 9 | SS | 1 | 0 13 43 44 |
| 10 | SS | 2 | |
| 11 | SS | 8 | |

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (231 to 217); 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.



+7, ×5 : Numbers refer to Sensitivity

20 / 15—○—5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd.
CONSULTING ENGINEERS
Foundation Design

# RECORD OF BOREHOLE No 14-4



**METRIC**

| | | | | | |
|---|---|---|---|---|---|
| **G.W.P.** | 2360-10-00 | **LOCATION** | Coords: 4 920 483.9 N; 292 649.1 E | **ORIGINATED BY** | F.P. |
| **DIST** Central | **HWY** 400 | **BOREHOLE TYPE** | Continuous Flight Hollow Stem Augers | **COMPILED BY** | S.D. |
| **DATUM** | Geodetic | **DATE** | November 25, 2014 | **CHECKED BY** | D.D. |

| SOIL PROFILE | | | SAMPLES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
| 216.2 | | | | | | | | | | | |
| 15.0 | Dynamic cone penetration test (Cont'd.) | | | | | | 216 | | | | |
| | | | | | | | 215 | | | | |
| | | | | | | | 214 | | | | |
| | | | | | | | 213 | | | | |
| | | | | | | | 212 | | | | |
| | | | | | | | 211 | | | | |
| | | | | | | | 210 | | | | |
| | | | | | | | 209 | | | | |
| | | | | | | | 208 | | | | |
| | | | | | | | 207 | | | | |
| | | | | | | | 206 | | | | |
| | | | | | | | 205 | | | | |
| | | | | | | | 204 | | | | |
| | | | | | | | 203 | | | | |
| | | | | | | | 202 | | | | |
| 201.2 | Cont'd | | | | | | | | | | |



+7 , ×5 : Numbers refer to Sensitivity

20 / 15 — 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

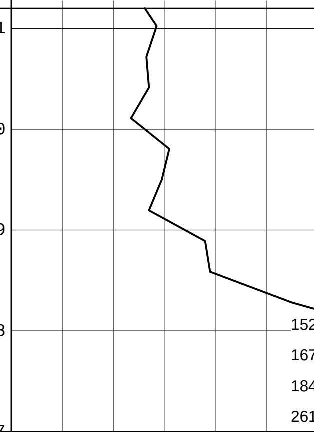
# RECORD OF BOREHOLE No 14-4



**METRIC**

| | | | |
|---|---|---|---|
| **G.W.P.** 2360-10-00 | **LOCATION** Coords: 4 920 483.9 N; 292 649.1 E | | **ORIGINATED BY** F.P. |
| **DIST** Central **HWY** 400 | **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers | | **COMPILED BY** S.D. |
| **DATUM** Geodetic | **DATE** November 25, 2014 | | **CHECKED BY** D.D. |

| 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 γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 201.2 | | | | | | | | | | | |
| 30.0 | Dynamic cone penetration test (Cont'd.) | | | | | | 201 | | | | |
| | | | | | | | 200 | | | | |
| | | | | | | | 199 | | | | |
| | | | | | | | 198 | 152 | | | |
| | | | | | | | | 167 | | | |
| | | | | | | | | 184 | | | |
| 197.0 | | | | | | | | 261 | | | |
| 34.2 | End of dynamic cone penetration test | | | | | | 197 | 120/88cm | | | |



* 2014 11 25

▽ Water level observed during drilling

▼ Water level measured after drilling

WH** denotes penetration due to weight of rods and hammer

**Piezometer Readings:**

| Date | Depth (m) | Elev. |
|---|---|---|
| Jan.26,15 | 1.5 | 229.7 |

Piezometer Legend:

- Bentonite seal
- Auger cuttings
- Filter sand
- Screen



+7, ×5: Numbers refer to Sensitivity

20 / 15 —○— 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd.
CONSULTING ENGINEERS

Foundation Design

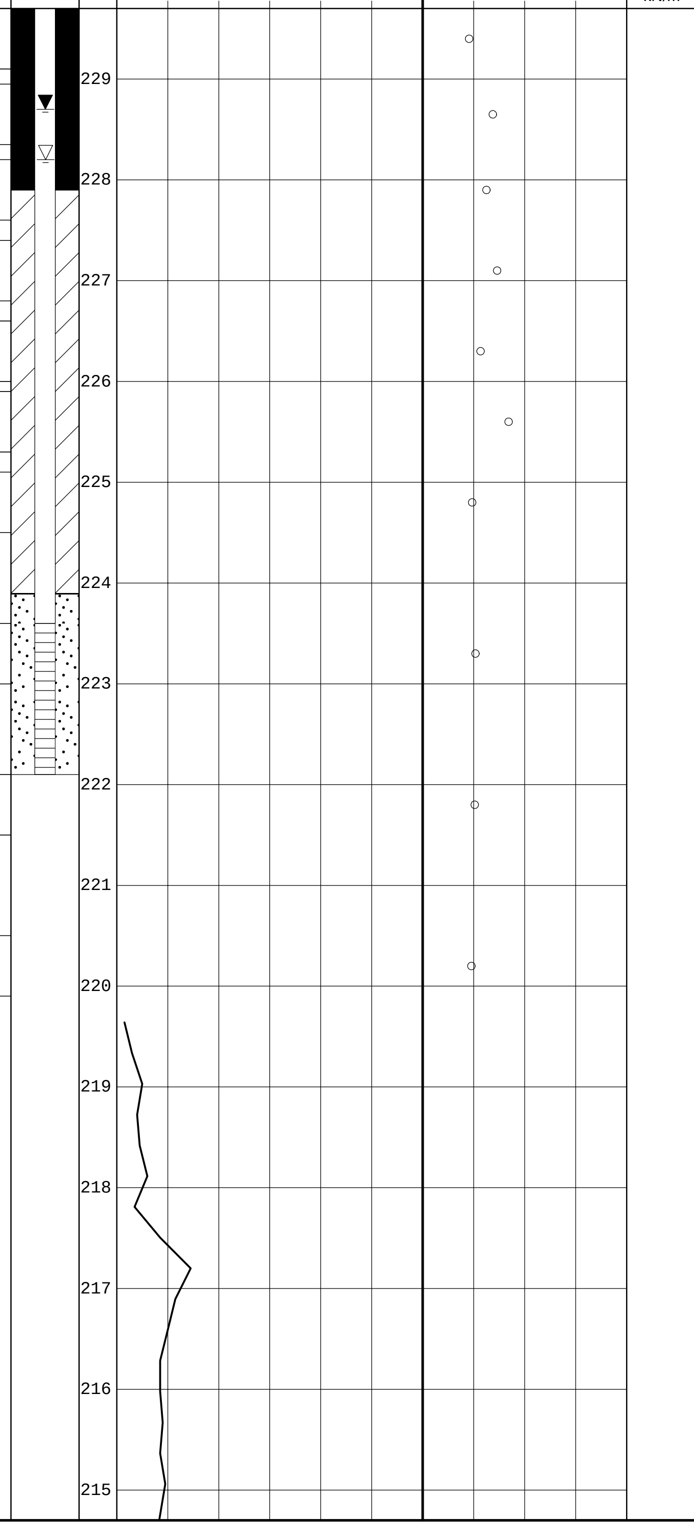
# RECORD OF BOREHOLE No 14-5



**METRIC**

| | | | |
|---|---|---|---|
| **G.W.P.** 2360-10-00 | **LOCATION** Coords: 4 920 522.7 N; 292 606.8 E | | **ORIGINATED BY** F.P. |
| **DIST** Central **HWY** 400 | **BOREHOLE TYPE** C.F.S.S.A. and Dynamic Cone Penetration Test | | **COMPILED BY** S.D. |
| **DATUM** Geodetic | **DATE** November 10, 2014 | | **CHECKED BY** D.D. |

| ELEV / DEPTH (m) | SOIL PROFILE – DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|
| 229.7 | Ground Surface | | | | |
| 0.0 | Topsoil | | | | |
| 229.4 / 0.3 | Silty sand, organics<br>Very loose Brown Moist<br>trace clay, trace gravel<br>Loose Dark grey Moist<br>(ALLUVIUM) | 1 | SS | 1 | |
| | | 2 | SS | 7 | 1 53 37 9 |
| 228.3 / 1.4 | Silty sand, trace gravel<br>Compact to very loose Grey Wet | 3 | SS | 11 | |
| | | 4 | SS | 4 | |
| | sand layer<br>some silt, trace clay | 5 | SS | 2 | 1 85 (14) |
| | silty clay layers | 6 | SS | 4 | |
| | | 7 | SS | 7 | |
| | sand layer<br>some clay, trace silt | 8 | SS | 4 | 1 83 5 11 |
| | | 9 | SS | 4 | |
| | | 10 | SS | 3 | |
| 219.9 / 9.8 | Switched to dynamic cone penetration test | | | | |
| 214.7 | Cont'd | | | | |






+7, ×5 : Numbers refer to Sensitivity

20 / 15—○—5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd.
CONSULTING ENGINEERS

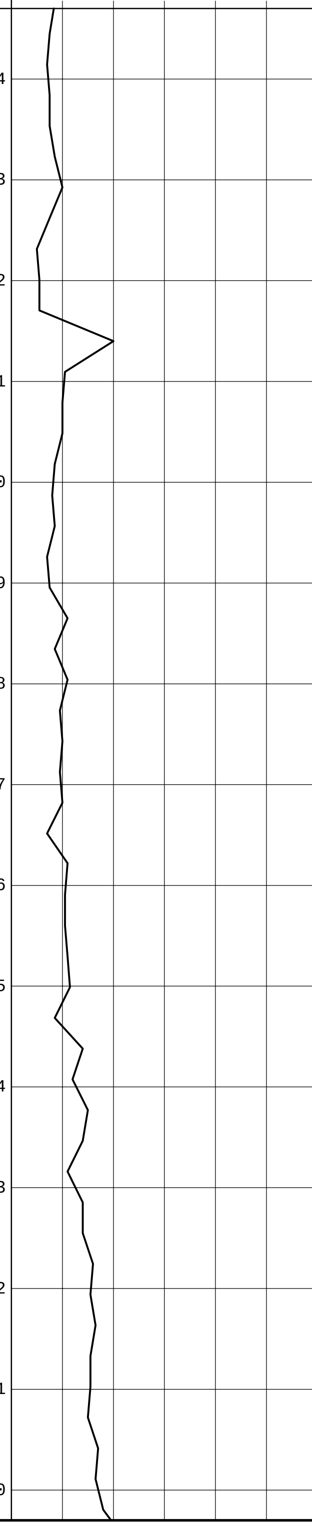
Foundation Design

# RECORD OF BOREHOLE No 14-5



**METRIC**

| | | | | | |
|---|---|---|---|---|---|
| **G.W.P.** 2360-10-00 | | **LOCATION** | Coords: 4 920 522.7 N; 292 606.8 E | **ORIGINATED BY** | F.P. |
| **DIST** Central | **HWY** 400 | **BOREHOLE TYPE** | C.F.S.S.A. and Dynamic Cone Penetration Test | **COMPILED BY** | S.D. |
| **DATUM** Geodetic | | **DATE** | November 10, 2014 | **CHECKED BY** | D.D. |

| 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 | | | | | | |
| 214.7 / 15.0 | Dynamic cone penetration test (Cont'd.) | | | | | | 214, 213, 212, 211, 210, 209, 208, 207, 206, 205, 204, 203, 202, 201, 200 |  | | | |
| 199.7 | Cont'd | | | | | | | | | | |



+7, ×5 : Numbers refer to Sensitivity

20 / 15 —○— 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

# RECORD OF BOREHOLE No 14-5



METRIC

| | | | |
|---|---|---|---|
| G.W.P. 2360-10-00 | LOCATION Coords: 4 920 522.7 N; 292 606.8 E | ORIGINATED BY F.P. |
| DIST Central HWY 400 | BOREHOLE TYPE C.F.S.S.A. and Dynamic Cone Penetration Test | COMPILED BY S.D. |
| DATUM Geodetic | DATE November 10, 2014 | CHECKED BY D.D. |

| 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 γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 199.7 | | | | | | | | | | | |
| 30.0 | Dynamic cone penetration test (Cont'd.) | | | | | | 199 | | | | |
| 198.0 / 31.7 | End of dynamic cone penetration test<br>Refusal on probable bedrock | | | | | | 198 | 341/30cm | | | |

* 2014 11 10

▽ Water level observed during drilling

▼ Water level measured after drilling

Piezometer Readings:

| Date | Depth (m) | Elev. |
|---|---|---|
| Jan.26,15 | Frozen | |

Piezometer Legend:

- Bentonite seal
- Auger cuttings
- Filter sand
- Screen



+7, ×5 : Numbers refer to Sensitivity

20 / 15 —○— 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

# RECORD OF BOREHOLE No 14-6



**METRIC**

G.W.P. 2360-10-00 | LOCATION Coords: 4 920 516.3 N; 292 673.8 E | ORIGINATED BY F.P.

DIST Central | HWY 400 | BOREHOLE TYPE Continuous Flight Hollow Stem Augers and Mud Rotary | COMPILED BY S.D.

DATUM Geodetic | DATE November 17 -21, 2014 | CHECKED BY D.D.

## SOIL PROFILE

| ELEV / DEPTH | DESCRIPTION |
|---|---|
| 230.1 | Ground Surface |
| 0.0 | Topsoil |
| | Sandy silt, trace clay, organics. Very loose to loose, Dark Brown, Moist |
| | Sand, organics (FILL) |
| 228.1 / 2.0 | Clayey silt, some sand. Very soft to soft, Grey, Moist to wet |
| 225.8 / 4.3 | Silty sand. Compact, Grey, Wet |
| | silt and sand layer, trace clay. Very loose to compact, Grey, Wet |
| | silt layer, with sand, with clay, trace gravel. Loose to very loose, Grey, Wet |
| 215.1 | Cont'd |

## SAMPLES

| NUMBER | TYPE | "N" VALUES | Water content (%) (approx.) | REMARKS: GR SA SI CL |
|---|---|---|---|---|
| 1 | SS | 2 | | |
| 2 | SS | 5 | | |
| 3 | SS | 9 | | |
| 4 | SS | 1 | | |
| | FV | | | |
| 5 | SS | 3 | H | 0 15 63 22 |
| 6 | SS | 2 | | |
| 7 | SS | 13 | | |
| 8 | SS | 11 | | |
| 9 | SS | 12 | | |
| 10 | SS | 11 | | |
| 11 | SS | 3 | | 0 44 48 8 |
| 12 | SS | 3 | | |
| 13 | SS | 29 | | |
| 14 | SS | 29 | | |
| 15 | SS | 5 | | 1 22 55 22 |

Elevation scale: 230 – 216. 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 γ kN/m³.



+7, ×5 : Numbers refer to Sensitivity. 20 / 15–○–5 / 10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 14-6



**METRIC**

**G.W.P.** 2360-10-00 **LOCATION** Coords: 4 920 516.3 N; 292 673.8 E **ORIGINATED BY** F.P.

**DIST** Central **HWY** 400 **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers and Mud Rotary **COMPILED BY** S.D.

**DATUM** Geodetic **DATE** November 17 -21, 2014 **CHECKED BY** D.D.

| ELEV / DEPTH | SOIL PROFILE DESCRIPTION | NUMBER | TYPE | "N" VALUES | WATER CONTENT (%) | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|
| 215.1 / 15.0 | Silty sand<br>Loose to very loose, Grey, Wet | 16 | SS | 2 | | |
| | Compact to loose | 17 | SS | 19 | ○ | |
| | | 18 | SS | 7 | ○ | |
| 209.4 / 20.7 | Clayey silt to silty clay trace sand<br>Very soft, Grey, Moist to wet | 19 | SS | 1 | ├─○ | 0 2 56 42 |
| | clay layer some silt, trace sand<br>Firm, Grey, Moist to wet | 20 | SS | 7 | ○ | 0 2 (98) |
| | | 21 | SS | 4 | ○ | |
| 200.1 | Cont'd | | | | | |

Elevation scale: 215, 214, 213, 212, 211, 210, 209, 208, 207, 206, 205, 204, 203, 202, 201

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



+7, ×5: Numbers refer to Sensitivity; 20 / 15 —○— 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

# RECORD OF BOREHOLE No 14-6



**METRIC**

**G.W.P.** 2360-10-00 **LOCATION** Coords: 4 920 516.3 N; 292 673.8 E **ORIGINATED BY** F.P.

**DIST** Central **HWY** 400 **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers and Mud Rotary **COMPILED BY** S.D.

