Foundation Investigation Report – Ron McNeil Line Interchange Underpass – Highway 4 widening from Clinton Line to New Talbotville Bypass and New Talbotville Bypass from Highway 4 to Highway 3 at Ron McNeil Line

Highway 3 Township of Southwold,
County of Elgin, ON
West Region

GWP 3042-22-00

Latitude 42.809693
Longitude -81.229026

Geocres No. 40I14-223

Prepared for:

Ministry of Transportation, Ontario (MTO), West Region

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FOUNDATION INVESTIGATION REPORT
For
G.W.P. 3042-22-00
Ron McNeil Line Interchange Underpass

Highway 4 widening from Clinton Line to New Talbotville Bypass and New Talbotville Bypass from Highway 4 to Highway 3 at Ron McNeil Line
West Region, Township of Southwold, County of Elgin, Ontario

1.0 INTRODUCTION

Stantec has been retained by the Ministry of Transportation Ontario (MTO) to provide preliminary and detailed design services for the Highway 4 widening from Clinton Line to the new Talbotville Bypass and for the new Talbotville Bypass from Highway 4 to Highway 3 at Ron McNeil Line (GWP 3042-22-00), and for the Highway 3 widening from Ron McNeil Line to Centennial Avenue (GWP 3041-22-00).

As part of the GWP 3042-22-00 new Talbotville Bypass from Highway 4 to Highway 3 at Ron McNeil Line, the following new structures are proposed:

- CNR Talbotville Overhead - Two (2) Single Span Bridges with about 300 m long approach embankment on both sides of bridges,
- Ron McNeil Line Interchange Overpass - Two Span Bridge with approach embankments, and
- Lindsay Creek Culvert (formerly Dodd's Creek Culvert).

As part of the GWP 3041-22-00 Highway 3 Twinning from Ron McNeil Line to Centennial Avenue, the following new structures, including two existing culverts replacement, are proposed:

- Wellington Road Interchange Underpass – New Two Span Bridge with approach embankments
- Kettle Creek WBL Bridge – New Three Span Bridge
- 05X-0266/C0 Underhill Drain Culvert – New Culvert Construction Under the proposed Highway Twinning
- 05X-0268/C0 – Existing CSP Culvert replacement & New Culvert Construction Under the proposed Highway Twinning
- Noise Walls (between Stations 13+100 and 11+100, south side of the existing Highway 3 & between Stations 12+400 and 13+600 on both sides of Highway 3)
- Deep Cuts (between Stations 13+650 and 15+050, north of the existing Highway 3)

Eighteen (18) Overhead Signs and three (3) Storm Water Management Ponds (SWMPs) were also planned at the early stage of the project. As per the preliminary design, three (3) Storm Water Management Ponds were eliminated, and four (4) structural culverts were added at the Ron McNeil Line interchange area.

This Foundation Investigation Report has been prepared specifically and solely for the proposed Ron McNeil Line Overpass. Other project foundations engineering components are reported under separate cover.

The terms of reference for the foundation investigation work scope were provided in the MTO's RFP (Request for Proposal) and addenda. The MTO Guideline for Foundation Engineering Services V.3.0 is also considered for the borehole termination depth based on the clarifications provided during the bid phase.

2.0 SITE DESCRIPTION AND GEOLOGY

2.1 SITE LOCATION

Ron McNeil Line is planned to cross over the Talbotville Bypass at approximate Station 10+000, about 100 m northwest of its current intersection with Highway 3 in the City of St. Thomas, Ontario. The site location is shown on the Key Plan inset to Drawing No. 1 included in Appendix A.

2.2 GENERAL SITE DESCRIPTION

At the proposed location of the Ron McNeil Interchange Overpass, Highway 3 is planned to be a six-lane divided freeway, with three traffic lanes and shoulders in each direction.

At the site location, Ron McNeil Line is currently a two-lane roadway with shoulders on both sides. As part of the project, Ron McNeil Line is planned to be widened (two traffic lanes in each direction, with outer shoulders) and realigned to the west, and to connect to Highway 3 approximately 100 m northwest of its current intersection with Highway 3 and Ford Road.

The orientation of Highway 3 is approximately northwest-southeast, and the orientation of the Ron McNeil Line is approximately northeast-southwest. For the purposes of this report, the orientation of the Talbotville Bypass and the Ron McNeil Line are taken as east-west and north-south, respectively.

The area immediately adjacent to the proposed overpass consists of agricultural fields. The ground surface at the site generally is flat to gently undulating.

Photo 1. Ron McNeil Line Underpass Site (looking north)

2.3 PROPOSED STRUCTURE

Based on the General Arrangement (GA) drawing, a two-span bridge structure with cast-in-place, post-tensioned concrete deck and integral abutments is planned for the underpass. The drawing also indicates that the bridge will be approximately 72 m long, and approximately 21.8 to 22.7 m wide, and will be located perpendicular to the planned alignment of Highway 3. The top of the highest sections of the proposed south and north approach embankments (at the locations of the abutments) are planned to be at approximately elevations 244 m and 246 m, approximately 7 m and 8 m higher than the surrounding lands, respectively. The embankments are planned to have 2 horizontal : 1 vertical side slopes and foreslopes.

The GA drawing is included in Appendix A for reference.

2.4 GEOLOGICAL INFORMATION

The site is located within the physiographic region of Ekfrid Clay Plain, as delineated in the Physiography of Southern Ontario (Chapman and Putnam, 1983). According to the Ontario Department of Mines Preliminary Geological Maps 238 (Pleistocene Geology of The St. Thomas Area, West Half) and P.606 (Pleistocene Geology of The St. Thomas Area, East Half), the site subsurface conditions are generally characterized by lacustrine deposits of silt, silty sand and clay, Port Stanley silty clay to clayey silt till and modern alluvium deposits of gravel, sand, and silt along watercourses. As per the Ontario Geological Survey Map 2441 (Geological Highway Map Southern Ontario), the bedrock within the project area is described as grey limestone of the Dundee Formation. Based on the Ontario Department of Mines Preliminary Geological Map P. 482 (St. Thomas Sheet), the bedrock depths with the bridge site is estimated to be about 85 m below the original ground surface (o.g.).

2.5 EXISTING UTILITIES

A review of available information indicated that there is a water main and a gas main running parallel to Wonderland Road and extending to the immediate west of the planned Ron McNeil Line Overpass. There also overhead cables running north-south to the immediate west of the planned Ron McNeil Line Overpass. No critical buried utilities were identified within the proposed structure foundations and embankments' footprint

3.0 REVIEW OF PREVIOUS INVESTIGATIONS

A review of MTO GEOCRES database identified the following report at the Ron McNeil Line Overpass site:

GEOCRES Reference No. 40I14-35

A foundation investigation report dated August 13, 1973, was available for the proposed crossing at St. Thomas Expressway and County Road #52.

The report was referenced as follows:

Foundation Investigation Report
For Proposed Crossing at
St. Thomas Expressway and County Road #52
Twps. Of Southwold; Co. of Elgin
District #2 (London)
W.O. 73-11021 - W.P. 89-69-07

The investigation included a total of three (3) sampled boreholes (BH No. 1 to 3), advanced to depths of approximately 18.8 m, 15.7 and 24.8 m below grade (corresponding to approximately elevations 218.4 m, 221.4 m and 212.7 m) and six (6) dynamic cone penetration tests advanced in May 1973.

The boreholes encountered a deep stratum of very stiff to hard clayey silt to silty clay with small amounts of sand and trace gravel. Occasional pockets and/or thin seams of silt were also noted, and sand partings were inferred to be present within this deposit. Except within the top 2 m, the stratum had a moisture content that was at or below the Plastic Limit. Based on the N-values obtained, the undrained shear strength of the stratum was inferred to be higher than approximately 100 kPa everywhere and as high as 240 kPa.

The boreholes were dry upon completion. However, it was noted in the report that due to the relatively impermeable nature of the soils encountered and short duration of the fieldwork, groundwater levels at the site could not be established conclusively but were inferred to be well below the elevation of the proposed structure footing at the time (i.e., approximately Elevation 234 m). It was noted that the randomly distributed silt seams and/or sand partings could be water bearing.

For reference, copies of the Borehole Location Plan, stratigraphic profile, borehole records and laboratory test results are included in Appendix B.

4.0 INVESTIGATION PROCEDURES

4.1 FIELD INVESTIGATION

The geotechnical investigation for the detailed design of the proposed Ron McNeil Line consisted of a total of five (5) boreholes. Two (2) of the boreholes, designated as RMN-UP1 and RMN-UP3 were advanced for the abutments, borehole RMN-UP2 was advanced for the central pier, and two (2) boreholes, designated as RMN-A1 and RMN-A2 were advanced for the approach embankments. The investigation also included advancing one (1) Cone Penetration Test, designated as CPT24-RMNAPP01 (and additional shear wave velocity measurements in a separate sounding -sCPT24-RMNAPP01). The locations of the boreholes and CPT are shown on the Borehole Location Plan, Drawing No. 1 in Appendix A.

Prior to carrying out the investigation, Stantec contacted the public utility authorities to clear the borehole locations of private, public as well as and MTO-owned utilities.

The field drilling program was carried out between May 28, 2024, and July 4, 2024. The abutment boreholes were advanced to a depth of approximately 44.6 m below grade and boreholes RMN-A1 and RMN-A2 were advanced to the depths of approximately 14.5 m and 12.8 m below grade, respectively. All boreholes were advanced using hollow-stem continuous-flight augers. Wash boring technique was used below a depth of 3 m in boreholes RMN-UP1 to RMN-UP3. Drilling was carried out with CME55 and D50 track-mounted rigs equipped for soil sampling.

The subsurface stratigraphy encountered in each borehole was recorded in the field by an experienced Stantec field technician. Standard Penetration Tests (SPT) were carried out in the drilled holes and split spoon samples were collected at regular intervals (0.75 m interval for the shallow depth / critical zone, 1.5 m interval to 20 m below grade and 3 m interval to the termination depths of the boreholes to meet the typical MTO subsurface investigation sampling requirements) in accordance with ASTM D1586. Shelby tube (thin-walled steel tube) samples were also obtained in the boreholes at select depths. All recovered SPT and Shelby tube samples were returned to our Markham and Ottawa laboratories for detailed classification and testing. The undrained shear strength of cohesive soils was determined using an in-situ shear vane (MTO B-vane) in accordance with ASTM D2573 wherever applicable. A pocket penetrometer was also used to estimate the shear strength/consistency of clayey soil samples at the site.

One (1) CPT, designated as CPT24-RMNAPP01 (and additional shear wave velocity measurement - sCPT24-RMNAPP01) was conducted at the site on May 5, 2024. The CPT was advanced to a target depth of approximately 15 m, below grade. ConeTec CPT report dated May 24, 2024, is included in Appendix C.

A single line of Multi-Channel Analysis of Surface Wave (MASW) was also carried out at the site to determine the seismic site classification. The MASW report is included in Appendix F.

Groundwater was observed in open boreholes during drilling. Following completion of drilling, a 50 mm diameter groundwater monitoring well, screened over a depth of 4.6 m to 7.6 m below ground surface, was installed in Borehole RMN-UP2. The borehole annulus surrounding the slotted pipe section was backfilled with sand. The remaining annulus was backfilled with bentonite up to the ground surface. Groundwater level measurement in the monitoring well was carried out on September 11, 2024.

After completion of drilling, the remaining boreholes were backfilled with a mix of bentonite and drill cuttings.

4.2 LOCATION AND ELEVATION SURVEY

The borehole locations and respective ground surface elevations were surveyed by Stantec Geomatics personnel using Trimble R12i GPS with an elevation and spatial accuracy of ± 0.02 m vertically and ± 0.01 m horizontally to meet the survey accuracy requirements (vertical accuracy of 0.1 m and horizontal accuracy of 0.5 m) of the Guideline for MTO Foundation Engineering Services V2.

Table 4.1 below summarizes the borehole survey information and includes the drilling depth, end of borehole elevation and number of samples recovered for each borehole.

Table 4.1: Borehole Information Summary

Test Hole	MTM Zone 11 Coordinates		Ground surface elevation (m)	End of borehole depth (m)	End of borehole elevation (m)	Number of soil samples
	Northing	Easting				
RMN-A1	4741937.4	408801.5	239.2	14.5	224.7	14
RMN-A2	4741843.9	408703.6	237.2	12.8	224.4	13
RMN-UP1	4741914.1	408760.6	237.6	44.6	193.0	26
RMN-UP2	4741885.4	408747.7	237.6	44.8	192.8	26
RMN-UP3	4741861.5	408721.2	237.0	44.7	192.3	26
CPT24-RMNAPP01	4741913.8	408759.6	237.6	15.0	222.6	-

4.3 LABORATORY TESTING

All samples were taken to Stantec's Markham and Ottawa laboratories where they were subjected to a detailed visual and tactile examination by a Geotechnical Engineer.

The geotechnical laboratory testing program for the boreholes samples is summarized in the following table.

Table 4.2: Geotechnical Laboratory Testing Program

Laboratory Test Type	Number of Tests
Moisture Content	112
Gradation Analysis	25
Atterberg Limits	28
Consolidation (oedometer)	3
Unconsolidated Undrained Triaxial Compression Test (UU)	1
Chemical Analysis	3

Three soil samples from the boreholes advanced for the overpass structure abutments were forwarded to AGAT Laboratories. The samples were tested for pH, soluble sulphate content, chloride content, and resistivity.

Samples remaining after testing will be placed in storage for a period of one year after issuance of the final report. After the storage period, the samples will be discarded unless we are directed otherwise by MTO.

5.0 SUBSURFACE CONDITIONS

5.1 OVERVIEW

The detailed soil and groundwater conditions encountered in the boreholes and the results of the in-situ and laboratory testing are shown on the Borehole Records included in Appendix C. An explanation of the symbols and terms used to describe the Borehole Records is also provided in Appendix C. The results of the geotechnical laboratory testing are presented on Figures D1 to D6 included in Appendix D. It is noted that clay size particles include all particles smaller than 0.002 mm.

A borehole location plan and a stratigraphic section of the soils encountered in the boreholes along the bridge alignment are provided on Drawing No.1 in Appendix A.

The stratigraphic boundaries on the borehole records and the strata plot are inferred from non-continuous sampling and therefore represent transitions between soil types rather than exact boundaries between geological units. The subsurface conditions will vary between and beyond the borehole locations.

In general, the subsurface stratigraphy encountered in the boreholes generally consisted of:

- Topsoil; underlain by,
- Cohesionless fill comprising silty sand in RMN-A1; underlain by,
- Cohesive fill comprising silty clay and sandy clayey silt (except in RMN-UP1 and RMN-UP2); underlain by,
- Firm to hard clayey silt till; interbedded with,
- Hard clayey silt in RMN-A1, RMN-UP1 and RMN-UP2.

Groundwater level was measured at a depth of approximately 5.8 m below grade corresponding to approximate elevation 231.8 m in the monitoring well installed in borehole RMN-UP2.

Detailed descriptions of the subsurface conditions are provided below.

5.2 OVERBURDEN

5.2.1 Topsoil

Topsoil was encountered at all borehole locations, except RMN-A1 which was advanced from the existing Ron McNeil Line gravel shoulder. The thickness of the topsoil varied from approximately 200 mm to 300 mm.

5.2.2 Fill Materials

5.2.2.1 Cohesionless Fill

A layer of fill material comprising brown silty sand was encountered below the gravel shoulder in borehole RMN-A1. Samples obtained from the fill layer contained trace gravel. The fill layer was approximately 0.3 m thick.

An N-value of 13 blows per 0.3 m was obtained from the SPT advanced in the cohesionless fill layer, indicating a compact condition.

Laboratory tests conducted on the sample of the cohesionless fill yielded a natural moisture content of approximately 16%.

5.2.2.2 Cohesive Fill

A layer of brown to black silty clay fill was encountered below the cohesionless fill layer described in the preceding section in borehole RMN-A1. Layers of brown to grey sandy clayey silt fill were encountered below the topsoil in boreholes RMN-A2 and RMN-UP3. Samples obtained from these cohesive fill layers typically contained trace gravel.

The cohesive fill layer was approximately 2 m, 1.2 m and 1.3 m thick in boreholes RMN-A1, RMN-A2 and RMN-UP3, respectively. The bottom of the cohesive fill layer was encountered at the depths of approximately 2.3 m, 1.5 m and 1.5 m corresponding to approximately elevations 236.9 m, 235.7 m and 235.5 m, respectively in boreholes RMN-A1, RMN-A2 and RMN-UP3.

The N-values obtained from the SPTs advanced in the cohesive fill layer ranged from 2 to 9 blows per 0.3 m penetration, indicating a soft to stiff consistency.

Laboratory tests conducted on samples of the cohesive fill yielded natural moisture contents ranging from approximately 19% to 27%, averaging 21%.

Gradation analyses were carried out on a representative sample of the cohesive fill. The test results are illustrated on the borehole record in Appendix C and on the gradation curve on Figure No. D1 in Appendix D. The tests yielded the following results:

Gravel:	1%
Sand:	12%
Silt:	58%
Clay:	29%

Atterberg Limits tests were conducted on the sample referenced above. The tests yielded a Liquid Limit of approximately 38%, a Plastic Limit of approximately 22%, and a corresponding Plasticity Index of approximately 16%. The test results are illustrated on the borehole record in Appendix C and on the graph on Figure No. D2 in Appendix D.

Based on the results of the laboratory tests, the sample tested can be classified as silty clay with a group symbol of CI based on the Unified Soil Classification System (USCS).

5.2.3 Clayey Silt (CL) Till

An extensive deposit of brown to grey clayey silt till was encountered below the topsoil and/or fill materials in all boreholes. The deposit typically contained various but minor amounts of sand and gravel. Layers of soils with higher silt content and lower plasticity (described in the preceding section) were noted within this deposit in several boreholes. Presence of cobbles and/or boulders was inferred in the till deposit, based auger grinding.

All boreholes were terminated in this deposit after penetrating approximately 11.3 m to 44.7 m into the layer.

The N-values obtained from the SPTs advanced in the clayey silt till deposit ranged from 7 to in excess of 100. The lower N-values were generally obtained in the surficial zone of this deposit (i.e., top 1 m) and the refusal blow counts were obtained at depth.

In-situ shear vane tests (MTO B-vane) were conducted in the clayey silt till deposit in boreholes RMN-A1 and RMN-UP2. The results of the tests are summarized in Table 5.1 below.

Table 5.1: In-situ Shear Vane Test Results – Clayey Silt Till

Borehole	Type	Depth (m)	Elevation (m)	In-situ Undrained Shear Strength (kPa)	Sensitivity
RMN-A1	B-vane	14.4	224.8	170	1.4
RMN-UP2	B-vane	17.8	219.8	180	2.7

An Unconsolidated Undrained (UU) Triaxial test was conducted on a select Shelby tube sample retrieved at a depth of approximately 5.6 m below grade, corresponding to approximate elevation 232 m in borehole RMN-UP2. The test indicated a Compressive Strength of approximately 210 kPa corresponding to an undrained shear strength of approximately 105 kPa. The details of test are included in the test sheets in Appendix D.

Based on the results of these tests, the clayey silt till can generally be described as stiff to hard, except for the top 1 m, which can be described as firm.

Laboratory tests conducted on samples of the clayey silt till deposit yielded natural moisture contents ranging from approximately 11% to 29%, averaging 17%.

Gradation analyses were carried out on 21 samples of the clayey silt till soils. The test results are illustrated on the borehole records in Appendix C and on the gradation curve on Figure No. D3 in Appendix D. The tests yielded the following results:

Gravel: 0 to 15%
Sand: 5 to 28%
Silt: 40 to 52%
Clay: 22 to 53%

Atterberg Limits tests were conducted on the samples referenced above as well as three Shelby Tube samples retrieved from boreholes RMN-A1, RMN-A2 and RMN-UP2. The tests yielded Liquid Limits ranging from approximately 18% to 35%, Plastic Limits ranging from approximately 10% to 17%, and corresponding Plasticity Indices ranging from approximately 8% to 18%. The test results are illustrated on the borehole records in Appendix C and on the gradation curve on Figure No. D4 in Appendix D.

Based on the results of the laboratory tests, the samples tested can be classified as clayey silt with a group symbol of CL based on the Unified Soil Classification System (USCS).

One-dimensional oedometer consolidation tests were carried out on portions of select Shelby tube samples. The results are provided below in Table 5.2 and the details of the tests, including the data plots, are provided on the laboratory test sheets in Appendix D.

Table 5.2: One-Dimensional Oedometer Consolidation Test Results

Borehole/ Sample	Depth/ Elevation (m)	Initial Void Ratio	Initial Unit Weight (kN/m^3)	Estimated Pre-consolidation Stress, Pc' (kPa)	Recompression Index Cr / Compression Index Cc	Over Consolidation Ratio OCR	Coefficient of Consolidation C_v (cm^2/s)
RMN-A1/ TW9	6.3/232.9	0.42	21.9	400	0.01/0.084	3	2.7x10^{-3}

Borehole/ Sample	Depth/ Elevation (m)	Initial Void Ratio	Initial Unit Weight (kN/m^3)	Estimated Pre-consolidation Stress, Pc' (kPa)	Recompression Index Cr / Compression Index Cc	Over Consolidation Ratio OCR	Coefficient of Consolidation C_v (cm^2/s)
RMN-A2 TW7	4.8/232.4	0.47	21.4	480	0.015/0.12	4.7	3x10^{-3}
RMN-UP2 TW8	5.6/231.9	0.52	20.9	350	0.013/0.093	3	3x10^{-3}

5.2.4 Clayey Silt (CL-ML)

Localized layers of clayey silt with higher silt content and lower plasticity than the clayey silt till described in the preceding section were noted interbedded in the clayey silt till deposit in boreholes RMN-A1, RMN-UP1 and RMN-UP2. Samples obtained from the clayey silt layers typically contained trace sand and gravel.

The clayey silt layer was approximately 1.5 m, 3.6 m and 1 m thick and extended from depths of approximately 10.2 m, 7.2 m and 8.7 m below grade, corresponding to approximately elevations 229 m, 230.4 and 228.9 m to depths of approximately 11.7 m, 10.8 m and 9.7 m below grade, corresponding to approximately elevations 227.5 m, 226.8 m and 227.9 m, respectively; in boreholes RMN-A1, RMN-UP1 and RMN-UP2.

N-values obtained from the SPTs advanced in the clayey silt layer ranged from 44 to 63, indicating hard consistency.

Laboratory tests conducted on samples of the clayey silt layer yielded natural moisture contents ranging from approximately 13% to 17%, averaging 15%.

Gradation analyses were carried out on three (3) samples of the clayey silt soils. The test results are illustrated on the borehole records in Appendix C and on the gradation curve on Figure No. D5 in Appendix D. The tests yielded the following results:

Gravel:	0 to 10%
Sand:	2 to 9%
Silt:	54 to 74%
Clay:	24 to 28%

Atterberg Limits tests were conducted on the samples referenced above. The tests yielded Liquid Limits of approximately 19%, 20% and 20%, Plastic Limits of approximately 14%, 14% and 13%, and corresponding Plasticity Indices of approximately 5%, 6% and 7%. The test results are illustrated on the borehole records in Appendix C and on the graph on Figure No. D6 in Appendix D.

Based on the results of the laboratory tests, the samples tested can be classified as clayey silt with a group symbol of CL-ML based on the Unified Soil Classification System (USCS).

5.2.5 Bedrock

No bedrock was encountered in any boreholes within the investigation depths.

5.2.6 Groundwater

A monitoring well was installed in borehole RMN-UP2 to observe the long-term groundwater levels. In other boreholes, groundwater level observations were made during drilling operations, and in the open boreholes upon completion of drilling. The groundwater level recorded in RMN-UP2 and inferred in the other boreholes are summarized in Table 5.3 below.

Table 5.3: Measured and Inferred Groundwater Levels

Borehole No	Date	Groundwater Level (m)	
		Depth	Elevation
RMN-A1	Upon Completion	Dry	
RMN-A2	Upon Completion	Dry	
RMN-UP1	Upon commencement of mud drilling at 3 m below grade	Dry	
RMN-UP2	September 11, 2024	5.8	231.8
RMN-UP3	Upon commencement of mud drilling at 3 m below grade	Dry	

Groundwater levels at the site will be subject to fluctuations due to seasonal changes, snowmelt and precipitation events. The water levels should be expected to be higher during the spring season and during and following periods of heavy precipitation or snow melt.

5.3 CHEMICAL TESTING

One representative sample from the soils at the site was tested for pH, water-soluble sulphate and chloride concentrations, and resistivity. The analysis results are provided in the following table.

Table 5.4: Results of Chemical Analysis

Borehole No	Sample No.	Depth (m)	pH	Chloride (µg/g)	Sulphate (µg/g)	Resistivity (Ohm-cm)
RMN-UP1	SS10	7.9	8.79	6	272	2730
RMN-UP2	SS7	4.9	8.46	5	318	2520
RMN-UP3	SS8	5.6	8.38	7	174	3560

6.0 MISCELLANEOUS

The field work was carried out under the supervision of Mr. Muhammed Cuned and Mr. Harpreet Singh, under the direction of Mr. Gwangha Roh, P. Eng., Ph.D.

Both public and private utility locates were arranged by Stantec staff prior to initiation of drilling.

The drilling equipment was supplied and operated by London Soil Ltd. based in London, Ontario and DBW Drilling Ltd. based in North York, Ontario.

CPT, sCPT and MASW were carried out by ConeTec based in Richmond Hill, Ontario.

The borehole locations and elevations were surveyed by Stantec's Geomatics division based in London.

Geotechnical laboratory testing was carried out at Stantec's laboratories in Markham and Ottawa, Ontario.

This report was prepared by Roshan Rashed, M.Sc., P.Eng., and reviewed by Gwangha Roh, P. Eng., Ph.D., and Raymond Haché, M.Sc., P.Eng., Designated Principal MTO Foundation Contact.

7.0 CLOSURE

A subsurface investigation is a limited sampling of a site. The subsurface conditions given herein are based on information gathered at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information.

Respectfully Submitted;

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APPENDIX A

A.1 DRAWING NO. 1 – BOREHOLE LOCATION PLAN AND SOIL STRATA PLOTS

A.2 GENERAL ARRANGEMENT DRAWING

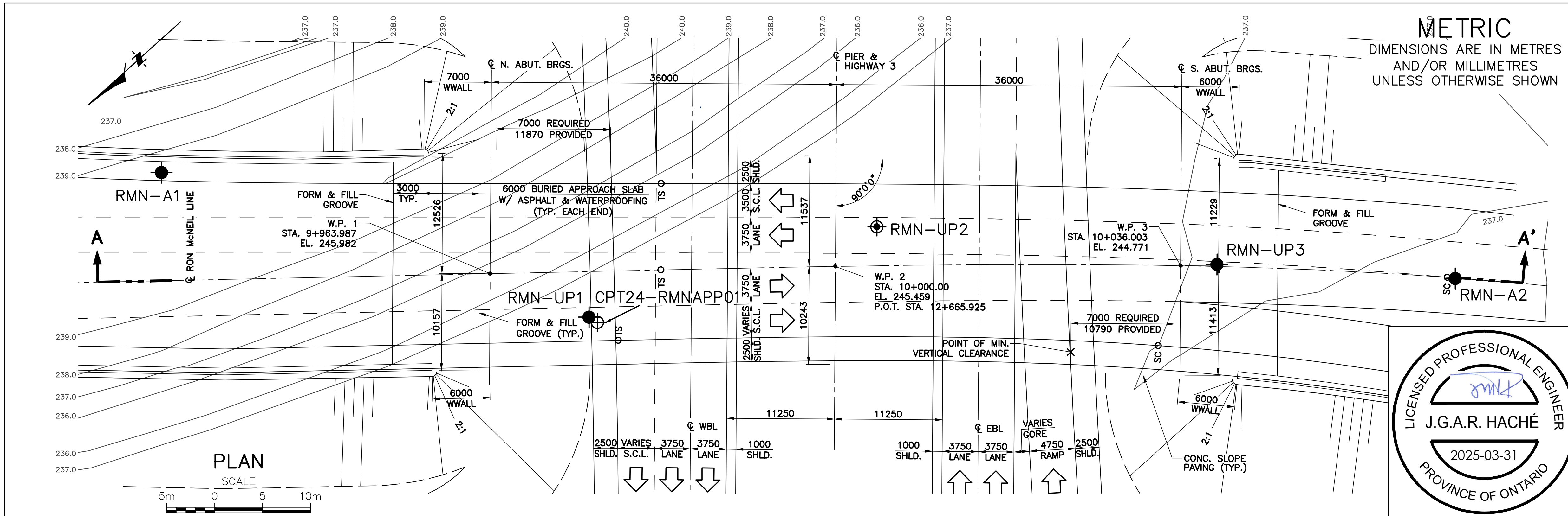
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

PLATE No
CONT WP 3042–22–00

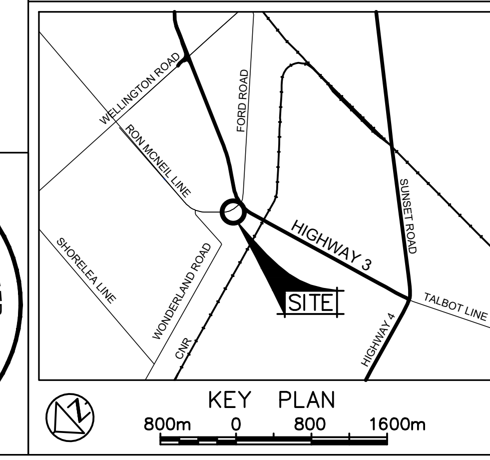
RON MCNEIL LINE INTERCHANGE BRIDGE
BOREHOLE LOCATIONS & SOIL STRATA

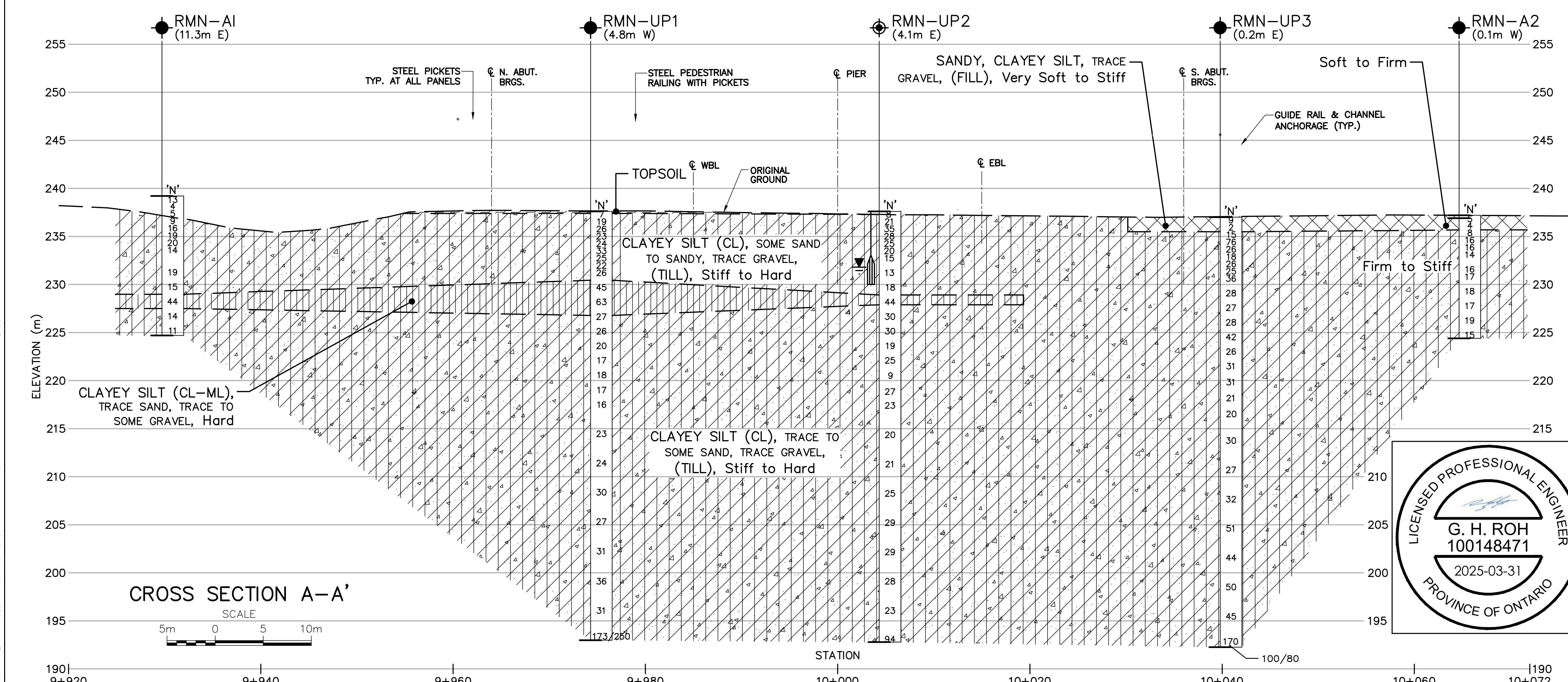
SHEET –

Stantec



LICENSED PROFESSIONAL ENGINEER
J.G.A.R. HACHÉ
2025-03-31
PROVINCE OF ONTARIO





LICENSED PROFESSIONAL ENGINEER
G. H. ROH
100148471
2025-03-31
PROVINCE OF ONTARIO

LEGEND

●	Borehole (Stantec, 2024)
⊕	Borehole with Monitoring Well (Stantec, 2024)
⊕	Cone Penetration Test (Stantec, 2024)
(x.x m)	Offset from Cross Section Line
N	Blows/0.3m (Std Pen Test, 475 J/blow)
▼	WL Measured on September 2024
▯	Piezometer

No	ELEV	MTM ZONE 11 COORDINATES NORTH	EAST
RMN–A1	239.2	4 741 937.4	408 801.5
RMN–A2	237.2	4 741 843.9	408 703.6
RMN–UP1	237.6	4 741 914.1	408 760.6
RMN–UP2	237.6	4 741 885.4	408 747.7
RMN–UP3	237.0	4 741 861.5	408 721.2
CPT24–RMNAPP01		4 741 913.8	408 759.6

NOTES

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

This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102–2 of Form 100.