**DATUM** Geodetic **DATE** November 17 -21, 2014 **CHECKED BY** D.D.

| ELEV / DEPTH | DESCRIPTION | NUMBER | TYPE | "N" VALUES | ELEVATION SCALE | WATER CONTENT | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|
| 200.1 | | | | | | | |
| 30.0 | Clayey silt, trace sand. Stiff to hard, Grey, Moist to wet | | | | 200 | | |
| | | 22 | SS | 15 | 199 | | |
| | | | | | 198 | | |
| | | | | | 197 | | |
| | | 23 | SS | 14 | 196 | ○ | |
| | | | | | 195 | | |
| | | | | | 194 | | |
| | | 24 | SS | 30 | 193 | ○ | |
| | silty clay layer trace sand | 25 | SS | 124/23cm | 192 | ○ | 0 4 (96) |
| | | | | | 191 | | |
| | | 26 | SS | 114 | 190 | ○ | |
| 189.6 / 40.5 | Silty sand. Very dense, Grey, Moist | | | | 189 | | |
| 188.7 | | 27 | SS | 100/23cm | | ○ | |
| 41.4 | End of borehole | | | | | | |

Sample 25: Sampler bouncing

* 2014 11 18 - 21

▽ Water level observed during drilling

▼ Water level measured after drilling

■ Penetrometer test Cont'd

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; Unit weight γ kN/m³

+7, ×5: Numbers refer to Sensitivity

15–○–5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

# RECORD OF BOREHOLE No 14-6



**METRIC**

**G.W.P.** 2360-10-00 **LOCATION** Coords: 4 920 516.3 N; 292 673.8 E **ORIGINATED BY** F.P.

**DIST** Central **HWY** 400 **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers and Mud Rotary **COMPILED BY** S.D.

**DATUM** Geodetic **DATE** November 17 -21, 2014 **CHECKED BY** D.D.

| 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 | | | | | | |
| | Piezometer Readings:<br>Date / Depth (m) / Elev.<br>Jan.26,15 / Frozen<br><br>Piezometer Legend:<br>Bentonite seal<br>Grout<br>Filter sand<br>19mm dia. Screen | | | | | | | | | | |



+7, ×5: Numbers refer to Sensitivity

20 / 15 —○— 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

# RECORD OF BOREHOLE No 14-7



**METRIC**

| | | | |
|---|---|---|---|
| **G.W.P.** 2360-10-00 | **LOCATION** Coords: 4 920 556.3 N; 292 622.5 E | | **ORIGINATED BY** F.P. |
| **DIST** Central | **HWY** 400 | **BOREHOLE TYPE** C.F.S.S.A.and Mud Rotary + Dynamic Cone Penetration test | **COMPILED BY** S.D. |
| **DATUM** Geodetic | **DATE** November 06 & 07, 2014 | | **CHECKED BY** D.D. |

## SOIL PROFILE

| ELEV / DEPTH | DESCRIPTION |
|---|---|
| 231.6 | Ground Surface |
| 0.0 | 140mm asphalt over sand and gravel (PAVEMENT FILL) |
| 230.8 / 0.8 | Sand and gravel trace silt; Loose Brown Moist (FILL) |
| 229.0 / 2.6 | Silty sand, some clay; Very loose Grey Wet to compact; occasional silt layer; silty clay layers; Loose to very loose; trace clay |
| 221.8 / 9.8 | Switched to dynamic cone penetration test |
| 216.6 | Cont'd |

## SAMPLES

| NUMBER | TYPE | "N" VALUES | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|
| 1 | SS | 19 | |
| 2 | SS | 8 | |
| 3 | SS | 4 | |
| 4 | SS | 3 | |
| 5 | SS | 5 | 0 30 55 15 |
| 6 | SS | 4 | |
| 7 | SS | 11 | |
| 8 | SS | 7 | |
| 9 | SS | 3 | |
| 10 | SS | 7 | 0 65 31 4 |

GROUND WATER CONDITIONS: ▽* at approx. elev. 229.0

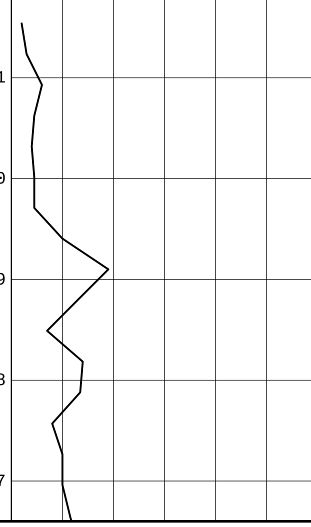
ELEVATION SCALE: 231, 230, 229, 228, 227, 226, 225, 224, 223, 222, 221, 220, 219, 218, 217

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH kPa (20 40 60 80 100): ○ 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 γ kN/m³





+7, ×5: Numbers refer to Sensitivity

20 / 15—○—5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd.
CONSULTING ENGINEERS

Foundation Design

# RECORD OF BOREHOLE No 14-7



**METRIC**

| | | | | | |
|---|---|---|---|---|---|
| **G.W.P.** | 2360-10-00 | **LOCATION** | Coords: 4 920 556.3 N; 292 622.5 E | **ORIGINATED BY** | F.P. |
| **DIST** Central | **HWY** 400 | **BOREHOLE TYPE** | C.F.S.S.A.and Mud Rotary + Dynamic Cone Penetration test | **COMPILED BY** | S.D. |
| **DATUM** | Geodetic | **DATE** | November 06 & 07, 2014 | **CHECKED BY** | D.D. |

| 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 γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | | | | |
| 216.6 | | | | | | | | | | | |
| 15.0 | Dynamic cone penetration test (Cont'd.) | | | | | | 216 215 214 213 212 211 210 209 208 207 206 205 204 203 202 |  | | | |
| 201.6 | Cont'd | | | | | | | | | | |



$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity

20 / 15 –○– 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

# RECORD OF BOREHOLE No 14-7



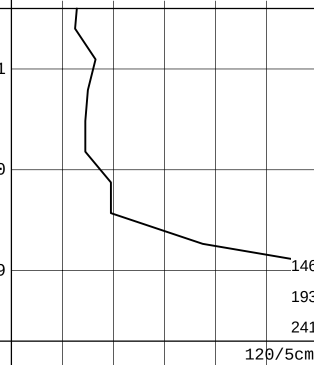
**METRIC**

**G.W.P.** 2360-10-00 **LOCATION** Coords: 4 920 556.3 N; 292 622.5 E **ORIGINATED BY** F.P.

**DIST** Central **HWY** 400 **BOREHOLE TYPE** C.F.S.S.A.and Mud Rotary + Dynamic Cone Penetration test **COMPILED BY** S.D.

**DATUM** Geodetic **DATE** November 06 & 07, 2014 **CHECKED BY** D.D.

| 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 γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 201.6 | | | | | | | | | | | |
| 30.0 | Dynamic cone penetration test (Cont'd.) | | | | | | 201 / 200 / 199 | 146 / 193 / 241 | | | |
| 198.3 / 33.3 | End of dynamic cone penetration test | | | | | | | 120/5cm | | | |




* 2014 11 06/07

▽ Water level observed during drilling

▼ Water level measured after drilling

■ Penetrometer test

C.F.S.S.A. denotes continuous flight soild stem augers



+7, ×5 : Numbers refer to Sensitivity

20 / 15 — ○ — 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

# RECORD OF BOREHOLE No 14-8



**METRIC**

**G.W.P.** 2360-10-00 **LOCATION** Coords: 4 920 529.1 N; 292 680.3 E **ORIGINATED BY** F.P.

**DIST** Central **HWY** 400 **BOREHOLE TYPE** C.F.S.S.A. and Dynamic Cone Penetration Test **COMPILED BY** S.D.

**DATUM** Geodetic **DATE** November 24, 2014 **CHECKED BY** D.D.

| ELEV / DEPTH | DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | SHEAR STRENGTH kPa | WATER CONTENT | UNIT WEIGHT γ kN/m³ | GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|
| 230.3 | Ground Surface | | | | | | | | | |
| 0.0 | Topsoil | 1 | SS | 4 | | 230 | | | | |
| | Silty clay trace sand, trace gravel Soft to firm Brown Moist (FILL) | | | | ∇* | | | | | |
| 229.4 / 0.9 | Silty sand, orgaincs Loose to very loose Black Wet (ALLUVIUM) | 2 | SS | 11 | | 229 | | | | |
| | | 3 | SS | 8 | | 228 | | | | |
| | clayey silt layer | 4 | SS | 2 | | | | | | 0 1 61 38 |
| 227.3 / 3.0 | Silty sand, trace gravel silty clay seams to 5.0m depth Very loose to compact Grey Wet | | FV | | | | +3 | | | |
| | | 5 | SS | 9 | | 227 | | | | |
| | | 6 | SS | 1 | | 226 | | | | |
| | | | FV | | | | +3 | | | |
| | | 7 | SS | 9 | | 225 | | | | 1 52 31 16 |
| | | 8 | SS | 6 | | | | | | |
| | | 9 | SS | 11 | | 224 | | | | |
| | | | | | | 223 | | | | |
| | | 10 | SS | 1 | | 222 | | | | |
| | | 11 | SS | 1 | | 221 | | | | |
| | | | | | | 220 | | | | |
| | | 12 | SS | 19 | | 219 | | | | |
| | | 13 | SS | 21 | | 218 | | | | |
| | | | | | | 217 | | | | |
| | Very loose Grey Wet | 14 | SS | 1 | | 216 | | | | |
| 215.3 | Cont'd | | | | | | | | | |

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

REMARKS & GRAIN SIZE DISTRIBUTION (%)



+7, ×5 : Numbers refer to Sensitivity

20 / 15 — ○ — 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd.
CONSULTING ENGINEERS

Foundation Design

# RECORD OF BOREHOLE No 14-8

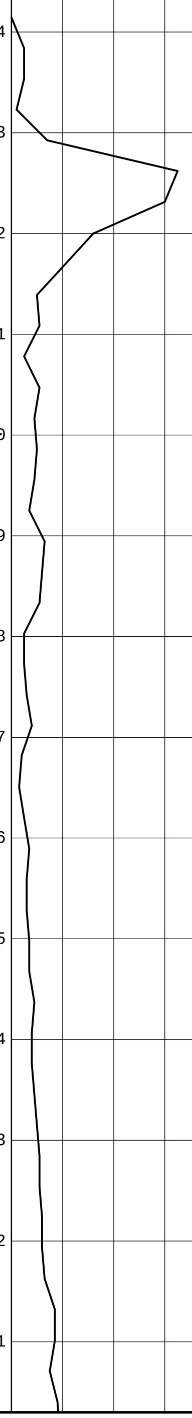


**METRIC**

**G.W.P.** 2360-10-00 **LOCATION** Coords: 4 920 529.1 N; 292 680.3 E **ORIGINATED BY** F.P.

**DIST** Central **HWY** 400 **BOREHOLE TYPE** C.F.S.S.A. and Dynamic Cone Penetration Test **COMPILED BY** S.D.

**DATUM** Geodetic **DATE** November 24, 2014 **CHECKED BY** D.D.

| 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 | | | | | | |
| 215.3 | | | | | | | | | | | |
| 15.0 | Silty sand<br>Very loose Grey Wet<br>(Cont'd.) | | 15 | SS | 2 | | 215 | | | | |
| 214.5<br>15.8 | Switched to dynamic cone penetration test | | | | | | 214, 213, 212, 211, 210, 209, 208, 207, 206, 205, 204, 203, 202, 201 |  | | | |
| 200.3 | Cont'd | | | | | | | | | | |

ON MTO_VER3 NEW LOGO 12KF037A.GPJ ON_MOT.GDT 4/1/2015

+7, ×5: Numbers refer to Sensitivity

20 / 15 —○— 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

# RECORD OF BOREHOLE No 14-8



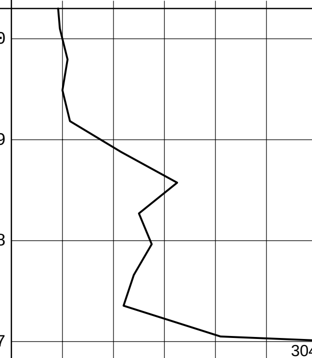
**METRIC**

**G.W.P.** 2360-10-00 **LOCATION** Coords: 4 920 529.1 N; 292 680.3 E **ORIGINATED BY** F.P.

**DIST** Central **HWY** 400 **BOREHOLE TYPE** C.F.S.S.A. and Dynamic Cone Penetration Test **COMPILED BY** S.D.

**DATUM** Geodetic **DATE** November 24, 2014 **CHECKED BY** D.D.

| 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 | | | | | | |
| 200.3 / 30.0 | Dynamic cone penetration test (Cont'd.) | | | | | | 200, 199, 198, 197 | 304 | | | |
| 196.8 / 33.5 | End of dynamic cone penetration test<br>Refusal on probable bedrock | | | | | | | 120/2cm | | | |



* 2014 11 24

▽ Water level observed during drilling

ON MTO_VER3 NEW LOGO 12KF037A.GPJ ON_MOT.GDT 4/1/2015

+7, ×5 : Numbers refer to Sensitivity

20 / 15 —○— 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

# RECORD OF BOREHOLE No 14-9



**METRIC**

**G.W.P.** 2360-10-00 **LOCATION** Coords: 4 920 570.7 N; 292 638.8 E **ORIGINATED BY** F.P.

**DIST** Central **HWY** 400 **BOREHOLE TYPE** Continuous Flight Solid Stem Augers **COMPILED BY** S.D.

**DATUM** Geodetic **DATE** November 03 & 04, 2014 **CHECKED BY** D.D.

| ELEV / DEPTH | DESCRIPTION | NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | SHEAR STRENGTH kPa | WATER CONTENT (%) | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 231.9 | Ground Surface | | | | | | | | | | | | |
| 0.0 | 140mm asphalt over sand and gravel (PAVEMENT FILL) | 1 | SS | 23 | | | | | | | | | |
| 231.1 / 0.8 | Sand and gravel organic seams; Compact Brown Wet | 2 | SS | 17 | ▽* | 231 | | | | | | | |
| | Sandy silt; Compact Grey Wet (FILL) | 3 | SS | 14 | | | | | | | | | |
| 230.1 / 1.8 | Silty sand, some clay orgaincs; Loose to very loose Dark brown Moist (ALLUVIUM) | 4 | SS | 6 | | 230 | | | | 0 | 56 | 31 | 13 |
| | | | | | ▼* | 229 | | | | | | | |
| | | 5 | SS | 3 | | | | | | | | | |
| 228.2 / 3.7 | Silty sand; Loose to compact Grey Wet | 6 | SS | 4 | | 228 | | | | | | | |
| | silty clay layers | 7 | SS | 20 | | 227 | | | | | | | |
| | sandy silt, some clay; Loose Grey Wet | 8 | SS | 4 | | 226 | | | | 0 | 37 | 47 | 16 |
| | | | FV | | | 225 | Field vane, sensitivity 3 | | | | | | |
| | sand layer some silt, trace clay; Very loose to compact Grey Wet | 9 | SS | 3 | | 224 | | | | 0 | 84 | (16) | |
| | | | | | | 223 | | | | | | | |
| | | 10 | SS | 23 | | | | | | | | | |
| 222.1 / 9.8 | End of borehole | | | | | | | | | | | | |

* 2014 11 03 & 04

▽ Water level observed during drilling

▼ Water level measured after drilling

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 (%)



+7, ×5 : Numbers refer to Sensitivity; 20 / 15 — 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

# RECORD OF BOREHOLE No 14-10



**METRIC**

**G.W.P.** 2360-10-00 **LOCATION** Coords: 4 920 546.9 N; 292 677.4 E **ORIGINATED BY** F.P.

**DIST** Central **HWY** 400 **BOREHOLE TYPE** Continuous Flight Solid Stem Augers **COMPILED BY** S.D.

**DATUM** Geodetic **DATE** November 04 & 05, 2014 **CHECKED BY** D.D.

| ELEV / DEPTH | DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | SHEAR STRENGTH kPa | WATER CONTENT | REMARKS GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|
| 231.9 | Ground Surface | | | | | | | | |
| 0.0 | 140mm asphalt over sand and gravel (PAVEMENT FILL) | 1 | SS | 19 | | | | ○ | |
| 231.3 / 0.6 | Sand and gravel; Compact, Brown, Wet (FILL) | 2 | SS | 14 | ▽* | 231 | | ○ | |
| | | 3 | SS | 20 | ▼* | 230 | | ○ | |
| 229.9 / 2.0 | Topsoil | | | | | | | | |
| 229.7 / 2.2 | Silty sand, silt seams; Compact, Grey, Wet | 4 | SS | 24 | | 229 | | ○ | |
| | seams of silt with sand, some clay; Loose, Grey, Wet | 5 | SS | 8 | | | | ○ | 0 22 65 13 |
| 227.9 / 4.0 | Clayey silt, trace sand; Very soft to stiff, Grey, Wet | 6 | SS | WH** | | 228 | | ○ | |
| | | | FV | | | 227 | + 6 | | |
| | | 7 | SS | 14 | | 226 | | | |
| | | 8 | SS | 1 | | | | ├┤ ○ | 0 12 56 31 |
| | | | FV | | | 225 | + 2 | | |
| 224.6 / 7.3 | Silty sand, trace clay, trace gravel; Loose to compact, Grey, Wet | 9 | SS | 9 | | 224 | | ○ | |
| | sand layer, some silt | | | | | 223 | | | |
| | | 10 | SS | 13 | | | | ○ | 1 79 16 4 |
| 222.1 / 9.8 | End of borehole | | | | | | | | |

* 2014 11 04 & 05

▽ Water level observed during drilling

▼ Water level measured after drilling

WH** denotes penetration due to weight of rods and hammer

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, × 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

+7, ×5 : Numbers refer to Sensitivity

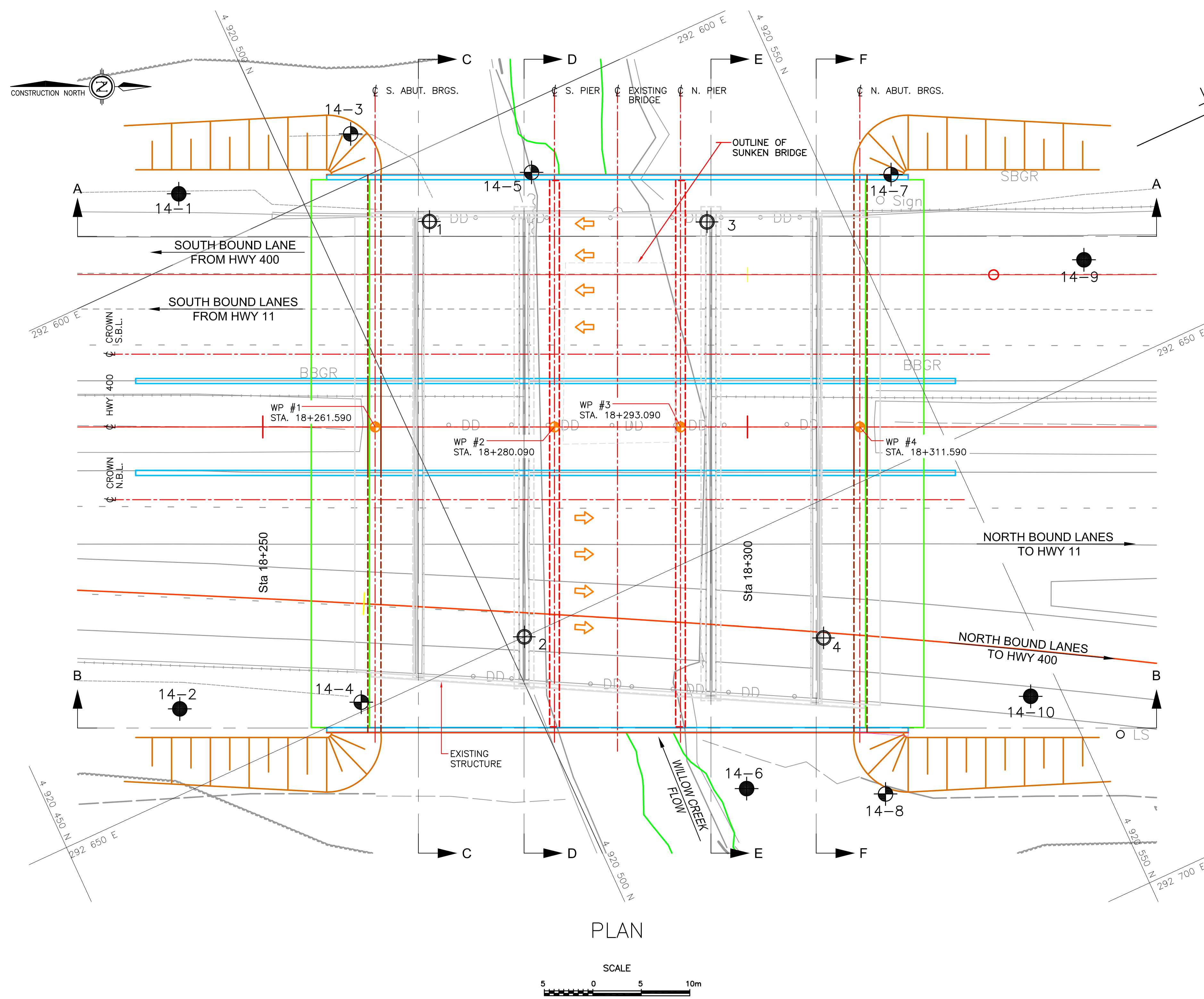
20 / 15 —○— 5 / 10 (%) STRAIN AT FAILURE

CONT No
GWP No 2360-10-00
WP No

WILLOW CREEK BRIDGE REPLACEMENT
HIGHWAY 11 & 400
BOREHOLE LOCATIONS

SHEET

**Peto MacCallum Ltd.**
CONSULTING ENGINEERS





LEGEND

- Borehole
- Borehole and Cone
- Geocres Borehole (31D-166)
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60 Cone, 475 J/blow)
- WL at time of investigation Nov. 2014
- Head ARTESIAN WATER Encountered
- PIEZOMETER

| BH No | ELEVATION | NORTHINGS | EASTINGS |
|---|---|---|---|
| 14-1 | 231.7 | 4 920 488.7 | 292 593.6 |
| 14-2 | 231.1 | 4 920 466.6 | 292 641.9 |
| 14-3 | 230.2 | 4 920 507.4 | 292 595.4 |
| 14-4 | 231.2 | 4 920 483.9 | 292 649.1 |
| 14-5 | 229.7 | 4 920 522.7 | 292 606.8 |
| 14-6 | 230.1 | 4 920 516.3 | 292 673.8 |
| 14-7 | 231.6 | 4 920 556.3 | 292 622.5 |
| 14-8 | 230.3 | 4 920 529.1 | 292 680.3 |
| 14-9 | 231.9 | 4 920 570.7 | 292 638.8 |
| 14-10 | 231.9 | 4 920 546.9 | 292 677.4 |

(Legend Continues)

(Legend Continued)
(Geocres Boreholes)

| BH No | ELEVATION | NORTHINGS | EASTINGS |
|---|---|---|---|
| 1 | 230.7 | 4 920 511 | 292 607 |
| 2 | 229.5 | 4 920 502 | 292 650 |
| 3 | 229.5 | 4 920 537 | 292 619 |
| 4 | 230.8 | 4 920 530 | 292 663 |

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

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
2. FOR PROFILES A-A AND B-B REFER TO DRAWING WC-2 AND FOR SECTIONS C-C, D-D, E-E, AND F-F DRAWING WC-3
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.

LICENSED PROFESSIONAL ENGINEER S. Y. DABBAGH 100129584 April 1, 15 PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER C M P Nascimento April 1, 15 PROVINCE OF ONTARIO

REF Drawings: S3212095-309-011GA-Replacement dated December 2014

| REVISIONS | DATE | BY | DESCRIPTION |
|---|---|---|---|

Geocres No. 31D-602

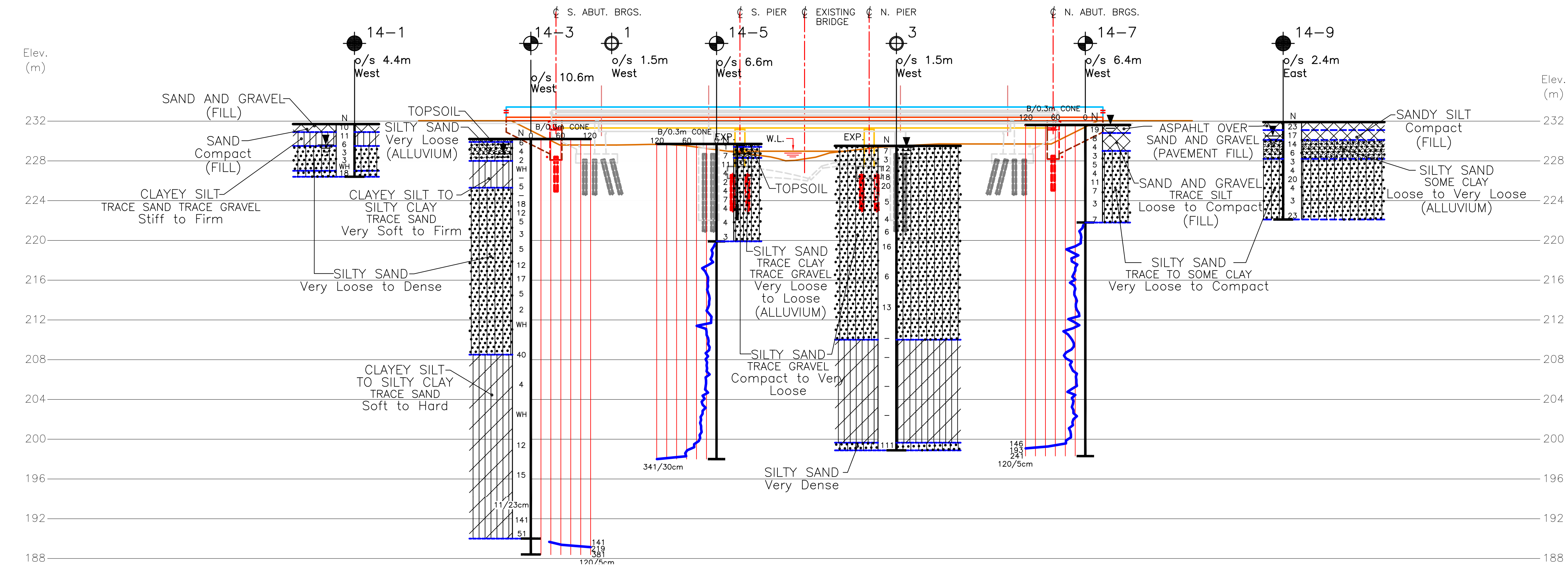
| | | | |
|---|---|---|---|
| HWY No 400 & 11 | | | DIST Central |
| SUBM'D NA | CHECKED DS | DATE APR. 01, 2015 | SITE 30-139/1&2 |
| DRAWN NL | CHECKED DD | APPROVED CN | DWG WC-1 |

CONT No
GWP No 2360-10-00
WP No

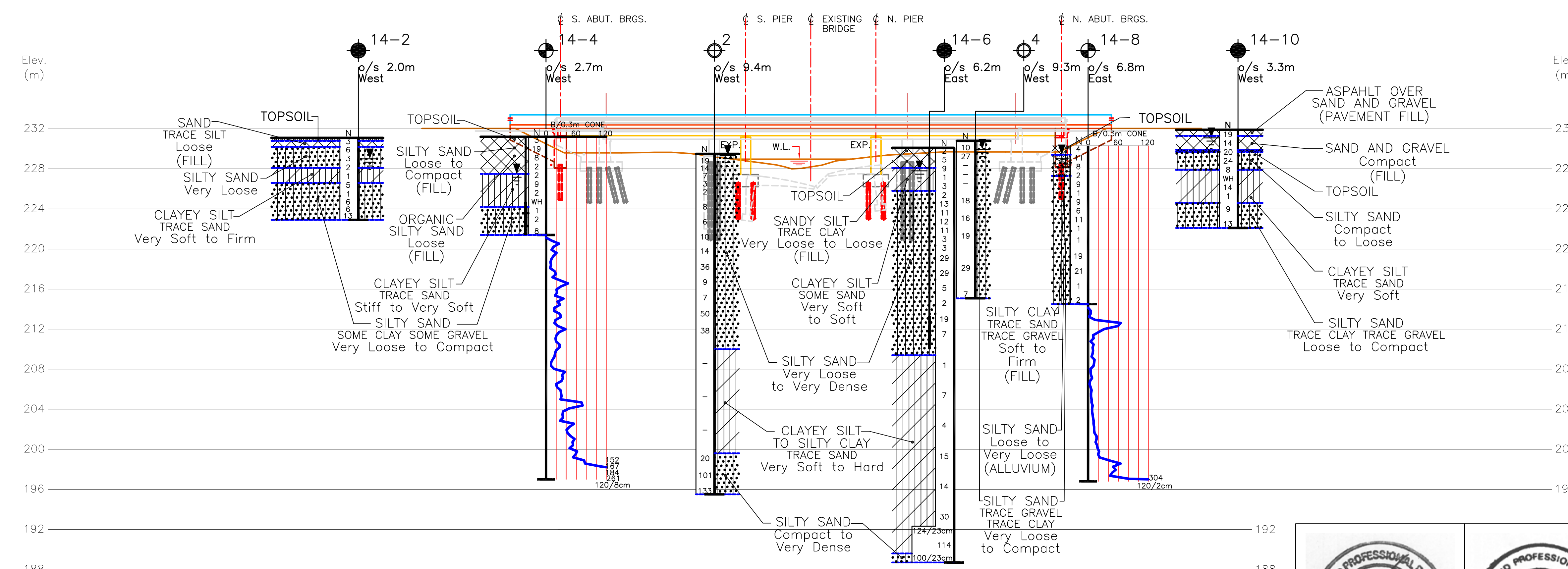
WILLOW CREEK BRIDGE REPLACEMENT
HIGHWAY 11 & 400
SOIL STRATA

SHEET

Peto MacCallum Ltd.
CONSULTING ENGINEERS


PROFILE A-A




PROFILE B-B

SCALE

5 0 5 10m

NOTES:

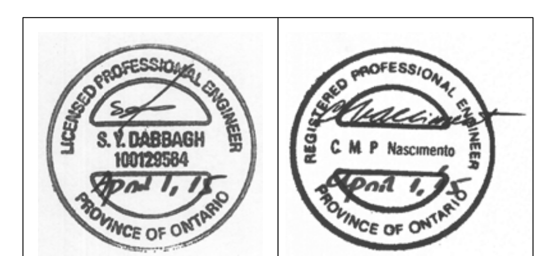
1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
2. FOR BOREHOLE LOCATIONS REFER TO DRAWING WC-1 AND FOR SECTIONS C-C, D-D, E-E, AND F-F DRAWING WC-3
3. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.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

LEGEND

- Borehole
- Borehole and Cone
- Geocress Borehole (31D-166)
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60 Cone, 475 J/blow)
- WL at time of investigation Nov. 2014
- * Water level not established
- Head ARTESIAN WATER Encountered
- PIEZOMETER

| BH No | ELEVATION | NORTHINGS | EASTINGS |
|---|---|---|---|
| FOR DETAILS REFER TO DRAWING WC-1 | | | |

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




REF Drawings: S3212095-309-011GA-Replacement dated December 2014

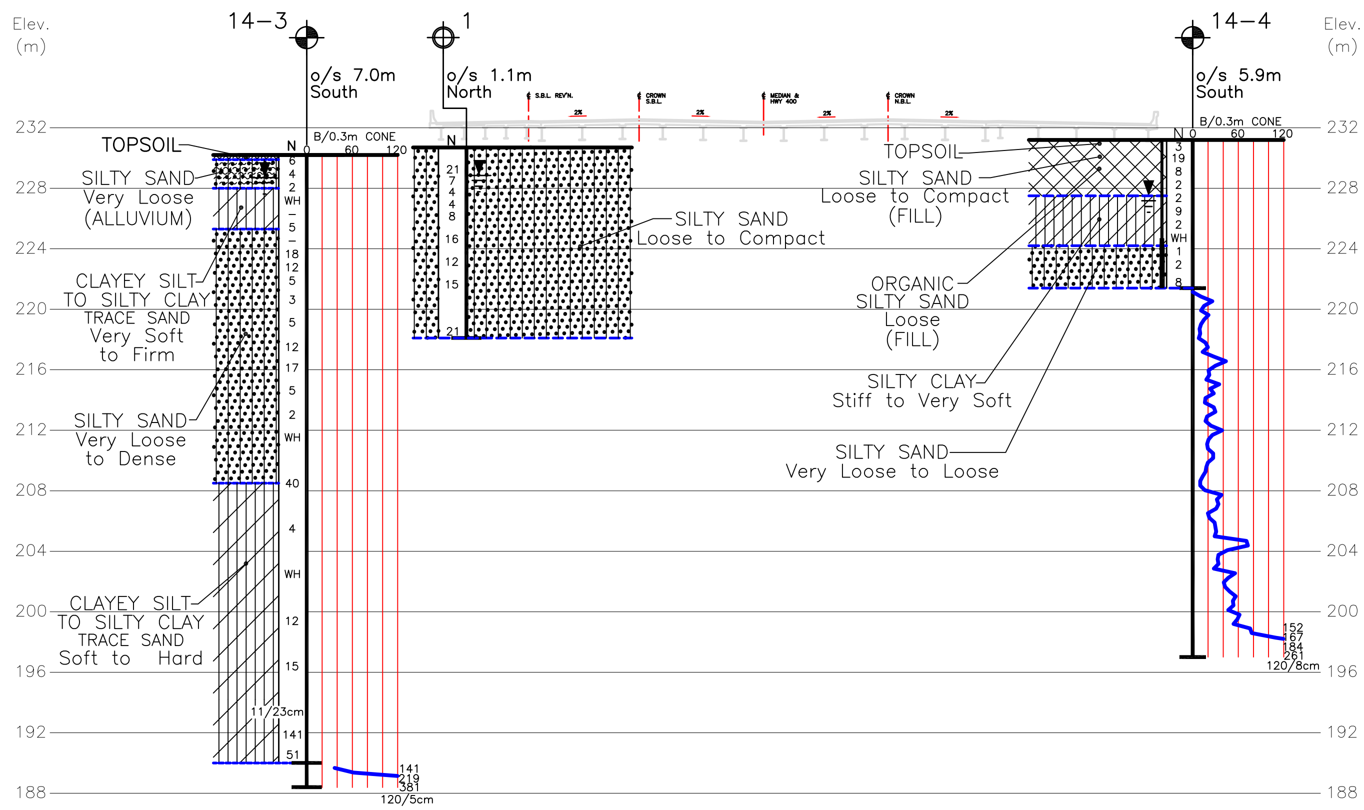
| REVISIONS | DATE | BY | DESCRIPTION |
|---|---|---|---|