REVISIONS DATE	BY	DESCRIPTION

GEOCRES No 40I14–223

HWY No 3			DIST
SUBM'D RR	CHECKED	DATE 2025–03–31	SITE 05X–0376/B0
DRAWN GBB	CHECKED	APPROVED	DWG 1

DRAWING NAME: 165001308_RMcNeil_PP_250331.dwg
CREATED BY: GBB MODIFIED:
C:\Users\gbriones\appdata\local\temp\AcPublish_38024\165001308_RMcNeil_PP_250331.dwg (1) Printed: Mar 31, 2025

METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

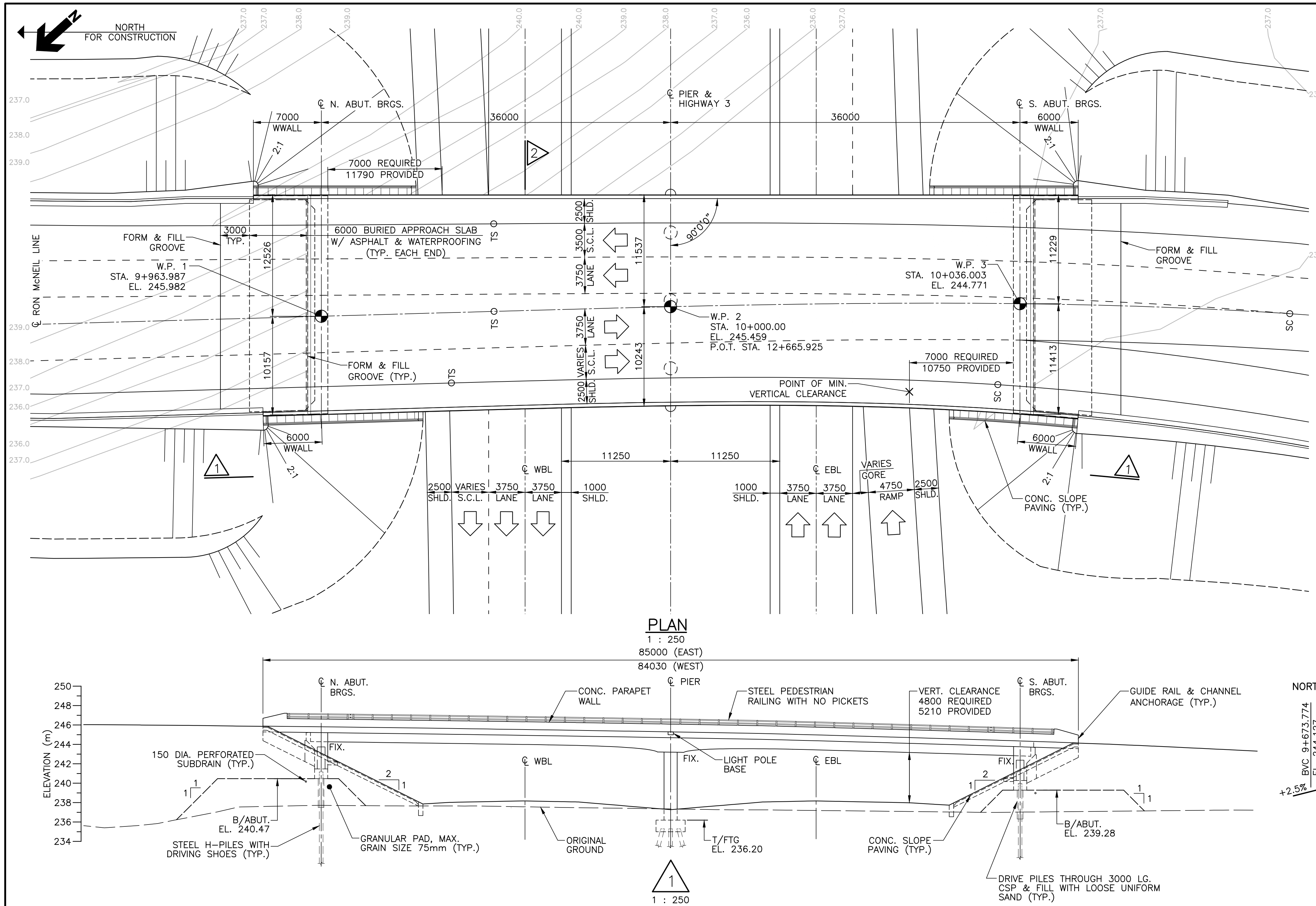
HWY 3
CONT 2025-3007
WP 3077-24-01

RON McNEIL LINE UNDERPASS

GENERAL ARRANGEMENT

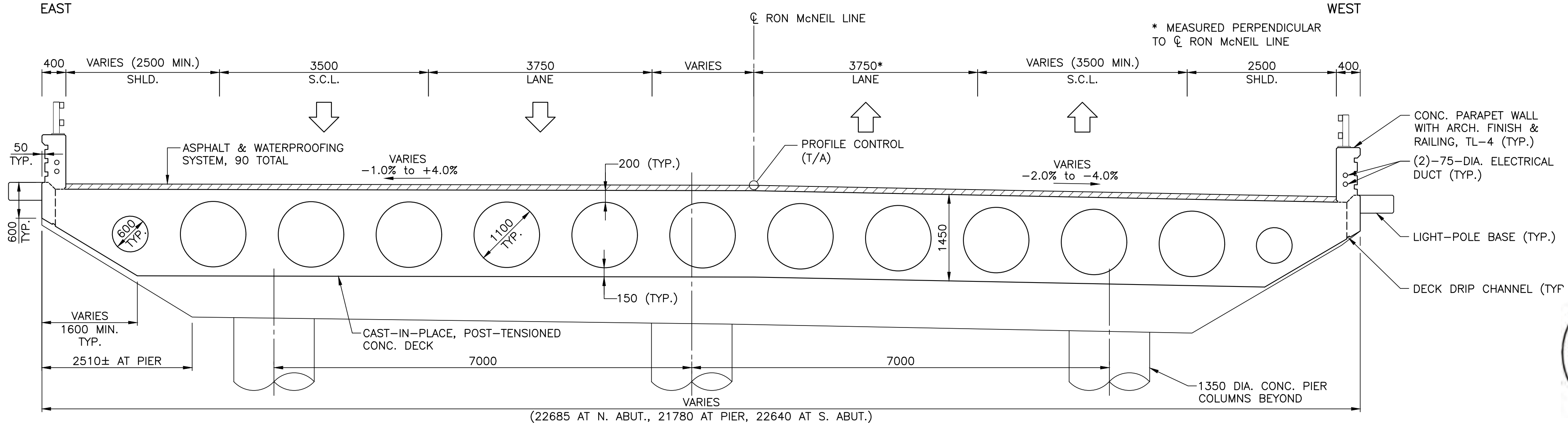
SHEET 415

Stantec



PLAN
1 : 250

1 : 250



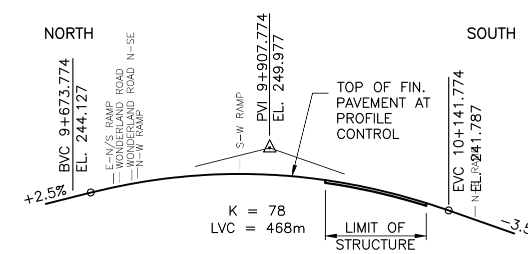
1 : 50

LIST OF DRAWINGS

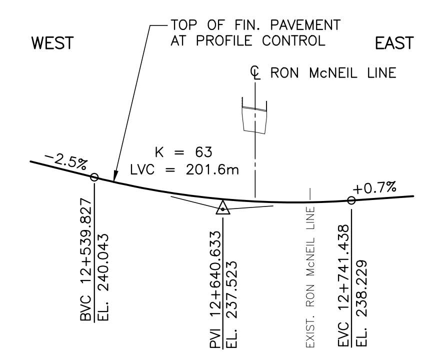
1. GENERAL ARRANGEMENT
2. BOREHOLE LOCATION & SOIL STRATA
3. FOUNDATION LAYOUT
4. PILE CAP, PIER FOOTING & COLUMN REINFORCING
5. SOUTH ABUTMENT
6. NORTH ABUTMENT
7. WINGWALLS
8. DECK DETAILS I
9. LONGITUDINAL TENDONS I
10. LONGITUDINAL TENDONS II
11. TRANSVERSE TENDONS I
12. DECK REINFORCING I
13. DECK REINFORCING II
14. PARAPET WALL
15. RAILING FOR PARAPET WALL
16. BURIED APPROACH SLAB
17. CONCRETE SLOPE PAVING
18. AS-CONSTRUCTED ELEVATIONS & DIMENSIONS
19. PILE DRIVING CONTROL
20. MISCELLANEOUS DETAILS
21. ELECTRICAL EMBEDDED WORK

LEGEND

W.P. – DENOTES WORKING POINT
T/A – DENOTES TOP OF ASPHALT
P.O.T. – DENOTES POINT ON TANGENT (HWY 3)
TS – DENOTES TANGENT TO SPIRAL
SC – DENOTES SPIRAL TO CURVE
S.C.L. – DENOTES SPEED CHANGE LANE



PROFILE OF RON McNEIL LINE
N.T.S.



PROFILE OF HIGHWAY 3
N.T.S.

GENERAL NOTES

1. SPECIFIED 28-DAY CONCRETE COMPRESSIVE STRENGTH:

DECK	35MPa
REMAINDER	30MPa

UNLESS OTHERWISE NOTED.

2. CLEAR COVER TO REINFORCING STEEL:

FOOTINGS		100±25
PIER COLUMNS		70±10
DECK	TOP	70±20
	BOTTOM, SIDES, WEBS	50±10
REMAINDER		70±20

UNLESS OTHERWISE NOTED.

3. REINFORCING STEEL:

REINFORCING STEEL SHALL BE GRADE 500W UNLESS OTHERWISE SPECIFIED.

STAINLESS REINFORCING STEEL SHALL BE TYPE 316LN, OR DUPLEX 2205 AND HAVE A MINIMUM YIELD STRENGTH OF 500MPa.

BAR MARKS WITH PREFIX 'S' DENOTE STAINLESS STEEL BARS.

TENSION LAP LENGTHS NOT INDICATED ON THE CONTRACT DRAWINGS SHALL BE CLASS B.

BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS112-1, UNLESS INDICATED OTHERWISE.

4. CONSTRUCTION

THE CONTRACTOR SHALL ESTABLISH THE BEARING SEAT ELEVATIONS BY DEDUCTING THE ACTUAL BEARING THICKNESSES FROM THE TOP OF BEARING ELEVATIONS. IF THE ACTUAL BEARING THICKNESSES ARE DIFFERENT FROM THOSE GIVEN WITH THE BEARING DESIGN DATA, THE CONTRACTOR SHALL ADJUST THE REINFORCING STEEL TO SUIT.

CONSTRUCT ABUTMENTS IN STAGES AS SHOWN ELSEWHERE.

THE CONTRACTOR SHALL DESIGN AND SUPPLY TWO TEMPORARY LATERAL BRACING SYSTEMS FOR THE ABUTMENT WALLS DURING CONSTRUCTION:

THE FIRST SYSTEM IS FOR THE LATERAL STABILITY OF THE FREE-STANDING ABUTMENTS CORE WALLS ON PILES SO THAT THEY REMAIN STABLE DURING THE CONSTRUCTION AND LOADING OF THE DECK SLAB UNTIL DECK AND ABUTMENT WALLS ARE MADE INTEGRAL.

THE SECOND SYSTEM IS FOR THE LATERAL STABILITY OF THE CORE WALLS TO PREVENT THEM FROM MOVING INWARD (TOWARD THE PIER) DURING THE DECK POST-TENSIONING OPERATIONS. DESIGN FORCES PER ABUTMENT AND OTHER REQUIREMENTS FOR THIS SYSTEM ARE STATED ON DWG. (5) AND ELSEWHERE IN THE CONTRACT DOCUMENTS

THE TWO LATERAL BRACING SYSTEMS CAN BE INTEGRATED INTO ONE SYSTEM IF PREFERRED BY THE CONTRACTOR. THE LATERAL BRACING SYSTEMS SHALL NOT BE REMOVED UNTIL THE DECK IS MADE INTEGRAL WITH THE ABUTMENT WALLS AND THE CONCRETE OF THE INTEGRAL CONNECTION HAS REACHED 70% OF IT'S 28 DAY STRENGTH.

BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH ABUTMENTS KEEPING THE HEIGHT OF THE BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL THE DIFFERENCE IN ELEVATION BE GREATER THAN 500mm.

APPLICABLE STANDARD DRAWINGS

OPSD 3101.150	WALLS ABUTMENT, BACKFILL MINIMUM GRANULAR REQUIREMENT
OPSD 3360.100	DECK, LIGHT POLE BASES, STRUCTURES WITH BARRIER WALLS (MODIFIED)
OPSD 3370.100	DECK, WATERPROOFING HOT APPLIED ASPHALT MEMBRANE WITH PROTECTION BOARD
OPSD 3370.101	DECK, WATERPROOFING HOT APPLIED ASPHALT MEMBRANE AT ACTIVE CRACKS GREATER THAN 2mm WIDE AND CONSTRUCTION JOINTS
OPSD 3390.100	DECK, DRIP CHANNEL
OPSD 3419.100	BARRIERS AND RAILINGS STEEL GUIDE RAIL AND CHANNEL ANCHORAGE
MTOD 3941.210	FIGURES IN CONCRETE, SITE NUMBER AND DATE LAYOUT
OPSD 3950.100	JOINTS, CONCRETE EXPANSION & CONSTRUCTION ON STRUCTURE

LICENSED PROFESSIONAL ENGINEER
M. R. CASSOLATO
100102629
5 Mar. 2025
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
M. D'ANDREA
100047013
05 MAR 2025
PROVINCE OF ONTARIO

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

DESIGN M.C.	CHK M.D.	CODE CSA S6:19	LOAD CL-625-ONT	DATE MAR 2025	
DRAWN B.L.H.	CHK M.C.	SITE 05X-0376/B0	STRUCT	SCHEME	DWG. 1

BENCHMARK 237.859m:
BASED ON CGVD28, TOP OF RIB, STATION: 13+153.27 SOUTHWOLD OFFSET: -20.59m

165001308-5-376-01.DWG Mar 5 2025

APPENDIX B

B.1 AVAILABLE GEOCRES INFORMATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

MEMORANDUM

~~401-183~~

TO: Mr. A. P. Watt, (2)
Regional Structural Planning Eng.,
Southwestern Region,
London, Ontario.

ATTENTION:

FROM: Foundations Office,
Design Services Branch,
West Bldg., Downsview.

DATE: August 13, 1973.

OUR FILE REF.

IN REPLY TO AUG 2 8 1973

SUBJECT:

40I14-35
GEOCRES No.

FOUNDATION INVESTIGATION REPORT
For
Proposed Crossing at St. Thomas
Expressway and County Road #52
Twp. of Southwold, Co. of Elgin
District #2 (London)
W.O. 73-11021 -- W.P. 89-69-07

Attached we are forwarding to you our detailed foundation investigation report on the subsoil conditions existing at the above-mentioned site.

We believe that the factual data and recommendations contained therein will prove adequate for your design requirements. Should additional information be required, please do not hesitate to contact our Office.

A. G. Stermac,
PRINCIPAL FOUNDATIONS ENGINEER.

AGS/ao
Attch.
c.c. E. J. Orr
B. R. Davis
A. Rutka
A. Wittenberg
L. E. Walker
B. J. Giroux
J. R. Roy
G. A. Wrong
B. A. Singh

Foundations Files ✓
Documents

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 1

JOB 73-11021
W.P. 89-69-07
DATUM Geodetic

LOCATION Co-ords. 15,556,624 N; 1,340,915 E.
BORING DATE May 18, 1973
BOREHOLE TYPE Hollow Stem Auger & Cone

ORIGINATED BY LJH
COMPILED BY LJH
CHECKED BY [illegible]

ELEV. / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	REMARKS (GR.SA.SI.CL.)
777.7	Ground Level					
0.0						
	Brown / Grey	1	SS	27		0 13 47 40
					770	
		2	SS	27		
		3	SS	36		
	Clayey silt to silty				760	
	clay, some sand,	4	SS	33		4 15 48 33
	traces of gravel.					
	Occasional thin seams	5	SS	33		
					750	
	or pockets of silt.	6	SS	43		
	Very Stiff to Hard	7	SS	33		
					740	
		8	SS	31		
		9	SS	30		
					730	
		10	SS	40		
		11	SS	26		Hole Dry
					720	
716.2		12	SS	24		1 19 45 35
61.5	End of Borehole					
					710	

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 20 40 60 80 100
SHEAR STRENGTH P.S.F. o UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE
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 10 % STRAIN AT FAILURE

OFFICE REPORT SOIL EXPLORATION

777-3

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

DESIGN SERVICES BRANCH | FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 2

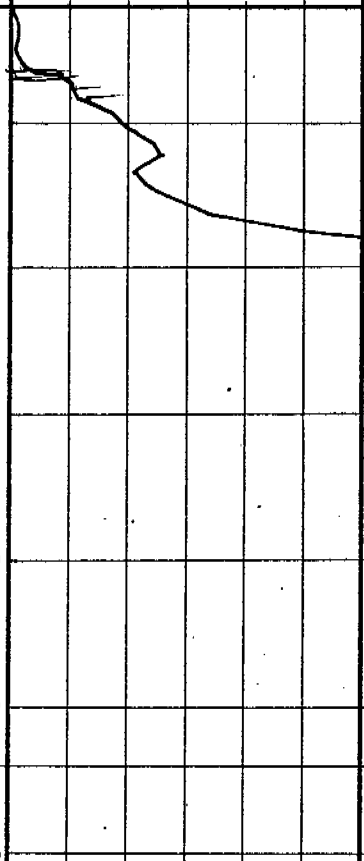
JOB 73-11021
W.P. 89-69-01
DATUM Geodetic

LOCATION Co-ords. 15,556,715 N; 1,340,955 E.
BORING DATE May 18, 1973
BOREHOLE TYPE Hollow Stem Auger & Cone

ORIGINATED BY LJH
COMPILED BY LJH
CHECKED BY MC

ELEV. DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	WATER CONTENT % (W_P – w – W_L)	REMARKS GR.SA.SI.CL.
777.8	Ground Level						
	Brown / Grey	1	SS	31			
					770		
	Clayey silt to silty clay, some sand, traces of gravel. Occasional thin seams or pockets of silt.	2	SS	26		o–I–I	3 10 54 33
		3	SS	27			
					760		
		4	SS	25			
		5	SS	26		o–I–I	
					750		
		6	SS	25			
	Very Stiff to Hard	7	SS	36			
					740		
		8	SS	37		o–I–I	0 9 55 36
		9	SS	36			
					730		Hole Dry
726.3		10	SS	45			
51.5	End of Borehole						
					720		

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 20 40 60 80 100
SHEAR STRENGTH P.S.F. o UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE



LIQUID LIMIT — W_L; PLASTIC LIMIT — W_P; WATER CONTENT — w; WATER CONTENT % 10 20 30

BULK DENSITY γ P.C.F.

STRAT. PLOT

20 / 15 ◇ 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT — SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 3

JOB 73-11021
W.P. 89-69-07
DATUM GEODETIC

LOCATION Co-ords. 15,556,767 N; 1,341,045 E
BORING DATE May 22, 1973
BOREHOLE TYPE HOLLOW STEM AUGER AND CONE

ORIGINATED BY L.J.H.
COMPILED BY L.J.H.
CHECKED BY [illegible]

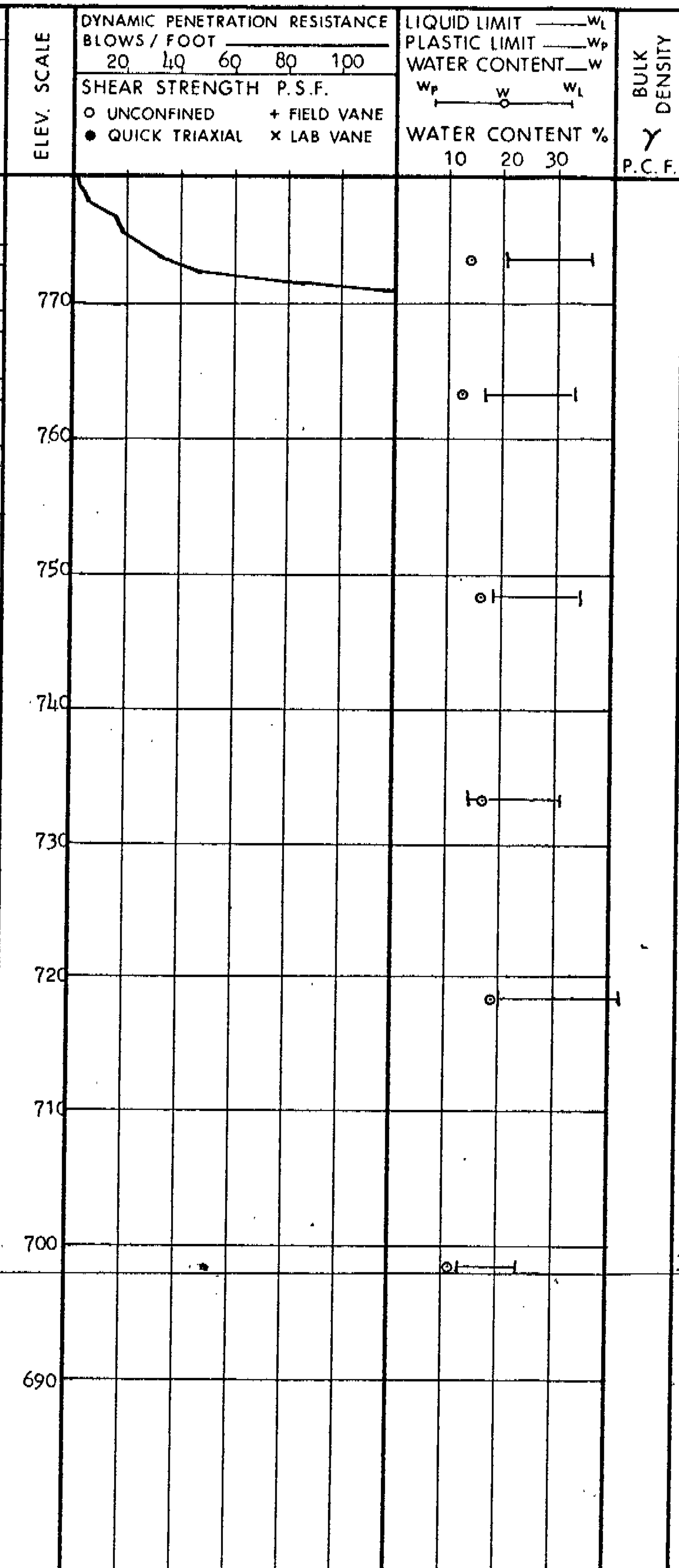
SOIL PROFILE

ELEV. / DEPTH	DESCRIPTION
779.3	GROUND LEVEL
0.0	Brown / Grey. Clayey silt to silty clay, some sand, traces of gravel; occasional thin seams or pockets of silt. Very Stiff to Hard
697.8 / 81.5	END OF BOREHOLE

SAMPLES

NUMBER	TYPE	BLOWS/FOOT	REMARKS (GR. SA. SI. CL.)
1	SS	45	2 31 53 32
2	SS	48	
3	SS	31	1 18 47 34
4	SS	25	
5	SS	15	
6	SS	26	
7	SS	43	
8	SS	26	
9	SS	26	3 9 56 32
10	SS	19	
11	SS	18	
12	SS	27	
13	SS	26	
14	SS	30	3 32 40 25

REMARKS: HOLE DRY.



15 ◇ 5 (20 / 10) % STRAIN AT FAILURE

OFFICE REPORT — SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 4

JOB 73-11021

W.P. 89-69-07

DATUM GEODETIC

LOCATION Co-ords. 15,556,642N; 1,340,891E

BORING DATE May 22, 1973

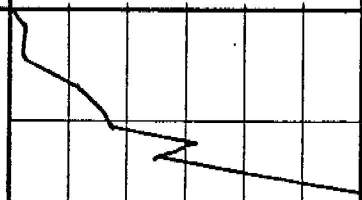
BOREHOLE TYPE CONE TEST

ORIGINATED BY L.J.H.

COMPILED BY L.J.H.

CHECKED BY [signature]

SOIL PROFILE: ELEV. / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 20 40 60 80 100; SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	LIQUID LIMIT — W_L; PLASTIC LIMIT — W_P; WATER CONTENT — W; W_P W W_L; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
777.3	GROUND LEVEL									
0.0						770				
764.0 / 13.0	END OF CONE TEST					760				



20 / 15 ⌖ 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 5

JOB 73-11021

W.P. 89-69-07

DATUM GEODETIC

LOCATION Co-ords. 15556694.38N; 1340978.19E

BORING DATE May 22, 1973

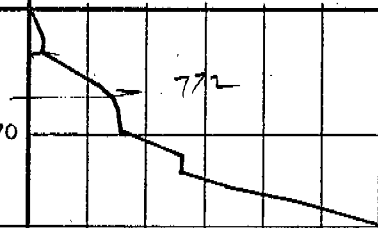
BOREHOLE TYPE CONE TEST

ORIGINATED BY L.J.H.

COMPILED BY L.J.H.

CHECKED BY [illegible]

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 20 40 60 80 100; SHEAR STRENGTH P.S.F. o UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	LIQUID LIMIT —W_L PLASTIC LIMIT —W_P WATER CONTENT —W; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL
ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT					
778.2	GROUND LEVEL									
0.0						770				
763.3 / 14.9	END OF CONE TEST					760				



20
15 ⌖ 5 % STRAIN AT FAILURE
10

OFFICE REPORT – SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

DESIGN SERVICES BRANCH | FOUNDATIONS OFFICE

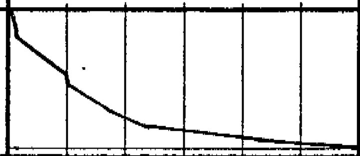
RECORD OF BOREHOLE Nº 6

JOB 73-11021
W.P. 89-69-07
DATUM GEODETIC

LOCATION Co-ords. 15556788.65N; 1341022.06E
BORING DATE May 18, 1973
BOREHOLE TYPE CONE TEST

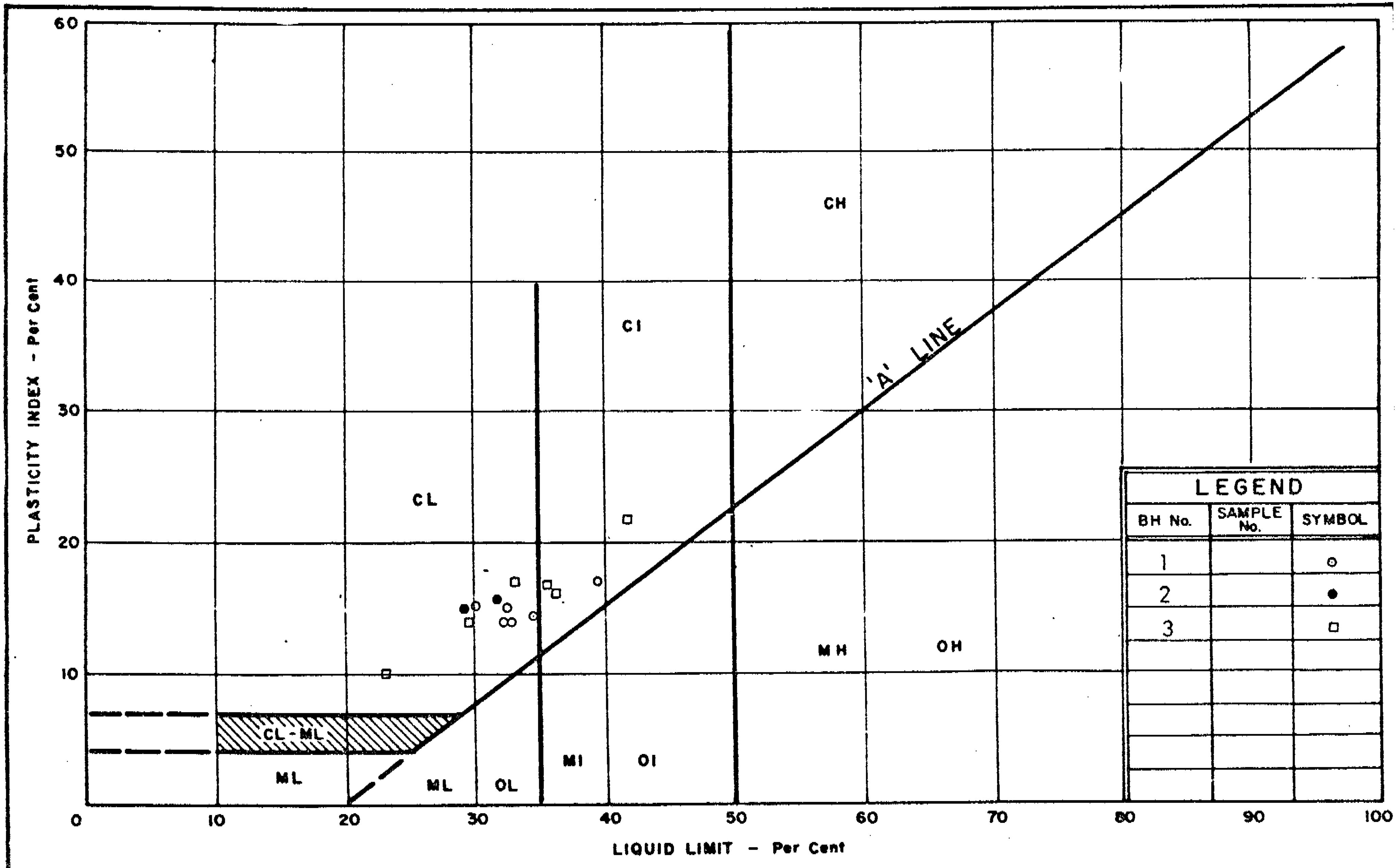
ORIGINATED BY L.J.H.
COMPILED BY L.J.H.
CHECKED BY [illegible]

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 20 40 60 80 100; SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	LIQUID LIMIT — W_L; PLASTIC LIMIT — W_P; WATER CONTENT — W; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT					
779.4	GROUND LEVEL									
768.5 / 10.9	END OF CONE TEST					770				
						760				



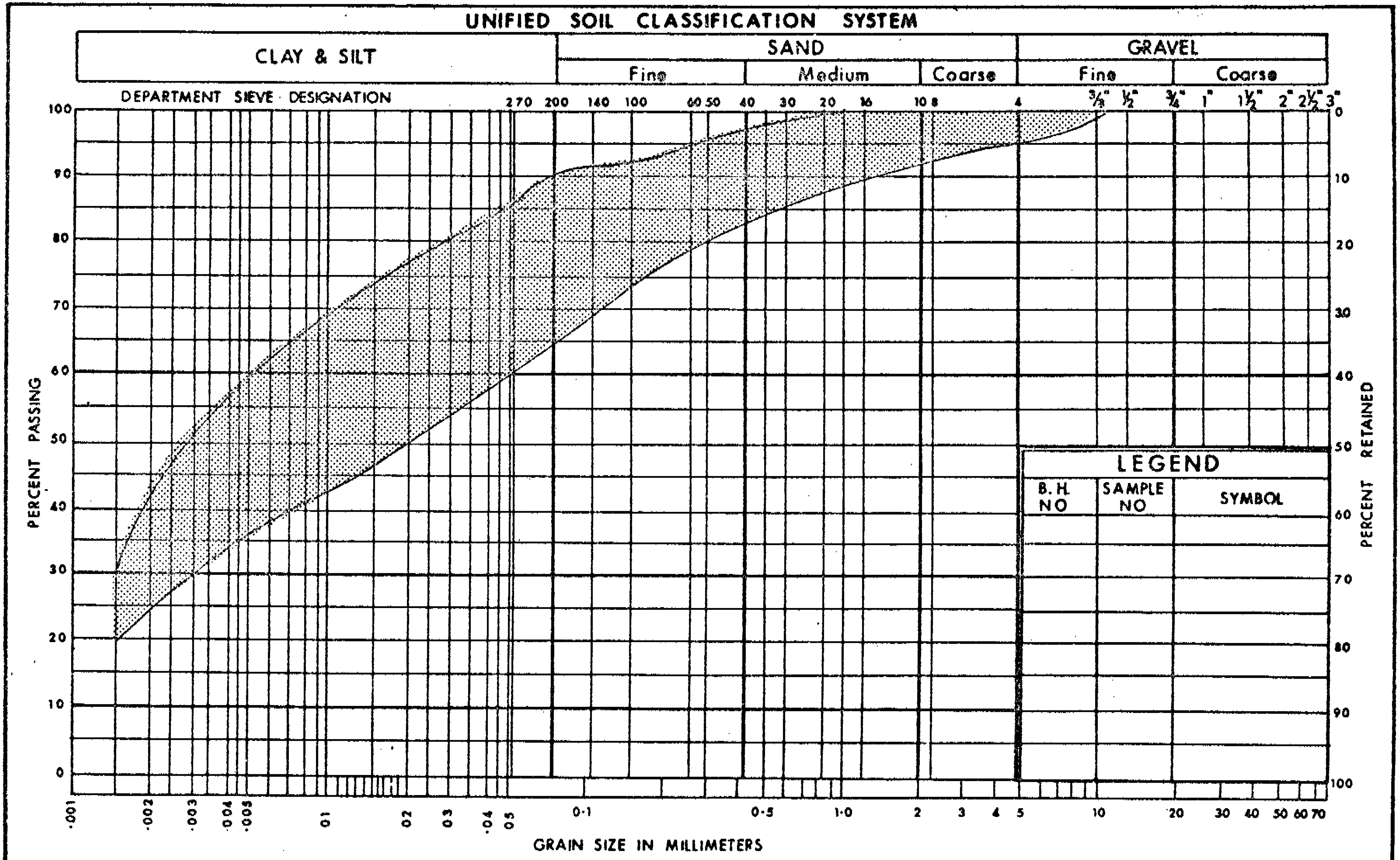
15 ◇ 5 (20 / 10) % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

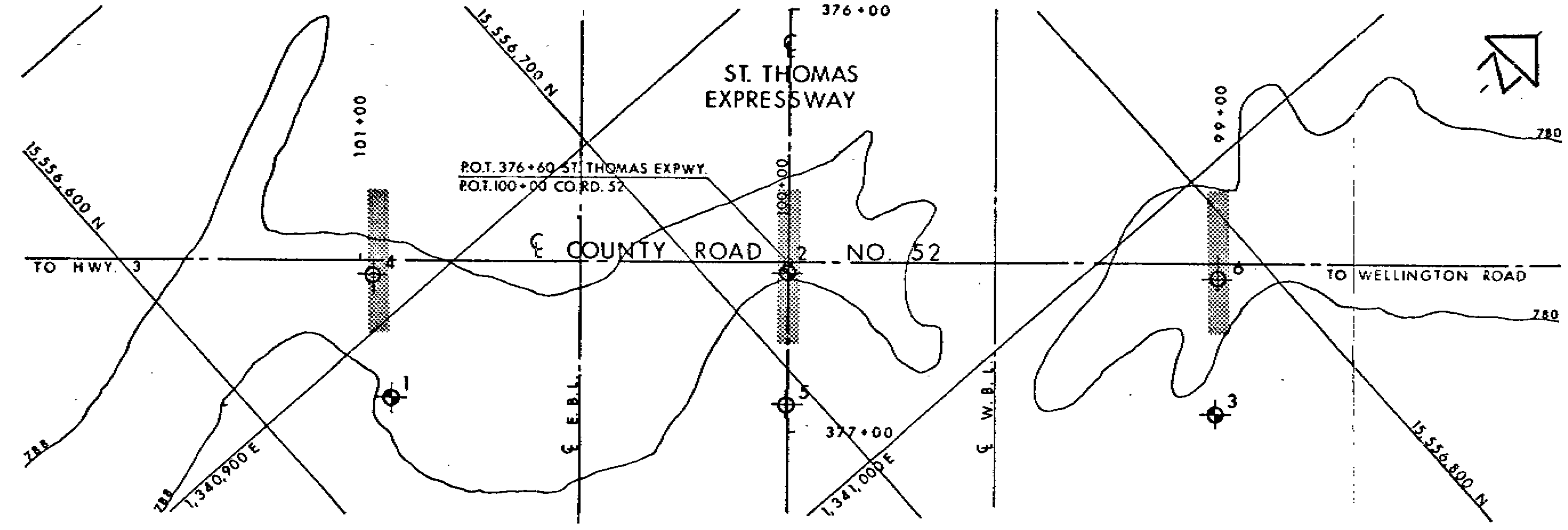


DEPARTMENT OF HIGHWAYS MATERIALS and TESTING DIVISION	PLASTICITY CHART CLAYEY SILT TO SILTY CLAY	W.P. No. 89-69-07 JOB No. 73-11021 FIG. 1

FORM OD-MT-17
REV. AUG. 197

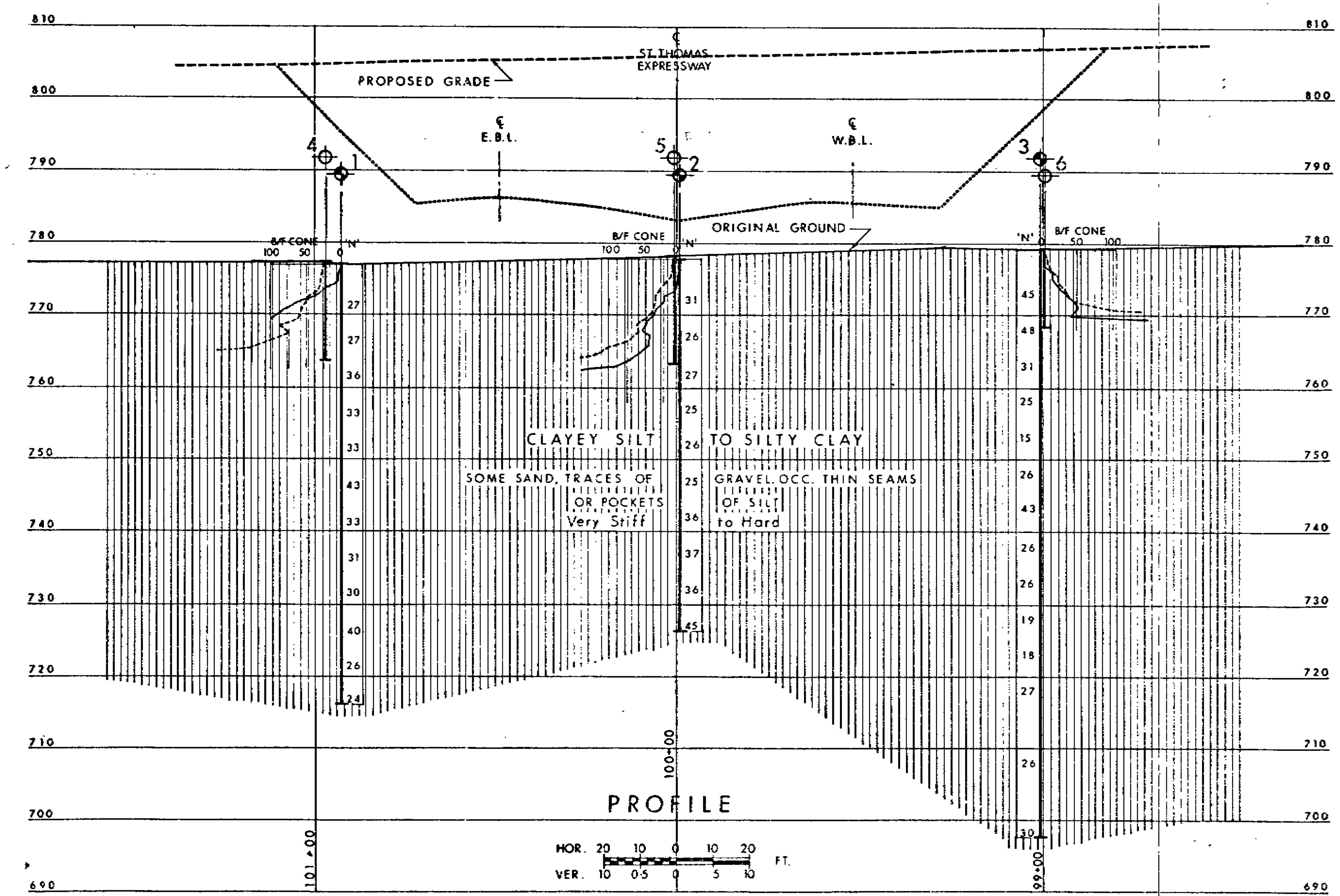


DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS ONTARIO DESIGN SERVICES BRANCH	**GRAIN SIZE DISTRIBUTION** CLAYEY SILT TO SILTY CLAY	W.P. No. 89-69-07 JOB No. 73-11021 FIG.2



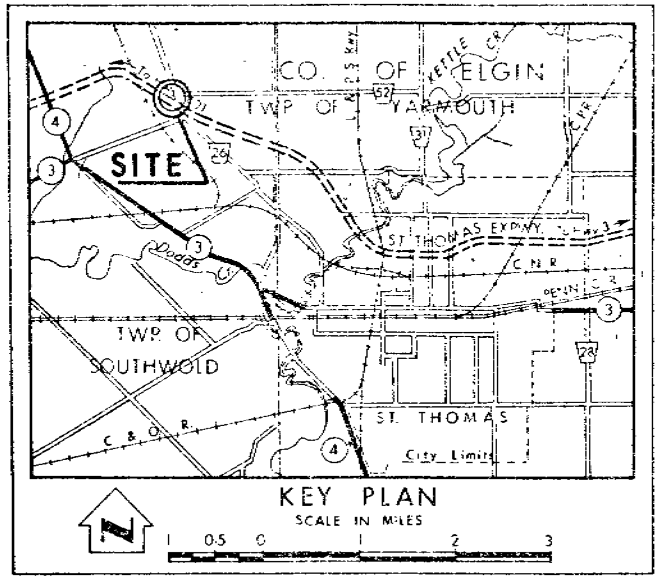
PLAN

20 10 0 10 20 FT.