Geocres No. 31D-602

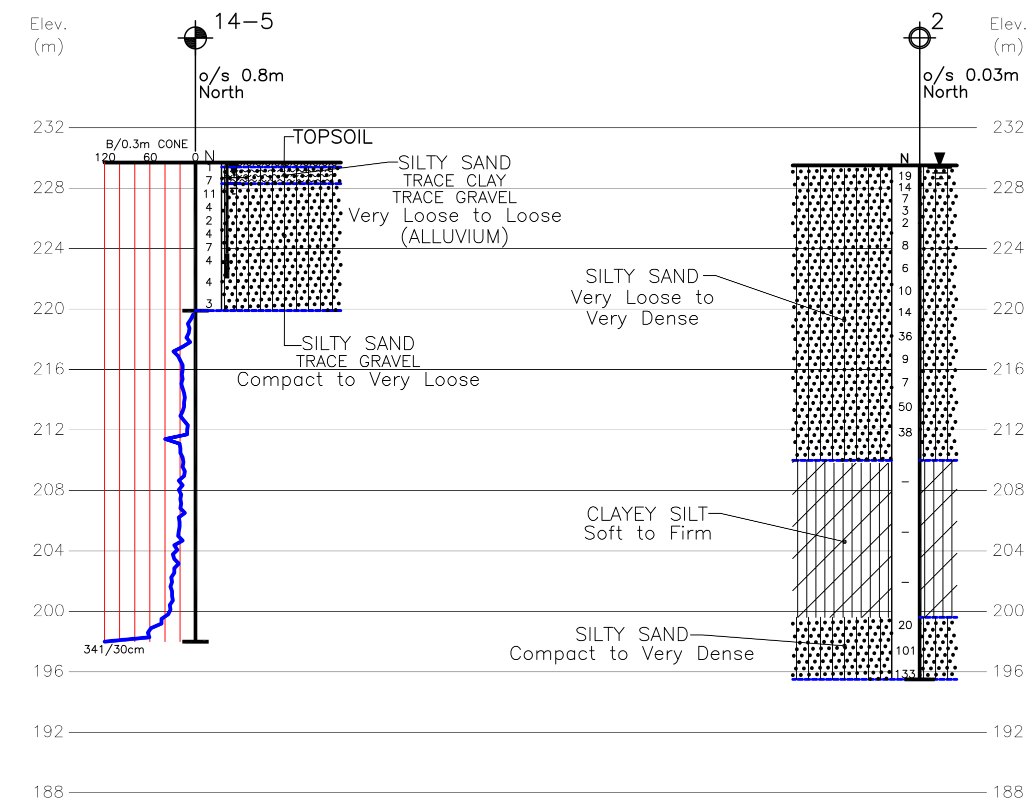
| HWY No 400 & 11 | | | DIST Central |
|---|---|---|---|
| SUBM'D NA | CHECKED DS | DATE APR. 01, 2015 | SITE 30-139/1&2 |
| DRAWN NL | CHECKED DD | APPROVED CN | DWG WC-2 |

| | |
|---|---|
| CONT No<br>GWP No 2360-10-00<br>WP No | |
| WILLOW CREEK BRIDGE REPLACEMENT<br>HIGHWAY 11 & 400<br>SOIL STRATA | SHEET |

PML Peto MacCallum Ltd.
CONSULTING ENGINEERS

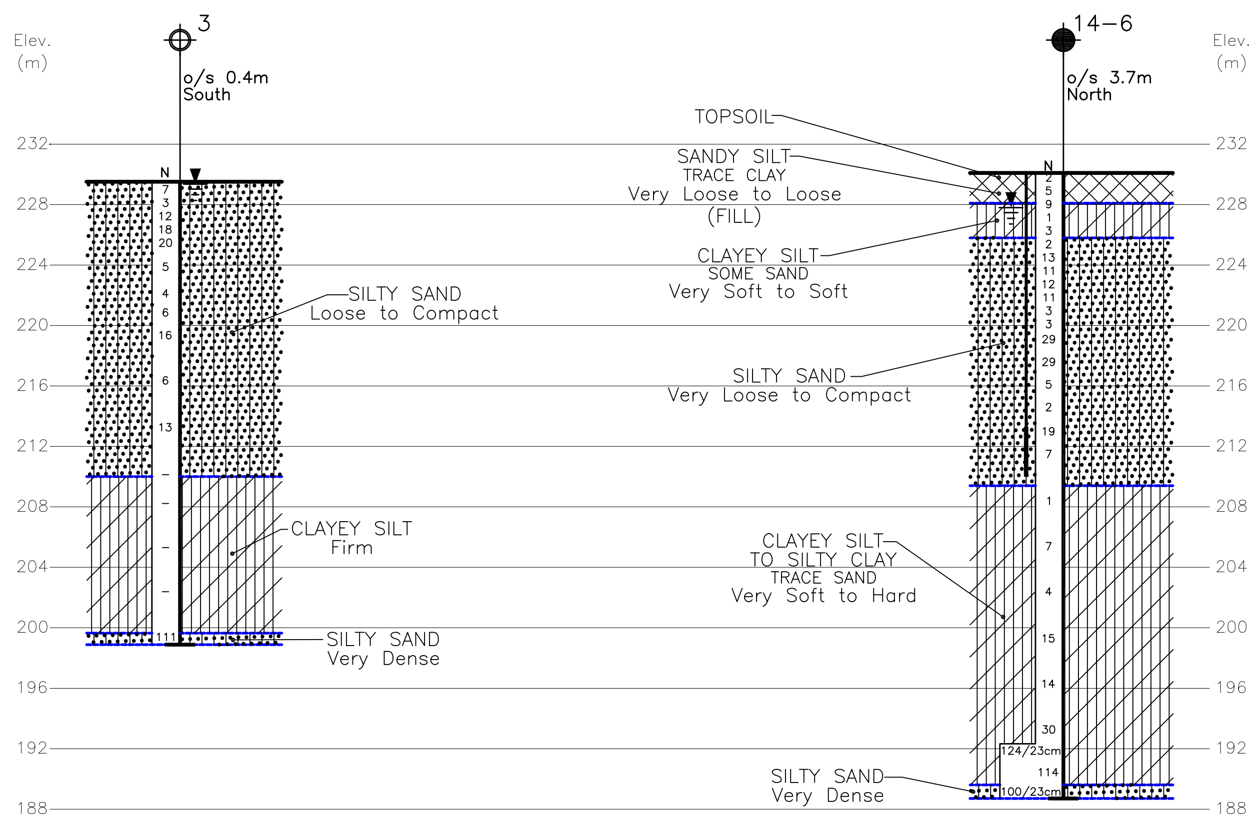



SECTION C-C ALONG ℄ SOUTH ABUTMENT

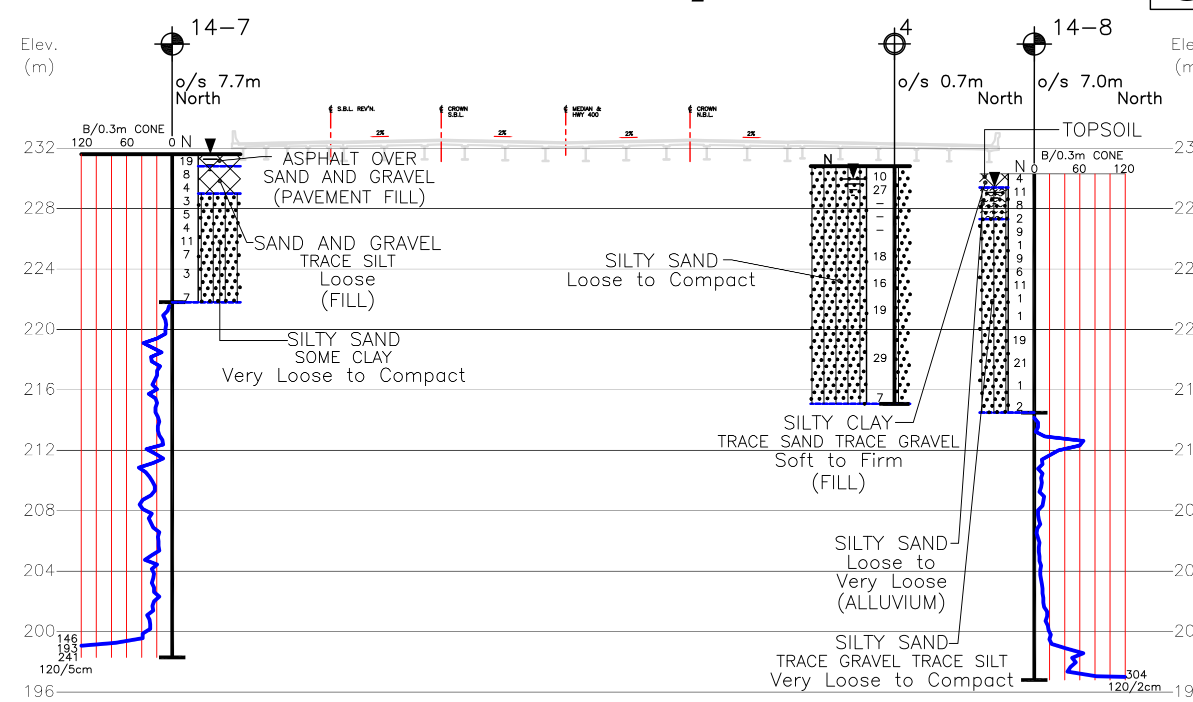



SECTION D-D ALONG ℄ SOUTH PIER


KEY PLAN




SECTION E-E ALONG ℄ NORTH PIER




PROFILE F-F ALONG ℄ NORTH ABUTMENT

SCALE
5 0 5 10m

## LEGEND

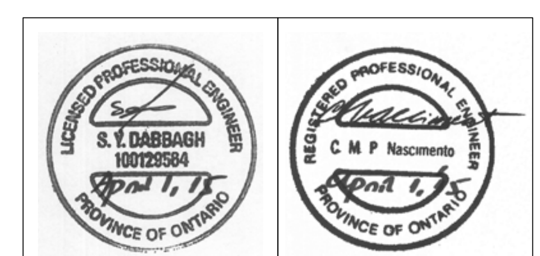
- Borehole
- Borehole and Cone
- Geocress Borehole (31D-166)
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60 Cone, 475 J/blow)
- WL at time of investigation Nov. 2014
- ∗ Water level not established
- Head ARTESIAN WATER Encountered
- PIEZOMETER

| BH No | ELEVATION | NORTHINGS | EASTINGS |
|---|---|---|---|
| FOR DETAILS REFER TO DRAWING WC-1 | | | |

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

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
2. FOR BOREHOLE LOCATIONS REFER TO DRAWING WC-1 AND FOR PROFILES A-A AND B-B DRAWING WC-2
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.




REF Drawings: S3212095-309-011GA-Replacement dated December 2014

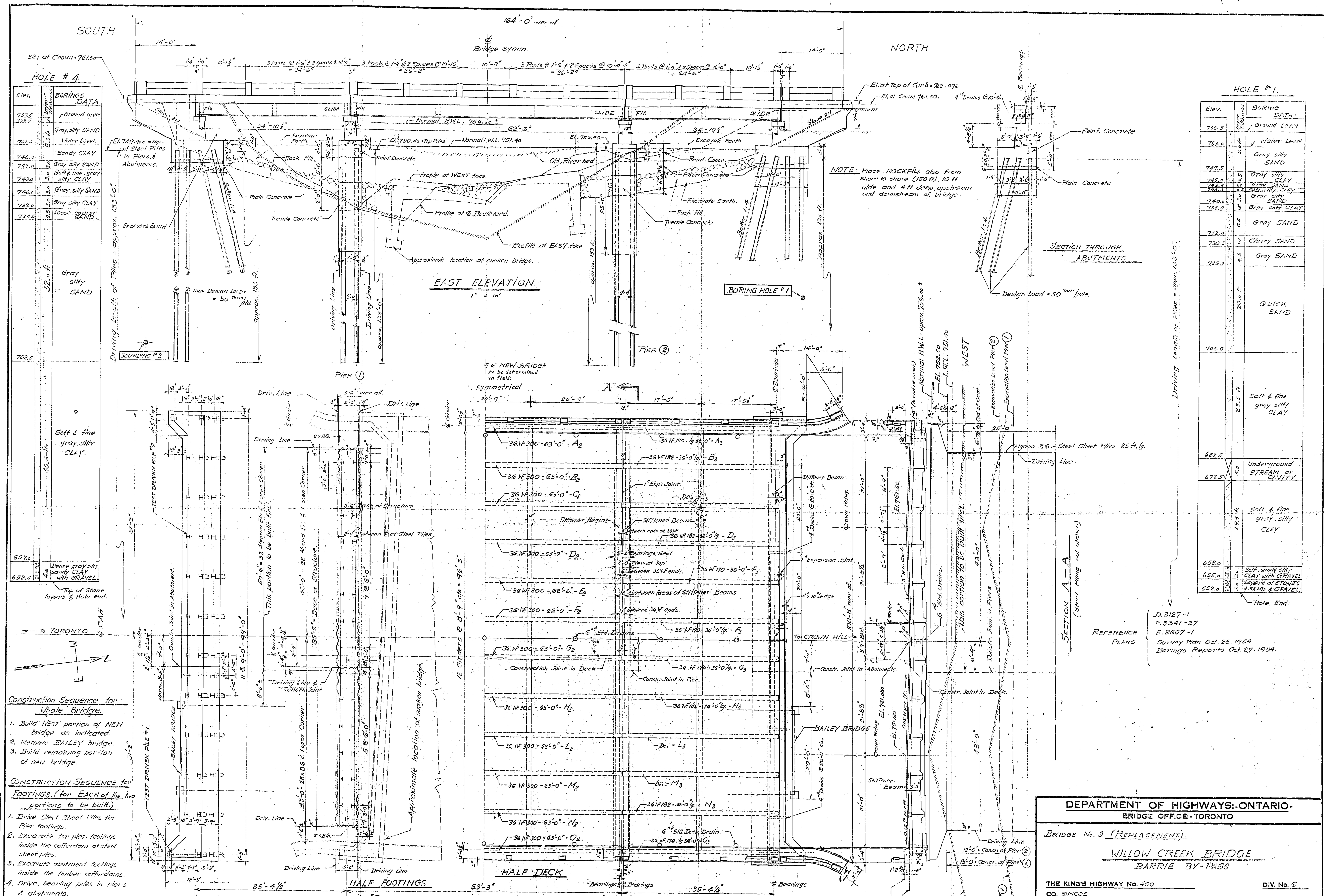
| REVISIONS | DATE | BY | DESCRIPTION |
|---|---|---|---|

Geocres No. 31D-602

| | | | |
|---|---|---|---|
| HWY No 400 & 11 | | | DIST Central |
| SUBM'D NA | CHECKED DS | DATE APR. 01, 2015 | SITE 30-139/1&2 |
| DRAWN NL | CHECKED DD | APPROVED CN | DWG WC-3 |

# APPENDIX FIR-A

Contract Drawing 55-12




Construction Sequence for Whole Bridge.

1. Build WEST portion of NEW bridge as indicated.
2. Remove BAILEY bridge.
3. Build remaining portion of new bridge.

CONSTRUCTION SEQUENCE for FOOTINGS. (for EACH of the two portions to be built.)

1. Drive Steel Sheet Piles for Pier footings.
2. Excavate for pier footings inside the cofferdam of steel sheet piles.
3. Excavate abutment footings inside the timber cofferdams.
4. Drive bearing piles in piers & abutments.
5. Place concrete in piers & abutment footings as shown.
6. Excavate earth below approach spans as shown.
7. Place rock fill as shown.

| PRINT RECORD | | |
|---|---|---|
| NO. | FOR | DATE |
| 35 | Tender | 16.2.55 |
| 11 | DS C & L/F | 14.3.55 |

REQUIRED FOR ONE ABUTMENT:
STEEL PILES:
25 12 BP 53 lbs/ft - 140 ft.lg
13 12 BP 53 lbs/ft - 135 ft.lg

REQUIRED FOR ONE PIER:
STEEL SHEET PILES:
Algoma BG-33.12 lbs/ft:
118 BG Std. Sheet Pile
4 BG Std Bent Open Corners
2 Halves BG Std. Sheet Pile.
STEEL PILES:
31 12 BP-53 lbs/ft - 135 ft. lg.

NOTE TO DIVISION ENGINEER:
Concrete work on this structure must not be commenced until monuments to fix control points have been erected and checked by the Division Engineer.

NOTE TO STRUCTURAL STEEL CONTRACTOR:
The design, fabrication and erection of the structural steel shall be in accordance with the "CSA Specification for Steel Highway Bridges S6-1952". The painting of the Structural Steel shall be in accordance with the "General Specifications for Highway Bridges, Ontario, 1935".

NOTE TO GENERAL CONTRACTOR:
Structure to be built in accordance with the "General Specifications for Highway Bridges Ontario 1935" Forms No. 9, and the Special Specifications attached to the "Information to Bidders" sheet; extra copies of which may be obtained from the Division Engineer. Ballast walls on abutments must not be built until structural Steel is erected.

CLASS OF CONCRETE: FOOTINGS - 2500# CONCRETE. All other Concrete - 3000# ". Add 1/4 lb Pozzolith "2A" per bag of cement.

| REVISIONS: | | |
|---|---|---|
| DATE | BY | DESCRIPTION |
| March 8.55 | M.J. | Details for shorter Girders E2 (62'-6") & F2 (62'-0") |
| 21.1.1955 | M.J. | Length of Steel Piles & Location of Boring Holes |

DEPARTMENT OF HIGHWAYS:-ONTARIO-
BRIDGE OFFICE:-TORONTO

BRIDGE No. 9 (REPLACEMENT).

WILLOW CREEK BRIDGE
BARRIE BY-PASS.

THE KING'S HIGHWAY No. 400 DIV. No. 6
CO. SIMCOE
TWP. VESPRA LOT 8 CON. I

GENERAL PLAN

APPROVED [signature] 58561
CHIEF BRIDGE ENGINEER CHIEF ENGINEER

| | | | | | |
|---|---|---|---|---|---|
| DESIGN | M.J. | CHECK | J.K. | CONTRACT NUMBERS | GENERAL 55-12 |
| DRAWING | M.J. | CHECK | J.K. | | |
| TRACING | | CHECK | | LOADING H20S16 | DRAWING NUMBER D. ~~3530~~-1 |
| DATE | Nov. 23. 1954 | | | | |

TWP# 78-139-1-B

# APPENDIX FIR-B

Previous Borehole Logs 1 to 4

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

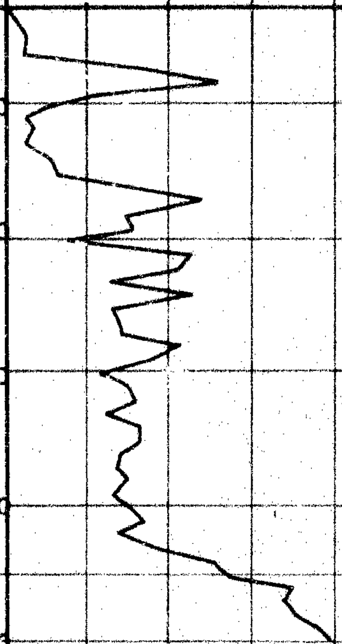
# RECORD OF BOREHOLE No. 1

FOUNDATION SECTION

JOB 70-11097 LOCATION Hwy. 400 & Willow Creek Sta. 371 + 24 70' Lt. ORIGINATED BY VK
W.P. 105-70-08 BORING DATE Nov. 25, 1970 COMPILED BY VK
DATUM Geodetic BOREHOLE TYPE Washboring with BX & NX Casing CHECKED BY [signature]

| ELEV. / DEPTH | SOIL PROFILE DESCRIPTION | SAMPLE NUMBER | TYPE | BLOWS / FOOT | ELEV. SCALE | WATER CONTENT % | REMARKS (G S M C) A.S.I.CL. |
|---|---|---|---|---|---|---|---|
| 757.0 | Ground Level | | | | | | |
| 0.0 | with organic matter | 1 | SS | 21 | | | |
| | | 2 | SS | 7 | 750 | o np | ▼ 0 70 19 5 |
| | with layers of clayey silt | 3 | SS | 4 | | | |
| | | 4 | SS | 4 | | o | 0 9 56 35 |
| | Silty fine sand, Loose to compact | 5 | SS | 8 | 740 | | |
| | | 6 | SS | 16 | | | |
| | | 7 | SS | 12 | 730 | o | 0 91 ( 9 ) |
| | | 8 | SS | 15 | | | |
| | | | | | 720 | | |
| 715.5 / 41.5 | End of Borehole | 9 | SS | 21 | | | |
| 710.0 / 47.0 | End of D.C.P. | | | | 710 | | |

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT: 20 40 60 80 100
SHEAR STRENGTH P.S.F.: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB. VANE; 400 800 1200 1600 2000
LIQUID LIMIT — $w_L$; PLASTIC LIMIT — $w_P$; WATER CONTENT — $w$; WATER CONTENT %: 10 20 30
BULK DENSITY γ P.C.F.



20
15 — 5 % STRAIN AT FAILURE
10

FORM OB-MT-126 (REV 1969) OFFICE REPORT ON SOIL EXPLORATION

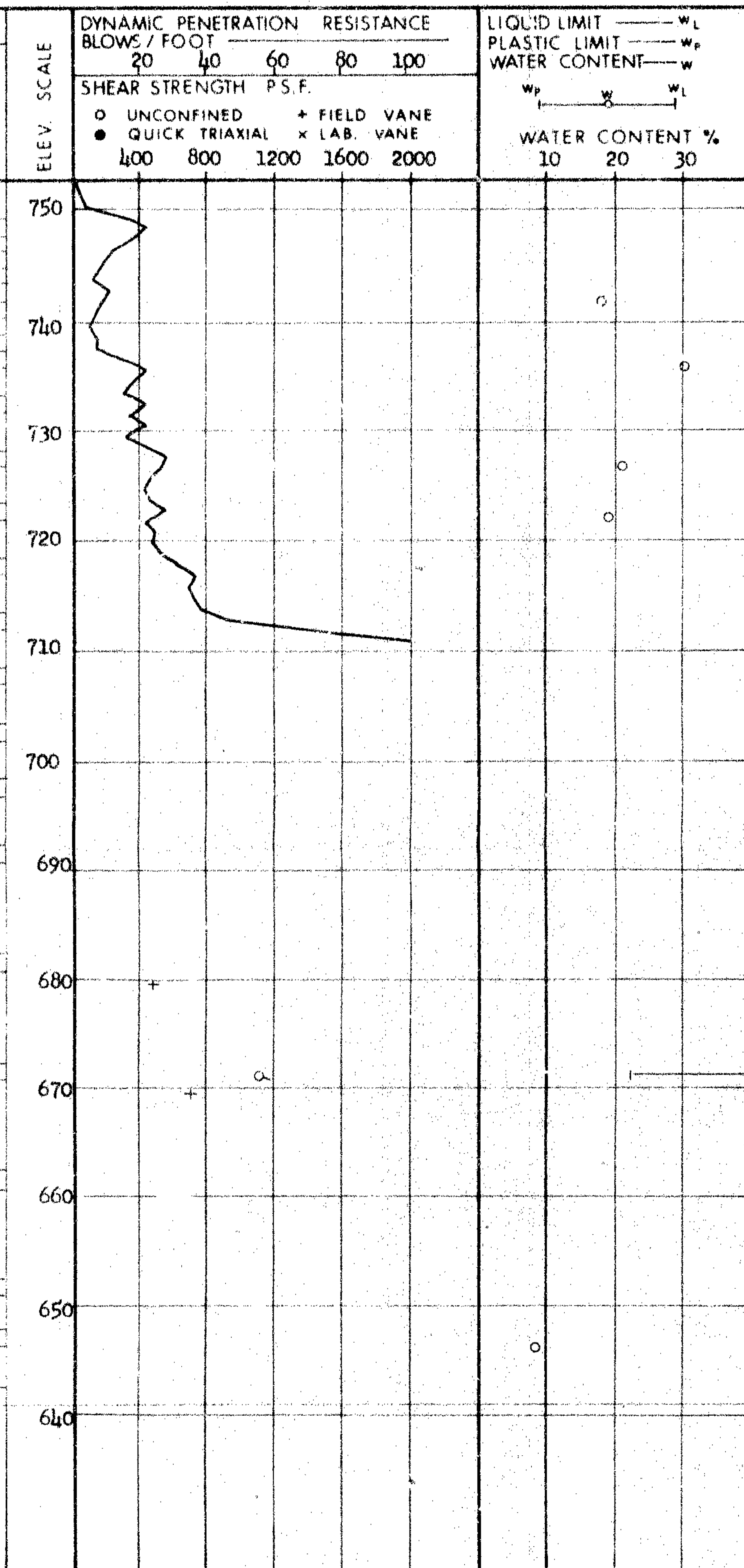
DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

# RECORD OF BOREHOLE No. 2

FOUNDATION SECTION

JOB 70-11097 LOCATION Hwy. 400 & Willow Cr. Sta. 371 + 61 70' Rt. ORIGINATED BY VK
W.P. 105-70-08 BORING DATE Nov. 5, 1970 COMPILED BY VK
DATUM Geodetic BOREHOLE TYPE Washboring with BX & NX Casing. Pendrill CHECKED BY

| ELEV. DEPTH | DESCRIPTION | NUMBER | TYPE | BLOWS / FOOT | BULK DENSITY γ P.C.F. | REMARKS GR. SA. SI. CL. |
|---|---|---|---|---|---|---|
| 752.8 | Ground Level | | | | | |
| 0.0 | with organic matter | 1 | SS | 19 | | |
| | | 2 | SS | 14 | | |
| | | 3 | SS | 7 | | 5 62 27 6 |
| | Silty fine sand, Loose to Dense | 4 | SS | 3 | | |
| | | 5 | SS | 2 | | |
| | | 6 | SS | 8 | | |
| | | 7 | SS | 6 | | |
| | | 8 | SS | 10 | | 0 62 34 4 |
| | | 9 | SS | 14 | | |
| | | 10 | SS | 36 | | |
| | | 11 | SS | 9 | | |
| | | 12 | SS | 7 | | |
| | | 13 | SS | 50 | | |
| | | 14 | SS | 38 | | |
| 688.8 / 64.0 | Clayey silt to clay, Soft to Firm | 15 | TW | PM | | |
| | | 16 | TW | PM | 104.5 | 0 5 32 63 |
| | | 17 | TW | PM | | |
| 654.8 / 98.0 | Silty sand, Compact to Very Dense | 18 | SS | 20 | | |
| | | 19 | SS | 101 | | 8 61 (31) |
| | | 20 | SS | 133 | | |
| 641.3 / 111.5 | End of Borehole | | | | | |




20 / 15 5 / 10 % STRAIN AT FAILURE

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

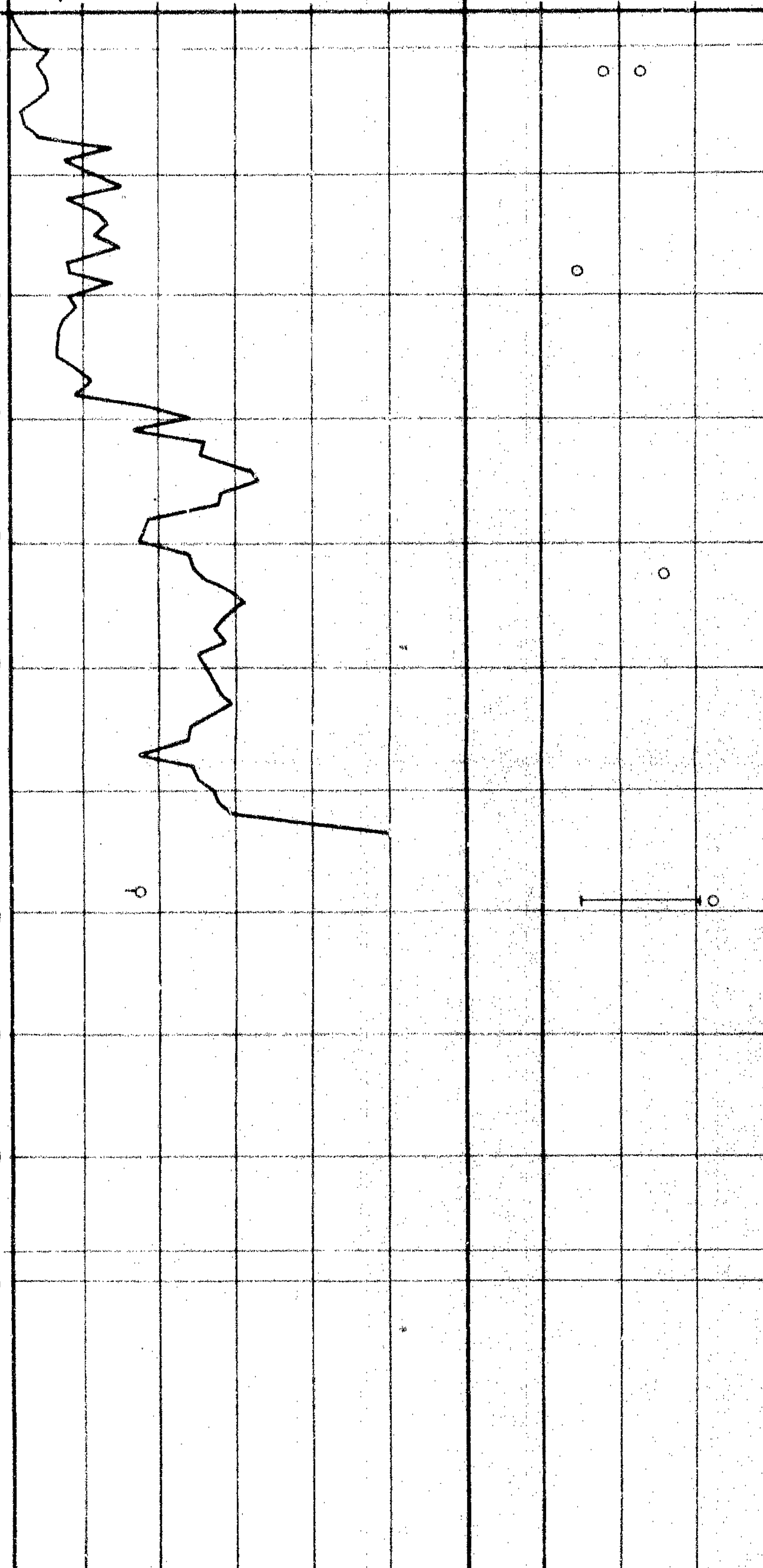
# RECORD OF BOREHOLE No. 3

FOUNDATION SECTION

JOB 70-11097 LOCATION Hwy. 400 & Willow Cr. Sta. 372 + 24 70' Lt. ORIGINATED BY VK
W.P. 105-70-08 BORING DATE Nov. 23, 1970 COMPILED BY VK
DATUM Geodetic BOREHOLE TYPE Washboring with NX & BX Casing CHECKED BY [signature]

| ELEV. / DEPTH | DESCRIPTION | NUMBER | TYPE | BLOWS/FOOT | ELEV. SCALE | BULK DENSITY γ P.C.F. | REMARKS GR.SA.SI.CL. |
|---|---|---|---|---|---|---|---|
| 753.0 | Ground Level | | | | | | ⊥752.0 |
| 0.0 | with organic mater | 1 | SS | 7 | 750 | | 0 58 38 4 |
| | | 2 | SS | 3 | | | 0 18 62 20 |
| | Silty sand, layers of clayey silt up to 10" thick below elev. 740. | 3 | SS | 12 | | | |
| | | 4 | SS | 18 | 740 | | |
| | | 5 | SS | 20 | | | |
| | | 6 | SS | 5 | | | 0 90 (10) |
| | | 7 | SS | 4 | 730 | | |
| | | 8 | SS | 6 | | | |
| | | 9 | SS | 16 | 720 | | |
| | | 10 | SS | 6 | 710 | | 0 5 71 24 |
| | Loose to Compact | 11 | SS | 13 | 700 | | |
| 689.0 / 64.0 | Clayey silt, Firm | 12 | TW | PM | 690 | | |
| | | 13 | TW | PM | 680 | 118 | 0 1 49 50 |
| | | 14 | TW | PM | 670 | | |
| | | 15 | TW | PM | 660 | | |
| 655.0 / 652.5 | Silty Sand, Very Dense | 16 | SS | 111 | | | |
| 100.5 | End of Borehole | | | | 650 | | |

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 20 40 60 80 100
SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB. VANE 400 800 1200 1600 2000
LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_P$ WATER CONTENT — w
WATER CONTENT % 10 20 30



20
15 ⊕ 5 % STRAIN AT FAILURE
10

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

# RECORD OF BOREHOLE No. 4

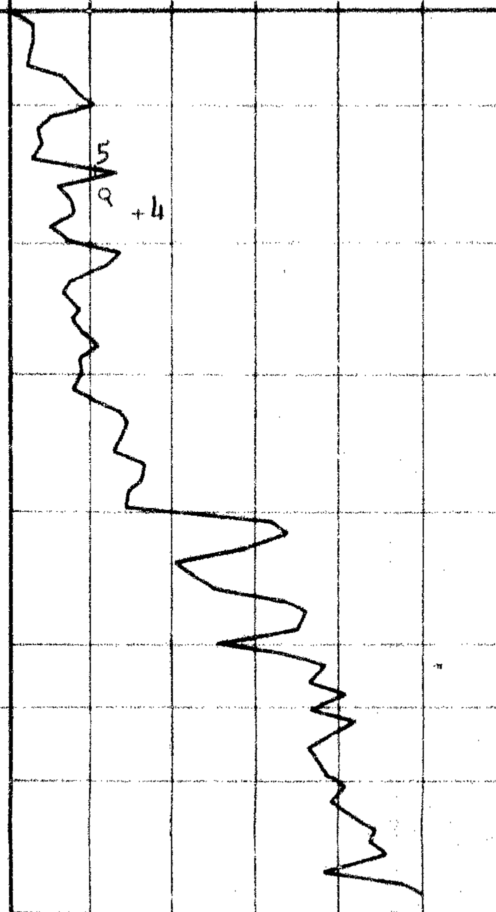
FOUNDATION SECTION

JOB 70-11097 LOCATION Hwy. 400 & Willow Cr. Sta. 372 + 60 70' Rt. ORIGINATED BY VK
W.P. 105-70-08 BORING DATE Nov. 23, 1970 COMPILED BY VK
DATUM Geodetic BOREHOLE TYPE Washboring with BX & NX Casing CHECKED BY [signature]

| ELEV. DEPTH | DESCRIPTION | NUMBER | TYPE | BLOWS / FOOT | ELEV SCALE | BULK DENSITY γ P.C.F. | REMARKS GR.SA.SI.CL. |
|---|---|---|---|---|---|---|---|
| 757.2 | Ground Level | | | | | | |
| 0.0 | | | | | | | |
| | with organic matter | 1 | SS | 10 | | | ▼ 752.0 |
| | | 2 | SS | 27 | 750 | | |
| | layers of clayey silt | 3 | TW | PM | | | 0 5 84 11 |
| | | 4 | TW | PM | | 118 | 0 68 29 3 |
| | soft to firm | 5 | TW | PM | 740 | | |
| | | 6 | SS | 18 | | | |
| | | 7 | SS | 16 | 730 | | 2 72 (26) |
| | | 8 | SS | 19 | | | |
| | Silty fine sand | | | | 720 | | |
| | | 9 | SS | 29 | | | |
| | Loose to Compact | | | | | | |
| | | | | | 710 | | |
| 705.7 | | 10 | SS | 7 | | | |
| 51.5 | End of Borehole | | | | | | |
| | | | | | 700 | | |
| 691.7 | | | | | | | |
| 65.5 | End of D.C.P. | | | | 690 | | |