PROFILE

HOR. 20 10 0 10 20 FT.
VER. 10 05 0 5 10



KEY PLAN

SCALE IN MILES

LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation. Holes Dry May 1973

NO.	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
1	777·7	15,556,624	1,340,915
2	777·8	15,556,715	1,340,955
3	779·3	15,556,767	1,341,045
4	777·3	15,556,642	1,340,891
5	778·2	15,556,694	1,340,978
6	779·4	15,556,789	1,341,022

— NOTE —

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

REVISIONS	DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
DESIGN SERVICES BRANCH—FOUNDATIONS OFFICE

COUNTY ROAD NO. 52

HIGHWAY NO PROP. ST. THOMAS EXPWY. DIST. NO. 2
CO. ELGIN
TWP. SOUTHWOLD LOT ____ CON ____

BORE HOLE LOCATIONS & SOIL STRATA

SUBM'D A. P.	CHECKED	W.P. NO. 89-69-47	DRAWING NO. 73-11021A
DRAWN OL. J.	CHECKED	W.O. NO. 73-11021	
DATE 20 AUG 1973		SITE NO.	BRIDGE DRAWING NO.
APPROVED (signature) PRINCIPAL FOUNDATION ENGINEER		CONT. NO.	

REF. No FENCO 3802-87-03

APPENDIX C

C.1 SYMBOLS AND TERMS USED ON BOREHOLE RECORDS

C.2 BOREHOLE RECORDS

C.3 SITE INVESTIGATION RESULTS, HIGHWAY 3 ST. THOMAS CPT

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

Rootmat	- vegetation, roots and moss with organic matter and topsoil typically forming a mattress at the ground surface
Topsoil	- mixture of soil and humus capable of supporting vegetative growth
Peat	- mixture of visible and invisible fragments of decayed organic matter
Till	- unstratified glacial deposit which may range from clay to boulders
Fill	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

Desiccated	- having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
Fissured	- having cracks, and hence a blocky structure
Varved	- composed of regular alternating layers of silt and clay
Stratified	- composed of alternating successions of different soil types, e.g. silt and sand
Layer	- > 75 mm in thickness
Seam	- 2 mm to 75 mm in thickness
Parting	- < 2 mm in thickness

Terminology describing soil types:
The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488) which excludes particles larger than 75 mm. For particles larger than 75 mm, and for defining percent clay fraction in hydrometer results, definitions proposed by Canadian Foundation Engineering Manual, 4th Edition are used. The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):
Terminology describing materials outside the USCS, (e.g. particles larger than 75 mm, visible organic matter, and construction debris) is based upon the proportion of these materials present:

Trace, or occasional	Less than 10%
Some	10-20%
Frequent	> 20%

Terminology describing compactness of cohesionless soils:
The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test (SPT) N-Value - also known as N-Index. The SPT N-Value is described further on page 3. A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
Very Loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very Dense	>50

Terminology describing consistency of cohesive soils:
The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests. Consistency may be crudely estimated from SPT N-Value based on the correlation shown in the following table (Terzaghi and Peck, 1967). The correlation to SPT N-Value is used with caution as it is only very approximate.

Consistency	Undrained Shear Strength		Approximate SPT N-Value
	kips/sq.ft.	kPa	
Very Soft	<0.25	<12.5	<2
Soft	0.25 - 0.5	12.5 - 25	2-4
Firm	0.5 - 1.0	25 - 50	4-8
Stiff	1.0 - 2.0	50 – 100	8-15
Very Stiff	2.0 - 4.0	100 - 200	15-30
Hard	>4.0	>200	>30

ROCK DESCRIPTION

Except where specified below, terminology for describing rock is as defined by the International Society for Rock Mechanics (ISRM) 2007 publication "The Complete ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 1974-2006"

Terminology describing rock quality:

RQD	Rock Mass Quality
0-25	*Very Poor Quality*
25-50	*Poor Quality*
50-75	*Fair Quality*
75-90	*Good Quality*
90-100	*Excellent Quality*

Alternate (Colloquial) Rock Mass Quality	
Very Severely Fractured	*Crushed*
Severely Fractured	*Shattered or Very Blocky*
Fractured	*Blocky*
Moderately Jointed	*Sound*
Intact	*Very Sound*

RQD (Rock Quality Designation) denotes the percentage of intact and sound rock retrieved from a borehole of any orientation. All pieces of intact and sound rock core equal to or greater than 100 mm (4 in.) long are summed and divided by the total length of the core run. RQD is determined in accordance with ASTM D6032.

SCR (Solid Core Recovery) denotes the percentage of solid core (cylindrical) retrieved from a borehole of any orientation. All pieces of solid (cylindrical) core are summed and divided by the total length of the core run (It excludes all portions of core pieces that are not fully cylindrical as well as crushed or rubble zones).

Fracture Index (FI) is defined as the number of naturally occurring fractures within a given length of core. The Fracture Index is reported as a simple count of natural occurring fractures.

Terminology describing rock with respect to discontinuity and bedding spacing:

Spacing (mm)	Discontinuities	Bedding
>6000	*Extremely Wide*	-
2000-6000	*Very Wide*	*Very Thick*
600-2000	*Wide*	*Thick*
200-600	*Moderate*	*Medium*
60-200	*Close*	*Thin*
20-60	*Very Close*	*Very Thin*
<20	*Extremely Close*	*Laminated*
<6	-	*Thinly Laminated*

Terminology describing rock strength:

Strength Classification	Grade	Unconfined Compressive Strength (MPa)
Extremely Weak	R0	<1
Very Weak	R1	1 – 5
Weak	R2	5 – 25
Medium Strong	R3	25 – 50
Strong	R4	50 – 100
Very Strong	R5	100 – 250
Extremely Strong	R6	>250

Terminology describing rock weathering:

Term	Symbol	Description
Fresh	W1	No visible signs of rock weathering. Slight discoloration along major discontinuities
Slightly	W2	Discoloration indicates weathering of rock on discontinuity surfaces. All the rock material may be discolored.
Moderately	W3	Less than half the rock is decomposed and/or disintegrated into soil.
Highly	W4	More than half the rock is decomposed and/or disintegrated into soil.
Completely	W5	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
Residual Soil	W6	All the rock converted to soil. Structure and fabric destroyed.

STRATA PLOT

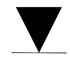
Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.

Boulders Cobbles Gravel	Sand	Silt	Clay	Organics	Asphalt	Concrete	Fill	Igneous Bedrock	Meta-morphic Bedrock	Sedi-mentary Bedrock

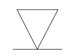
SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

WATER LEVEL MEASUREMENT



measured in standpipe, piezometer, or well



inferred

RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

N-VALUE

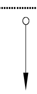
Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (63.5 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (300 mm) into the soil. In accordance with ASTM D1586, the N-Value equals the sum of the number of blows (N) required to drive the sampler over the interval of 6 to 18 in. (150 to 450 mm). However, when a 24 in. (610 mm) sampler is used, the number of blows (N) required to drive the sampler over the interval of 12 to 24 in. (300 to 610 mm) may be reported if this value is lower. For split spoon samples where insufficient penetration was achieved and N-Values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N-values corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to 'A' size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (300 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
γ	Unit weight
G_s	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
Q_U	Unconfined compression
I_p	Point Load Index (I_p on Borehole Record equals $I_p(50)$ in which the index is corrected to a reference diameter of 50 mm)

	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer

Ministry of Transportation Ontario

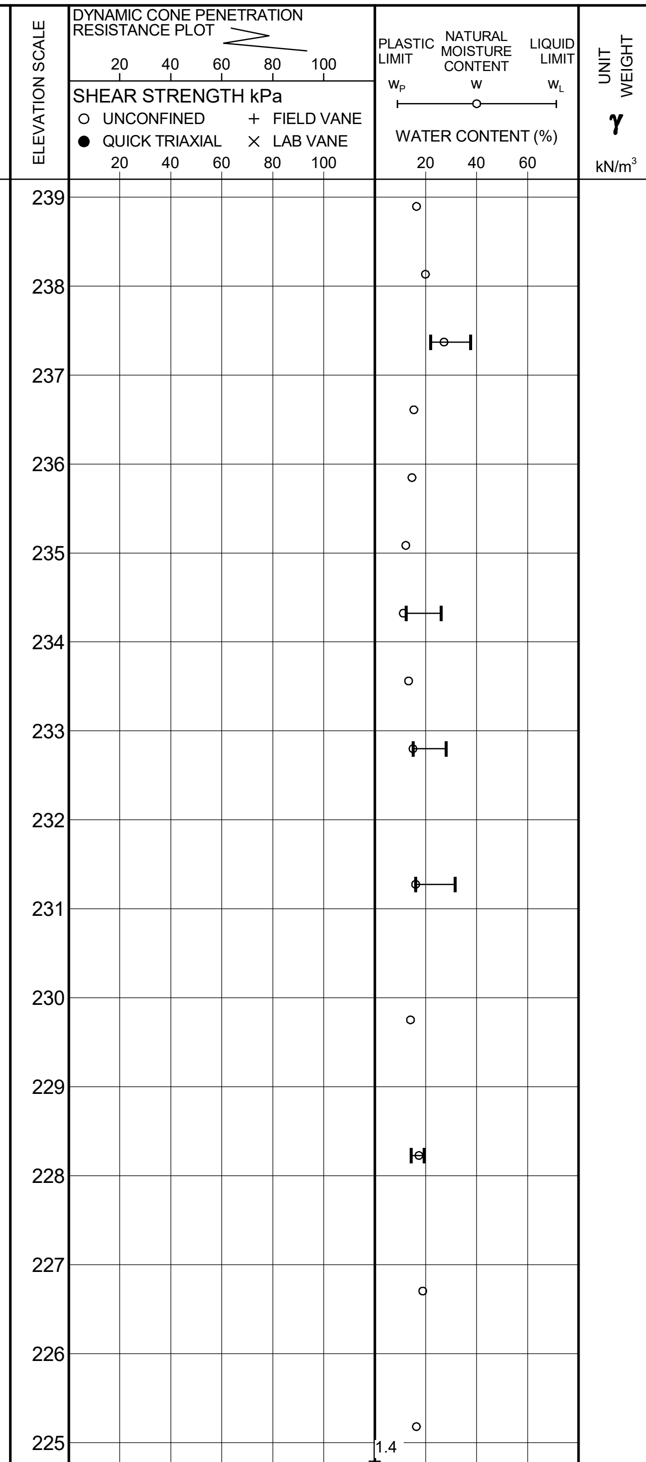
Foundation Design

RECORD OF BOREHOLE No RMN-A1

METRIC

W.P. 3041-22-00	LOCATION Ron McNeil Line Underpass, Southwold, Ontario N:4741937.4 E:408801.5		ORIGINATED BY MC
DIST West HWY Hwy 3	BOREHOLE TYPE Hollow Stem Auger		COMPILED BY KL
DATUM Geodetic	DATE 2024.06.25 - 2024.06.25	LATITUDE 42.810131 LONGITUDE -81.228339	CHECKED BY RR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
239.2	Gravel Shoulder				
239.2 / 0.0	SILTY SAND to SAND, trace gravel (FILL) Compact Brown Moist	1	SS	13	
238.9 / 0.3	SILTY CLAY, trace to some sand, trace gravel (FILL) Soft to stiff Brown to black Moist	2	SS	4	
		3	SS	5	1 12 59 29
236.9 / 2.3	CLAYEY SILT (CL), some sand to sandy, trace gravel (TILL) Stiff to very stiff Brown to grey Moist	4	SS	9	PP > 4.5 TSF
		5	SS	16	PP > 4.5 TSF
	Grey below 3.8 m	6	SS	19	PP > 4.5 TSF
		7	SS	20	9 21 41 29 PP = 4.25 TSF
		8	SS	14	
		9	TW	PH	Consolidation Test
		10	SS	19	1 10 40 48 PP = 4.5 TSF
		11	SS	15	
229.0 / 10.2	CLAYEY SILT (CL-ML), trace sand Hard Grey Moist	12	SS	44	0 2 72 26
227.5 / 11.7	CLAYEY SILT (CL), trace to some sand, trace gravel (TILL) Stiff Grey Moist	13	SS	14	PP = 3.0 TSF
		14	SS	11	PP = 1.5 TSF Su=170 kPa (B-Vane)
224.7 / 14.5	END OF BOREHOLE Borehole open and dry upon completion of drilling.				



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

RECORD OF BOREHOLE No RMN-A2

METRIC

W.P. 3041-22-00 LOCATION Ron McNeil Line Underpass, Southwold, Ontario N:4741843.9 E:408703.6 ORIGINATED BY MC

DIST West HWY Hwy 3 BOREHOLE TYPE Hollow Stem Auger COMPILED BY KL

DATUM Geodetic DATE 2024.06.24 - 2024.06.24 LATITUDE 42.809303 LONGITUDE -81.229552 CHECKED BY RR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
237.2	Grass				
236.9 / 0.0	300 mm TOPSOIL	1	SS	5	
0.3	SANDY, CLAYEY SILT, trace gravel (FILL) Soft to firm Brown to grey Moist	2	SS	4	
235.7 / 1.5	CLAYEY SILT (CL), some sand, trace gravel (TILL) Firm to stiff Brown to grey Moist Grey below 2.3 m	3	SS	8	
		4	SS	16	9 15 40 36
		5	SS	16	
		6	SS	14	PP > 4.5 TSF
		7	TW	PH	Consolidation Test
		8	SS	16	4 16 43 37 PP > 4.5 TSF
		9	SS	17	
		10	SS	18	PP = 4.25 TSF
		11	SS	17	PP = 4.25 TSF
		12	SS	19	PP = 4.25 TSF
		13	SS	15	7 17 44 33 PP = 3.5 TSF
224.4 / 12.8	END OF BOREHOLE Borehole open and dry upon completion of drilling.				

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (237 to 225); 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

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

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Ontario

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RECORD OF BOREHOLE No RMN-UP1

METRIC

W.P. 3041-22-00	LOCATION Ron McNeil Line Underpass, Southwold, Ontario N:4741914.1 E:408760.6		ORIGINATED BY HS
DIST West HWY Hwy 3	BOREHOLE TYPE Hollow Stem Auger/Wash Boring		COMPILED BY KL
DATUM Geodetic	DATE 2024.05.28 - 2024.07.04 LATITUDE 42.809927	LONGITUDE -81.228843	CHECKED BY RR

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
237.6	Grass
237.4 / 0.0	200 mm TOPSOIL
0.2	CLAYEY SILT (CL), some sand, trace gravel (TILL) Very stiff to hard Brown to grey Moist Grey below 3.0 m
230.4 / 7.2	CLAYEY SILT (CL-ML), trace sand Hard Grey Moist
226.8 / 10.8	CLAYEY SILT (CL), trace to some sand, trace gravel (TILL) Very stiff Grey Moist
220.6	

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SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS	GR	SA	SI	CL
1	SS	7					
2	SS	19		2	12	42	43
3	SS	26					
4	SS	23	PP = 4.5 TSF Wash Boring below 3.0m				
5	SS	24	PP = 4.5 TSF				
6	SS	33	PP = 4.5 TSF				
7	SS	25	PP = 4.5 TSF	1	16	47	35
8	SS	22	PP = 4.0 TSF				
9	SS	26	PP = 4.0 TSF				
10	SS	45					
11	SS	63		0	2	74	24
12	SS	27					
13	SS	26	PP = 1.0 TSF				
14	SS	20	PP = 1.0 TSF				
15	SS	17	PP = 1.0 TSF				
15A	TW	PH					

Columns: STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (237, 236, 235, 234, 233, 232, 231, 230, 229, 228, 227, 226, 225, 224, 223, 222, 221); 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/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL.

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

RECORD OF BOREHOLE No RMN-UP1

METRIC

W.P. 3041-22-00
LOCATION Ron McNeil Line Underpass, Southwold, Ontario N:4741914.1 E:408760.6
ORIGINATED BY HS
DIST West HWY Hwy 3
BOREHOLE TYPE Hollow Stem Auger/Wash Boring
COMPILED BY KL
DATUM Geodetic
DATE 2024.05.28 - 2024.07.04
LATITUDE 42.809927
LONGITUDE -81.228843
CHECKED BY RR

SOIL PROFILE: 17.0 to 203.6 — CLAYEY SILT (CL), trace to some sand, trace gravel (TILL). Very stiff to hard. Grey. Moist.

Sample Number	Type	"N" Values	Remarks (GR SA SI CL)
16	SS	18	PP = 1.0 TSF
17	SS	17	1 13 42 43; PP = 1.0 TSF
18	SS	16	PP = 1.0 TSF
19	SS	23	PP = 1.0 TSF
20	SS	24	PP = 1.0 TSF
21	SS	30	3 5 42 50; PP = 1.0 TSF
22	SS	27	PP = 1.0 TSF

Elevation scale: 220, 219, 218, 217, 216, 215, 214, 213, 212, 211, 210, 209, 208, 207, 206, 205, 204

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/m^3

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

RECORD OF BOREHOLE No RMN-UP1

METRIC

W.P. 3041-22-00	LOCATION Ron McNeil Line Underpass, Southwold, Ontario N:4741914.1 E:408760.6		ORIGINATED BY HS
DIST West HWY Hwy 3	BOREHOLE TYPE Hollow Stem Auger/Wash Boring		COMPILED BY KL
DATUM Geodetic	DATE 2024.05.28 - 2024.07.04	LATITUDE 42.809927 LONGITUDE -81.228843	CHECKED BY RR

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
34.0	CLAYEY SILT (CL), sandy to some sand, trace gravel (TILL) Hard Grey Moist					203	
		23	SS	31		202	PP = 1.0 TSF
		24	SS	36		199	
		25	SS	31		196	
193.0		26	SS	173/250		193	3 27 43 27
44.6	END OF BOREHOLE Borehole dry upon commencement of mud drilling at 3 m below grade.						

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

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

Ministry of Transportation Ontario

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RECORD OF BOREHOLE No RMN-UP2

METRIC

W.P. 3041-22-00 | LOCATION Ron McNeil Line Underpass, Southwold, Ontario N:4741885.4 E:408747.7 | ORIGINATED BY MC/HS

DIST West HWY Hwy 3 | BOREHOLE TYPE Hollow Stem Auger/Wash Boring | COMPILED BY KL

DATUM Geodetic | DATE 2024.06.14 - 2024.06.28 | LATITUDE 42.80967 | LONGITUDE -81.229006 | CHECKED BY RR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
237.6	Grass						
237.4 / 0.0	200 mm TOPSOIL	1	SS	8			
0.2	CLAYEY SILT (CL), trace to some sand, trace to some gravel (TILL) Stiff to hard Brown to grey Moist	2	SS	21	237		
		3	SS	35	236		
		4	SS	28	235		3 14 45 38
		5	SS	25			Wash Boring below 3.0m
	Grey below 3.8 m	6	SS	20	234		PP = 4.5 TSF
		7	SS	15	233		15 6 44 35; PP = 3.25 TSF
		8	TW	PH	232	Unconfined: 15.0% strain at failure	Consolidation Test
		9	SS	13	231		PP = 1.75 TSF
		10	SS	18	230		PP = 1.0 TSF
228.9 / 8.7	CLAYEY SILT (CL-ML), trace sand, trace to some gravel Hard Grey Moist	11	SS	44	229 / 228		10 9 54 28
227.9 / 9.7	CLAYEY SILT (CL), trace to some sand, trace gravel (TILL) Very stiff to hard Grey Moist	12	SS	30	227		PP = 4.5 TSF
		13	SS	30	226 / 225		PP = 1.5 TSF
	SS14 contains a layer of fine sand	14	SS	19	224		
		15	SS	25	223 / 222		PP = 1.5 TSF
220.6					221		

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Chart axes: 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

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

RECORD OF BOREHOLE No RMN-UP2

METRIC

W.P. 3041-22-00	LOCATION Ron McNeil Line Underpass, Southwold, Ontario N:4741885.4 E:408747.7		ORIGINATED BY MC/HS
DIST West HWY Hwy 3	BOREHOLE TYPE Hollow Stem Auger/Wash Boring		COMPILED BY KL
DATUM Geodetic	DATE 2024.06.14 - 2024.06.28 LATITUDE 42.80967	LONGITUDE -81.229006	CHECKED BY RR

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%) / SHEAR STRENGTH	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
17.0	CLAYEY SILT (CL), trace to some sand, trace gravel (TILL) Stiff to very stiff Grey Moist	16	SS	9			w ≈ 25	PP = 0.5 TSF
						220	Field vane 2.7	Su = 180 kPa (B-Vane)
		17	SS	27		219	wP–wL plotted	1 5 42 53
		18	SS	23		218		PP = 0.5 TSF
						217		
						216		
						215		
		19	SS	20		214		PP = 0.5 TSF
						213		
						212		
		20	SS	21		211		PP = 1.0 TSF
						210		
						209		
		21	SS	25		208		PP = 1.0 TSF
						207		
						206		
		22	SS	29		205	wP–wL plotted	1 8 47 44 PP = 1.0 TSF
203.6						204		

Continued Next Page

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No RMN-UP2

METRIC

W.P. 3041-22-00 LOCATION Ron McNeil Line Underpass, Southwold, Ontario N:4741885.4 E:408747.7 ORIGINATED BY MC/HS

DIST West HWY Hwy 3 BOREHOLE TYPE Hollow Stem Auger/Wash Boring COMPILED BY KL

DATUM Geodetic DATE 2024.06.14 - 2024.06.28 LATITUDE 42.80967 LONGITUDE -81.229006 CHECKED BY RR

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
34.0	CLAYEY SILT (CL), sandy to some sand, trace gravel (TILL) Very stiff to hard Grey Moist				203		
		23	SS	29	202	~20	PP = 0.5 TSF
					201		
					200		
	Inferred cobbles/boulder based on auger grinding at 37.8 m	24	SS	28	199	~19	PP = 2.0 TSF
					198		
					197		
		25	SS	23	196	~20	PP = 0.5 TSF
					195		
					194		
192.8		26	SS	94	193	~12 (with plastic/liquid limits)	6 28 44 22 PP = 3.0 TSF
44.8	END OF BOREHOLE						

Monitoring well installed in borehole, screened from approximately 4.6 m to 7.6 m below grade.

Groundwater recorded in the monitoring well at approximately 5.8 m below grade (~ EL. 231.8 m) on September 11, 2024.

Legend: SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE. DYNAMIC CONE PENETRATION RESISTANCE PLOT. PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L. UNIT WEIGHT γ kN/m³.

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

RECORD OF BOREHOLE No RMN-UP3

METRIC

W.P. 3041-22-00	LOCATION Ron McNeil Line Underpass, Southwold, Ontario N:4741861.5 E:408721.2		ORIGINATED BY MC
DIST West HWY Hwy 3	BOREHOLE TYPE Hollow Stem Auger/Wash Boring		COMPILED BY KL
DATUM Geodetic	DATE 2024.06.11 - 2024.06.14	LATITUDE 42.809459 LONGITUDE -81.229334	CHECKED BY RR

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
237.0	Grass
236.8 / 0.0	230 mm TOPSOIL
0.2	SANDY, CLAYEY SILT, trace gravel (TILL) Very soft to stiff Brown to grey Moist
235.5 / 1.5	CLAYEY SILT (CL), some sand, trace gravel (TILL) Stiff to hard Brown to grey Moist Inferred cobbles/boulder based on auger grinding between 1.8 m and 2.1 m Grey below 3.8 m Inferred cobbles/boulder based on auger grinding at 6.9 m
220.0	

Continued Next Page

SAMPLES

NUMBER	TYPE	"N" VALUES	ELEVATION SCALE (approx.)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	9		
2	SS	2	236	
3	SS	15	235	1 9 50 40
4	SS	76		
5	SS	26	234	Wash Boring below 3.0m
6	SS	18	233	
7	SS	26	232	
8	SS	25	231	
9	SS	36	230	2 11 52 35
10	SS	28	229	
11	SS	27	228–227	PP = 4.5 TSF
12	SS	28	226	2 15 45 38 PP = 4.0 TSF
13	SS	42	225–224	PP = 4.5 TSF
14	SS	26	223	PP = 3.25 TSF
15	SS	31	222–221	PP = 2.75 TSF

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

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No RMN-UP3

METRIC

W.P. 3041-22-00	LOCATION Ron McNeil Line Underpass, Southwold, Ontario N:4741861.5 E:408721.2		ORIGINATED BY MC
DIST West HWY Hwy 3	BOREHOLE TYPE Hollow Stem Auger/Wash Boring		COMPILED BY KL
DATUM Geodetic	DATE 2024.06.11 - 2024.06.14	LATITUDE 42.809459 LONGITUDE -81.229334	CHECKED BY RR

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

17.0 — CLAYEY SILT (CL), trace to some sand, trace gravel (TILL)
Very stiff to hard
Grey
Moist

Inferred cobbles/boulder based on auger grinding at 32.9 m

203.0

Elevation scale: 219, 218, 217, 216, 215, 214, 213, 212, 211, 210, 209, 208, 207, 206, 205, 204

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
16	SS	31	PP = 2.75 TSF
17	SS	21	1 12 40 47 PP = 1.75 TSF
18	SS	20	PP = 1.75 TSF
18A	TW	PH	
19	SS	30	PP = 2.25 TSF
20	SS	27	PP = 2.0 TSF
21	SS	32	1 5 45 49 PP = 2.25 TSF
22	SS	51	

Continued Next Page

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

RECORD OF BOREHOLE No RMN-UP3

METRIC

W.P. 3041-22-00 | LOCATION Ron McNeil Line Underpass, Southwold, Ontario N:4741861.5 E:408721.2 | ORIGINATED BY MC

DIST West HWY Hwy 3 | BOREHOLE TYPE Hollow Stem Auger/Wash Boring | COMPILED BY KL

DATUM Geodetic | DATE 2024.06.11 - 2024.06.14 | LATITUDE 42.809459 | LONGITUDE -81.229334 | CHECKED BY RR

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
34.0	CLAYEY SILT (CL), some sand, trace gravel (TILL) Hard Grey Moist						
						202	
		23	SS	44			PP = 1.0 TSF
						201	
						200	
						199	
		24	SS	50			PP = 2.25 TSF
						198	
	Inferred cobbles/boulder based on auger grinding at 39.0 m						
						197	
						196	
		25	SS	45			4 11 44 41 PP = 1.5 TSF
						195	
						194	
						193	
		26	SS	170			PP > 4.5 TSF
192.3 44.7	DCPT refusal at 44.7 m END OF BOREHOLE Borehole dry upon commencement of mud drilling at 3 m below grade.			100/80			

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

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

PRESENTATION OF SITE INVESTIGATION RESULTS

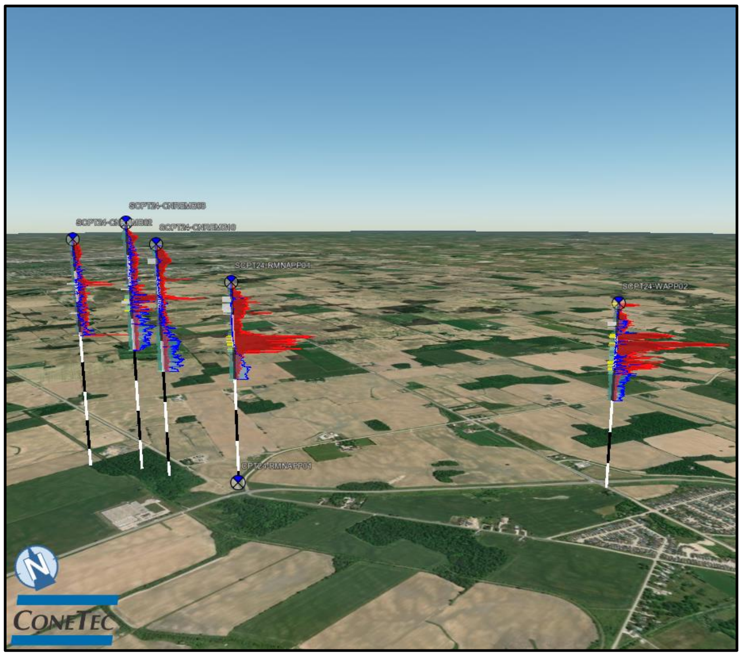
HWY 3 St Thomas CPT

Prepared for:

Stantec Consulting Ltd.

ConeTec Job No: 24-05-27609

Project Start Date: 2024-05-09
Project End Date: 2024-05-10
Report Date: 2024-05-24



Prepared by:

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www.conetecdataservices.com

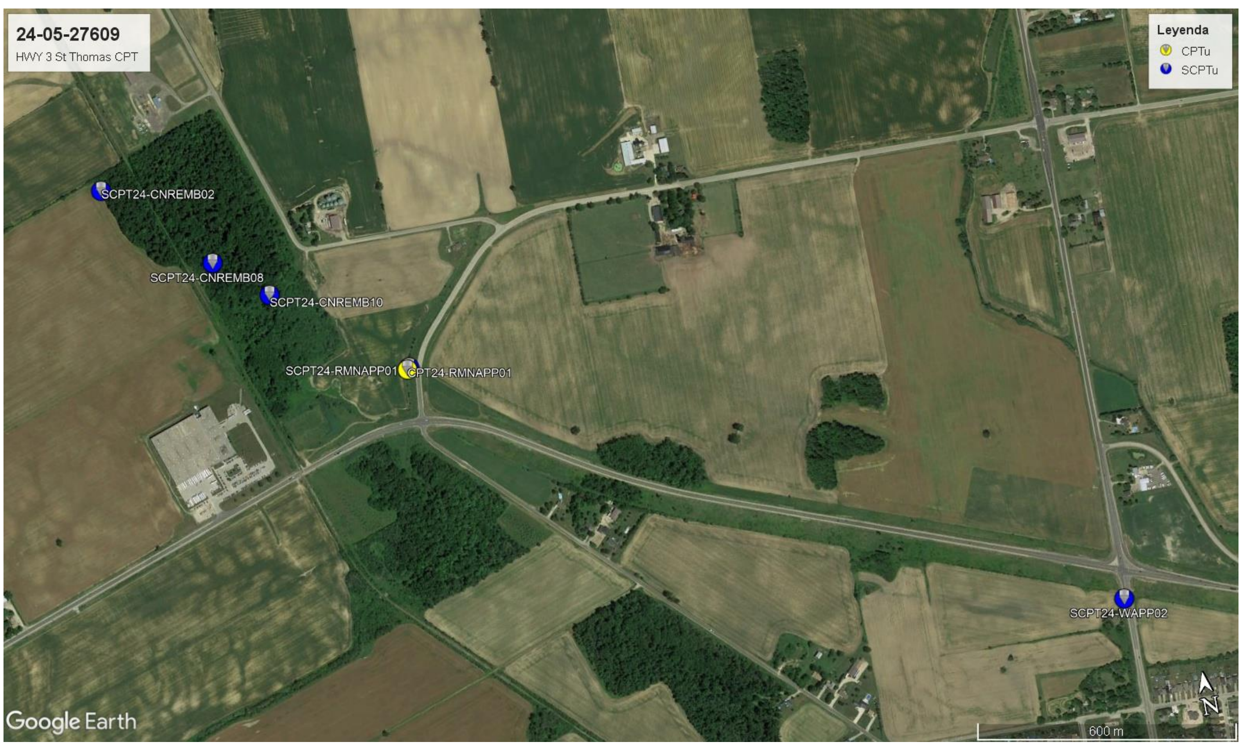
Introduction

The enclosed report presents the results of the site investigation program conducted by ConeTec Investigations Ltd. for Stantec Consulting Ltd. at HWY 3, St. Thomas, ON. The program consisted of 1 cone penetration test (CPTu) and 5 seismic cone penetration tests (SCPTu). Please note that this report, which also includes all accompanying data, are subject to the 3rd Party Disclaimer and Client Disclaimer that follow in the 'Limitations' section of this report.

Project Information

Project	
Client	Stantec Consulting Ltd.
Project	HWY 3 St Thomas CPT
ConeTec project number	24-05-27609

An aerial overview from Google Earth including the test locations is presented below.



Rig Description	Deployment System	Test Type
CPT track rig (TC23)	30 ton rig cylinder	CPTu, SCPTu

Coordinates		
Test Type	Collection Method	EPSG Number
CPTu, SCPTu	Consumer grade GPS	26917

Cone Penetrometers Used for this Project						
Cone Description	Cone Number	Cross Sectional Area (cm^2)	Sleeve Area (cm^2)	Tip Capacity (bar)	Sleeve Capacity (bar)	Pore Pressure Capacity (bar)
729:T1500F15U35	729	15	225	1500	15	35
Cone 729 was used for all CPTu soundings.						

Cone Penetration Test (CPTu)	
Depth reference	Depths are referenced to the existing ground surface at the time of each test.
Tip and sleeve data offset	0.1 meter This has been accounted for in the CPT data files.
Additional plots	• Advanced plots with Ic, Su, phi and N1(60)Ic • Seismic shear wave velocity plots • Soil Behaviour Type (SBT) scatter plots

Calculated Geotechnical Parameter Tables	
Additional information	The Normalized Soil Behaviour Type Chart based on Q_{tn} (SBT Q_{tn}) (Robertson, 2009) was used to classify the soil for this project. A detailed set of calculated CPTu parameters have been generated and are provided in Excel format files in the release folder. The CPTu parameter calculations are based on values of corrected tip resistance (q_t) sleeve friction (f_s) and pore pressure (u_2). Effective stresses are calculated based on unit weights that have been assigned to the individual soil behaviour type zones and hydrostatic conditions were assumed. Soils were classified as either drained or undrained based on the Qtn Normalized Soil Behaviour Type Chart (Robertson, 2009). Calculations for both drained and undrained parameters were included for materials that classified as silt mixtures (zone 4).

Limitations

3rd Party Disclaimer

This report titled “HWY 3 St Thomas CPT”, referred to as the (“Report”), was prepared by ConeTec for Stantec Consulting Ltd. The Report is confidential and may not be distributed to or relied upon by any third parties without the express written consent of ConeTec. Any third parties gaining access to the Report do not acquire any rights as a result of such access. Any use which a third party makes of the Report, or any reliance on or decisions made based on it, are the responsibility of such third parties. ConeTec accepts no responsibility for loss, damage and/or expense, if any, suffered by any third parties as a result of decisions made, or actions taken or not taken, which are in any way based on, or related to, the Report or any portion(s) thereof.

Client Disclaimer

ConeTec was retained by Stantec Consulting Ltd. to collect and provide the raw data (“Data”) which is included in this report titled “HWY 3 St Thomas CPT”, which is referred to as the (“Report”). ConeTec has collected and reported the Data in accordance with current industry standards. No other warranty, express or implied, with respect to the Data is made by ConeTec. In order to properly understand the Data included in the Report, reference must be made to the documents accompanying and other sources referenced in the Report in their entirety. Any analysis, interpretation, judgment, calculations and/or geotechnical parameters (collectively “Interpretations”) included in the Report, including those based on the Data, are outside the scope of ConeTec’s retainer and are included in the Report as a courtesy only. Other than the Data, the contents of the Report (including any Interpretations) should not be relied upon in any fashion without independent verification and ConeTec is in no way responsible for any loss, damage or expense resulting from the use of, and/or reliance on, such material by any party.

Cone penetration tests (CPTu) are conducted using an integrated electronic piezocone penetrometer and data acquisition system manufactured by Adara Systems Ltd., a subsidiary of ConeTec.

ConeTec's piezocone penetrometers are compression type designs in which the tip and friction sleeve load cells are independent and have separate load capacities. The piezocones use strain gauged load cells for tip and sleeve friction and a strain gauged diaphragm type transducer for recording pore pressure. The piezocones also have a platinum resistive temperature device (RTD) for monitoring the temperature of the sensors, an accelerometer type dual axis inclinometer and two geophone sensors for recording seismic signals. All signals are amplified and measured with minimum sixteen-bit resolution down hole within the cone body, and the signals are sent to the surface using a high bandwidth, error corrected digital interface through a shielded cable.

ConeTec penetrometers are manufactured with various tip, friction and pore pressure capacities in both 10 cm^2 and 15 cm^2 tip base area configurations in order to maximize signal resolution for various soil conditions. The specific piezocone used for each test is described in the CPT summary table presented in the first appendix. The 15 cm^2 penetrometers do not require friction reducers as they have a diameter larger than the deployment rods. The 10 cm^2 piezocones use a friction reducer consisting of a rod adapter extension behind the main cone body with an enlarged cross sectional area (typically 44 millimeters diameter over a length of 32 millimeters with tapered leading and trailing edges) located at a distance of 585 millimeters above the cone tip.

The penetrometers are designed with equal end area friction sleeves, a net end area ratio of 0.8 and cone tips with a 60 degree apex angle.

All ConeTec piezocones can record pore pressure at various locations. Unless otherwise noted, the pore pressure filter is located directly behind the cone tip in the "u_2" position (ASTM Type 2). The filter is six millimeters thick, made of porous plastic (polyethylene) having an average pore size of 125 microns (90-160 microns). The function of the filter is to allow rapid movements of extremely small volumes of water needed to activate the pressure transducer while preventing soil ingress or blockage.

The piezocone penetrometers are manufactured with dimensions, tolerances and sensor characteristics that are in general accordance with the current ASTM D5778 standard. ConeTec's calibration criteria also meets or exceeds those of the current ASTM D5778 standard. An illustration of the piezocone penetrometer is presented in Figure CPTu.

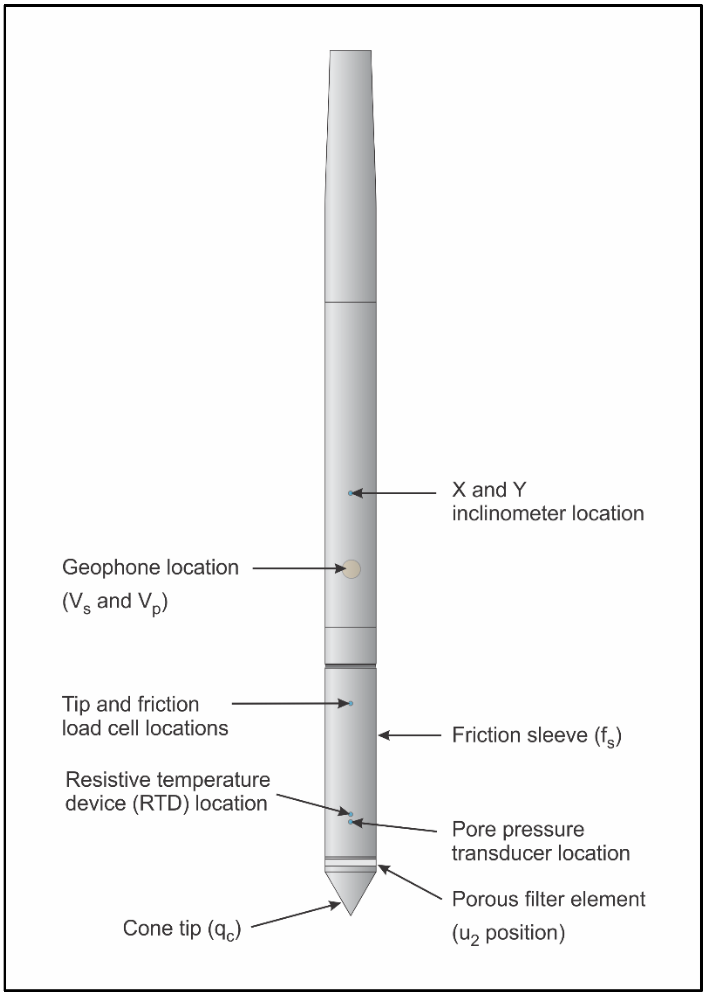


Figure CPTu. Piezocone Penetrometer (15 cm^2)

The ConeTec data acquisition systems consist of a Windows based computer and a signal interface box and power supply. The signal interface combines depth increment signals, seismic trigger signals and the downhole digital data. This combined data is then sent to the Windows based computer for collection and presentation. The data is recorded at fixed depth increments using a depth wheel attached to the push cylinders or by using a spring loaded rubber depth wheel that is held against the cone rods. The typical recording interval is 2.5 centimeters; custom recording intervals are possible.

The system displays the CPTu data in real time and records the following parameters to a storage media during penetration:

- Depth
- Uncorrected tip resistance (q_c)
- Sleeve friction (f_s)
- Dynamic pore pressure (u)
- Additional sensors such as resistivity, passive gamma, ultra violet induced fluorescence, if applicable

All testing is performed in accordance to ConeTec's CPTu operating procedures which are in general accordance with the current ASTM D5778 standard.

Prior to the start of a CPTu sounding a suitable cone is selected, the cone and data acquisition system are powered on, the pore pressure system is saturated with silicone oil and the baseline readings are recorded with the cone hanging freely in a vertical position.

The CPTu is conducted at a steady rate of two centimeters per second, within acceptable tolerances. Typically one meter length rods with an outer diameter of 38.1 millimeters are added to advance the cone to the sounding termination depth. After cone retraction final baselines are recorded.

Additional information pertaining to ConeTec's cone penetration testing procedures:

- Each filter is saturated in silicone oil under vacuum pressure prior to use
- Baseline readings are compared to previous readings
- Soundings are terminated at the client's target depth or at a depth where an obstruction is encountered, excessive rod flex occurs, excessive inclination occurs, equipment damage is likely to take place, or a dangerous working environment arises
- Differences between initial and final baselines are calculated to ensure zero load offsets have not occurred and to ensure compliance with ASTM standards

The interpretation of piezocone data for this report is based on the corrected tip resistance (q_t), sleeve friction (f_s) and pore water pressure (u). The interpretation of soil type is based on the correlations developed by Robertson et al. (1986) and Robertson (1990, 2009). It should be noted that it is not always possible to accurately identify a soil behaviour type based on these parameters. In these situations, experience, judgment and an assessment of other parameters may be used to infer soil behaviour type.

The recorded tip resistance (q_c) is the total force acting on the piezocone tip divided by its base area. The tip resistance is corrected for pore pressure effects and termed corrected tip resistance (q_t) according to the following expression presented in Robertson et al. (1986):

$$q_t = q_c + (1-a) \bullet u_2$$

where: q_t is the corrected tip resistance
q_c is the recorded tip resistance
u_2 is the recorded dynamic pore pressure behind the tip (u_2 position)
a is the Net Area Ratio for the piezocone (0.8 for ConeTec probes)

The sleeve friction (f_s) is the frictional force on the sleeve divided by its surface area. As all ConeTec piezocones have equal end area friction sleeves, pore pressure corrections to the sleeve data are not required.

The dynamic pore pressure (u) is a measure of the pore pressures generated during cone penetration. To record equilibrium pore pressure, the penetration must be stopped to allow the dynamic pore pressures to stabilize. The rate at which this occurs is predominantly a function of the permeability of the soil and the diameter of the cone.

The friction ratio (Rf) is a calculated parameter. It is defined as the ratio of sleeve friction to the tip resistance expressed as a percentage. Generally, saturated cohesive soils have low tip resistance, high friction ratios and generate large excess pore water pressures. Cohesionless soils have higher tip resistances, lower friction ratios and do not generate significant excess pore water pressure.

A summary of the CPTu soundings along with test details and individual plots are provided in the appendices. A set of files with calculated geotechnical parameters were generated for each sounding based on published correlations and are provided in Excel format in the data release folder. Information regarding the methods used is also included in the data release folder.

For additional information on CPTu interpretations and calculated geotechnical parameters, refer to Robertson et al. (1986), Lunne et al. (1997), Robertson (2009), Mayne (2013, 2014), Mayne and Peuchen (2012) and Mayne et al. (2023).

References

ASTM D5778-20, 2020, "Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils", ASTM International, West Conshohocken, PA. DOI: 10.1520/D5778-20.

Lunne, T., Robertson, P.K. and Powell, J. J. M., 1997, “Cone Penetration Testing in Geotechnical Practice”, Blackie Academic and Professional.

Mayne, P.W., 2013, “Evaluating yield stress of soils from laboratory consolidation and in-situ cone penetration tests”, Sound Geotechnical Research to Practice (Holtz Volume) GSP 230, ASCE, Reston/VA: 406-420. DOI: 10.1061/9780784412770.027.

Mayne, P.W. and Peuchen, J., 2012, “Unit weight trends with cone resistance in soft to firm clays”, Geotechnical and Geophysical Site Characterization *4,* Vol. 1 (Proc. ISC-4, Pernambuco), CRC Press, London: 903-910.

Mayne, P.W., 2014, “Interpretation of geotechnical parameters from seismic piezocone tests”, CPT’14 Keynote Address, Las Vegas, NV, May 2014.

Mayne, P.W., Cargill, E. and Greig, J. (2023). The Cone Penetration Test: Better Information, Better Decisions. produced by ConeTec Group, Burnaby, B.C. www.conetec.com

Robertson, P.K., Campanella, R.G., Gillespie, D. and Greig, J., 1986, “Use of Piezometer Cone Data”, Proceedings of InSitu 86, ASCE Specialty Conference, Blacksburg, Virginia.

Robertson, P.K., 1990, “Soil Classification Using the Cone Penetration Test”, Canadian Geotechnical Journal, Volume 27: 151-158. DOI: 10.1139/T90-014.

Robertson, P.K., 2009, “Interpretation of cone penetration tests – a unified approach”, Canadian Geotechnical Journal, Volume 46: 1337-1355. DOI: 10.1139/T09-065.

Shear wave velocity (Vs) testing is performed in conjunction with the piezocone penetration test (SCPTu) in order to collect interval velocities. For some projects seismic compression wave velocity (Vp) testing is also performed.

ConeTec's 15 cm^2 piezocone penetrometers are manufactured with one horizontally active geophone (28 hertz) and one vertically active geophone (28 hertz). Both geophones are rigidly mounted in the body of the cone penetrometer, 0.2 meters behind the cone tip. The vertically mounted geophone is more sensitive to compression waves; however, it is often affected by the compression wave travelling through the cone rods.

Shear waves are typically generated by using an impact hammer horizontally striking a beam that is held in place by a normal load. In some instances, an auger source or an imbedded impulsive source may be used for both shear waves and compression waves. The hammer and beam act as a contact trigger that initiates the recording of the seismic wave traces. For impulsive devices an accelerometer trigger may be used. The traces are recorded in the memory of the cone using a fast analog to digital converter. The seismic trace is then transmitted digitally uphole to a Windows based computer through a signal interface box for recording and analysis. An illustration of the shear wave testing configuration is presented in Figure SCPTu-1.

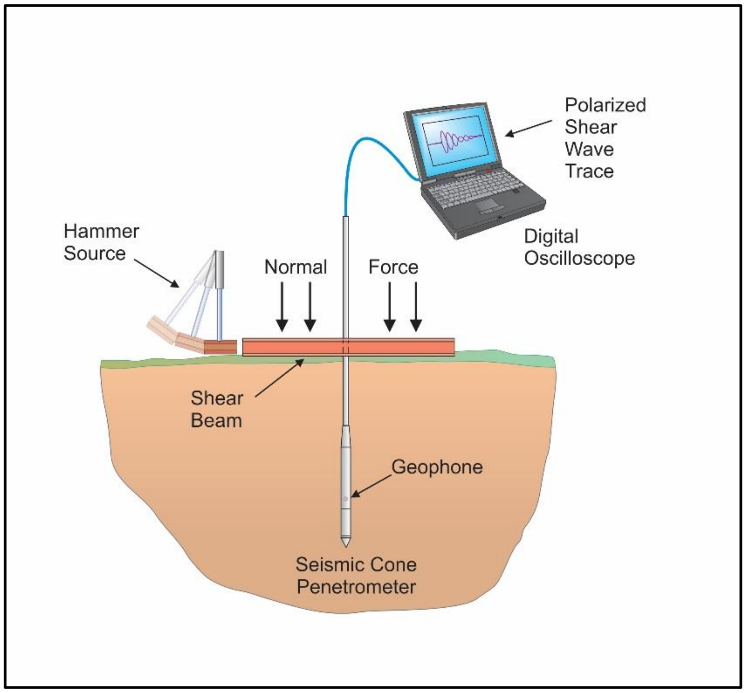


Figure SCPTu-1. Illustration of the SCPTu system

All testing is performed in accordance to ConeTec's SCPTu operating procedures which are in general accordance with the current ASTM D5778 and ASTM D7400 standards.

Prior to the start of a SCPTu sounding, the procedures described in the Cone Penetration Test section are followed. In addition, the active axis of the geophone is aligned parallel to the beam (or source) and the horizontal offset between the cone and the source is measured and recorded.

Prior to recording seismic waves at each test depth, cone penetration is stopped and the rods are decoupled from the rig to avoid transmission of rig energy down the rods. Typically, five wave traces for each orientation are recorded for quality control and uncertainty analysis purposes. After reviewing wave traces for consistency the cone is pushed to the next test depth (typically one meter intervals or as requested by the client). Figure SCPTu-2 presents an illustration of a SCPTu test.

For additional information on seismic cone penetration testing refer to Robertson et al. (1986).

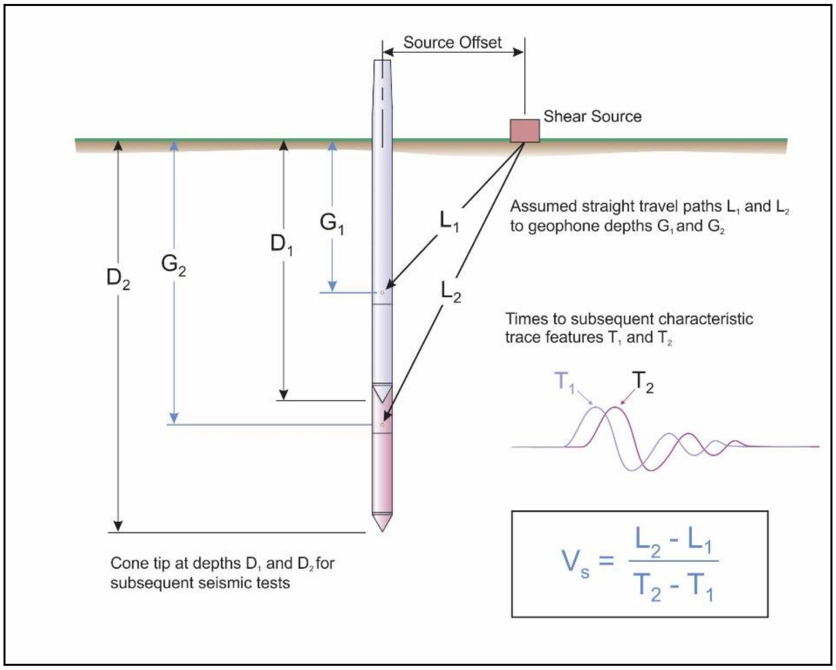


Figure SCPTu-2. Illustration of a seismic cone penetration test

For the determination of interval travel times the wave traces from all depths are displayed in analysis software. The results of the interval picks are supplied in the relevant appendix of this report. Standard practice for ConeTec is to record five wave traces for each source direction at each test depth. Outlier impacts are identified in the field and the impacts are repeated. For the final wave trace profile, the traces are stacked in the time domain to display a single average trace.

Determination of the shear wave interval velocities are performed by visually picking a common feature (e.g. the first characteristic peak, trough, or crossover) on all of the trace depths and taking the difference in ray path divided by the time difference between features at subsequent depths. The same process is used for compression waves, however the first break is most commonly used for selecting an arrival time. For velocity calculation, the ray path is defined as the straight-line distance from the seismic source to the geophone, accounting for beam offset, source depth and geophone offset from the cone tip.

In some cases, usually for shear wave velocity testing, more than one characteristic marker may be used. If there is an overlap between different sets of characteristic markers, then the average time value for those sets of interval times is applied to the determination of velocity.

Ideally, all depths are used for the determination of the velocity profile. However, an interval may be skipped if there is some ambiguity or quality concern with a particular depth, resulting in a larger interval.

Tabular results and SCPTu plots are presented in the relevant appendix.

The average shear wave velocity to a depth of thirty meters (V_{s30}) has been calculated and provided for all applicable soundings using an equation presented in Crow et al. (2012).

$$V_{s30} = \frac{\text{total thickness of all layers (30m)}}{\sum(\text{layer traveltimes})}$$

The layer travel times refers to the travel times propagating in the vertical direction, not the measured travel times from an offset source.

References

ASTM D5778-20, 2020, "Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils", ASTM International, West Conshohocken, PA. DOI: 10.1520/D5778-20.

ASTM D7400/D7400M-19, 2019, "Standard Test Methods for Downhole Seismic Testing", ASTM International, West Conshohocken, PA. DOI: 10.1520/D7400_D7400M-19.

Crow, H.L., Hunter, J.A., Bobrowsky, P.T., 2012, “National shear wave measurement guidelines for Canadian seismic site assessment”, GeoManitoba 2012, Sept 30 to Oct 2, Winnipeg, Manitoba.

Robertson, P.K., Campanella, R.G., Gillespie D and Rice, A., 1986, “Seismic CPT to Measure In-Situ Shear Wave Velocity”, Journal of Geotechnical Engineering ASCE, Vol. 112, No. 8: 791-803. DOI: 10.1061/(ASCE)0733-9410(1986)112:8(791).

The cone penetration test is halted at specific depths to carry out pore pressure dissipation (PPD) tests, shown in Figure PPD-1. For each dissipation test the cone and rods are decoupled from the rig and the data acquisition system measures and records the variation of the pore pressure (u) with time (t).

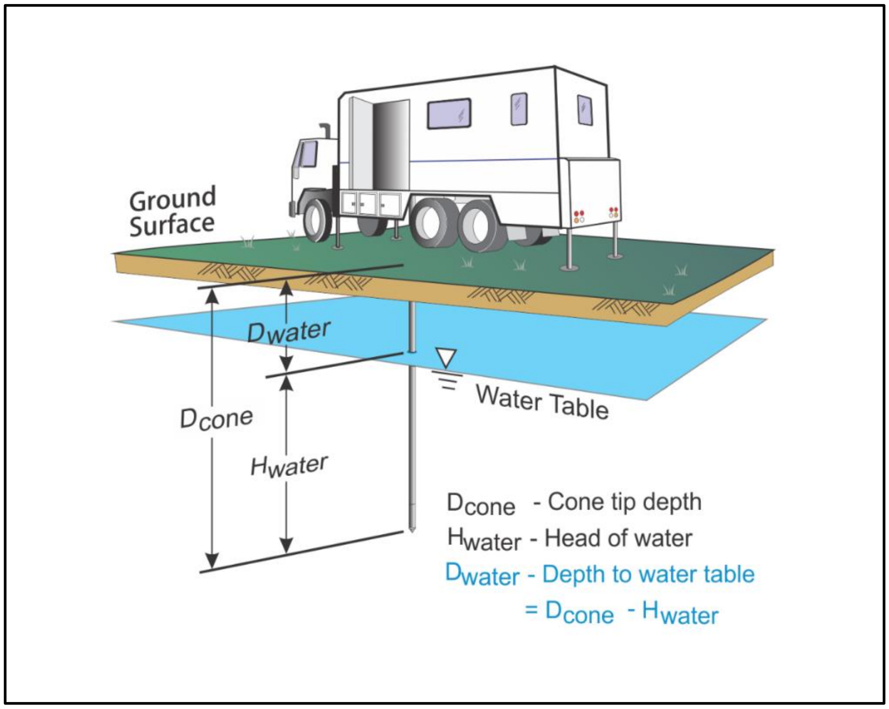


Figure PPD-1. Pore pressure dissipation test setup

Pore pressure dissipation data can be interpreted to provide estimates of ground water conditions, permeability, consolidation characteristics and soil behaviour.

The typical shapes of dissipation curves shown in Figure PPD-2 are very useful in assessing soil type, drainage, in situ pore pressure and soil properties. A flat curve that stabilizes quickly is typical of a freely draining sand. Undrained soils such as clays will typically show positive excess pore pressure and have long dissipation times. Dilative soils will often exhibit dynamic pore pressures below equilibrium that then rise over time. Overconsolidated fine-grained soils will often exhibit an initial dilatory response where there is an initial rise in pore pressure before reaching a peak and dissipating.

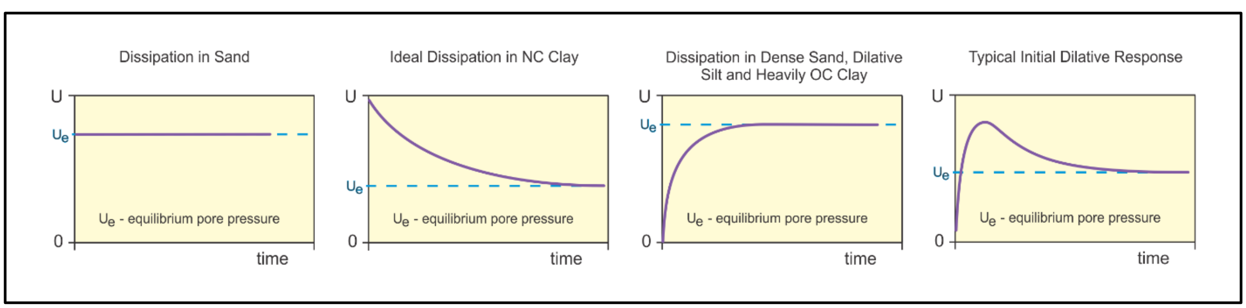


Figure PPD-2. Pore pressure dissipation curve examples

In order to interpret the equilibrium pore pressure (u_{eq}) and the apparent phreatic surface, the pore pressure should be monitored until such time as there is no variation in pore pressure with time as shown for each curve in Figure PPD-2.

In fine grained deposits the point at which 100% of the excess pore pressure has dissipated is known as t_{100}. In some cases this can take an excessive amount of time and it may be impractical to take the dissipation to t_{100}. A theoretical analysis of pore pressure dissipations by Teh and Houlsby, 1991 showed that a single curve relating degree of dissipation versus theoretical time factor (T*) may be used to calculate the coefficient of consolidation (c_h) at various degrees of dissipation resulting in the expression for c_h shown below.

$$c_h = \frac{T^* \cdot a^2 \cdot \sqrt{I_r}}{t}$$

Where:

T* is the dimensionless time factor (Table Time Factor)
a is the radius of the cone
I_r is the rigidity index
t is the time at the degree of consolidation

Table Time Factor. T* versus degree of dissipation (Teh and Houlsby, 1991)

Degree of Dissipation (%)	20	30	40	50	60	70	80
T* (u_2)	0.038	0.078	0.142	0.245	0.439	0.804	1.60

The coefficient of consolidation is typically analyzed using the time (t_{50}) corresponding to a degree of dissipation of 50% (u_{50}). In order to determine t_{50}, dissipation tests must be taken to a pressure less than u_{50}. The u_{50} value is half way between the initial maximum pore pressure and the equilibrium pore pressure value, known as u_{100}. To estimate u_{50}, both the initial maximum pore pressure and u_{100} must be known or estimated. Other degrees of dissipations may be considered, particularly for extremely long dissipations.

At any specific degree of dissipation the equilibrium pore pressure (u at t_{100}) must be estimated at the depth of interest. The equilibrium value may be determined from one or more sources such as measuring the value directly (u_{100}), estimating it from other dissipations in the same profile, estimating the phreatic surface and assuming hydrostatic conditions, from nearby soundings, from client provided information, from site observations and/or past experience, or from other site instrumentation.

For calculations of c_h (Teh and Houlsby, 1991), t_{50} values are estimated from the corresponding pore pressure dissipation curve and a rigidity index (I_r) is assumed. For curves having an initial dilatory response in which an initial rise in pore pressure occurs before reaching a peak, the relative time from the peak value is used in determining t_{50}. In cases where the time to peak is excessive, t_{50} values are not calculated.

A summary of the pore pressure dissipation tests and dissipation plots are presented in the relevant appendix.

References

Teh, C.I., and Houlsby, G.T., 1991, "An analytical study of the cone penetration test in clay", Geotechnique, 41(1): 17-34. DOI: 10.1680/geot.1991.41.1.17.

The appendices listed below are included in the report:

- Cone Penetration Test Summary and Standard Cone Penetration Test Plots
- Advanced Cone Penetration Test Plots
- Seismic Cone Penetration Test Plots
- Seismic Cone Penetration Test Shear Wave (Vs) Tabular Results
- Seismic Cone Penetration Test Shear Wave (Vs) Traces
- Soil Behaviour Type (SBT) Scatter Plots
- Pore Pressure Dissipation Summary and Pore Pressure Dissipation Plots
- Description of Methods for Calculated CPT Geotechnical Parameters

Cone Penetration Test Summary and Standard Cone Penetration Test Plots

Job No:	24-05-27609
Client:	Stantec Consulting Ltd.
Project:	HWY 3 St Thomas CPT
Start Date:	2024-05-09
End Date:	2024-05-10

CONE PENETRATION TEST SUMMARY

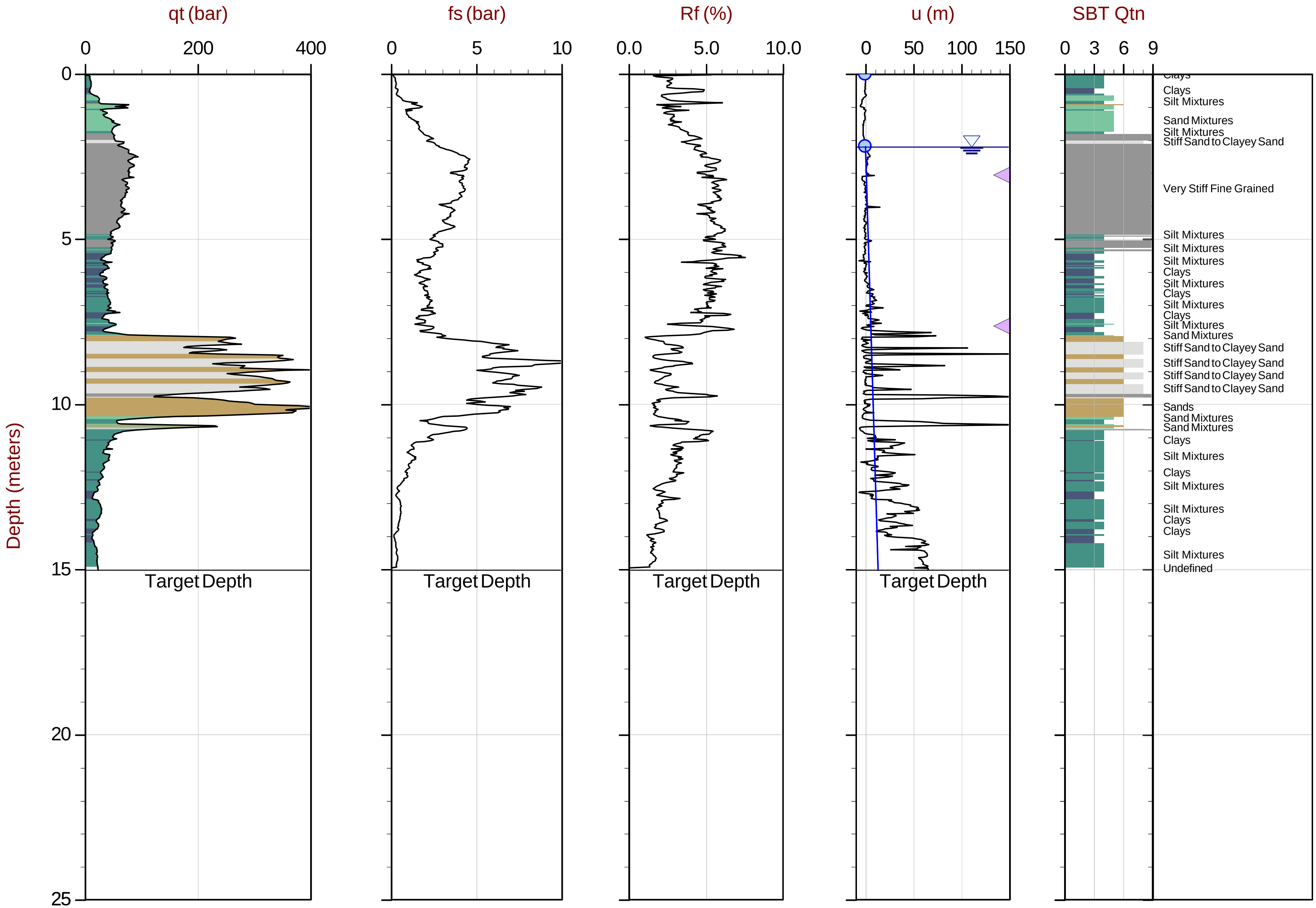
Sounding ID	File Name	Date	Cone	Cone Area (cm^2)	Assumed Phreatic Surface[1] (m)	Final Depth (m)	Northing[2] (m)	Easting[2] (m)	Refer to Notation Number
CPT24-RMNAPP01	24-05-27609_CP-RM-01	2024-05-10	729:T1500F15U35	15	2.2	15.025	4739733	481289	
SCPT24-RMNAPP01	24-05-27609_SP-RM-01	2024-05-10	729:T1500F15U35	15	2.2	15.075	4739737	481294	
SCPT24-CNREMB02	24-05-27609_SP-CN-02	2024-05-09	729:T1500F15U35	15	2.0	15.575	4740267	480674	
SCPT24-WAPP02	24-05-27609_SP-WA-02	2024-05-10	729:T1500F15U35	15	1.8	15.000	4738905	482817	3
SCPT24-CNREMB08	24-05-27609_SP-CN-08	2024-05-09	729:T1500F15U35	15	1.5	20.100	4740056	480896	
SCPT24-CNREMB10	24-05-27609_SP-CN-10	2024-05-10	729:T1500F15U35	15	2.0	20.000	4739960	481010	

1. The assumed phreatic surface was based on the dynamic pore pressure response, unless otherwise noted. Hydrostatic conditions were assumed for the calculated parameters.
2. Coordinates were collected with a consumer grade GPS device with datum WGS84/UTM Zone 17 North.
3. The assumed phreatic surface was based on a pore pressure dissipation test.

Stantec

Job No: 24-05-27609
Date: 2024-05-10 12:15
Site: HWY 3, St.Thomas, ON

Sounding: CPT24-RMNAPP01
Cone: 729:T1500F15U35 Area=15 cm²



Max Depth: 15.025 m / 49.29 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 24-05-27609_CP-RM-01.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 17N N: 4739733m E: 481289m
Sheet No: 1 of 1

Overplot Item: Ueq, Assumed Ueq, Dissipation, Ueq achieved, Dissipation, Ueq not achieved, Dissipation, Ueq assumed, Hydrostatic Line

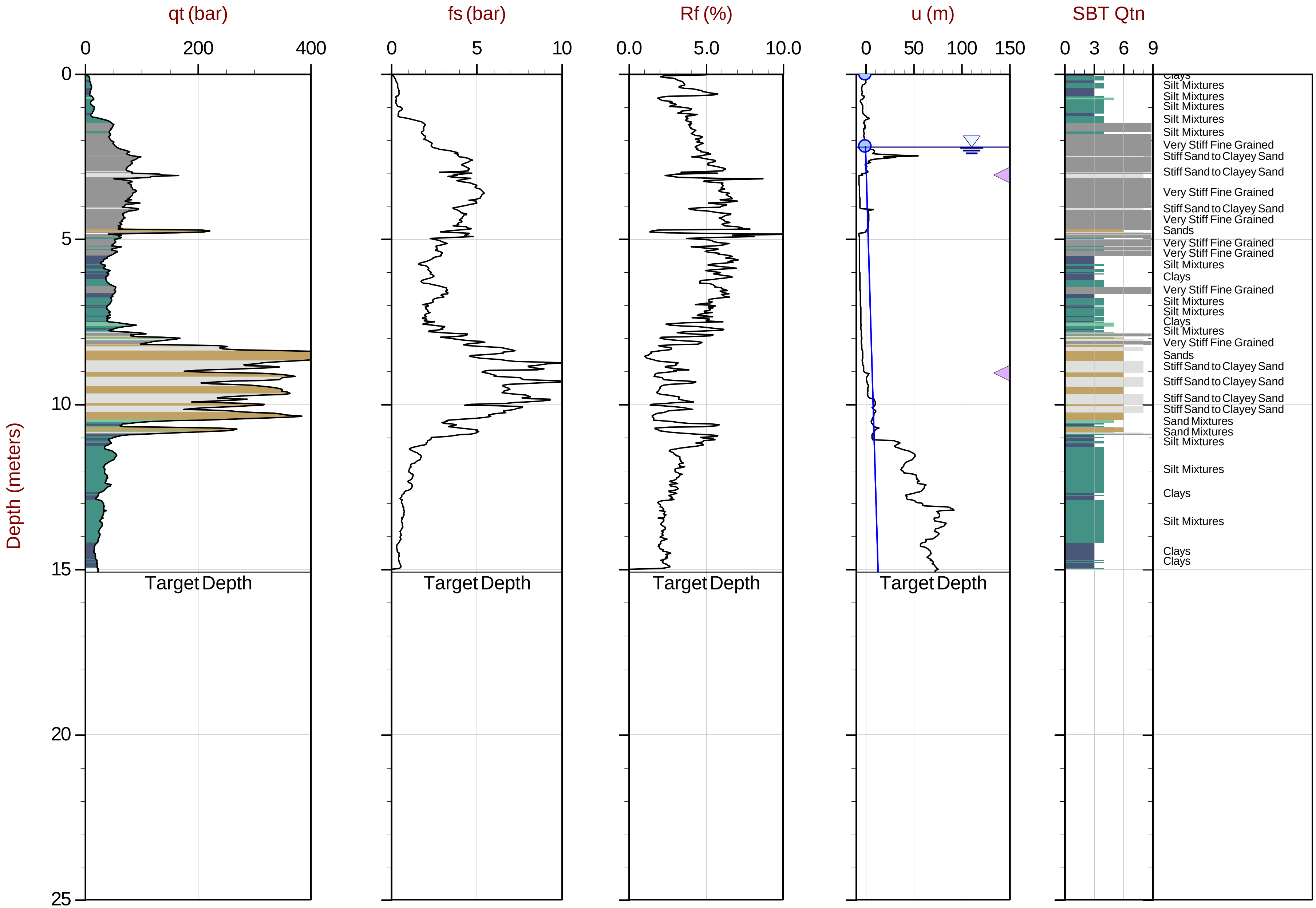
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Stantec

Job No: 24-05-27609
Date: 2024-05-10 10:24
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-RMNAPP01
Cone: 729:T1500F15U35 Area=15 cm²



Max Depth: 15.075 m / 49.46 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 24-05-27609_SP-RM-01.COR
Unit Wt: SBTQtn (PKR2009)

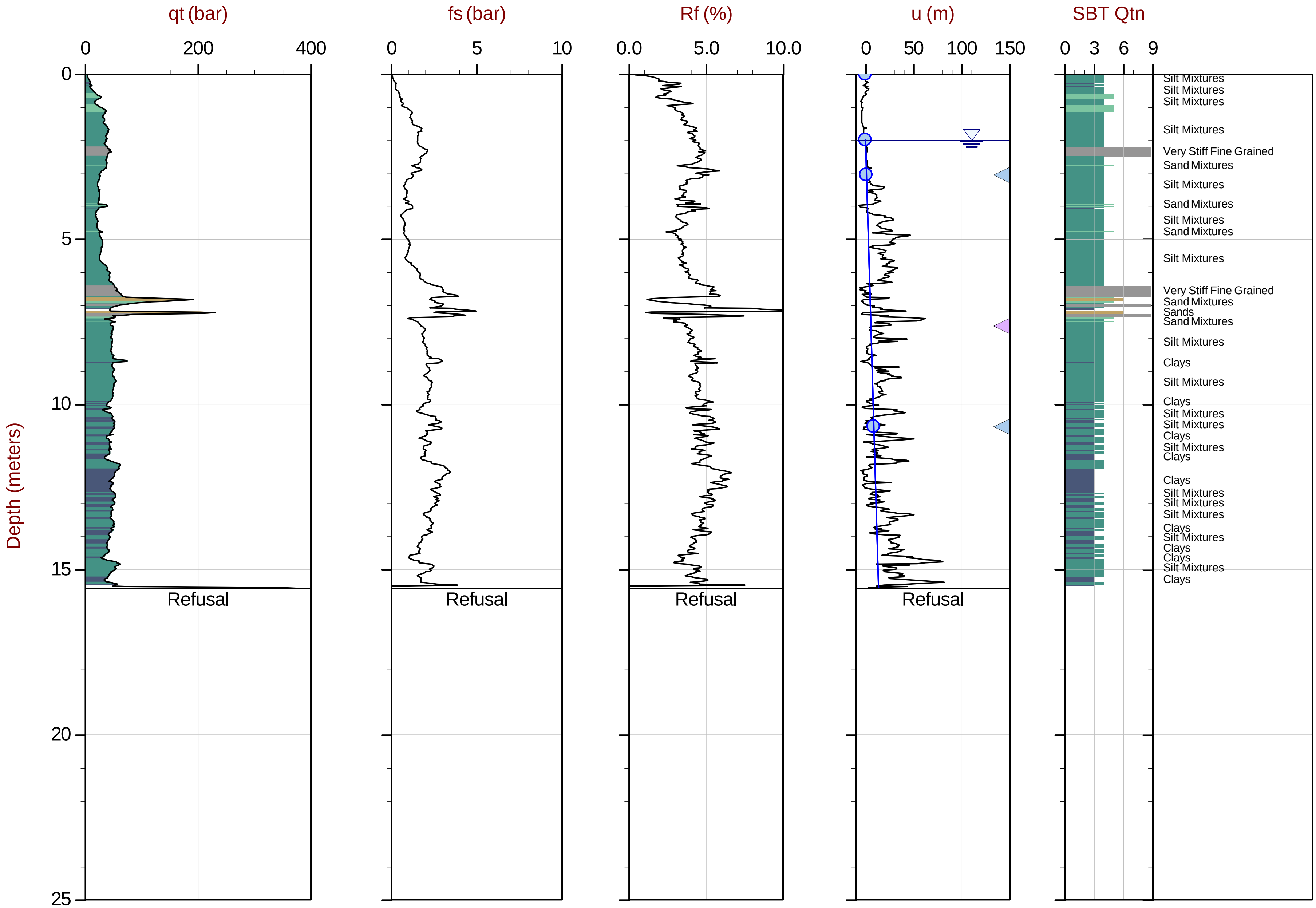
SBT: Robertson, 2009 and 2010
Coords: UTM 17N N: 4739737m E: 481294m
Sheet No: 1 of 1