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT: 20 40 60 80 100
SHEAR STRENGTH P.S.F.: o UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB. VANE — 400 800 1200 1600 2000

LIQUID LIMIT — $w_L$; PLASTIC LIMIT — $w_P$; WATER CONTENT — $w$; WATER CONTENT %: 10 20 30




20 / 15 5 / 10 % STRAIN AT FAILURE

**FOUNDATION DESIGN REPORT**

**for**

**WILLOW CREEK BRIDGE REPLACEMENT**
**GWP NO. 2360-10-00; SITE NO. 30-139/1&2**
**HIGHWAY 400**
**BARRIE, ONTARIO**

PETO MacCALLUM LTD.
165 CARTWRIGHT AVENUE
TORONTO, ONTARIO
M6A 1V5
Phone: (416) 785-5110
Fax: (416) 785-5120
Email: toronto@petomaccallum.com

Distribution:
3 cc: MMM Group Limited for distribution to MTO, Project Manager, + 1 digital copy (pdf)
1 cc: MMM Group Limited for distribution to MTO, Pavements and Foundations Section + 1 digital copy (pdf)
2 cc: MMM Group Limited + 1 digital copy (pdf)
1 cc: PML Kitchener
1 cc: PML Toronto

PML Ref.: 12KF037A
Index No.: 120FDR
Geocres No.: 31D-602
April 1, 2015
(April 21, 2015)

# TABLE OF CONTENTS

1. INTRODUCTION ....1
2. EVALUATION OF FOUNDATION ALTERNATIVES ....2
3. CONSTRUCTION SEQUENCE ....3
4. DRIVEN H-PILES ....3
   4.1 Pile Driving ....3
   4.2 Axial Geotechnical Resistance ....4
   4.3 Lateral Geotechnical Resistances ....5
5. ABUTMENT AND WING WALLS ....8
6. FROST PROTECTION ....9
7. SEISMIC DESIGN ....9
8. APPROACH EMBANKMENTS ....10
9. CREEK CHANNEL EROSION PROTECTION ....11
10. CONSTRUCTION CONSIDERATIONS ....11
   10.1 Excavation and Obstructions ....11
   10.2 Dewatering ....12
   10.3 Permission to Take Water (PTTW) ....12
   10.4 Vibration and Settlement Monitoring ....12
11. CLOSURE ....13

Appendix FDR-A - General Arrangement - Contract 77-112 (Willow Creek Bridge Widening)

Appendix FDR-B - OPSS's and NSSP's

**FOUNDATION DESIGN REPORT**

**for**

Willow Creek Bridge Replacement
Highway 400
GWP No. 2360-10-00
Barrie, Ontario

## 1. INTRODUCTION

This report provides foundation engineering comments and recommendations regarding design and construction of bridge foundations and approach fill embankments for the proposed replacement of existing Willow Creek Bridge. This investigation was carried out by Peto MacCallum Ltd. (PML) for MMM Group Limited (MMM) on behalf of the Ministry of Transportation of Ontario (MTO).

The existing Willow Creek bridge is located about 500 m south of the existing overpass structure at the Highway 400/Highway 11 interchange. The site is located at the north end of the City of Barrie.

Refer to the Foundation Investigation Report for site description and geology of the site.

The existing three-span bridge was constructed in 1955, and widened in 1971 and 1977. A partial bridge deck replacement was carried out in 1992. The existing bridge deck is about 48.1 to 50.7 m wide with an approximate total length of 41.0 m between abutments. Span lengths of the existing bridge are 10.33 m - 19.28 m – 10.33 m. The deck area of this concrete slab on steel girder bridge is about 1982 $m^2$.

The existing structure is founded on steel H-piles driven to depths ranging from 36 m to 42 m. The underside elevation of the existing abutment and pier pile caps ranges from 228.0 m to 230.0 m. The existing piers are surrounded by steel sheet piles extending to about elevation 222.0 m.

Refer to Appendix FDR-A for the General Arrangement of for Contract 77-112 for design values for pile resistances and pile lengths for the Willow Creek Bridge Widening.

The existing approach embankments are about 2 m high (elevation 232.0 m) at the bridge site and original ground level is at approximately elevation 230.0 m.

According to Contract Drawing 55-12 dated November 23, 1954, the original single-span bridge (pre-1940’s) that was located along the existing SB alignment, was abandoned and dropped into the creek between the piers of the existing three-span bridge. The location of sunken bridge was investigated-by Global GPR Services on behalf of MMM using ground penetrating radar. Refer to the Foundation Investigation portion of this report for interpretations of the location of the sunken bridge based on this information.

According to the preliminary general arrangement drawing prepared by MRC (currently MMM) and dated July 2013, the proposed new bridge will also have 3-spans to be placed on new abutments and new piers. Span lengths of the new bridge are 18.5 m - 13.0 m – 18.5 m. The centreline of the new abutments are to be at approximately 4.5 m from the existing abutments centreline and the new piers centreline are at approximately 3.0 m from the existing piers centreline. The new bridge will be comprised of two independent three span structures. The northbound and southbound bridge superstructure widths are 27.05 and 21.55 m, respectively. The grade of the Highway 400 will be raised by 0.25 to 0.5 m at the two ends.

## 2. EVALUATION OF FOUNDATION ALTERNATIVES

The following Table 2 presents an evaluation of the advantages, disadvantages, risks/consequences and relative costs of considered alternatives for comparison purposes and to support the selection of the preferred alternative.

**Table 2 – Evaluation of Foundation Alternatives**

| FOUNDATION TYPE | ADVANTAGES | DISADVANTAGES | RISKS / CONSEQUENCES | RELATIVE COST |
|---|---|---|---|---|
| Spread footings on native soil | • Conventional construction techniques | • Relatively low bearing resistance in comparison to deep foundation options<br>• Less reliable settlement performance than deep foundation options<br>• Dewatering becomes critical to prevent disturbance of the founding soil below the footing<br>• Potential obstructions due to debris of old sunken bridge | • Undermining of travelled portion of bridge during construction | • Low cost |
| Driven piles | • Superior axial and lateral resistance<br>• Superior differential settlement performance | • Vibrations induced during pile driving<br>• Potential obstructions to pile driving due to debris of old sunken bridge | • Vibration damage to foundations of travelled portion of bridge during construction<br>• Difficult pile driving or pile damage if driving through debris from sunken bridge | • Moderate cost |

| FOUNDATION TYPE | ADVANTAGES | DISADVANTAGES | RISKS / CONSEQUENCES | RELATIVE COST |
|---|---|---|---|---|
| Caissons | • Superior axial and lateral resistance<br>• Superior differential settlement performance | • Challenging site conditions consisting of high water table and ground susceptible to disturbance<br>• Potential obstructions to caisson installation due to debris of old sunken bridge<br>• Installation would probably require temporary liners and mud drilling/tremie concreting techniques required for caisson installation | • Undermining of travelled portion of bridge during construction<br>• Necking of concrete in caisson reducing the reliability to support axial or lateral loads<br>• Caisson installation difficulties could result in construction delays and cost overrun | • High cost |

Based on this evaluation, steel H-piles driven to the lower competent very dense / hard soils is the preferred option from a Foundations Engineering perspective. The soil conditions are not favourable for spread footings due to their relatively low bearing resistance. The combination of high groundwater table and loose noncohesive deposits present risks of caisson installation difficulties through loss of ground and associated ground settlement and potential necking of the caisson concrete column.

## 3. CONSTRUCTION SEQUENCE

The anticipated construction sequence and traffic staging should be considered in the design. Portions of the bridge will be removed and reconstructed in stages. Traffic will be maintained using the remaining portion of the existing bridge and/or portions of the new bridge, depending on the construction stage. Temporary roadway protection will probably be required to facilitate this operation. Following transfer of traffic to the newly constructed half of the bridge, the remaining portion of the old bridge will be removed and reconstructed.

## 4. DRIVEN H-PILES

### 4.1 Pile Driving

Debris from the sunken bridge should be removed under the plan limits of pile caps to facilitate pile driving at these locations. The Contractor will be responsible to select and implement the appropriate method of demolition and excavation to remove the bridge while preserving the integrity of remaining or new portions of the bridge and any shoring. It is anticipated that the Contractor may give consideration to using conventional excavation equipment with hoe rams.

Backfill placed beneath the plan limits of pile caps should be restricted to a maximum nominal size of 75 mm to facilitate driving of the piles. Free draining noncohesive material such as Granular B Type II is recommended if backfill is required below the water table.

The piles should be installed, controlled and monitored in accordance with the requirements of SP 903S01 and with Standard Drawing SS103-11 (Hiley Formula). Piles should be equipped with driving shoes and driven to elevation 200 m and then controlled by the Hiley formula assuming an ultimate resistance of twice the Factored Resistance at ULS used for design.

In response to comments from MTO, alternative methods for pile driving control will be considered subject to the conditions of the NSSP for pile driving control in Appendix FDR-B, which should be included in Contract Documents.

Estimated pile lengths at the foundations elements are provided in Table 4.1. Actual pile lengths will be determined by the pile driving control method during pile driving. The pile lengths should be such that welds in the portion of piles above the point of contraflexure are avoided.

**Table 4.1 – Estimated Pile Lengths at Foundation Elements**

| Pile Location | Cutoff Elevation (m) | Pile Tip Elevation (m) | Pile Length (m) |
|---|---|---|---|
| North Abutment | 228.2 | 196.0 | 32.2 |
| North Pier | 226.2 | 192.0 | 34.2 |
| South Pier | 226.2 | 196.0 | 30.5 |
| South Abutment | 228.2 | 194.0 | 34.2 |

The Contractor should be responsible for using pile driving hammers that deliver the required energy to drive the piles to the design refusal elevation considering the length of piles and the subsurface conditions presented in the Foundation Investigation portion of this report.

## 4.2 Axial Geotechnical Resistance

The H-piles should be designed using the following values for axial resistance at factored ultimate limit states (ULS) and at the serviceability limit states (SLS) for steel HP 310 x 110 H-piles.

| Pile Section | Factored Geotechnical Axial Resistance at ULS (kN) | Geotechnical Axial Resistance at SLS (kN) |
|---|---|---|
| HP 310 x 110 | 1600 | 1250 |

The resistance at serviceability limit states (SLS) assumes a maximum 25 mm settlement. The amount of structural compression should also be considered. In accordance with CHBDC Clause 6.8.9.2, where the centre-to-centre spacing of piles at the underside of the footing is less than 2.5b or less than 750mm, the effects of interaction between piles shall be considered.

## 4.3 Lateral Geotechnical Resistances

Recommendations for lateral geotechnical resistance of vertical piles are provided below. If greater lateral resistance is required, the horizontal component of battered piles may be used to provide lateral resistance.

The lateral resistance for those portions of piles within the frost penetration depth and for those portions of piles within installations where annular space has been provided for pile flexibility at integral abutments should be disregarded.

The lateral resistance of the piles may be calculated by using a value for the coefficient of horizontal subgrade reaction ($k_s$) and ultimate lateral resistance ($p_{ult}$) as follows:

| | | | |
|---|---|---|---|
| $k_s$ | = | $n_h z / b$ | ($kN/m^3$) for cohesionless soil |
| | = | $67 S_u / b$ | ($kN/m^3$) for cohesive soil |
| | = | $125 S_u / b$ | ($kN/m^3$) for clayey silt till |
| $p_{ult}$ | = | $3 \gamma' z K_p$ | (kPa) for cohesionless soil |
| | = | 0 | (kPa) for cohesive soil between ground surface and 3b |
| | = | $9 S_u$ | (kPa) for cohesive soil at and below a depth of 3b |

where
- $n_h$ = coefficient of horizontal subgrade reaction ($kN/m^3$)
- $z$ = depth of pile embedment (m)
- $b$ = pile width (m)
- $S_u$ = undrained shear strength (kPa) (sometimes expressed as $C_u$)
- $\gamma'$ = unit weight ($kN/m^3$)
- $K_p$ = passive earth pressure coefficient

The above equations and recommended parameters below may be used to analyse the interaction between a pile and the surrounding soils. The lateral pressures obtained from the analysis should not exceed the ultimate lateral resistance.

The parameters recommended for design with the above equations are provided in the following Tables 4.3(c) and 4.3(d) – one for above the groundwater and one for below groundwater. Refer to the Record of Borehole Sheets for elevations of various soil layers.

**Table 4.3(c) – Soil Parameters for Subgrade Reaction Calculation For Ground Above Groundwater**

| Soil Unit above Groundwater | Soil Parameters | | | |
|---|---|---|---|---|
| | $\gamma'$ (kN/m$^3$) | $n_h$ (kN/m$^3$) | $K_p$ | $S_u$ (kPa) |
| Mixed Fills | 20 | 3000 | 3.0 | – |
| Noncohesive Deposits | 20 | 6000 | 3.3 | – |
| Cohesive Deposits | 20 | 2000 | 2.7 | 5 x SPT value |

**Table 4.3(d) – Soil Parameters for Subgrade Reaction Calculation For Ground Below Groundwater**

| Soil Unit below Groundwater | Soil Parameters | | | |
|---|---|---|---|---|
| | $\gamma'$ (kN/m$^3$) | $n_h$ (kN/m$^3$) | $K_p$ | $S_u$ (kPa) |
| Mixed Fills | 10 | 2500 | 3.0 | – |
| Noncohesive Deposits | 10 | 5000 | 2.8 | – |
| Cohesive Deposits | 10 | 1700 | 2.6 | 5 x SPT value |

The spring constant, $K_s$, for analysis may be obtained by the expression, $K_s = k_s * L * D$ (kN/m), where $k_s$ is the coefficient of horizontal subgrade reaction (kN/m$^3$), D is the pile width (m) and L is the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance on any one segment of the pile, $P_{ult}$, may be obtained from the expression $P_{ult} = p_{ult} * L * D$. This represents the ultimate load at which the pile fails and will not support any additional load at greater displacements.

However, it is recommended that the design value used for lateral pile resistance should not exceed 160 kN for Factored Resistance at ULS and 125 kN for Resistance at SLS. If greater lateral resistance is required, it can be provided by the horizontal component of battered piles.

The coefficient of subgrade reaction and ultimate lateral resistance may have to be reduced, based on pile spacing. The reduction factors to be used for a pile group oriented perpendicular or parallel to the direction of loading are provided in the following Table 4.3(e):

**Table 4.3(e) – Lateral Resistance Reduction for Pile Spacing**

| Condition | Pile Spacing (Centre to Centre) | Reduction Factor |
|---|---|---|
| Pile group oriented **perpendicular** to the direction of loading | 4 D | 1.0 |
| | 1 D | 0.5 |
| Pile group oriented **parallel** to direction of loading | 8 D | 1.0 |
| | 6 D | 0.7 |
| | 4 D | 0.4 |
| | 3 D | 0.25 |

Since H-piles are low displacement piles, the dense cohesionless soils under the tips of the existing piles are not expected to be affected by pile driving.

Refer to MTO Report SO-96-11 for procedures to determine the earth pressure coefficient to be employed in design of integral abutments.

The soil adjacent to the upper portion of the abutment piles is expected to consist of granular fill over loose to compact sand. The lowest risk configuration to accommodate movement of the integral abutment piles is to place two concentric CSPs that extend at least 3.0 m below the bottom of the abutment placed around the pile to create an annular space. The inner CSP of 600 mm diameter should be filled with sand meeting the gradation requirements of Granular B Type I. Alternatively, a slightly higher risk configuration would consist of installing the pile within a single CSP filled with loose uniform sand meeting the requirements given in Table 4.3(b) below. The single CSP configuration is recommended for this structure.

**Table 4.3(b) – Gradation Specification for Sand Fill in Pre-Augered Single CSP's at Integral Abutments**

| MTO Sieve Designation | Percentage Passing by Mass |
|---|---|
| 2 mm (#10) | 100 |
| 600 μm (#30) | 80 – 100 |
| 425 μm (#40) | 40 – 80 |
| 250 μm (#60) | 5 – 25 |
| 150 μm (#100) | 0 – 6 |

Note: From MTO Report S0-96-01, Revision 1 – July, 1996.