Overplot Item: Ueq, Assumed Ueq, Dissipation, Ueq achieved, Dissipation, Ueq not achieved, Dissipation, Ueq assumed, Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Job No: 24-05-27609
Date: 2024-05-09 12:06
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-CNREMB02
Cone: 729:T1500F15U35 Area=15 cm²



Max Depth: 15.575 m / 51.10 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 24-05-27609_SP-CN-02.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 17N N: 4740267m E: 480674m
Sheet No: 1 of 1

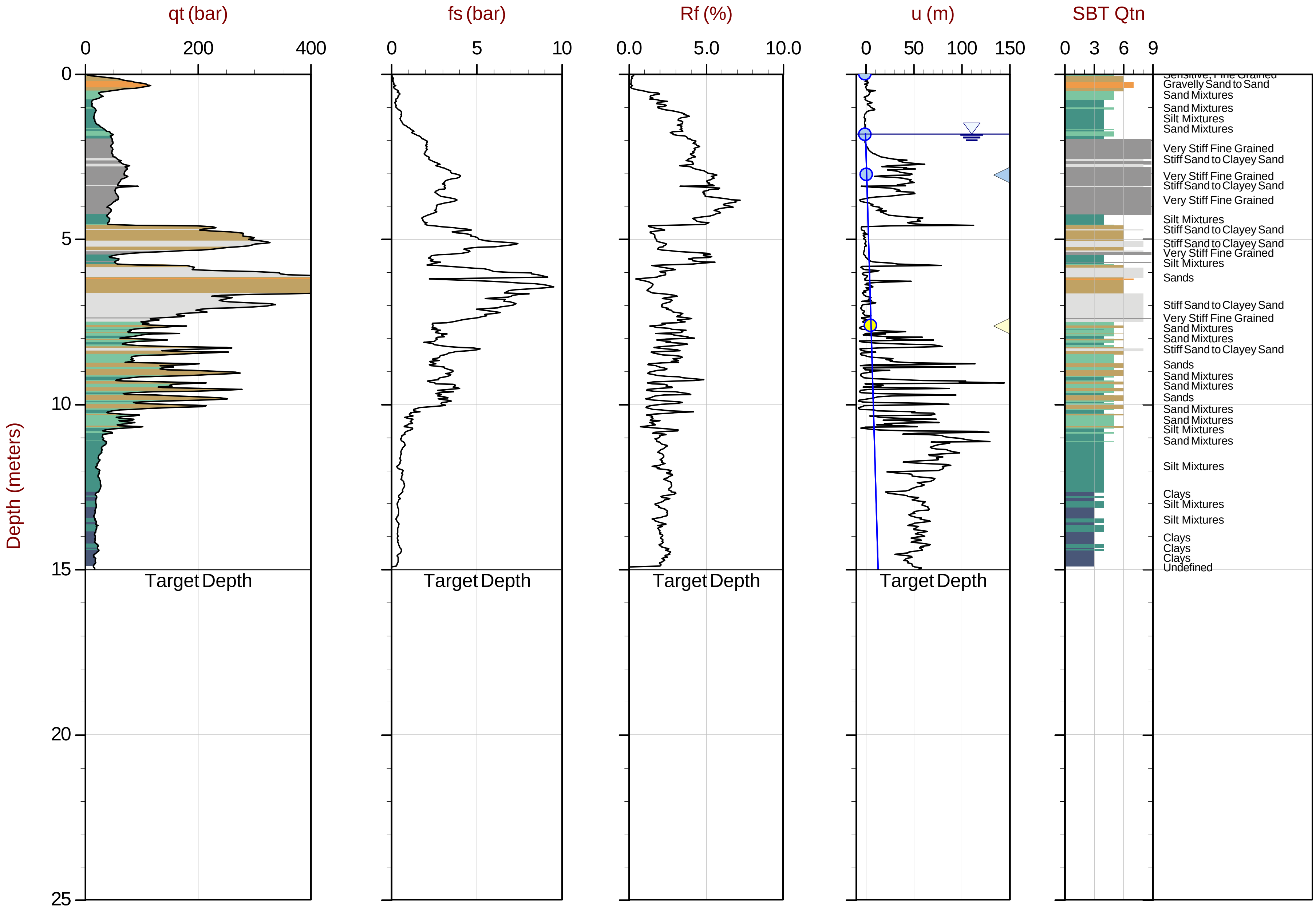
Overplot Item: Ueq Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Dissipation, Ueq assumed Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Job No: 24-05-27609
Date: 2024-05-10 14:49
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-WAPP02
Cone: 729:T1500F15U35 Area=15 cm²

Stantec



Max Depth: 15.000 m / 49.21 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 24-05-27609_SP-WA-02.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 17N N: 4738905m E: 482817m
Sheet No: 1 of 1

Overplot Item: Ueq Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Dissipation, Ueq assumed Hydrostatic Line

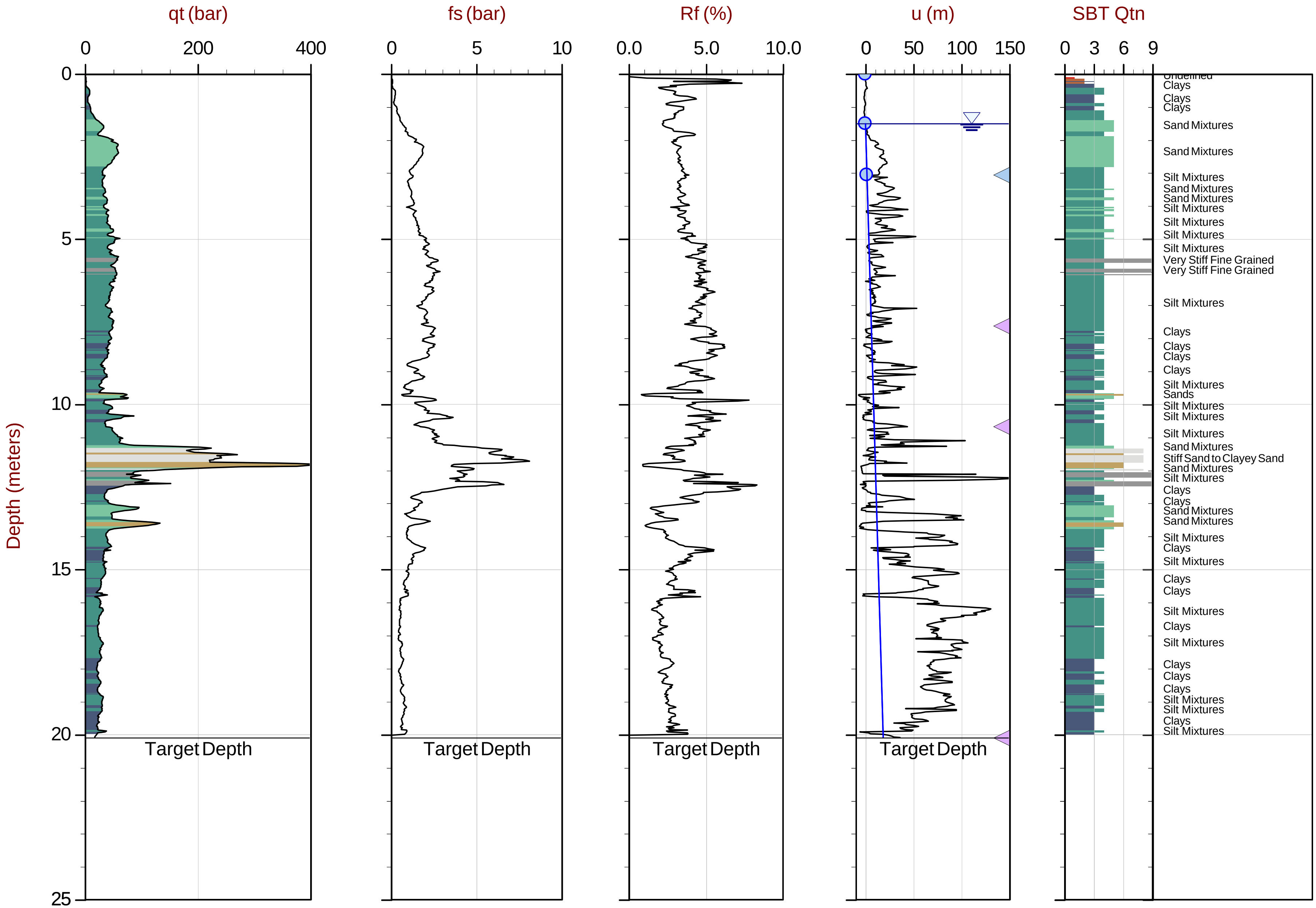
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Stantec

Job No: 24-05-27609
Date: 2024-05-09 16:43
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-CNREMB08
Cone: 729:T1500F15U35 Area=15 cm²



Max Depth: 20.100 m / 65.94 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 24-05-27609_SP-CN-08.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 17N N: 4740056m E: 480896m
Sheet No: 1 of 1

Overplot Item: Ueq   Assumed Ueq   Dissipation, Ueq achieved   Dissipation, Ueq not achieved   Dissipation, Ueq assumed   Hydrostatic Line

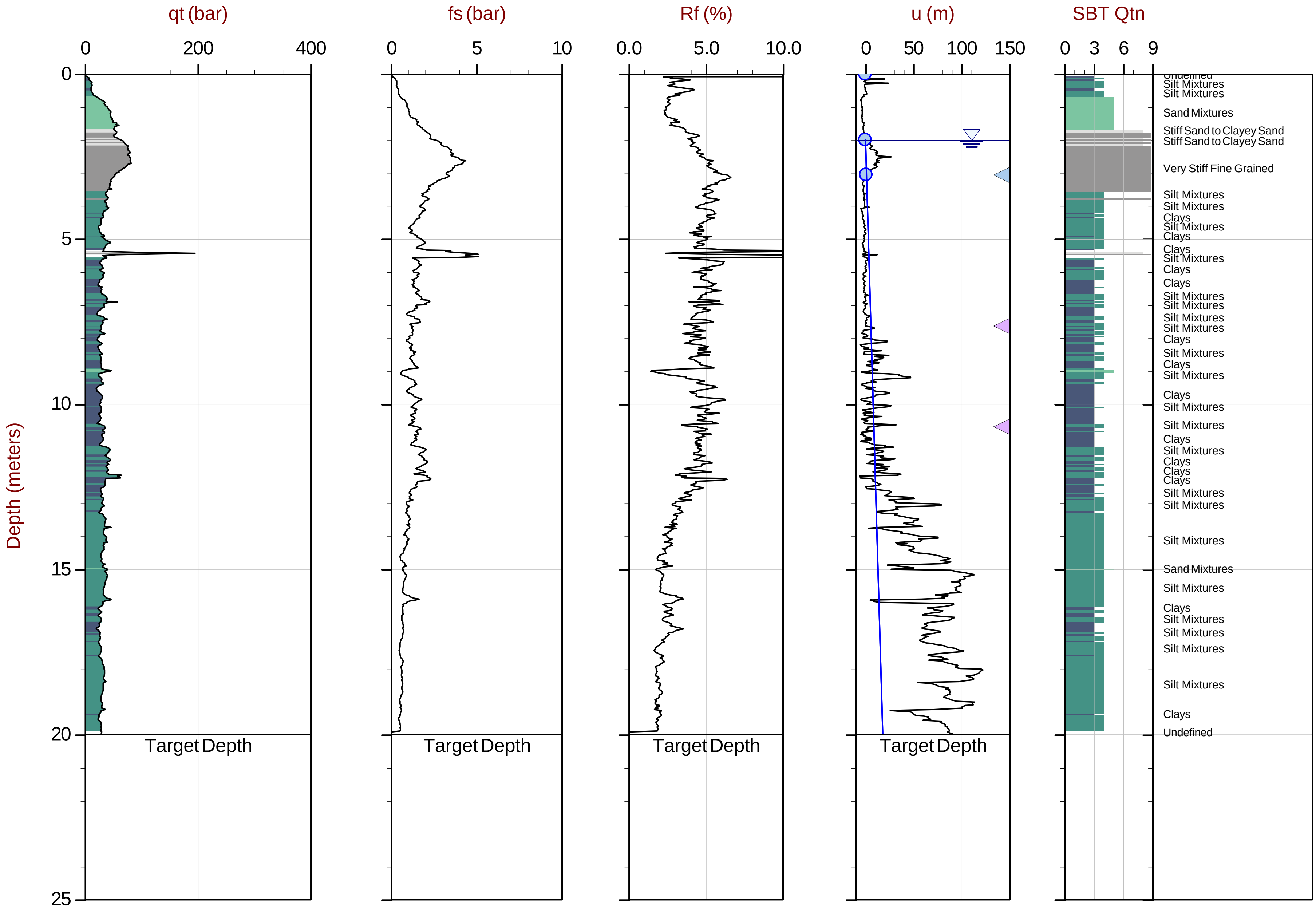
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Stantec

Job No: 24-05-27609
Date: 2024-05-10 06:58
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-CNREMB10
Cone: 729:T1500F15U35 Area=15 cm²



Max Depth: 20.000 m / 65.62 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 24-05-27609_SP-CN-10.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 17N N: 4739960m E: 481010m
Sheet No: 1 of 1

Overplot Item: Ueq Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Dissipation, Ueq assumed Hydrostatic Line

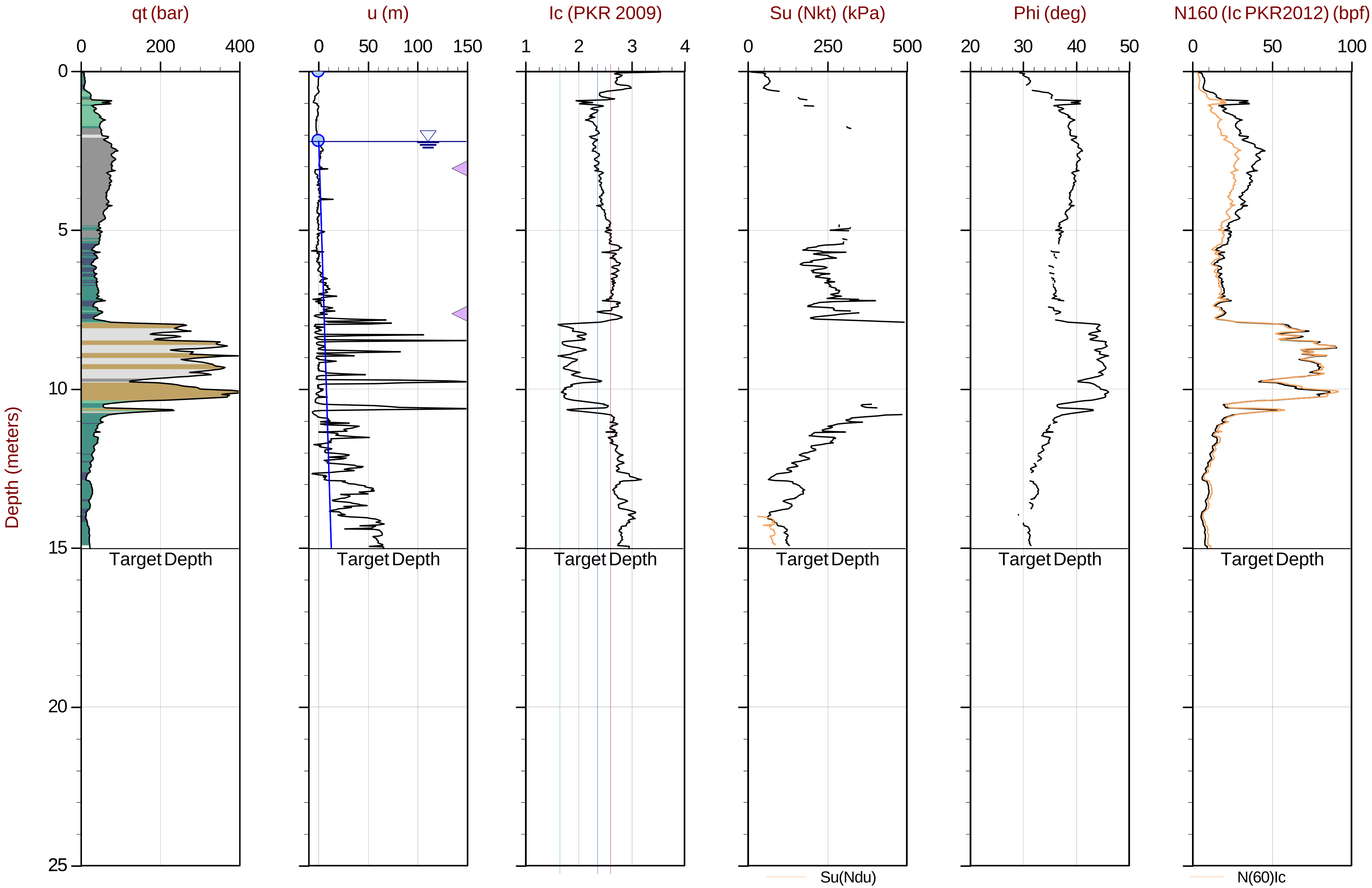
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Advanced Cone Penetration Test Plots

Stantec

Job No: 24-05-27609
Date: 2024-05-10 12:15
Site: HWY 3, St.Thomas, ON

Sounding: CPT24-RMNAPP01
Cone: 729:T1500F15U35 Area=15 cm²



Max Depth: 15.025 m / 49.29 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 24-05-27609_CP-RM-01.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt/Ndu: 15.0 / 6.0

SBT: Robertson, 2009 and 2010
Coords: UTM 17N N: 4739733m E: 481289m
Sheet No: 1 of 1

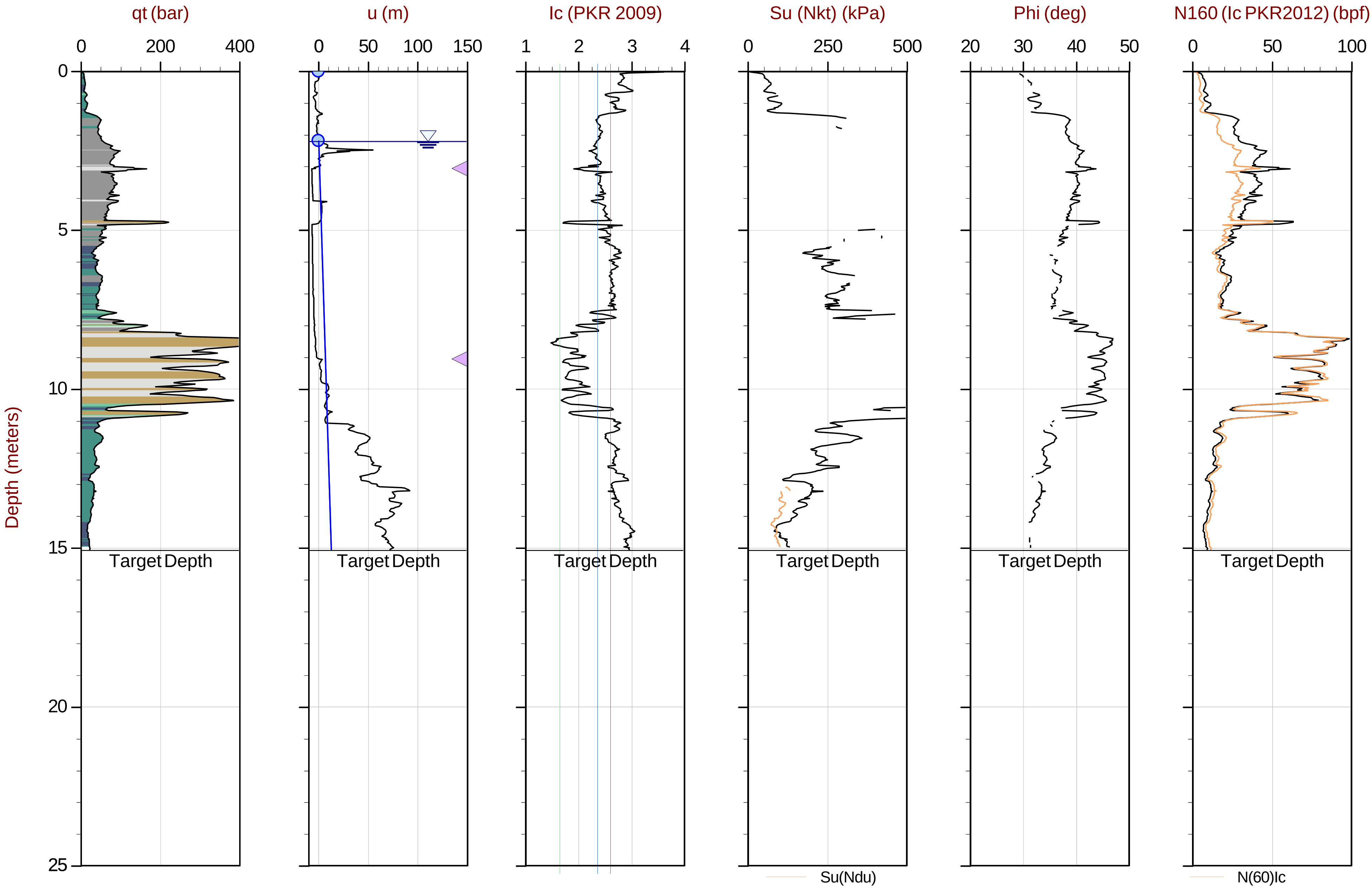
Overplot Item: Ueq, Assumed Ueq, Dissipation, Ueq achieved, Dissipation, Ueq not achieved, Dissipation, Ueq assumed, Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Stantec

Job No: 24-05-27609
Date: 2024-05-10 10:24
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-RMNAPP01
Cone: 729:T1500F15U35 Area=15 cm²



Max Depth: 15.075 m / 49.46 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 24-05-27609_SP-RM-01.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt/Ndu: 15.0 / 6.0

SBT: Robertson, 2009 and 2010
Coords: UTM 17N N: 4739737m E: 481294m
Sheet No: 1 of 1

Overplot Item: Ueq Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Dissipation, Ueq assumed Hydrostatic Line

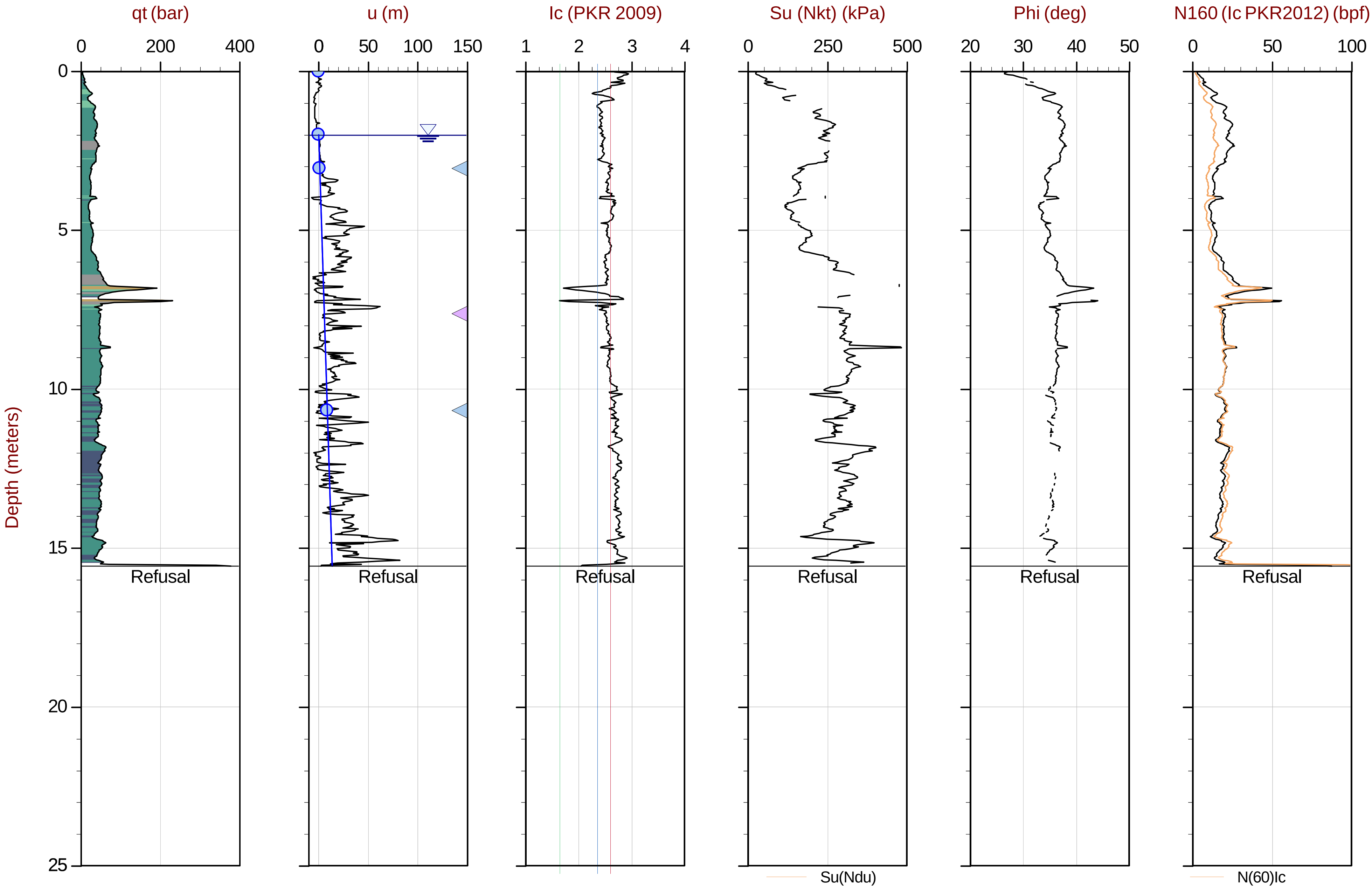
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Stantec

Job No: 24-05-27609
Date: 2024-05-09 12:06
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-CNREMB02
Cone: 729:T1500F15U35 Area=15 cm²



Max Depth: 15.575 m / 51.10 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 24-05-27609_SP-CN-02.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt/Ndu: 15.0 / 6.0

SBT: Robertson, 2009 and 2010
Coords: UTM 17N N: 4740267m E: 480674m
Sheet No: 1 of 1

Overplot Item: Ueq Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Dissipation, Ueq assumed Hydrostatic Line

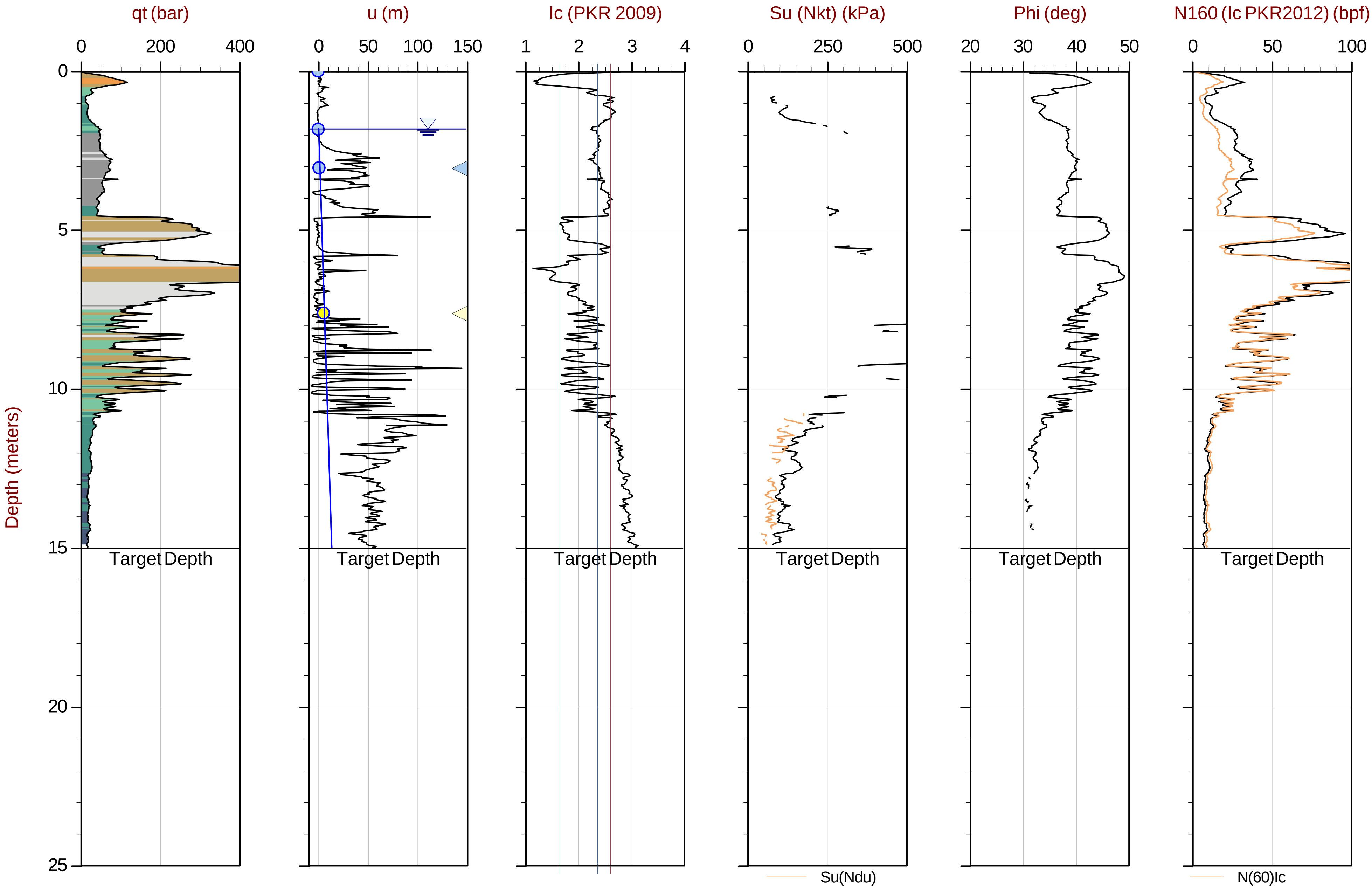
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Stantec

Job No: 24-05-27609
Date: 2024-05-10 14:49
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-WAPP02
Cone: 729:T1500F15U35 Area=15 cm²



Max Depth: 15.000 m / 49.21 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 24-05-27609_SP-WA-02.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt/Ndu: 15.0 / 6.0

SBT: Robertson, 2009 and 2010
Coords: UTM 17N N: 4738905m E: 482817m
Sheet No: 1 of 1

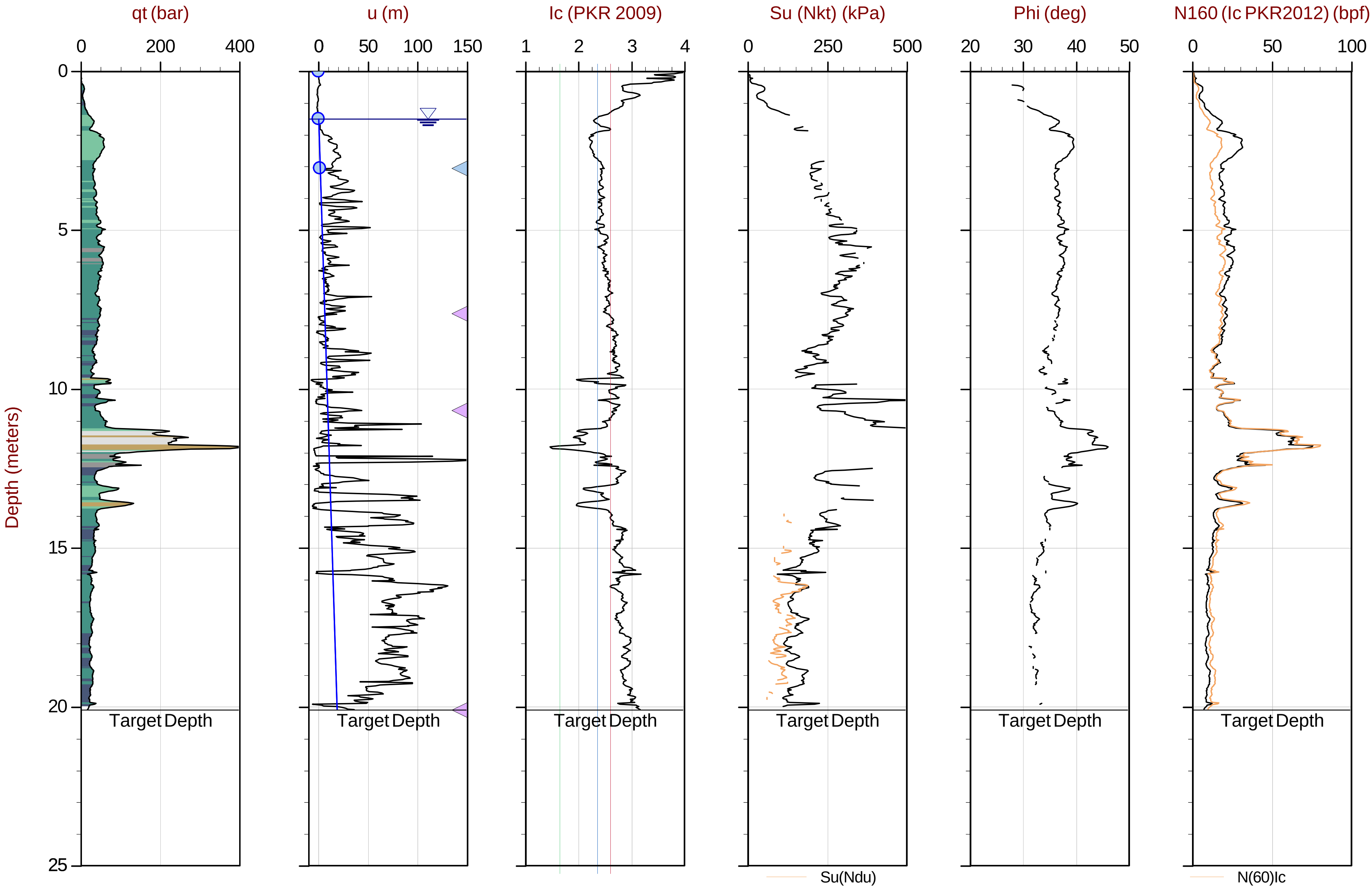
Overplot Item: Ueq | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Dissipation, Ueq assumed | Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Stantec

Job No: 24-05-27609
Date: 2024-05-09 16:43
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-CNREMB08
Cone: 729:T1500F15U35 Area=15 cm²



Max Depth: 20.100 m / 65.94 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

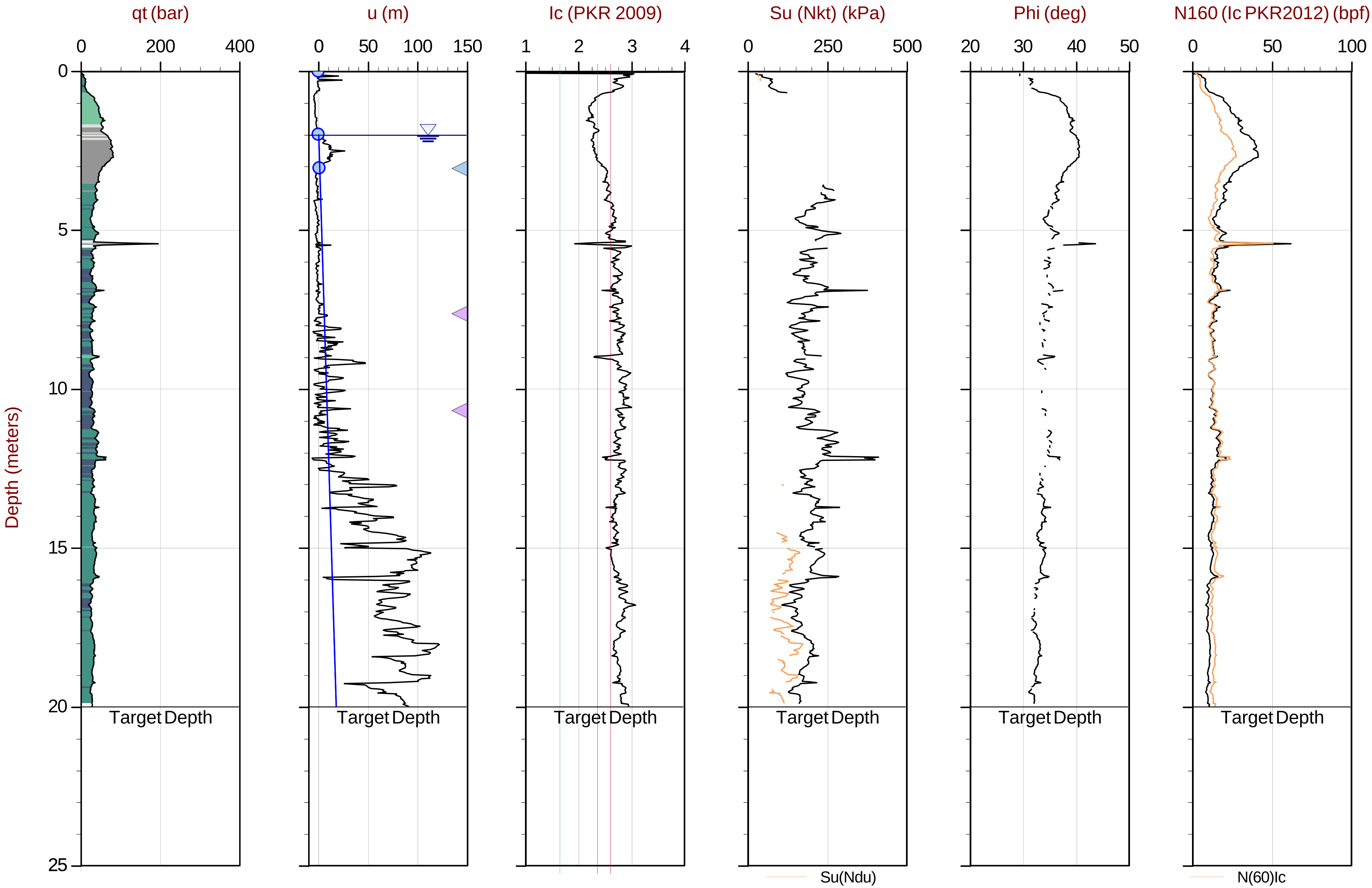
File: 24-05-27609_SP-CN-08.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt/Ndu: 15.0 / 6.0

SBT: Robertson, 2009 and 2010
Coords: UTM 17N N: 4740056m E: 480896m
Sheet No: 1 of 1

Overplot Item: Ueq, Assumed Ueq, Dissipation, Ueq achieved, Dissipation, Ueq not achieved, Dissipation, Ueq assumed, Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Job No: 24-05-27609
Date: 2024-05-10 06:58
Site: HWY 3, St.Thomas, ON
Sounding: SCPT24-CNREMB10
Cone: 729:T1500F15U35 Area=15 cm²



Max Depth: 20.000 m / 65.62 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 24-05-27609_SP-CN-10.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt/Ndu: 15.0 / 6.0

SBT: Robertson, 2009 and 2010
Coords: UTM 17N N: 4739960m E: 481010m
Sheet No: 1 of 1

Overplot Item: Ueq, Assumed Ueq, Dissipation, Ueq achieved, Dissipation, Ueq not achieved, Dissipation, Ueq assumed, Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

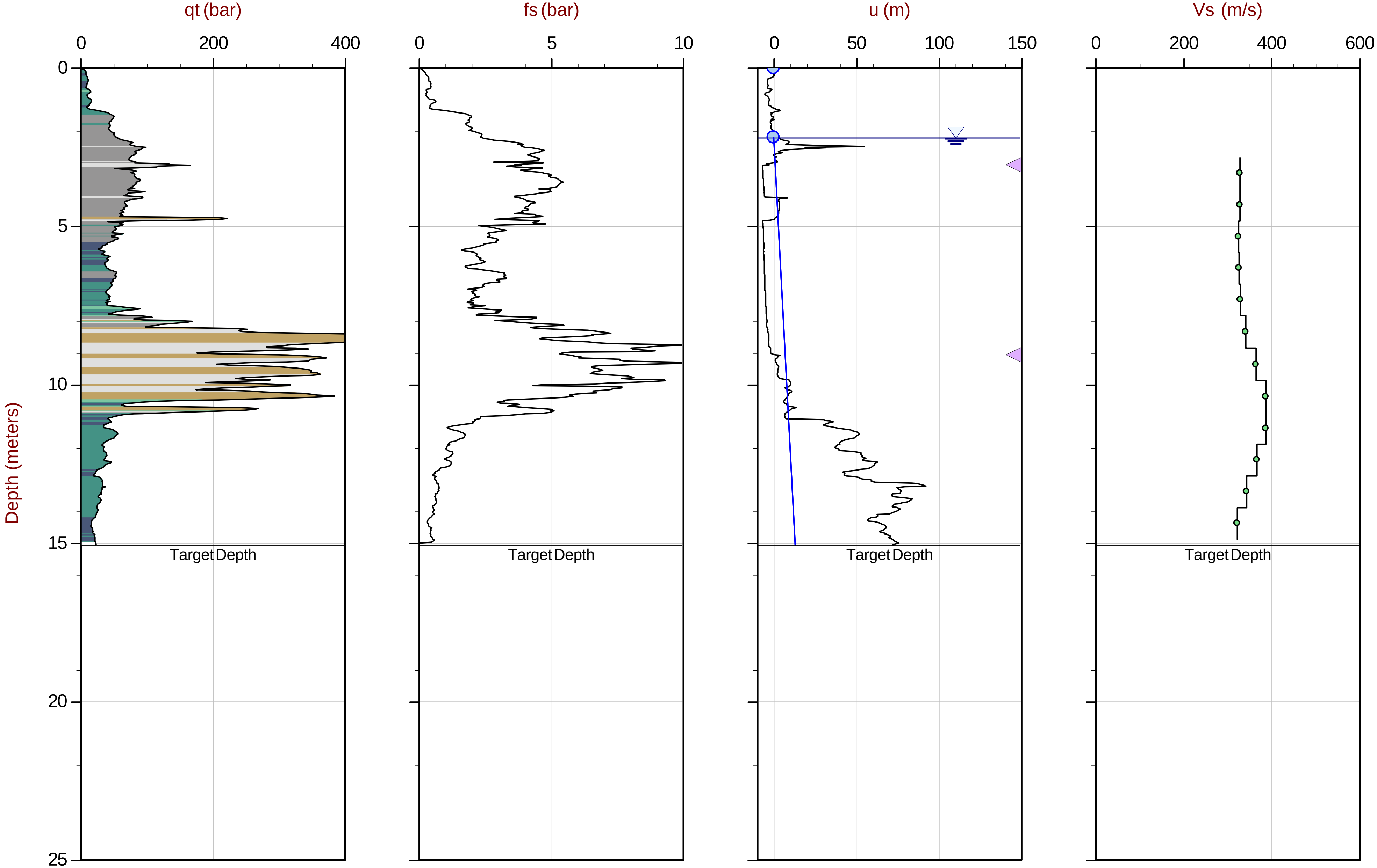
Seismic Cone Penetration Test Plots

ConeTec

Stantec

Job No: 24-05-27609
Date: 2024-05-10 10:24
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-RMNAPP01
Cone: 729:T1500F15U35 Area=15 cm²



Max Depth: 15.075 m / 49.46 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 24-05-27609_SP-RM-01.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 17N N: 4739737m E: 481294m
Sheet No: 1 of 1

Overplot Item: Ueq, Assumed Ueq, Dissipation, Ueq achieved, Dissipation, Ueq not achieved, Dissipation, Ueq assumed, Hydrostatic Line

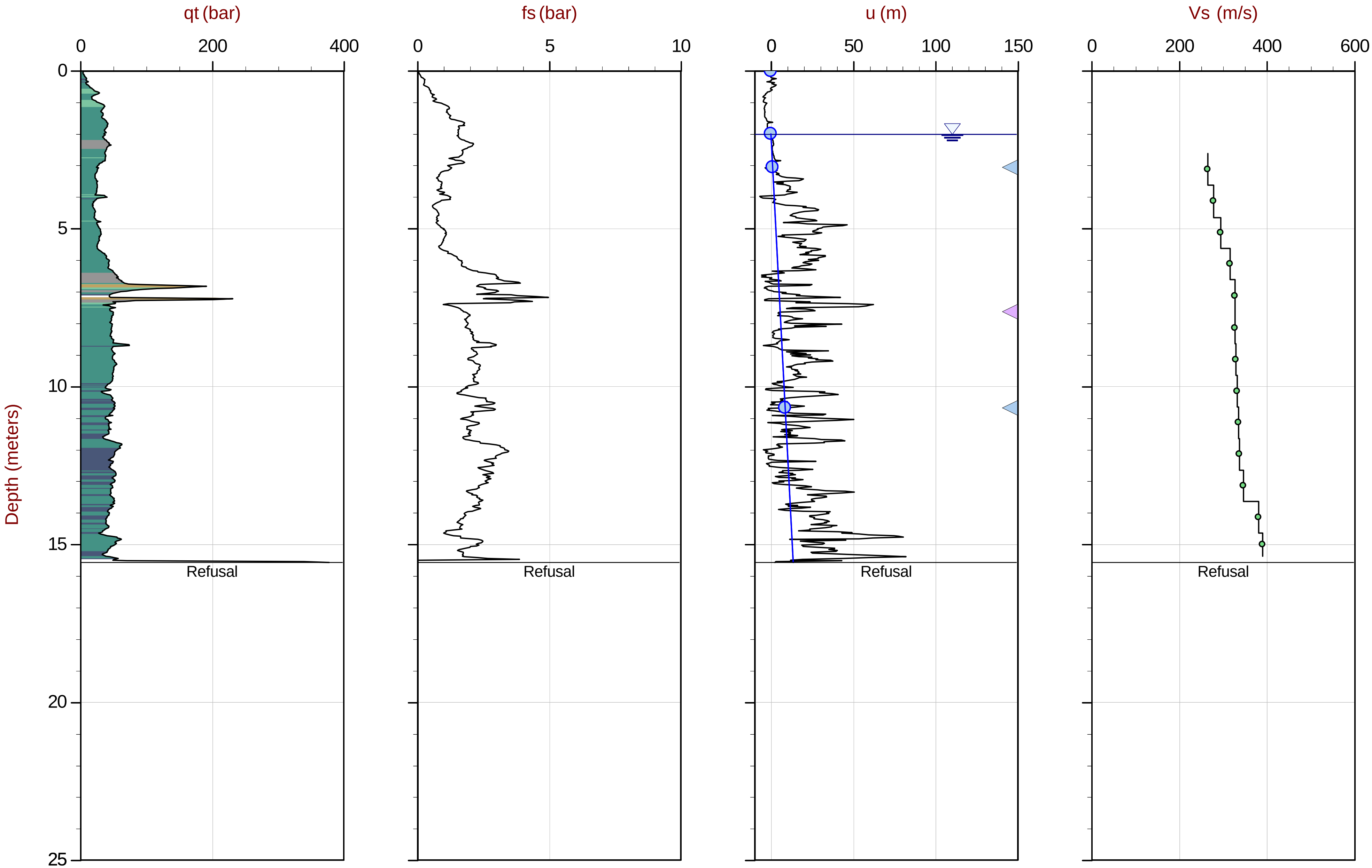
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Stantec

Job No: 24-05-27609
Date: 2024-05-09 12:06
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-CNREMB02
Cone: 729:T1500F15U35 Area=15 cm²



Max Depth: 15.575 m / 51.10 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 24-05-27609_SP-CN-02.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 17N N: 4740267m E: 480674m
Sheet No: 1 of 1

Overplot Item: Ueq Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Dissipation, Ueq assumed Hydrostatic Line

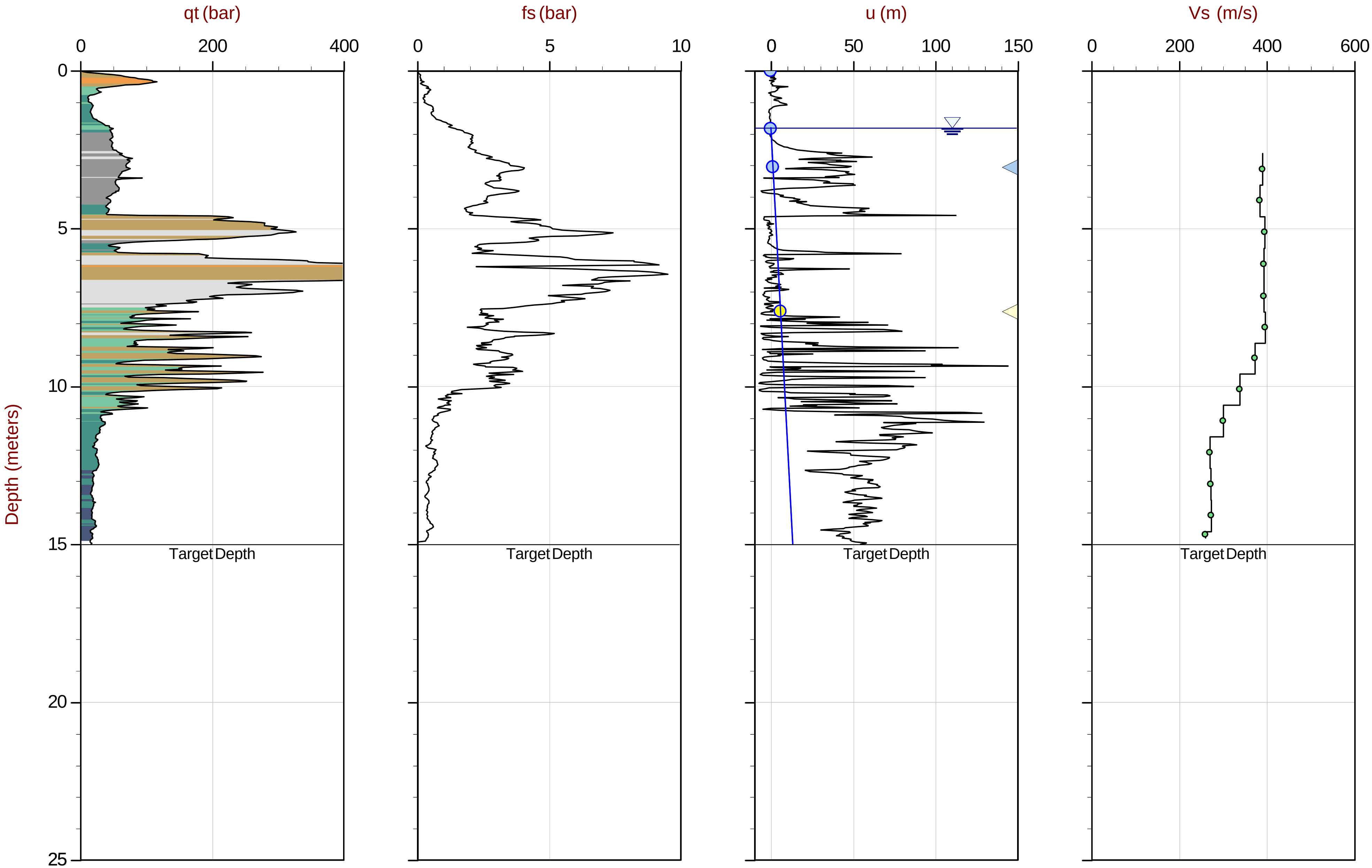
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

Stantec

Job No: 24-05-27609
Date: 2024-05-10 14:49
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-WAPP02
Cone: 729:T1500F15U35 Area=15 cm²



Max Depth: 15.000 m / 49.21 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

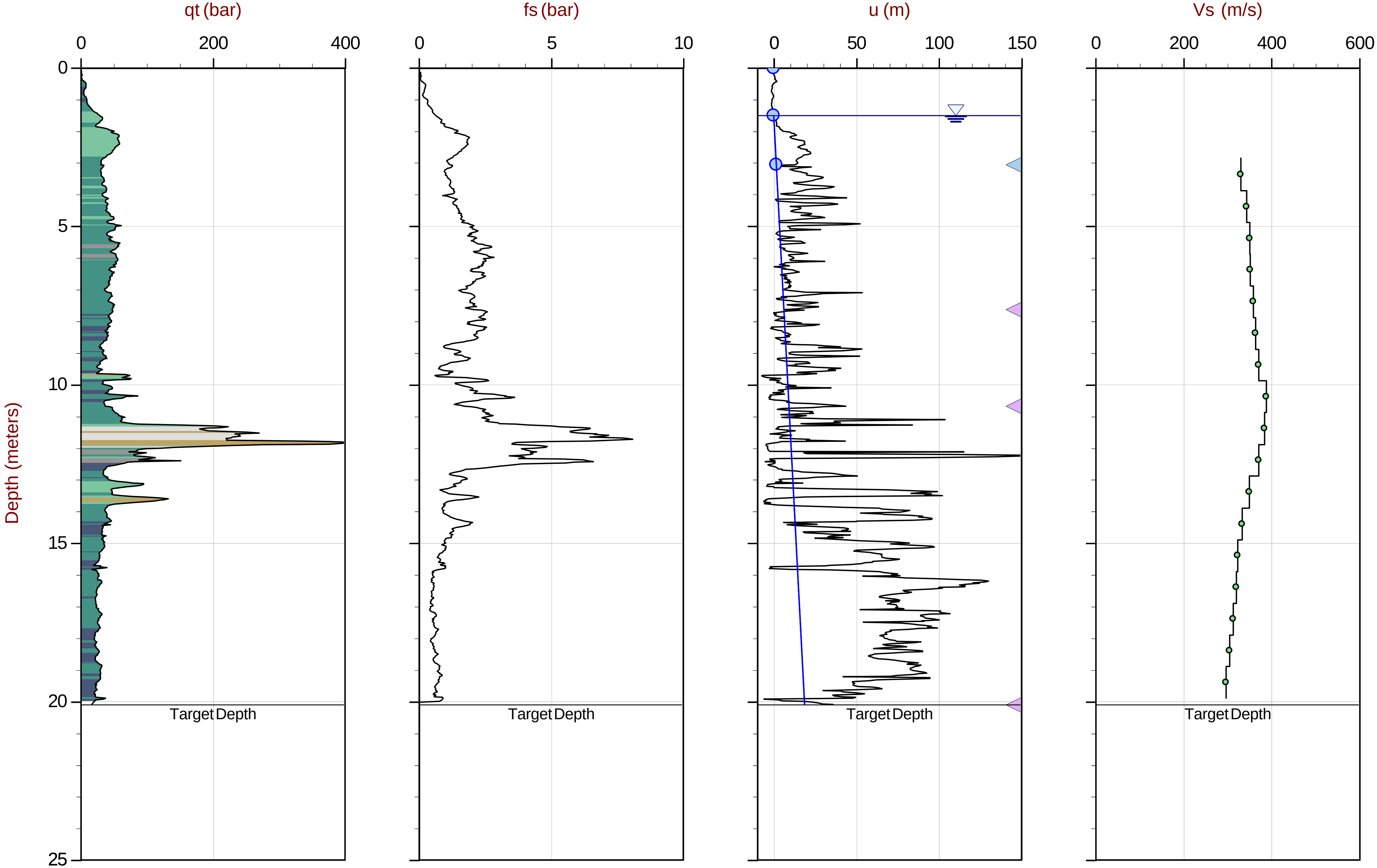
File: 24-05-27609_SP-WA-02.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 17N N: 4738905m E: 482817m
Sheet No: 1 of 1

Overplot Item: Ueq, Assumed Ueq, Dissipation, Ueq achieved, Dissipation, Ueq not achieved, Dissipation, Ueq assumed, Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Job No: 24-05-27609
Date: 2024-05-09 16:43
Site: HWY 3, St.Thomas, ON
Sounding: SCPT24-CNREMB08
Cone: 729:T1500F15U35 Area=15 cm²



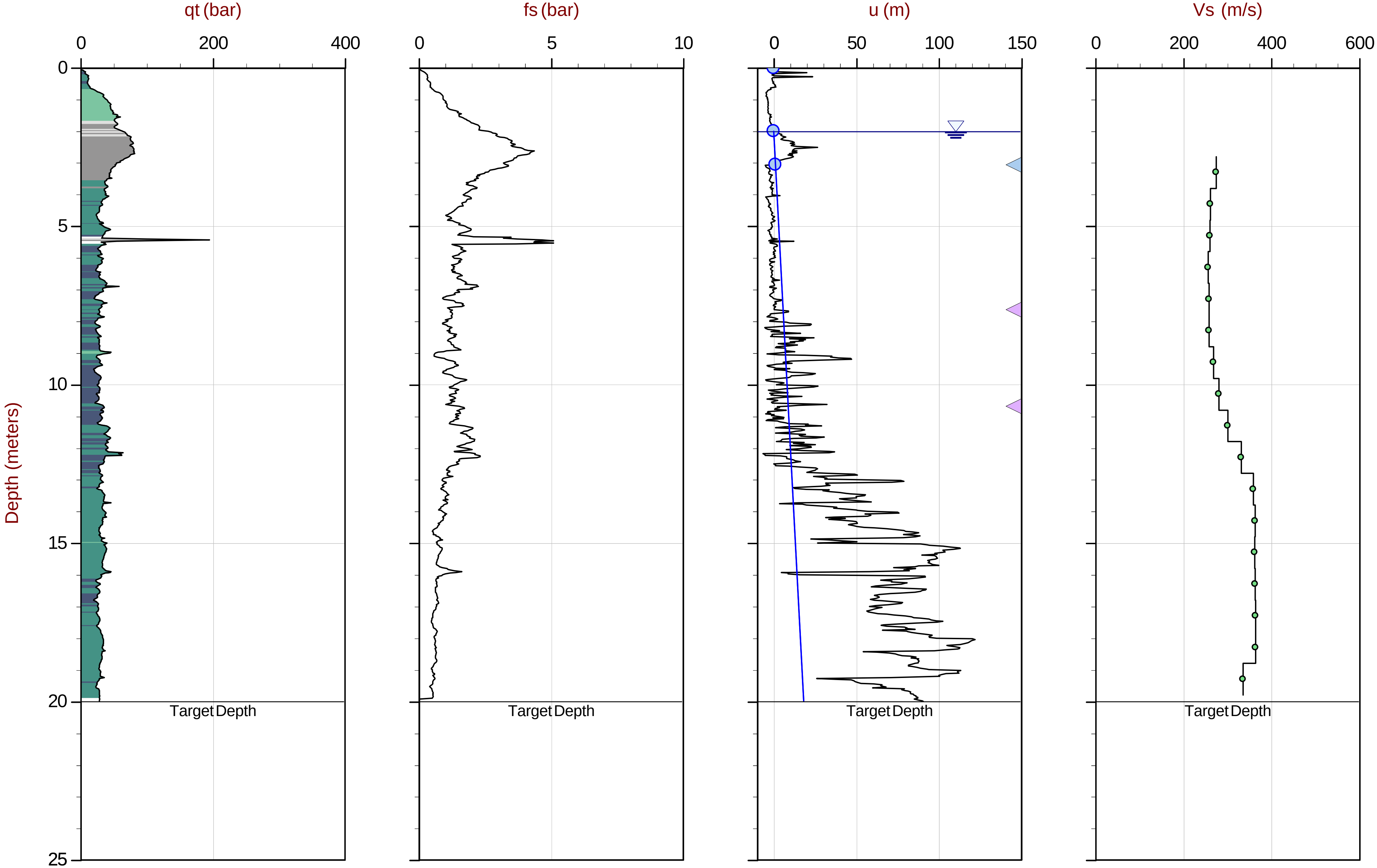
Max Depth: 20.100 m / 65.94 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point
File: 24-05-27609_SP-CN-08.COR
Unit Wt: SBTQtn (PKR2009)
SBT: Robertson, 2009 and 2010
Coords: UTM 17N N: 4740056m E: 480896m
Sheet No: 1 of 1
Overplot Item: Ueq Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Dissipation, Ueq assumed Hydrostatic Line
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Stantec

Job No: 24-05-27609
Date: 2024-05-10 06:58
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-CNREMB10
Cone: 729:T1500F15U35 Area=15 cm²



Max Depth: 20.000 m / 65.62 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 24-05-27609_SP-CN-10.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 17N N: 4739960m E: 481010m
Sheet No: 1 of 1

Overplot Item: Ueq Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Dissipation, Ueq assumed Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Seismic Cone Penetration Test Shear Wave (Vs) Tabular Results

Job No:	24-05-27609
Client:	Stantec
Project:	HWY 3 St Thomas CPT
Sounding ID:	SCPT24-RMNAPP01
Date:	2024-05-10
Seismic Source:	Beam
Seismic Offset (m):	3.20
Source Depth (m):	0.00
Geophone Offset (m):	0.20

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
3.03	2.83	4.27			
4.03	3.83	4.99	0.72	2.19	328
5.03	4.83	5.79	0.80	2.45	328
6.02	5.82	6.64	0.85	2.61	325
7.02	6.82	7.53	0.89	2.73	326
8.02	7.82	8.45	0.92	2.78	329
9.05	8.85	9.41	0.96	2.82	341
10.08	9.88	10.39	0.97	2.67	365
11.08	10.88	11.34	0.96	2.47	387
12.08	11.88	12.30	0.96	2.49	387
13.08	12.88	13.27	0.97	2.64	367
14.08	13.88	14.24	0.97	2.83	343
15.08	14.88	15.22	0.98	3.03	322

Job No: 24-05-27609
Client: Stantec
Project: HWY 3 St Thomas CPT
Sounding ID: SCPT24-CNREMB02
Date: 2024-05-09

Seismic Source: Beam
Seismic Offset (m): 3.20
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
2.82	2.62	4.14			
3.82	3.62	4.83	0.70	2.63	265
4.85	4.65	5.65	0.81	2.92	279
5.82	5.62	6.47	0.82	2.79	295
6.82	6.62	7.35	0.89	2.80	316
7.85	7.65	8.29	0.94	2.87	327
8.85	8.65	9.22	0.93	2.84	327
9.85	9.65	10.17	0.94	2.87	329
10.85	10.65	11.12	0.95	2.87	332
11.85	11.65	12.08	0.96	2.87	335
12.85	12.65	13.05	0.97	2.87	337
13.85	13.65	14.02	0.97	2.81	346
14.85	14.65	15.00	0.98	2.56	380
15.58	15.38	15.71	0.71	1.83	390

Job No:	24-05-27609
Client:	Stantec
Project:	HWY 3 St Thomas CPT
Sounding ID:	SCPT24-WAPP02
Date:	2024-05-10
Seismic Source:	Beam
Seismic Offset (m):	3.20
Source Depth (m):	0.00
Geophone Offset (m):	0.20

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
2.82	2.62	4.14			
3.82	3.62	4.83	0.70	1.79	390
4.82	4.62	5.62	0.79	2.05	384
5.82	5.62	6.47	0.85	2.14	396
6.85	6.65	7.38	0.91	2.32	393
7.85	7.65	8.29	0.91	2.32	393
8.83	8.63	9.20	0.91	2.30	396
9.80	9.60	10.12	0.92	2.46	373
10.80	10.60	11.07	0.95	2.82	338
11.80	11.60	12.03	0.96	3.20	300
12.80	12.60	13.00	0.97	3.58	270
13.80	13.60	13.97	0.97	3.57	272
14.80	14.60	14.95	0.98	3.58	273
15.00	14.80	15.14	0.20	0.75	260

Job No: 24-05-27609
Client: Stantec
Project: HWY 3 St Thomas CPT
Sounding ID: SCPT24-CNREMB08
Date: 2024-05-09

Seismic Source: Beam
Seismic Offset (m): 3.20
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
3.05	2.85	4.29			
4.08	3.88	5.03	0.74	2.26	330
5.08	4.88	5.84	0.81	2.35	343
6.08	5.88	6.69	0.86	2.45	351
7.08	6.88	7.59	0.89	2.55	351
8.08	7.88	8.51	0.92	2.56	358
9.08	8.88	9.44	0.93	2.57	363
10.08	9.88	10.39	0.95	2.56	370
11.08	10.88	11.34	0.96	2.46	388
12.10	11.90	12.32	0.98	2.56	384
13.08	12.88	13.27	0.95	2.56	371
14.10	13.90	14.26	0.99	2.84	349
15.10	14.90	15.24	0.98	2.93	333
16.10	15.90	16.22	0.98	3.03	323
17.10	16.90	17.20	0.98	3.07	319
18.10	17.90	18.18	0.98	3.15	313
19.10	18.90	19.17	0.99	3.23	305
20.10	19.90	20.16	0.99	3.32	297

Job No: 24-05-27609
Client: Stantec
Project: HWY 3 St Thomas CPT
Sounding ID: SCPT24-CNREMB10
Date: 2024-05-10

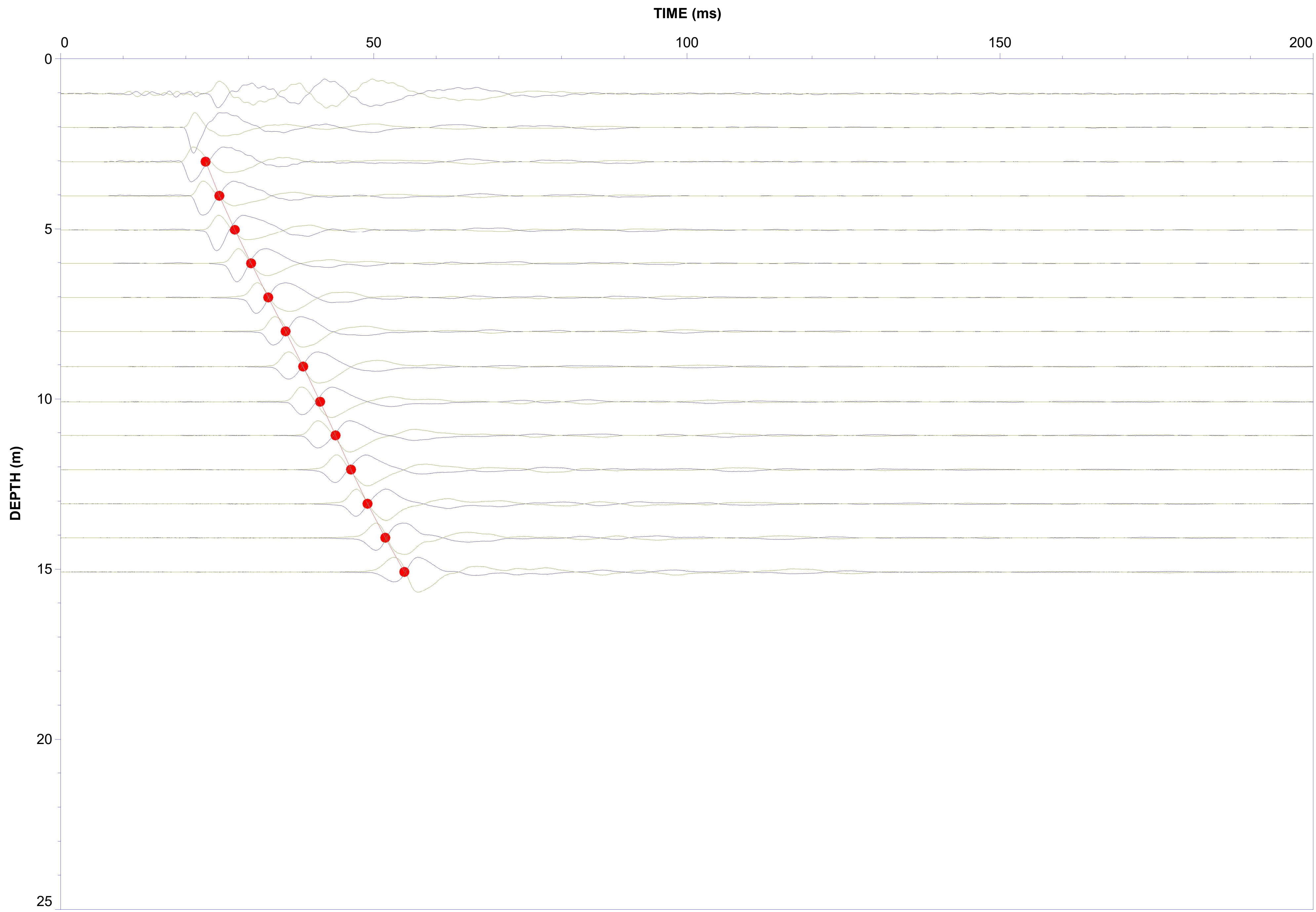
Seismic Source: Beam
Seismic Offset (m): 3.20
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

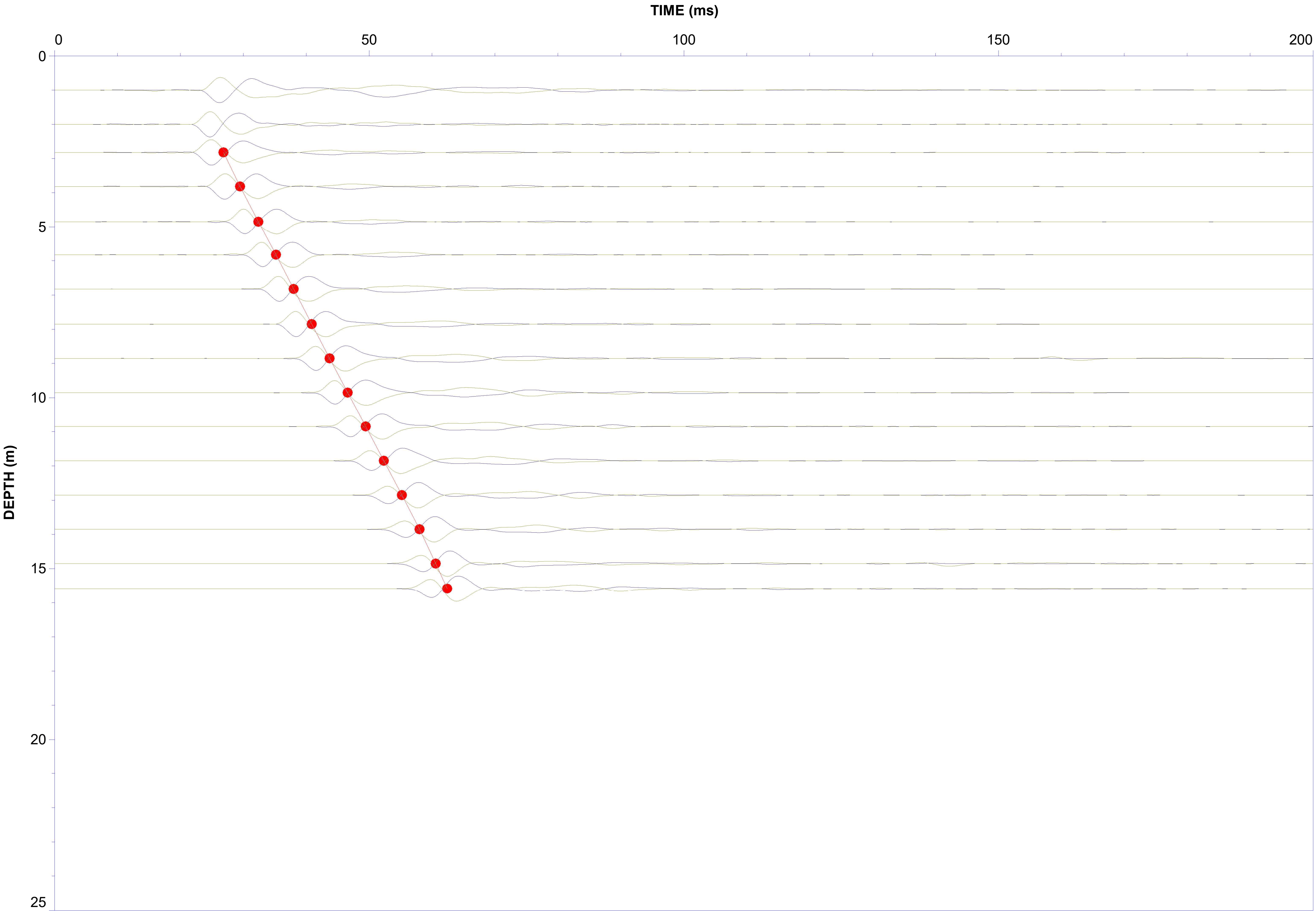
Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
3.00	2.80	4.25			
4.00	3.80	4.97	0.72	2.61	275
5.00	4.80	5.77	0.80	3.07	261
6.00	5.80	6.62	0.86	3.29	260
7.00	6.80	7.52	0.89	3.48	256
8.00	7.80	8.43	0.92	3.55	258
9.00	8.80	9.36	0.93	3.61	258
10.00	9.80	10.31	0.95	3.53	268
11.00	10.80	11.26	0.96	3.41	280
12.00	11.80	12.23	0.96	3.20	301
13.00	12.80	13.19	0.97	2.92	332
14.00	13.80	14.17	0.97	2.71	359
15.00	14.80	15.14	0.98	2.70	362
16.00	15.80	16.12	0.98	2.71	362
17.00	16.80	17.10	0.98	2.71	363
18.00	17.80	18.09	0.98	2.71	363
19.00	18.80	19.07	0.99	2.71	364
20.00	19.80	20.06	0.99	2.95	335