## 5. ABUTMENT AND WING WALLS

The abutment walls should be designed to resist the unbalanced horizontal earth pressure imposed by the backfill adjacent to the wall. The lateral earth pressure, p (kPa), may be computed using the equivalent fluid pressure diagrams presented in section 6.9 of the CHBDC or employing the following equation, assuming a triangular pressure distribution:

$$p = K(\gamma h + q) + Cp + Cs$$

where
- K = coefficient of lateral earth pressure (dimensionless)
- $\gamma$ = unit weight of free-draining granular material (kN/$m^{3)}$
- h = depth below final grade (m)
- q = surcharge load (kPa) if present
- Cp = compaction pressure (kPa) (refer to clause 6.9.3 of CHBDC)
- Cs = earth pressure induced by seismic events, (kPa) (refer to clause 4.6.4 of CHBDC)

Free-draining granular material should be used as backfill behind the wall. The following Table 5 presents soil parameters recommended for earth pressure design for identified granular materials.

**Table 5 – Soil Parameters for Lateral Earth Pressure Design under Static Load**

| PARAMETERS | GRANULAR A or GRANULAR B TYPE II |
|---|---|
| Internal Friction Angle, Ø (degrees) | 35 |
| Unit weight, $\gamma$ (kN/$m^3$) | 22.8 |
| Coefficient of Active Earth Pressure, $K_a$ | 0.27 |
| Coefficient of Earth Pressure At Rest, $K_o$ | 0.43 |
| Coefficient of Passive Earth Pressure, $K_p$ | 3.69 |

where
- Ø = angle of internal friction of retained soil ($35^o$ for Granular A or Granular B Type II or Type III)
- $\delta$ = angle of friction between the soil and wall ($23.5^o$ for Granular A or Granular B Type II or Type III)

The coefficient of earth pressure at rest should be used for design of rigid and unyielding walls, the active earth pressure coefficient for unrestrained structures.

A weeping tile system (OPSS 405 and OPSD 3190.100) should be installed to minimise the build-up of hydrostatic pressure behind the walls. The weeping tiles should be surrounded by a properly designed granular filter or geotextile to prevent migration of fines into the system. The drainage pipe should be placed on a positive grade and lead to a frost-free outlet.

The backfill placed adjacent to the abutments should be placed and compacted in accordance with the requirements of OPSS 902.

Heavy vibratory compaction equipment adjacent to retaining structures should be restricted to limit the compaction pressure noted in clause 6.9.3 of the CHBDC. Refer to OPSS 501 for additional information in this regard.

## 6. FROST PROTECTION

Pile caps should be provided with a minimum of 1.5 m of earth cover or equivalent thermal insulation as protection against frost action. Equivalent thermal insulation can be provided by appropriate thickness of rigid polystyrene. Polystyrene insulation should meet requirements of National Standards of Canada CAN/ULC-S701 (Standard for Thermal Insulation, Polystyrene, Boards and Pipe Covering). Appropriate thickness can be determined from manufacturer's literature.

## 7. SEISMIC DESIGN

For design, the seismic site coefficient for the conditions at this site is 1.5 (Type III soil profile as per clause 4.4.6 of the Canadian Highway Bridge Design Code (CHBDC), CAN/CSA-S6-00). The noncohesive deposits at this site are susceptible to disturbance under seismic loading.

With reference to earth pressure design for abutments and retaining walls under seismic loading, free-draining granular material should be used as backfill. The following Table 6 presents soil parameters recommended for earth pressure design for identified granular materials.

**Table 6 – Lateral Earth Pressure Coefficients under Seismic Load**

| Wall Movement Category | GRANULAR A or GRANULAR B TYPE II |
|---|---|
| Yielding | 0.26 |
| Non-yielding | 0.30 |

## 8. APPROACH EMBANKMENTS

The existing embankments are constructed with side slopes of approximately 2H:1V. The existing road grade will be raised by 0.50 m at the south end of the bridge and by 0.25 m at the north end of the bridge. As the existing highway embankment is in the order of 2 m high, embankments along widened portions of the highway alignment may be in the order of 2.9 m above existing ground.

The anticipated magnitudes of settlement range from 10 mm to 15 mm under the plan limits of the existing highway embankment where grade raises are in the order of 0.25 m to 0.5 m. Outside of the plan limits of the existing highway embankment and under the existing embankment slopes where proposed grade raises are up to 2.9 m, the anticipated magnitude of settlement is up to 75 mm. However, much of that settlement will be relatively immediate and can be realized prior to paving provided that the following recommendations for subexcavation and a preload wait period are implemented.

The upper 0.3 m of ground under the plan limits of embankment widening should be subexcavated and the excavated surface should be proof rolled to identify underlying zones of compressible soil. All compressible soil identified during the proof rolling operation should be subexcavated and replaced with Granular A or Granular B Type II.

Embankment widening and raising should be designed and constructed in conformance with OPS.PROV 206 (Construction Specification for Grading). Benching should be in conformance with OPSD 208.01. The widened portion of the embankment, outside the existing edge of shoulders, should be preloaded for as long as possible prior to paving but at least for a period of 1 month. Preloading of the embankments under the plan area between the existing shoulders is not required.

The side slopes of the approach embankments should be inclined no steeper than 2H:1V for earth fill.

Earth fill slopes should be protected against surface erosion by sodding and suitable vegetation. Refer to OPSS 803 or 804 for time constraints and the type of seed and mulch required.

## 9. CREEK CHANNEL EROSION PROTECTION

Sheet piling may be used to define the river channel under the plan limits of the bridge and to provide erosion protection for the bridge foundations adjacent to the river channel. The sheet piling for this purpose should be designed with consideration of the scour depth. The erosion protection sheet piling may be integrated into temporary dewatering schemes.

The previously noted abandoned sunken bridge deck should be removed under the plan limits of sheet pile installations prior to installing sheet piles.

If sheet piling is not required, erosion and scour protection for the bridge and approach embankment foreslopes may consist of placing 0.6 m of rock protection (OPSS 511) on the banks of the Willow Creek channel under the plan limits of the bridge. Rock protection should extend from the high water level to the toe of slope and a minimum distance equivalent to the embankment height across the creek bottom.

## 10. CONSTRUCTION CONSIDERATIONS

### 10.1 Excavation, Pile Installation and Obstructions

Excavation and pile installation for construction of foundations at the pier and abutment locations is expected to extend through the embankment fill and very loose to compact sand to a depth of about 3 m below existing grade. Debris from the abandoned sunken bridge should be removed before proceeding with the foundation excavation. It is anticipated that the debris is underlying the existing SBL's only. Refer to Appendix FDR-B for the related NSSP's recommended for inclusion in the contract documents to provide notice of obstructions and requirements to avoid disturbing the foundations of the travelled portion of existing structures.

Excavations should be carried out in compliance with the Occupational Health and Safety Act (Ontario Regulation 213/91). The fill material and loose to compact sand at this site have been classified as Type 3 and the very loose sand has been classified as Type 4 soils according to OHSA criteria. Since open cut procedures are governed by soils with the highest number, temporary cut slopes over the full depth of excavation inclined at 3 horizontal to 1 vertical should be stable.

Although the method of shoring should be the responsibility of the Contractor, where shoring is required, it may consist of soldier pile/lagging systems above groundwater level or sheet pile systems above or below groundwater level. Shoring should be designed and installed in accordance with OPSS 539 Level 2 performance.

### 10.2 Dewatering

The prevailing groundwater should be lowered a minimum of 0.5m below the base of excavations for construction in-the-dry. Due to the noncohesive soils and the high groundwater table, conventional sump pump dewatering will not suffice. Although the responsibility for designing temporary dewatering to achieve this dewatering performance should remain with the Contractor, it is expected that sheet pile cofferdams will be required. The NSSP in Appendix FDR-B should be included in Contract Documentation.

### 10.3 Permission to Take Water (PTTW)

Although the requirement for a permit to take water (PTTW) will depend on the water tightness of the Contractor's selected dewatering system, it is recommended that a PTTW be obtained due to the noncohesive nature of the subsoils and the proximity to the creek.

### 10.4 Vibration and Settlement Monitoring

Construction activities that induce vibrations may cause consolidation of native soils and associated settlements of bridge foundations. Monitoring of vibration and settlement at the travelled portion of bridge foundations is required during removals, sheet pile installation and H-pile driving. Refer to Appendix FDR-B for the NSSP for vibration and settlement monitoring that should be included in the Contract Documentation.

## 11. CLOSURE

The field work was carried out under the supervision of Mr. F. Portela and direction of Mr. K. Daly, BEng, Project Supervisor, Geotechnical Services. The equipment was supplied by Canadian Soils Drilling.

This report was prepared by Ms. Souzan Dabbagh, MEng, P.Eng., Project Engineer, Geotechnical Services, and reviewed by Mr. David Dundas, P. Eng., Senior Engineer, Geotechnical Services. Mr. C.M.P. Nascimento, P.Eng., Project Manager and MTO Designated Principal Contact conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

LICENSED PROFESSIONAL ENGINEER
S. Y. DABBAGH
100129564
April 21, 2015
PROVINCE OF ONTARIO

Souzan Dabbagh, MEng, P.Eng.
Project Engineer, Geotechnical Services

LICENSED PROFESSIONAL ENGINEER
D. H. DUNDAS
April 21, 2015
PROVINCE OF ONTARIO

David Dundas, P. Eng.
Senior Engineer, Geotechnical Services

REGISTERED PROFESSIONAL ENGINEER
C M P Nascimento
April 21, 2015
PROVINCE OF ONTARIO

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

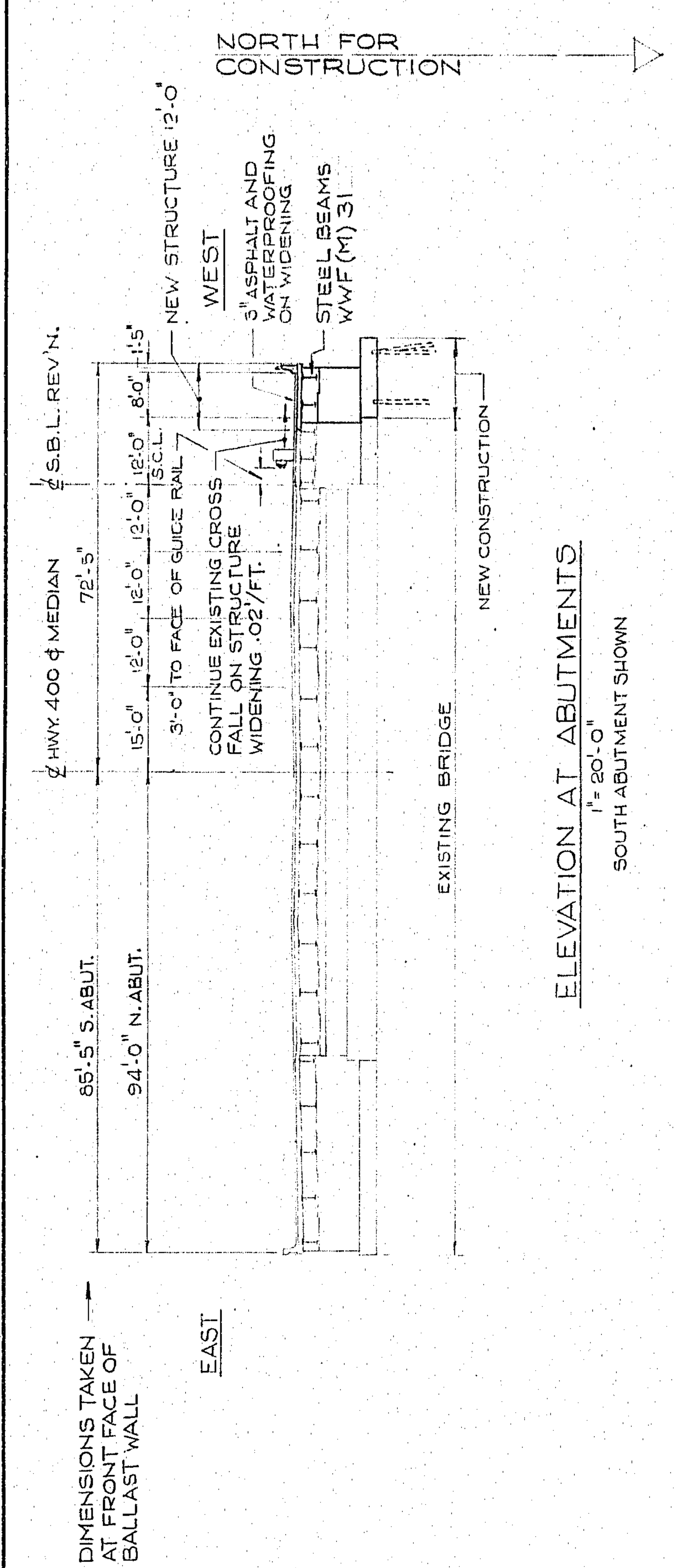
SD/DD/CN:dd-jk

# APPENDIX FDR-A

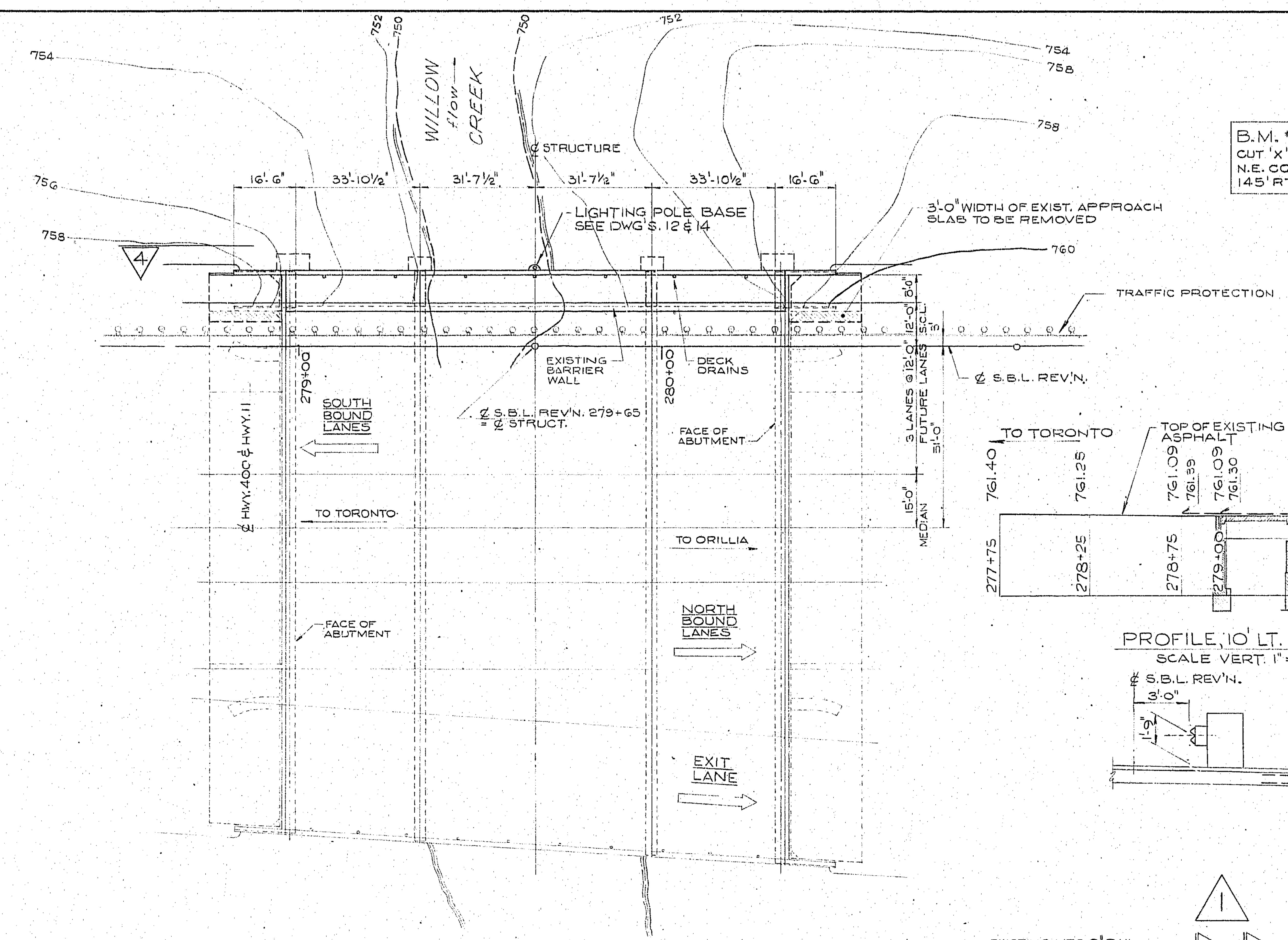
General Arrangement - Contract 77-112 (Willow Creek Bridge Widening)

| DISTRICT 5<br>CONT No 77-112<br>WP No 99-75-06 | |
|---|---|
| WILLOW CREEK BRIDGE WIDENING<br>GENERAL ARRANGEMENT | SHEET<br>90 |