Seismic Cone Penetration Test Shear Wave (Vs) Traces

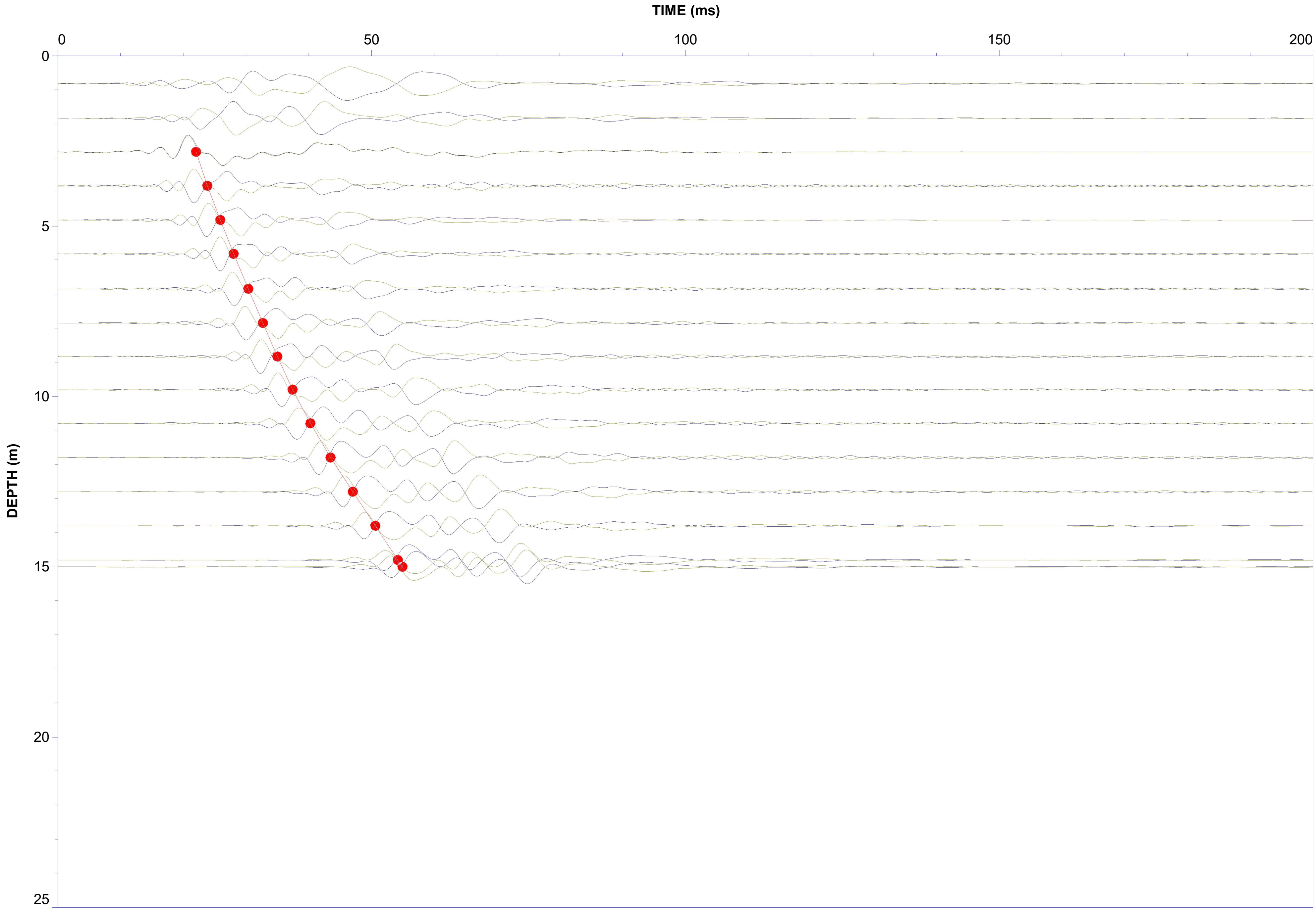
Job No: 24-05-27609 Client: Stantec Project: HWY 3 St Thomas CPT Sounding: SCPT24-RMNAPP01 Filter: None Date: 2024-05-10
Analysis: S Wave - Geo X



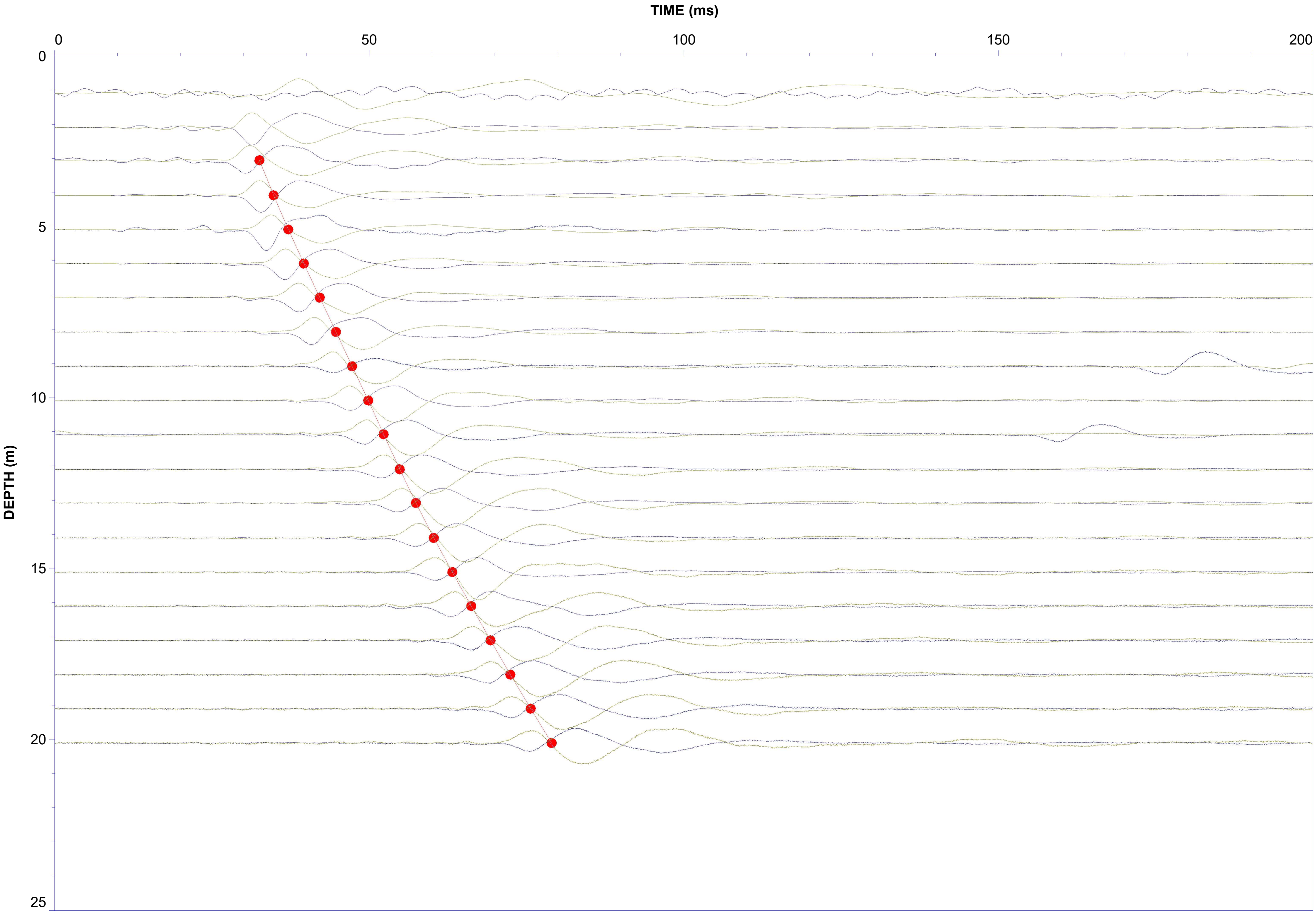
Job No: 24-05-27609 Client: Stantec Project: HWY 3 St Thomas CPT Sounding: SCPT24-CNREMB02 Filter: None Date: 2024-05-09
Analysis: S Wave - Geo X



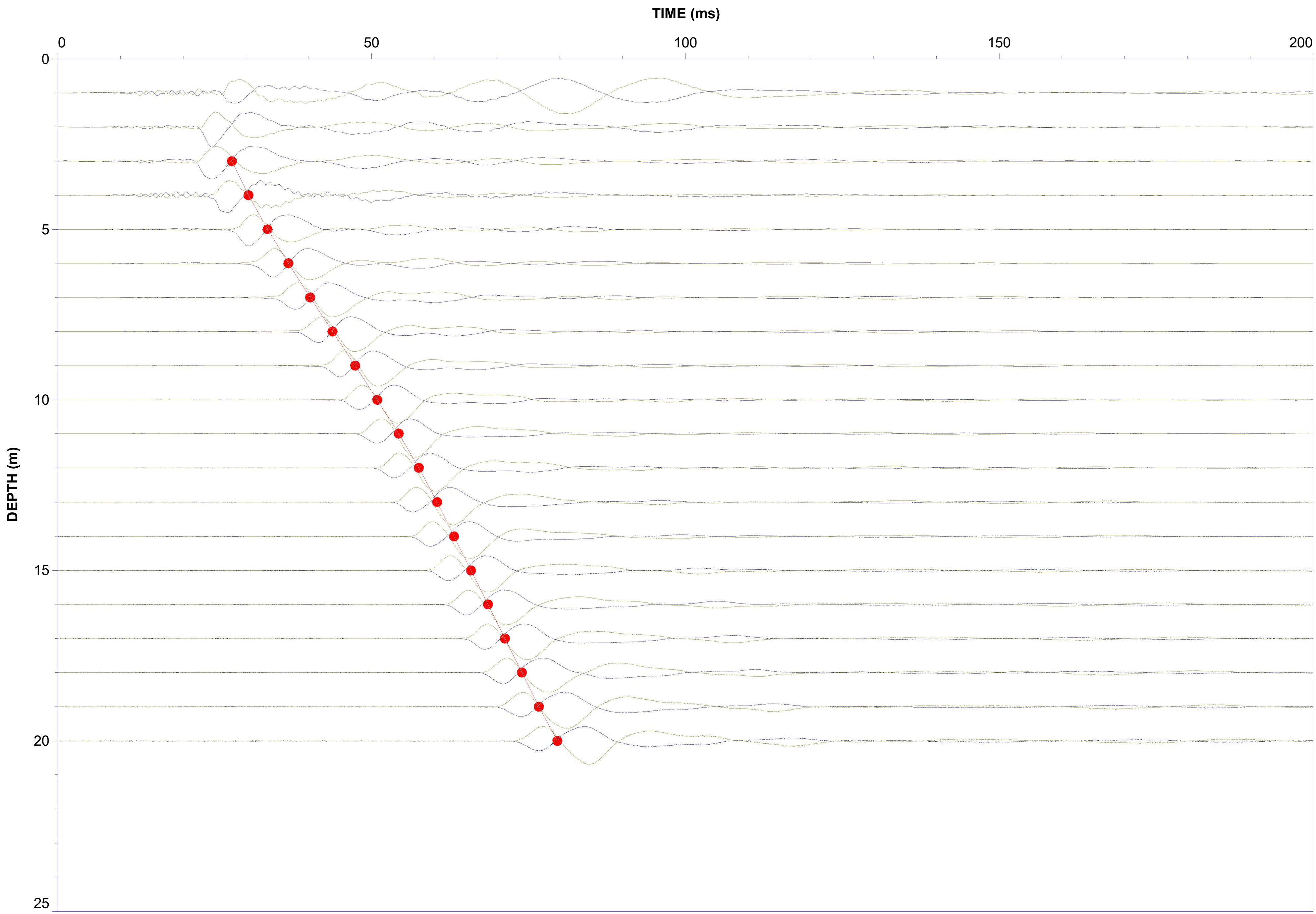
Job No: 24-05-27609 Client: Stantec Project: HWY 3 St Thomas CPT Sounding: SCPT24-WAPP02 Filter: 0-300Hz Date: 2024-05-10
Analysis: S Wave - Geo X



Job No: 24-05-27609 Client: Stantec Project: HWY 3 St Thomas CPT Sounding: SCPT24-CNREMB08 Filter: None Date: 2024-05-09
Analysis: S Wave - Geo X



Job No: 24-05-27609 Client: Stantec Project: HWY 3 St Thomas CPT Sounding: SCPT24-CNREMB10 Filter: None Date: 2024-05-10
Analysis: S Wave - Geo X



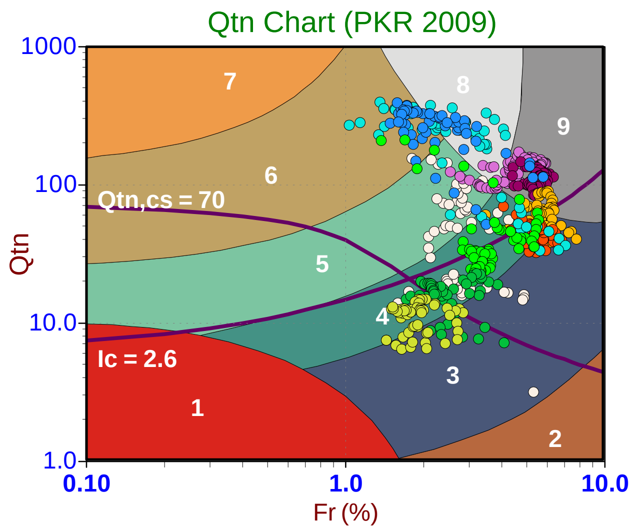
Soil Behaviour Type (SBT) Scatter Plots

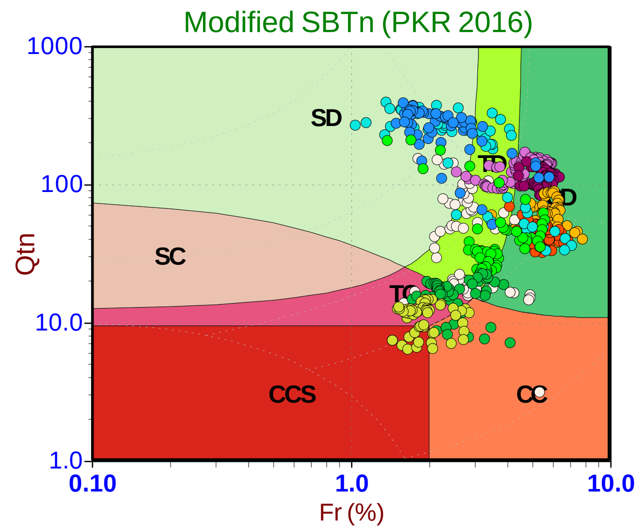
CONETEC

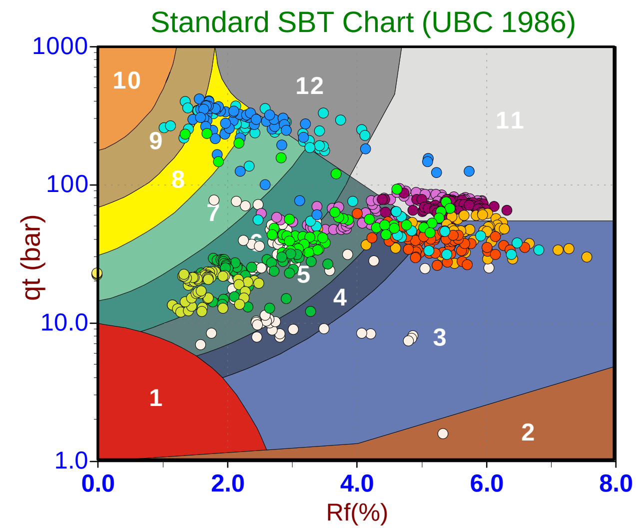
Stantec

Job No: 24-05-27609
Date: 2024-05-10 12:15
Site: HWY 3, St.Thomas, ON

Sounding: CPT24-RMNAPP01
Cone: 729:T1500F15U35 Area=15 cm²







Depth Ranges
- >0.0 to 1.5 m
- >1.5 to 3.0 m
- >3.0 to 4.5 m
- >4.5 to 6.0 m
- >6.0 to 7.5 m
- >7.5 to 9.0 m
- >9.0 to 10.5 m
- >10.5 to 12.0 m
- >12.0 to 13.5 m
- >13.5 to 15.0 m
- >15.0 m

Legend
- Sensitive, Fine Grained
- Organic Soils
- Clays
- Silt Mixtures
- Sand Mixtures
- Sands
- Gravelly Sand to Sand
- Stiff Sand to Clayey Sand
- Very Stiff Fine Grained

Legend
- CCS (Cont. sensitive clay like)
- CC (Cont. clay like)
- TC (Cont. transitional)
- SC (Cont. sand like)
- CD (Dil. clay like)
- TD (Dil. transitional)
- SD (Dil. sand like)

Legend
- Sensitive Fines
- Organic Soil
- Clay
- Silty Clay
- Clayey Silt
- Silt
- Sandy Silt
- Silty Sand/Sand
- Sand
- Gravelly Sand
- Stiff Fine Grained
- Cemented Sand

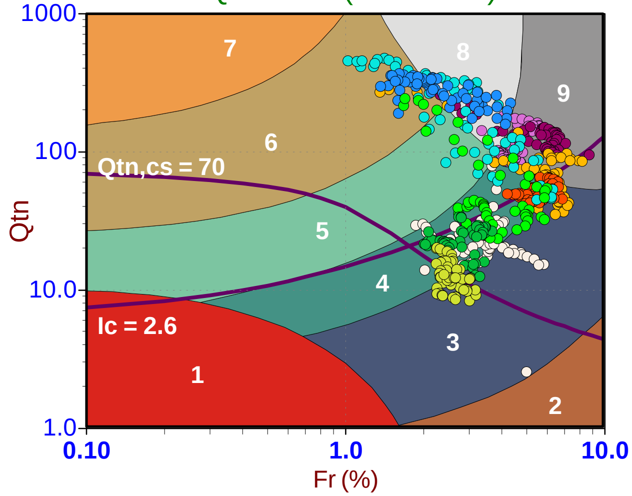
CONETEC

Stantec

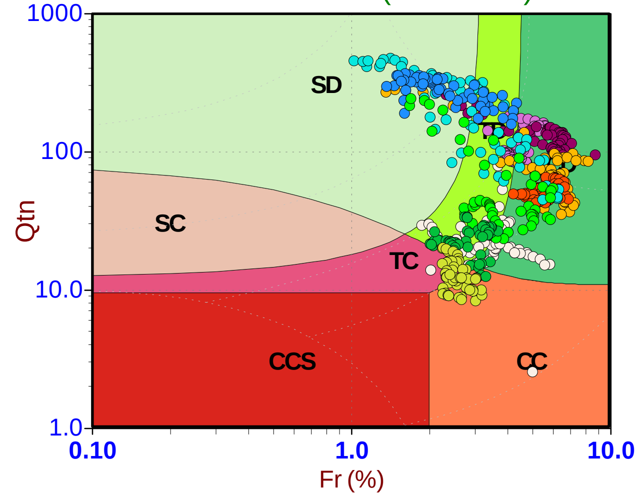
Job No: 24-05-27609
Date: 2024-05-10 10:24
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-RMNAPP01
Cone: 729:T1500F15U35 Area=15 cm²

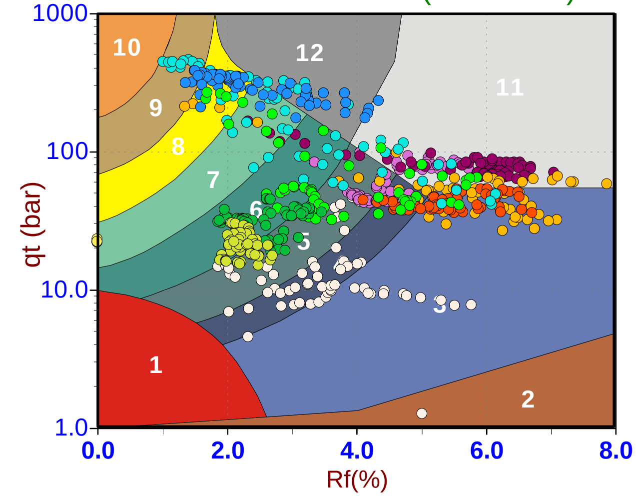
Qtn Chart (PKR 2009)



Modified SBTn (PKR 2016)



Standard SBT Chart (UBC 1986)



Depth Ranges

- >0.0 to 1.5 m
- >1.5 to 3.0 m
- >3.0 to 4.5 m
- >4.5 to 6.0 m
- >6.0 to 7.5 m
- >7.5 to 9.0 m
- >9.0 to 10.5 m
- >10.5 to 12.0 m
- >12.0 to 13.5 m
- >13.5 to 15.0 m
- >15.0 m

Legend

- Sensitive, Fine Grained
- Organic Soils
- Clays
- Silt Mixtures
- Sand Mixtures
- Sands
- Gravelly Sand to Sand
- Stiff Sand to Clayey Sand
- Very Stiff Fine Grained

Legend

- CCS (Cont. sensitive clay like)
- CC (Cont. clay like)
- TC (Cont. transitional)
- SC (Cont. sand like)
- CD (Dil. clay like)
- TD (Dil. transitional)
- SD (Dil. sand like)

Legend

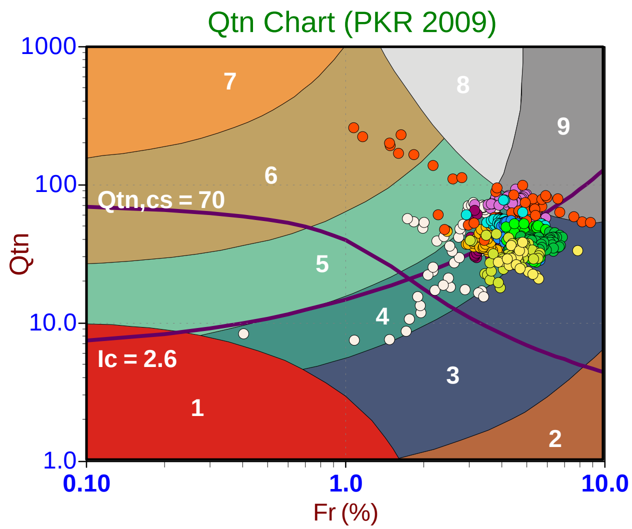
- Sensitive Fines
- Organic Soil
- Clay
- Silty Clay
- Clayey Silt
- Silt
- Sandy Silt
- Silty Sand/Sand
- Sand
- Gravelly Sand
- Stiff Fine Grained
- Cemented Sand

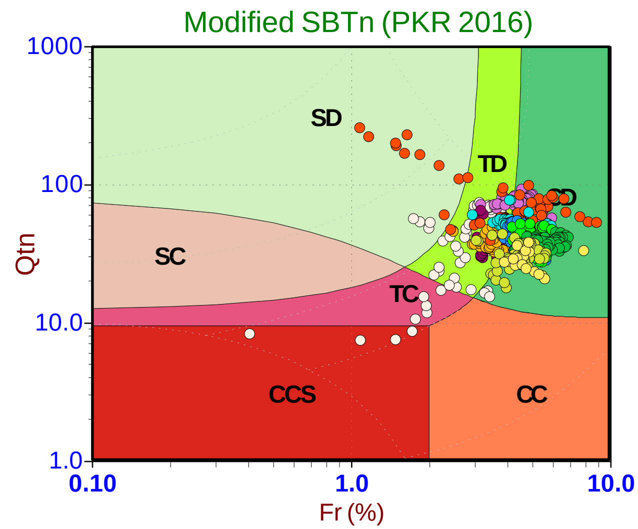
CONETEC

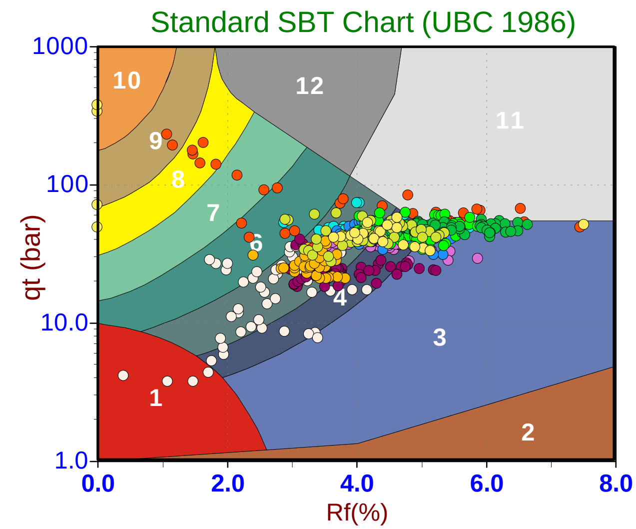
Stantec

Job No: 24-05-27609
Date: 2024-05-09 12:06
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-CNREMB02
Cone: 729:T1500F15U35 Area=15 cm²







Depth Ranges

- >0.0 to 1.5 m
- >1.5 to 3.0 m
- >3.0 to 4.5 m
- >4.5 to 6.0 m
- >6.0 to 7.5 m
- >7.5 to 9.0 m
- >9.0 to 10.5 m
- >10.5 to 12.0 m
- >12.0 to 13.5 m
- >13.5 to 15.0 m
- >15.0 m

Legend

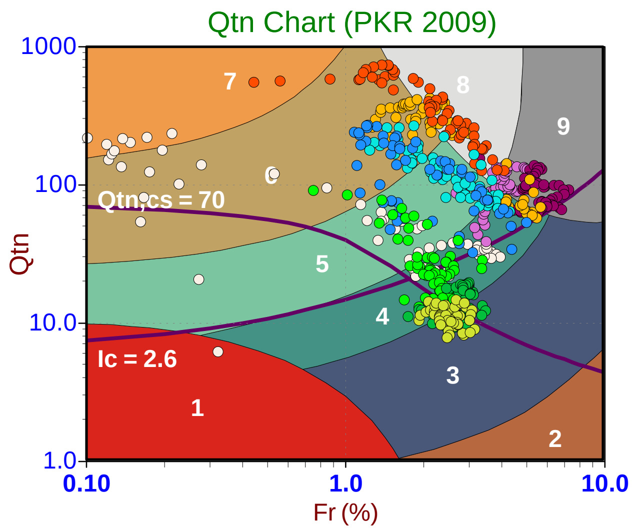
- Sensitive, Fine Grained
- Organic Soils
- Clays
- Silt Mixtures
- Sand Mixtures
- Sands
- Gravelly Sand to Sand
- Stiff Sand to Clayey Sand
- Very Stiff Fine Grained

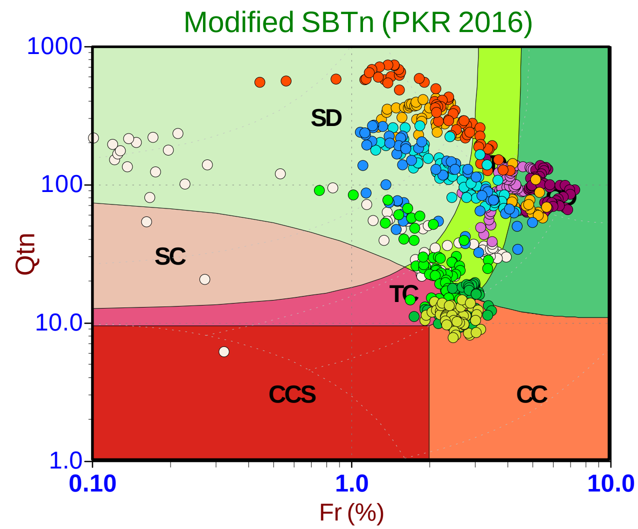
Legend

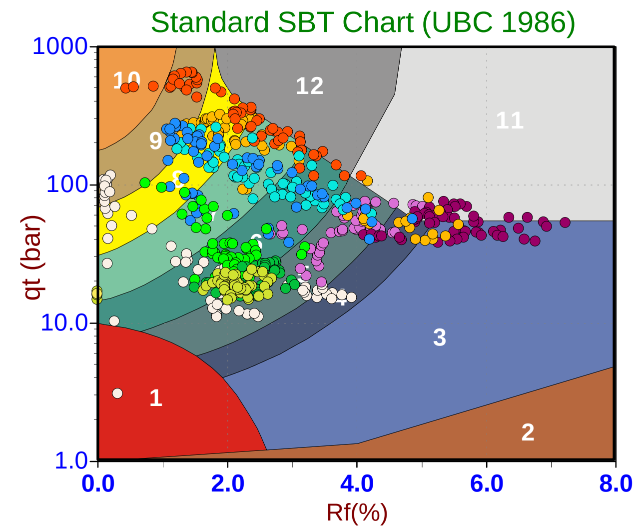
- CCS (Cont. sensitive clay like)
- CC (Cont. clay like)
- TC (Cont. transitional)
- SC (Cont. sand like)
- CD (Dil. clay like)
- TD (Dil. transitional)
- SD (Dil. sand like)

Legend

- Sensitive Fines
- Organic Soil
- Clay
- Silty Clay
- Clayey Silt
- Silt
- Sandy Silt
- Silty Sand/Sand
- Sand
- Gravelly Sand
- Stiff Fine Grained
- Cemented Sand







Depth Ranges

- >0.0 to 1.5 m
- >1.5 to 3.0 m
- >3.0 to 4.5 m
- >4.5 to 6.0 m
- >6.0 to 7.5 m
- >7.5 to 9.0 m
- >9.0 to 10.5 m
- >10.5 to 12.0 m
- >12.0 to 13.5 m
- >13.5 to 15.0 m
- >15.0 m

Legend

- Sensitive, Fine Grained
- Organic Soils
- Clays
- Silt Mixtures
- Sand Mixtures
- Sands
- Gravelly Sand to Sand
- Stiff Sand to Clayey Sand
- Very Stiff Fine Grained

Legend

- CCS (Cont. sensitive clay like)
- CC (Cont. clay like)
- TC (Cont. transitional)
- SC (Cont. sand like)
- CD (Dil. clay like)
- TD (Dil. transitional)
- SD (Dil. sand like)

Legend

- Sensitive Fines
- Organic Soil
- Clay
- Silty Clay
- Clayey Silt
- Silt
- Sandy Silt
- Silty Sand/Sand
- Sand
- Gravelly Sand
- Stiff Fine Grained
- Cemented Sand

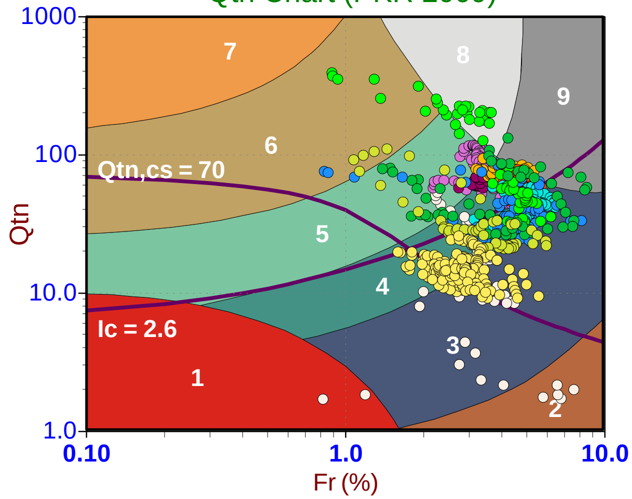
CONETEC

Stantec

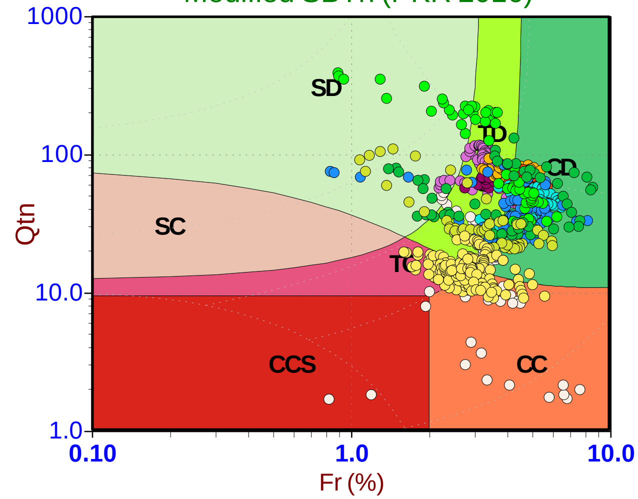
Job No: 24-05-27609
Date: 2024-05-09 16:43
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-CNREMB08
Cone: 729:T1500F15U35 Area=15 cm²

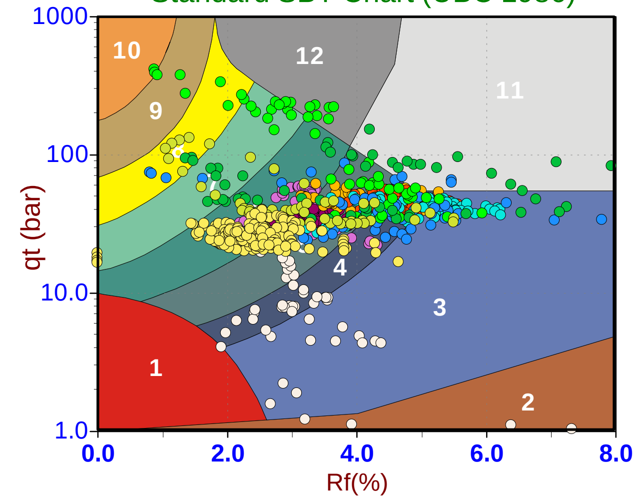
Qtn Chart (PKR 2009)



Modified SBTn (PKR 2016)



Standard SBT Chart (UBC 1986)



Depth Ranges

- >0.0 to 1.5 m
- >1.5 to 3.0 m
- >3.0 to 4.5 m
- >4.5 to 6.0 m
- >6.0 to 7.5 m
- >7.5 to 9.0 m
- >9.0 to 10.5 m
- >10.5 to 12.0 m
- >12.0 to 13.5 m
- >13.5 to 15.0 m
- >15.0 m

Legend

- Sensitive, Fine Grained
- Organic Soils
- Clays
- Silt Mixtures
- Sand Mixtures
- Sands
- Gravelly Sand to Sand
- Stiff Sand to Clayey Sand
- Very Stiff Fine Grained

Legend

- CCS (Cont. sensitive clay like)
- CC (Cont. clay like)
- TC (Cont. transitional)
- SC (Cont. sand like)
- CD (Dil. clay like)
- TD (Dil. transitional)
- SD (Dil. sand like)

Legend

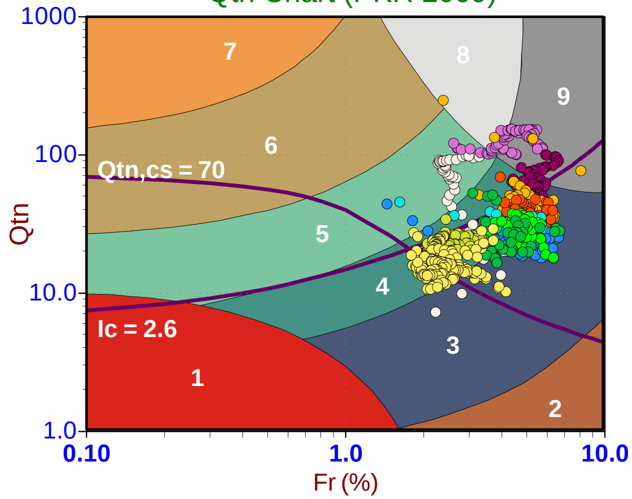
- Sensitive Fines
- Organic Soil
- Clay
- Silty Clay
- Clayey Silt
- Silt
- Sandy Silt
- Silty Sand/Sand
- Sand
- Gravelly Sand
- Stiff Fine Grained
- Cemented Sand

CONETEC | **Stantec**

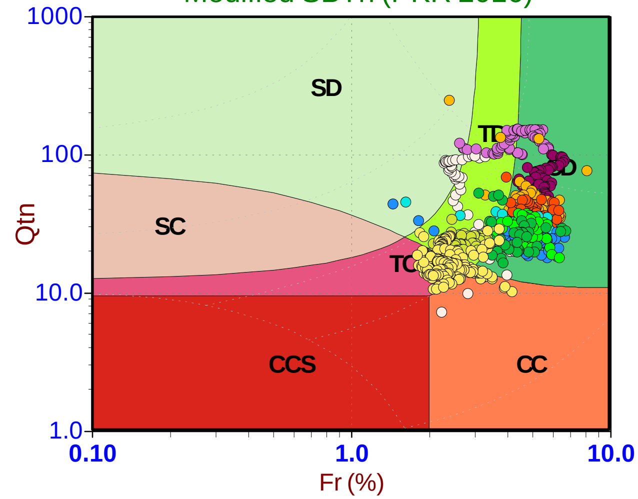
Job No: 24-05-27609
Date: 2024-05-10 06:58
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-CNREMB10
Cone: 729:T1500F15U35 Area=15 cm²

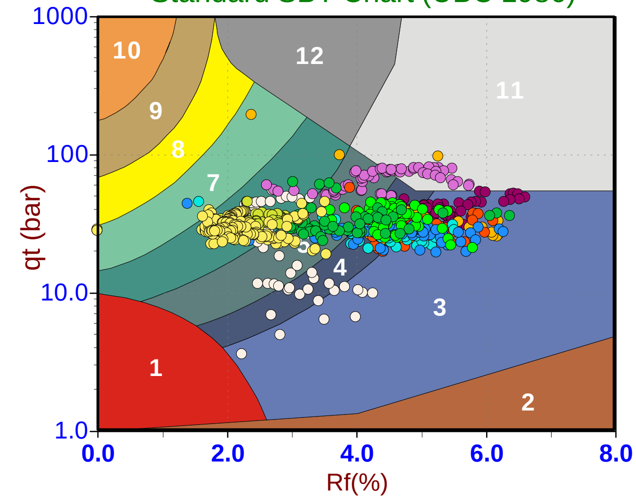
Qtn Chart (PKR 2009)