C.C. PARKER & ASSOCIATES LTD.
CONSULTING ENGINEERS — HAMILTON



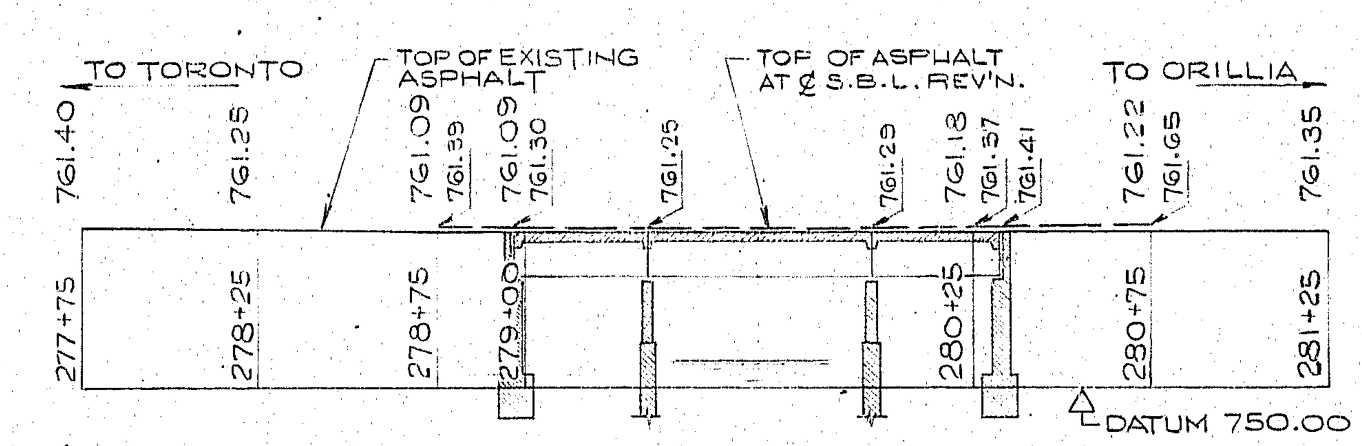

ELEVATION AT ABUTMENTS
1" = 20'-0"
SOUTH ABUTMENT SHOWN



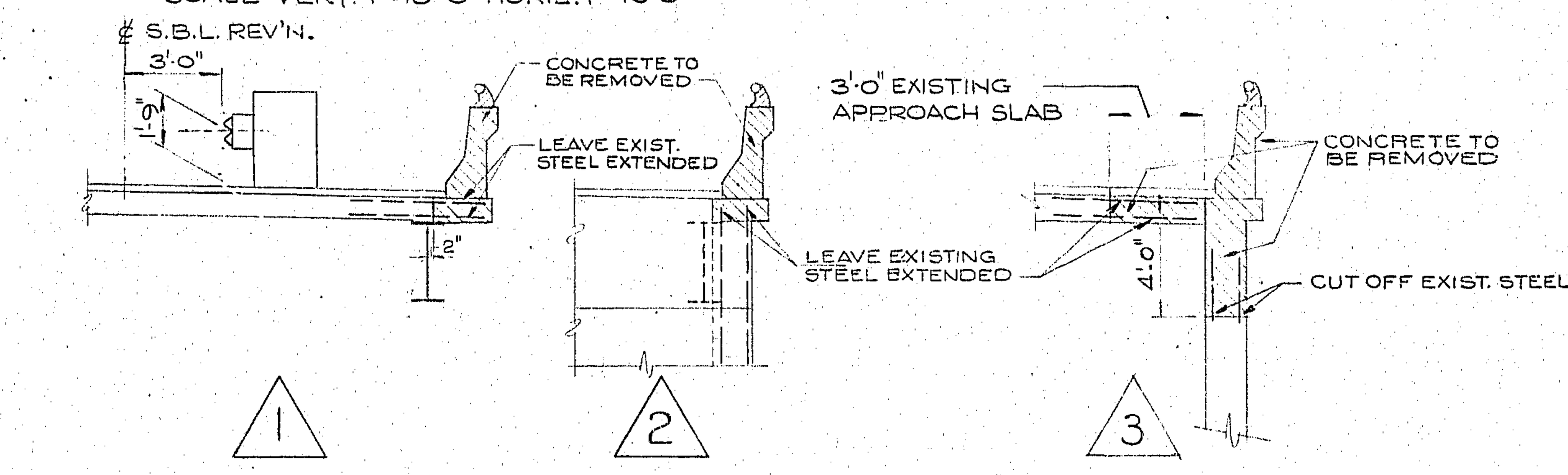

PLAN
1" = 20'-0"

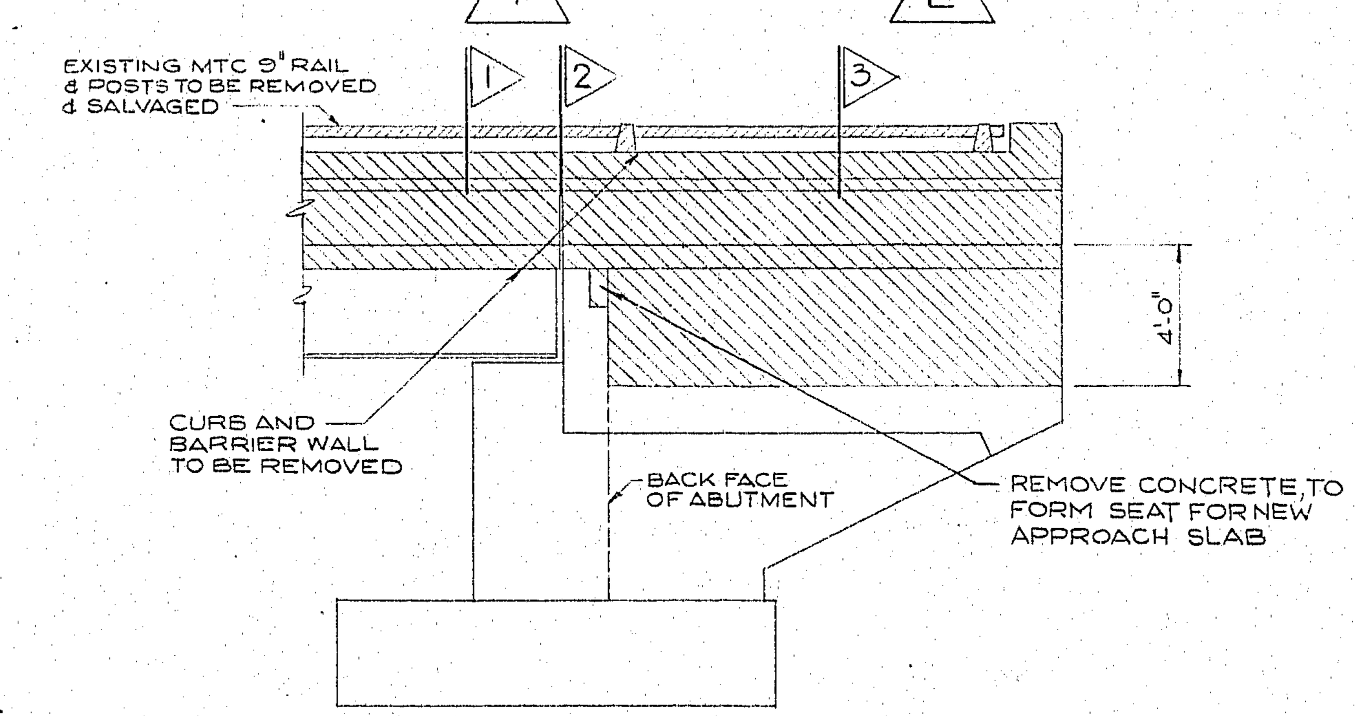
B.M. #104, EL. 763.94'
CUT 'X' ON TOP OF N. END OF N.E. CORNER, CONC. ABUT.
145' RT. 280+47

NOTE:
FOR DETAILS OF TRAFFIC PROTECTION SEE GRADING DRAWINGS.




PROFILE, 10' LT. OF S.B.L. REV'N.
SCALE VERT. 1" = 10'-0" HORIZ. 1" = 40'-0"




WINGWALL ELEVATION (EXIST.)
¼" = 1'-0"

REMOVAL DETAILS

## GENERAL NOTES

CLASS OF CONCRETE

| | |
|---|---|
| DECK AND BARRIER WALLS | 4,000 PSI |
| REMAINDER | 3,000 PSI |

CLEAR COVER ON REINFORCING STEEL

| FOOTINGS | ABUTMENTS AND PIERS | DECK |
|---|---|---|
| 3" | 3" | TOP 2"<br>BOT. 1-1/2" |
| BARRIER WALLS | END POSTS | APPROACH SLABS |
| 1-1/2" | 1-1/2" | 2" |

CONSTRUCTION NOTES

CONTRACTOR IS RESPONSIBLE FOR FINISHING THE BEARING SEATS DEAD LEVEL TO THE SPECIFIED ELEV. WITH TOLERANCE OF 1/8" NO CONCRETE SHALL BE PLACED IN THE BALLAST WALLS UNTIL THE STRUCTURAL STEEL HAS BEEN ERECTED.

REINFORCING STEEL

C.S.A. STANDARD G30.12, GRADE 50.

ELEVATIONS OF EXISTING BRIDGE

FOR NOTES ON ELEVATIONS OF EXISTING BRIDGE, SEE DRAWING 6.

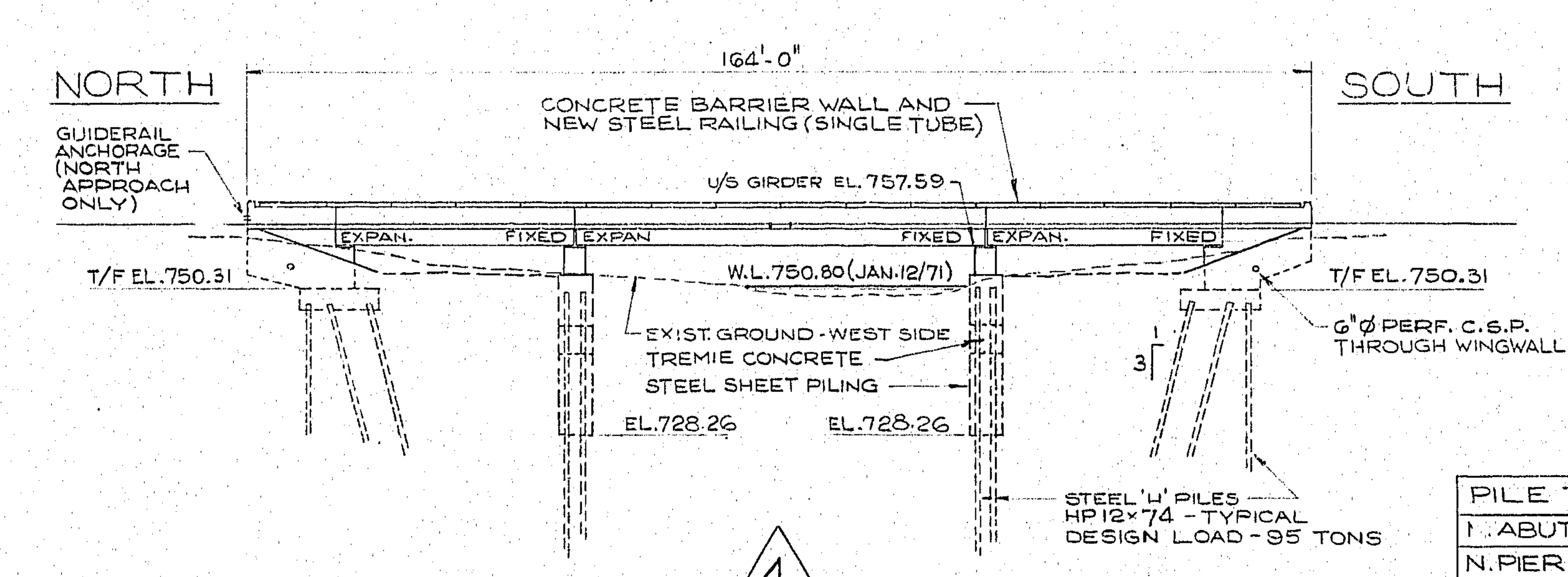
## LIST OF DRAWINGS


1. GENERAL ARRANGEMENT
2. BOREHOLE LOCATIONS & SOIL STRATA
3. FOUNDATION LAYOUT
4. ABUTMENT AND PIER DETAILS
5. STRUCTURAL STEEL DETAILS
6. DECK DETAILS
7. BARRIER WALL
8. STEEL RAILING (SINGLE TUBE)
9. 20 FT. APPROACH SLAB (BARRIER WALL)
10. STANDARD DETAILS I
11. STANDARD DETAILS II
12. STANDARD DETAILS III
13. AS CONSTRUCTED ELEV. & DIM.
14. BRIDGE ELECTRICAL DETAILS - TYPE IV


CONCRETE QUANTITIES ARE LISTED BELOW FOR THE APPROPRIATE CONCRETE LUMP SUM TENDER ITEMS

| QUANTITIES | | |
|---|---|---|
| CONCRETE | PIERS, ABUTMENTS AND WINGWALLS | 50 cu. yd |
| | DECK | 45 cu. yd |
| | BARRIER WALL | 13 cu. yd |
| | APPROACH SLABS | 17 cu. yd |

STRUCTURAL STEEL QUANTITY
TOTAL = 20.0 TONS




WEST SIDE ELEVATION
1" = 20'-0"

| PILE TIP ELEV. | |
|---|---|
| N. ABUT. | 624± |
| N. PIER | 618± |
| S. PIER | 623± |
| S. ABUT. | 624± |

REGISTERED PROFESSIONAL ENGINEER
Q. M. ISLAM
PROVINCE OF ONTARIO

FOR REDUCED PLAN
USE SCALE BELOW
0 1 2 3
3 INCHES ON ORIGINAL PLAN

| REVISIONS DATE | BY | DESCRIPTION | |
|---|---|---|---|
| DESIGN Q.M.I. | CHECK D.C.C. | LOADING HS 20-44 | DATE MAR. 28/77 |
| DRAWING S.N. | CHECK Q.M.I. | SITE No 30-139 | DWG 1 |

TWP 78-139-1-D

# APPENDIX FDR-B

OPSS's and NSSP's

## OPSS's Relevant to Report

| DOCUMENT | TITLE |
|---|---|
| OPSS 405 | Construction Specification for Pipe Subdrains |
| OPSS 501 | Construction Specification for Compacting |
| OPSS 511 | Construction Specification for Rip-Rap, Rock Protection, and Granular Sheeting |
| OPSS 539 | Construction Specification for Temporary Protection Systems |
| OPSS 802 | Construction Specification for Topsoil |
| OPSS 803 | Construction specification for Sodding |
| OPSS 804 | Construction Specification for Seed and Cover |
| OPSS 902 | Excavation and Backfilling of Structures |
| OPSS 903 | Construction Specification For Deep Foundations |
| OPSS.PROV 206 | Construction Specification for Grading |
| OPSD 3190.100 | Walls Retaining and Abutment Wall Drain |

## NSSP's Relevant to Report

**NSSP for Presence of Obstructions in the Ground - Addition to OPSS 539, OPSS 902, OPSS 903**

The Contractor shall be advised that an abandoned sunken bridge deck, foundations (including piles) from existing and pre-existing structures and cobbles and boulders are present within the ground. The Contractor shall avoid disturbing the foundations of travelled portions of existing structures during construction activities including excavation, installation of sheet piles for channel lining or dewatering cofferdams and for installation or bridge foundation piles. Although the methods of construction shall remain the responsibility of the Contractor, the Contractor may consider removing the abandoned bridge deck under the plan limits of pile installations, prior to construction activities such as installing piles.

**NSSP for Dewatering - Addition to OPSS 902**

The Contractor shall take measures to lower the prevailing groundwater level a minimum of 0.5 m below the base of excavations or foundation bases for construction in-the-dry. The Contractor shall be advised that the groundwater is at or near the natural ground surface and that the ground is susceptible to disturbance under conditions of unbalanced hydrostatic head. Although the Contractor shall be responsible for designing and implementing measures for surface water control and dewatering, the Contractor is advised that conventional sump pumping will not be effective and that consideration could be given to utilizing sheet pile cofferdams as appropriate.

**NSSP for Structure Foundation Vibration and Settlement Monitoring during Removal, Sheet Pile Installation and H-Pile Installation - Addition to OPSS 902 and OPSS 903**

Construction activities that induce vibrations may cause consolidation of native soils and associated settlements of bridge foundations. Monitoring of vibration and settlement at the travelled portion of bridge foundations is required during removals, excavations, sheet pile installation and H-pile driving. The Contractor shall monitor vibration and settlements at three (3) equally spaced points on each foundation element of travelled potions of the bridge during these operations.

Vibration and settlement monitoring shall be carried out on a daily basis, from 2 days prior to the commencement of the noted operations to establish a baseline. The Contractor shall submit to the CA, at the completion of each day during the specified construction operations, a cumulative tabular report indicating the current and previous readings to date of the vibration measurements and of the total amount of settlement change from the base line readings. If the vibration measurement exceeds 100 mm/sec and/or if the total amount of settlement change exceeds 10 mm, vibration inducing operations shall be stopped immediately and the issue shall be immediately referred to the CA for further instruction. The settlement monitoring shall consist of survey monitoring with minimum measurement precision of 1 mm.

**NSSP for Pile Driving Control - Addition to OPSS 903**

The Contractor shall be advised that methods of pile driving control alternative to those prescribed for the Hiley Formula (Standard Drawing SS-103-11), including PDA testing, will be considered provided that the proposal or alternative methods is supported by sufficient evidence to confirm their equivalence or superiority to the Hiley formula method and subject to the acceptance of the CA.