Modified SBTn (PKR 2016)



Standard SBT Chart (UBC 1986)



Depth Ranges

- >0.0 to 1.5 m
- >1.5 to 3.0 m
- >3.0 to 4.5 m
- >4.5 to 6.0 m
- >6.0 to 7.5 m
- >7.5 to 9.0 m
- >9.0 to 10.5 m
- >10.5 to 12.0 m
- >12.0 to 13.5 m
- >13.5 to 15.0 m
- >15.0 m

Legend

- Sensitive, Fine Grained
- Organic Soils
- Clays
- Silt Mixtures
- Sand Mixtures
- Sands
- Gravelly Sand to Sand
- Stiff Sand to Clayey Sand
- Very Stiff Fine Grained

Legend

- CCS (Cont. sensitive clay like)
- CC (Cont. clay like)
- TC (Cont. transitional)
- SC (Cont. sand like)
- CD (Dil. clay like)
- TD (Dil. transitional)
- SD (Dil. sand like)

Legend

- Sensitive Fines
- Organic Soil
- Clay
- Silty Clay
- Clayey Silt
- Silt
- Sandy Silt
- Silty Sand/Sand
- Sand
- Gravelly Sand
- Stiff Fine Grained
- Cemented Sand

Pore Pressure Dissipation Summary and Pore Pressure Dissipation Plots

ConeTec

Job No: 24-05-27609
Client: Stantec Consulting Ltd.
Project: HWY 3 St Thomas CPT
Start Date: 2024-05-09
End Date: 2024-05-10

CPTu PORE PRESSURE DISSIPATION SUMMARY

Sounding ID	File Name	Cone Area (cm^2)	Duration (s)	Test Depth (m)	$U_{initial}$ (m)	U_{max} (m)	U_{min} (m)	U_{final} (m)	Observed Equilibrium Pore Pressure U_{eq} (m)	Estimated Equilibrium Pore Pressure U_{eq} (m)	Assumed Phreatic Surface (m)	Percent Dissipation (%)	t_{50} $(s)_1$	Assumed Rigidity Index (I_r)	c_h $(cm^2/min)_2$	Refer to Notation Number
CPT24-RMNAPP01	24-05-27609_CP-RM-01	15	670	3.050	0.9	9.2	-2.2	9.2								
CPT24-RMNAPP01	24-05-27609_CP-RM-01	15	3090	7.625	0.4	44.6	0.4	26.4								
SCPT24-RMNAPP01	24-05-27609_SP-RM-01	15	790	3.050	1.4	1.4	-8.7	-7.3								
SCPT24-RMNAPP01	24-05-27609_SP-RM-01	15	1150	9.050	1.4	2.4	0.9	2.4								
SCPT24-CNREMB02	24-05-27609_SP-CN-02	15	3330	3.050	1.1	38.2	1.0	19.4		1.1	2.0	51	2923	100	0.2	3
SCPT24-CNREMB02	24-05-27609_SP-CN-02	15	1090	7.625	13.8	42.9	13.8	38.9								
SCPT24-CNREMB02	24-05-27609_SP-CN-02	15	2940	10.675	8.2	61.5	7.9	34.0		8.7	2.0	52	2423	100	0.3	3
SCPT24-WAPP02	24-05-27609_SP-WA-02	15	2010	3.050	31.5	99.6	31.5	49.9		1.2	1.8	51	1786	100	0.4	3
SCPT24-WAPP02	24-05-27609_SP-WA-02	15	1100	7.625	13.1	13.1	1.1	5.8	5.8		1.8	100				
SCPT24-CNREMB08	24-05-27609_SP-CN-08	15	3090	3.050	11.8	51.9	8.7	26.5		1.6	1.5	50	2773	100	0.3	3
SCPT24-CNREMB08	24-05-27609_SP-CN-08	15	1550	7.625	9.2	67.2	6.7	54.3								
SCPT24-CNREMB08	24-05-27609_SP-CN-08	15	2370	10.675	47.5	96.8	46.6	53.4								
SCPT24-CNREMB08	24-05-27609_SP-CN-08	15	470	20.100	40.1	70.1	40.1	66.8								
SCPT24-CNREMB10	24-05-27609_SP-CN-10	15	3030	3.050	-0.6	17.5	-0.6	9.2		1.1	2.0	50	2880	100	0.2	3
SCPT24-CNREMB10	24-05-27609_SP-CN-10	15	740	7.625	-0.6	30.1	-0.6	30.0								
SCPT24-CNREMB10	24-05-27609_SP-CN-10	15	3450	10.675	10.0	44.0	10.0	32.8								

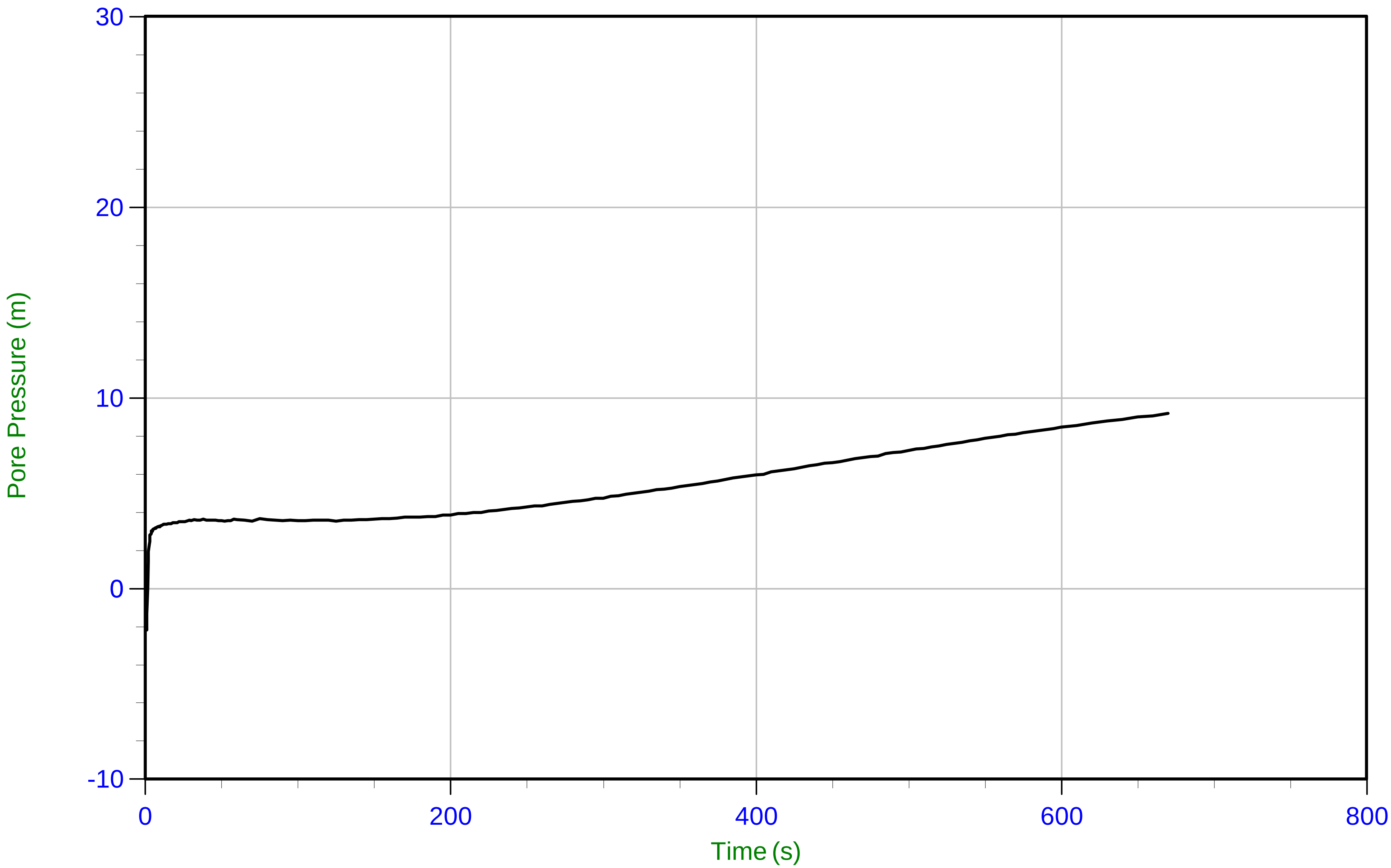
1. Time for 50 percent dissipation was based on U_{max}, U_{min}, and the applied U_{eq}. Note the time is relative to where U_{max} occurred.
2. Teh and Houlsby, 1991.
3. The estimated equilibrium pore pressure was based on a hydrostatic assumption from the assumed phreatic surface.

ConeTec

Stantec

Job No: 24-05-27609
Date: 2024-05-10 12:15
Site: HWY 3, St.Thomas, ON

Sounding: CPT24-RMNAPP01
Cone: 729:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 24-05-27609_CP-RM-01.PPF2
Depth: 3.050 m / 10.006 ft
Duration: 670.0 s

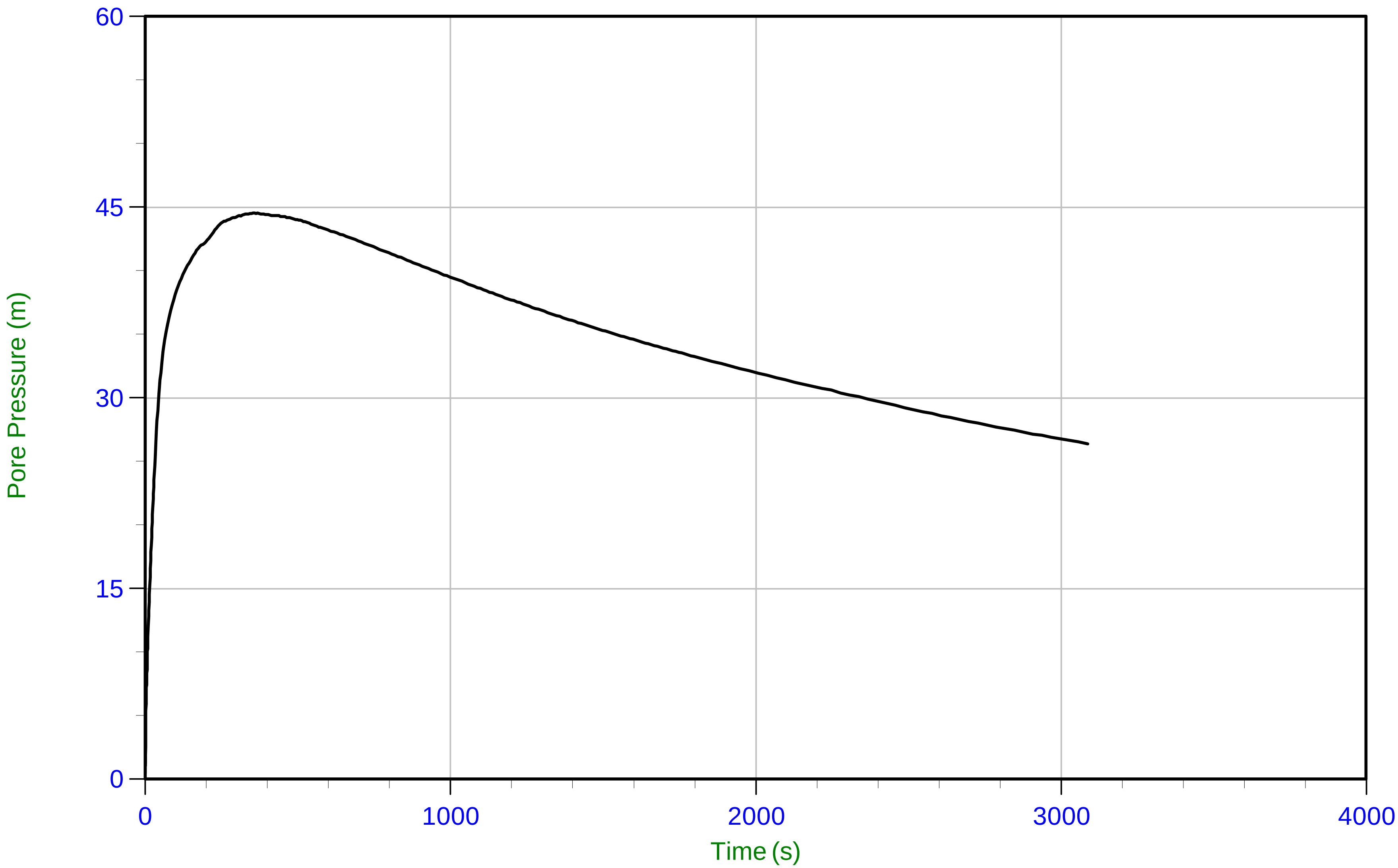
u Min: -2.2 m
u Max: 9.2 m
u Final: 9.2 m

ConeTec

Stantec

Job No: 24-05-27609
Date: 2024-05-10 12:15
Site: HWY 3, St.Thomas, ON

Sounding: CPT24-RMNAPP01
Cone: 729:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 24-05-27609_CP-RM-01.PPF2
Depth: 7.625 m / 25.016 ft
Duration: 3090.0 s

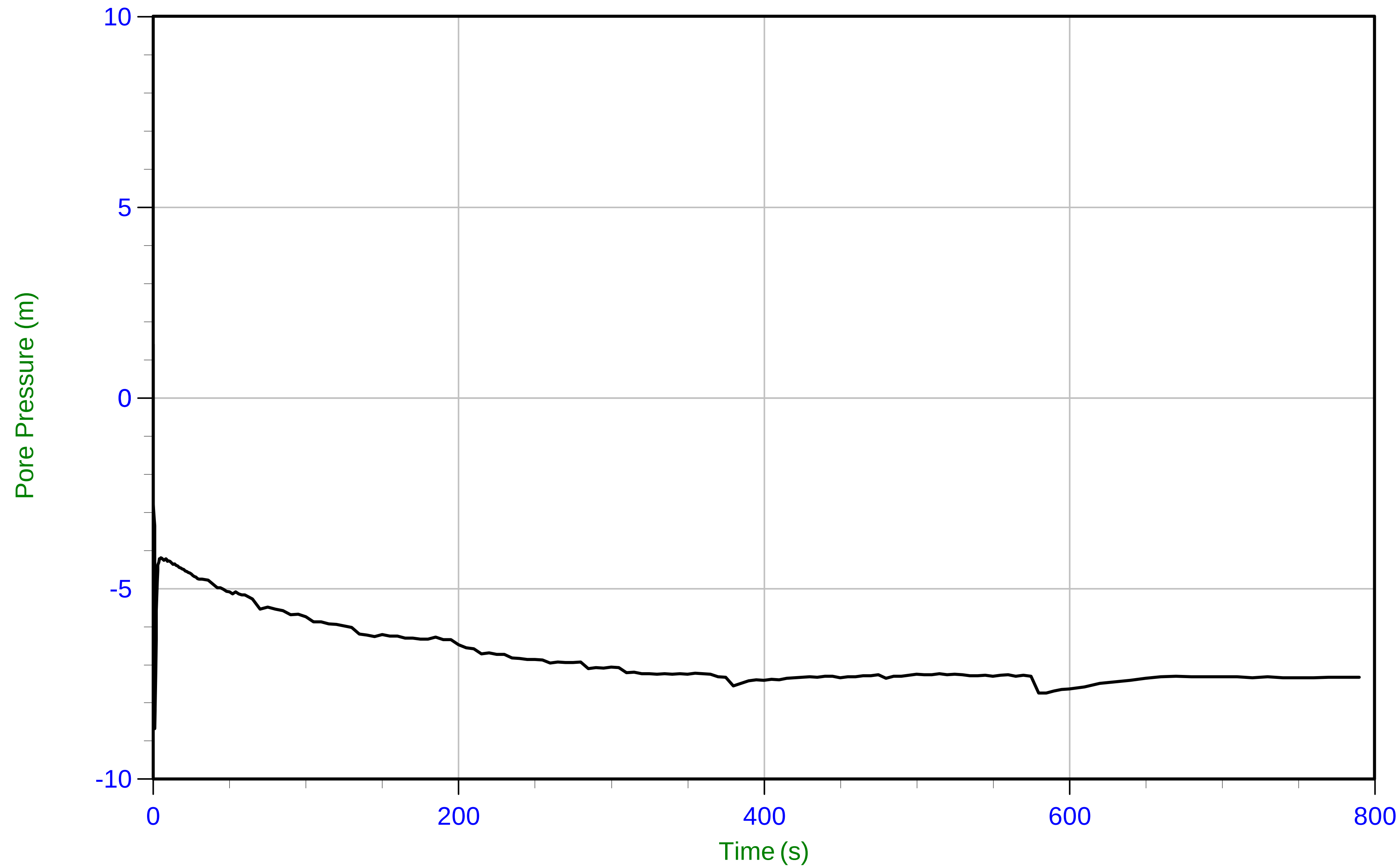
u Min: 0.4 m
u Max: 44.6 m
u Final: 26.4 m

ConeTec

Stantec

Job No: 24-05-27609
Date: 2024-05-10 10:24
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-RMNAPP01
Cone: 729:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 24-05-27609_SP-RM-01.PPF2
Depth: 3.050 m / 10.006 ft
Duration: 790.0 s

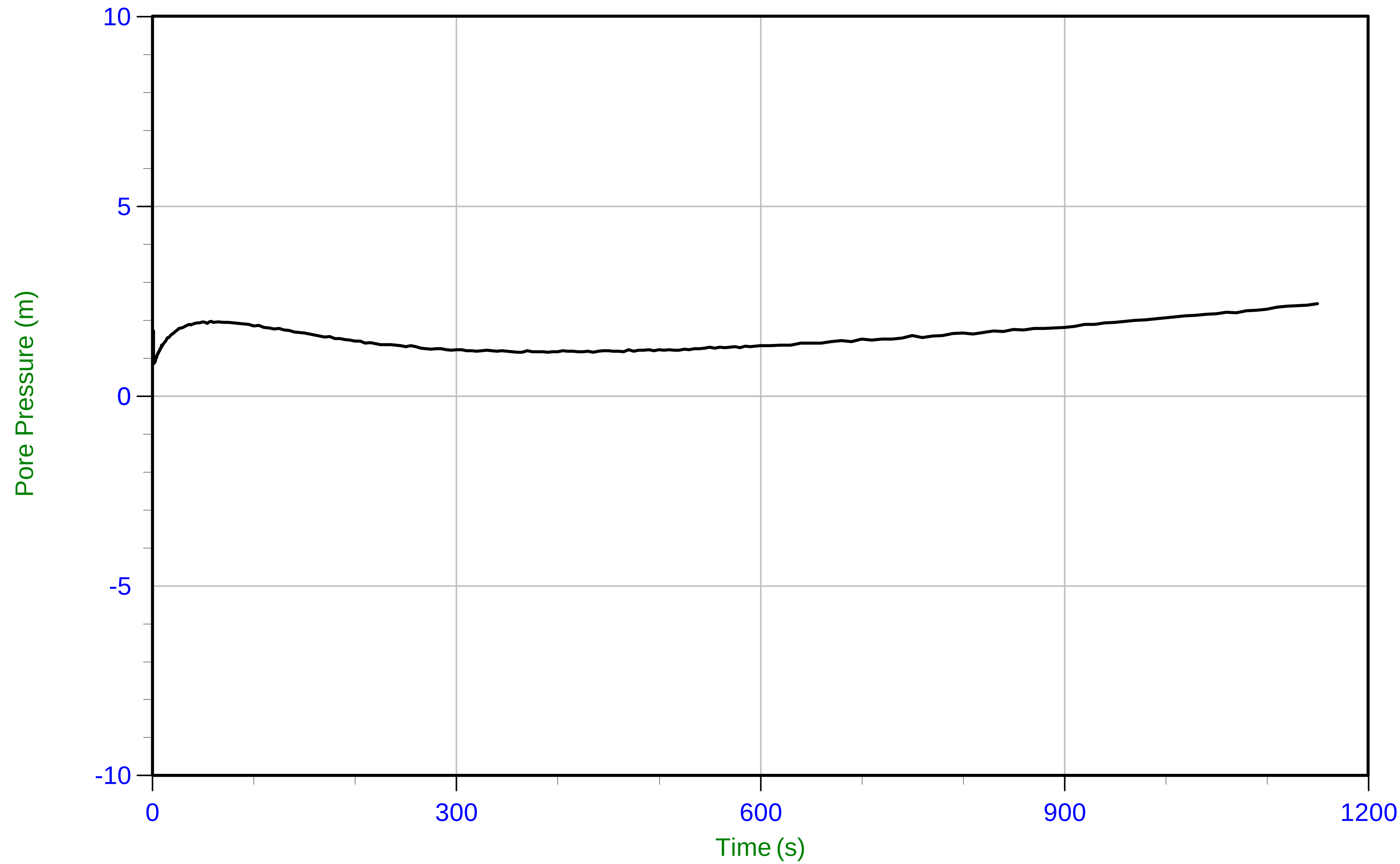
u Min: -8.7 m
u Max: 1.4 m
u Final: -7.3 m

CONETEC

Stantec

Job No: 24-05-27609
Date: 2024-05-10 10:24
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-RMNAPP01
Cone: 729:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 24-05-27609_SP-RM-01.PPF2
Depth: 9.050 m / 29.691 ft
Duration: 1150.0 s

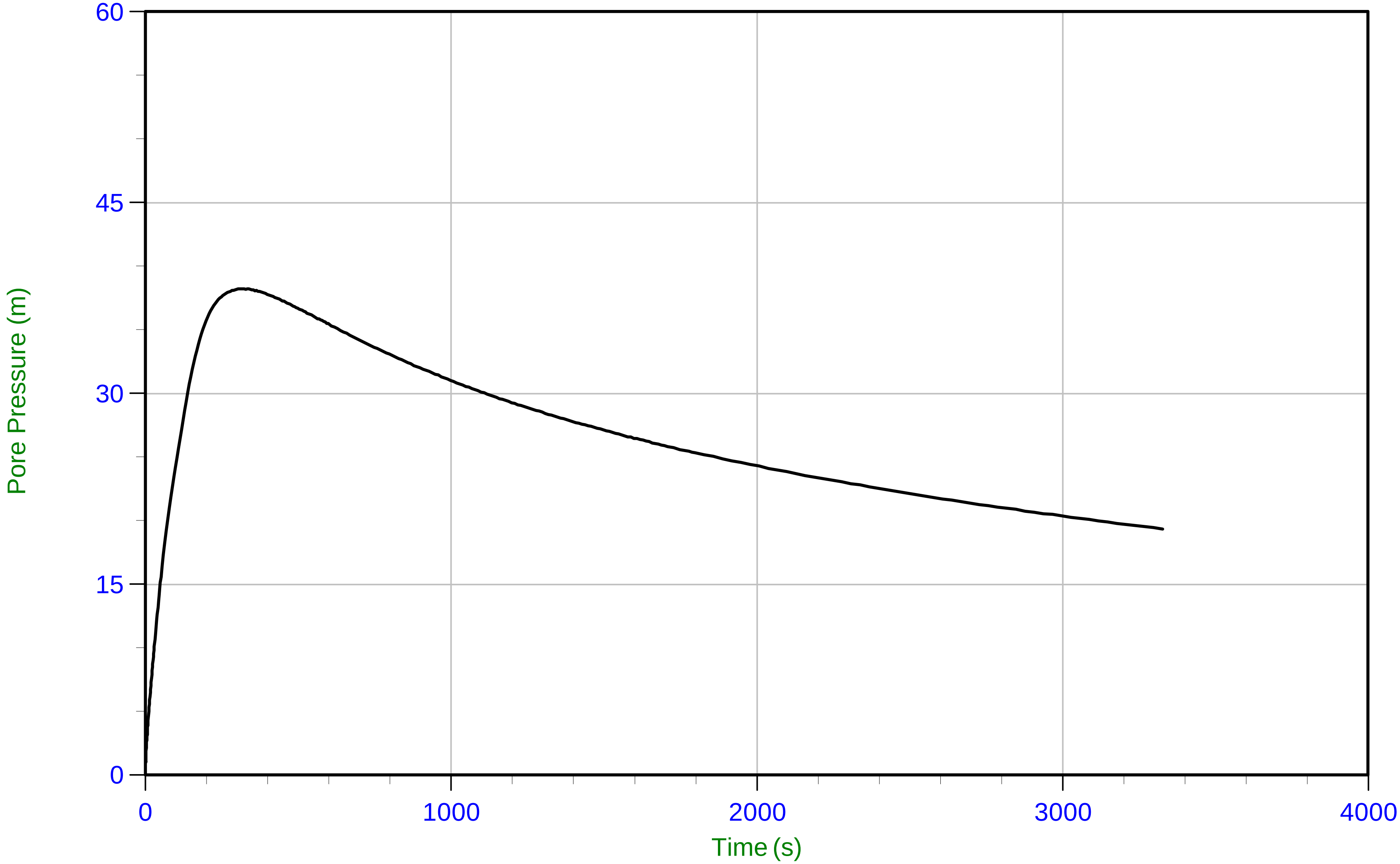
u Min: 0.9 m
u Max: 2.4 m
u Final: 2.4 m

ConeTec

Stantec

Job No: 24-05-27609
Date: 2024-05-09 12:06
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-CNREMB02
Cone: 729:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 24-05-27609_SP-CN-02.PPF2
Depth: 3.050 m / 10.006 ft
Duration: 3330.0 s

u Min: 1.0 m
u Max: 38.2 m
u Final: 19.4 m

WT: 2.0 m / 6.6 ft
Ueq: 1.1 m
U(50): 19.64 m

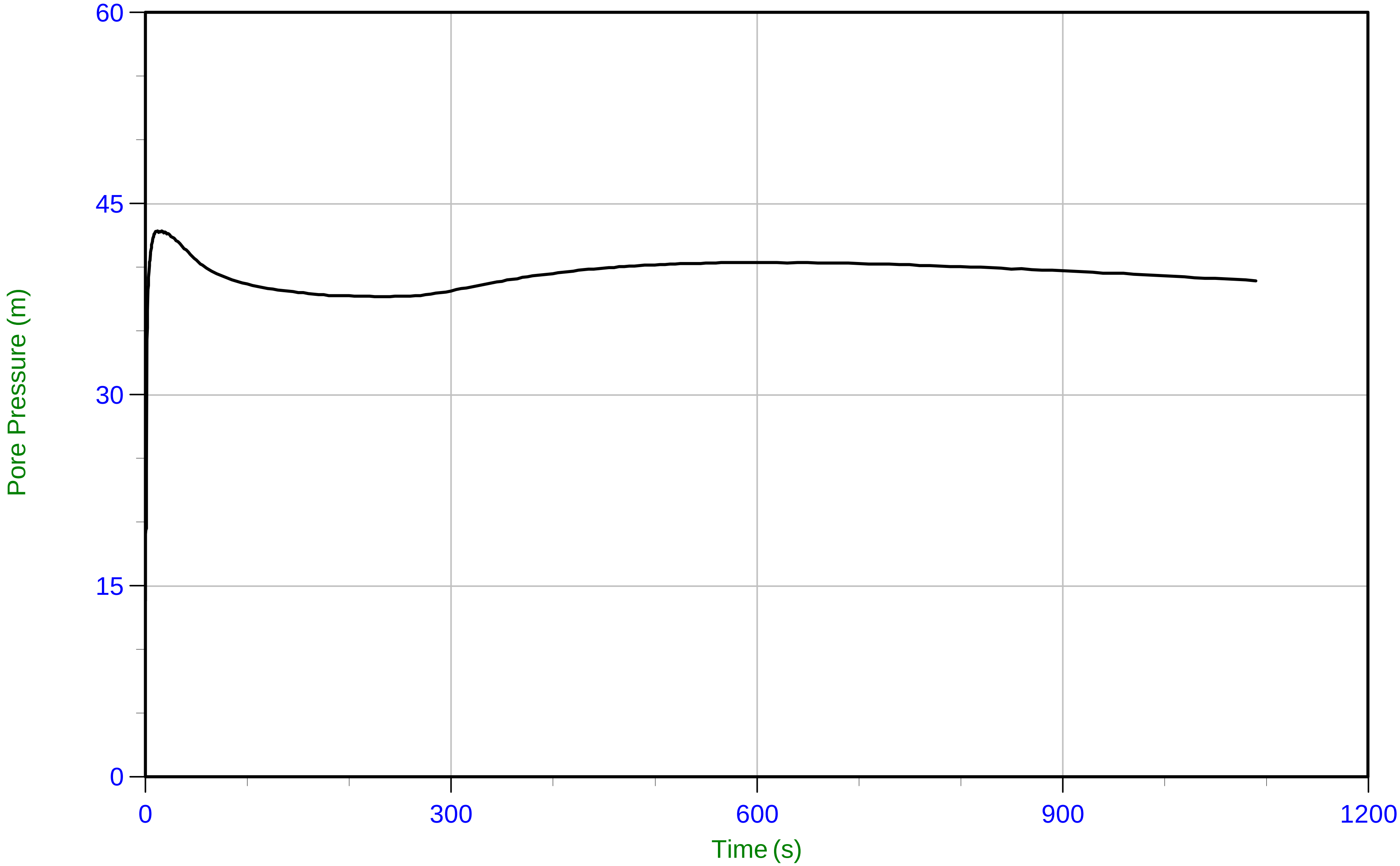
T(50): 2923.2 s
Ir: 100
Ch: 0.2 cm²/min

ConeTec

Stantec

Job No: 24-05-27609
Date: 2024-05-09 12:06
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-CNREMB02
Cone: 729:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 24-05-27609_SP-CN-02.PPF2
Depth: 7.625 m / 25.016 ft
Duration: 1090.0 s

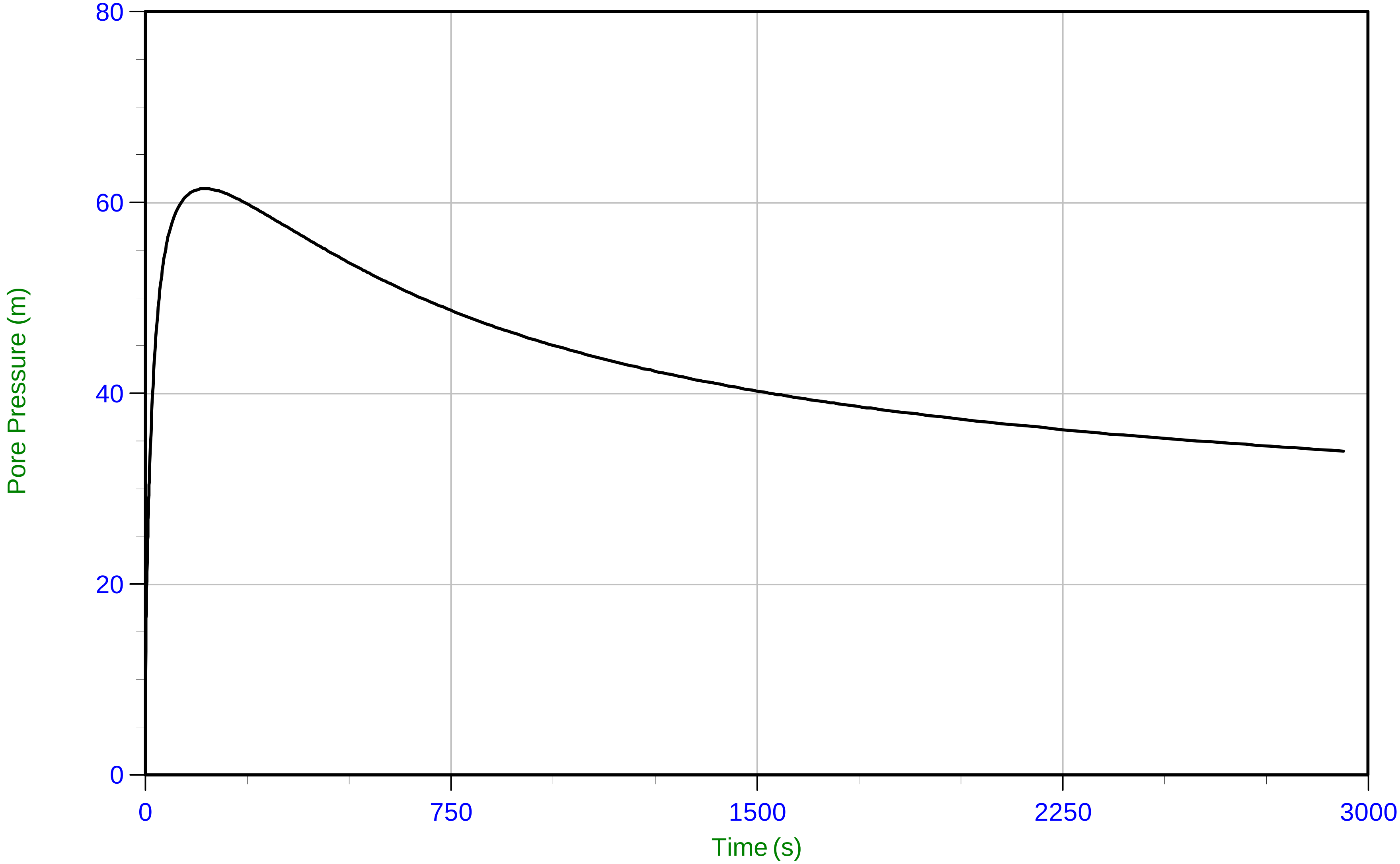
u Min: 13.8 m
u Max: 42.9 m
u Final: 38.9 m

ConeTec

Stantec

Job No: 24-05-27609
Date: 2024-05-09 12:06
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-CNREMB02
Cone: 729:T1500F15U35 Area=15 cm²



Trace Summary:

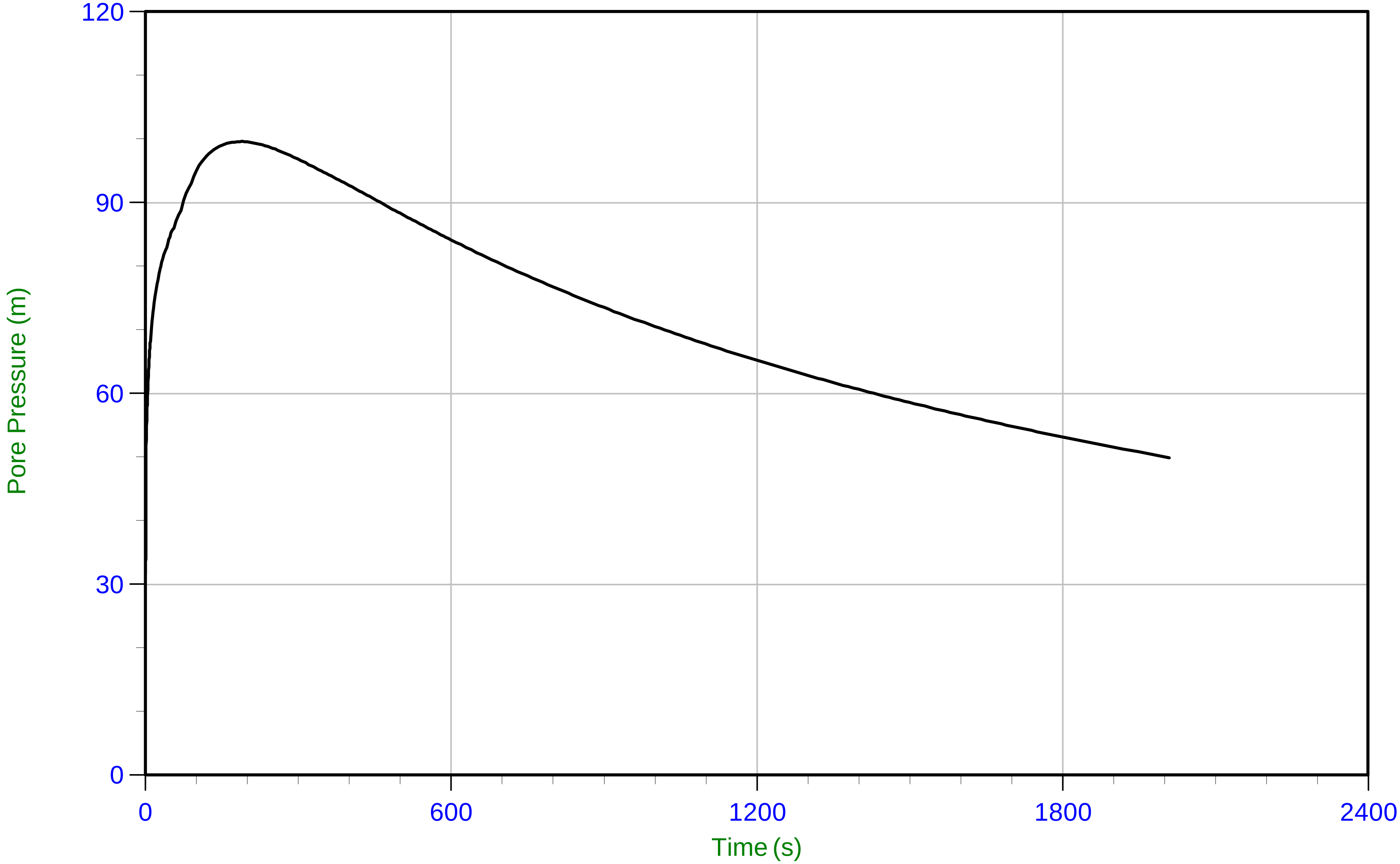
Filename: 24-05-27609_SP-CN-02.PPF2	u Min: 7.9 m	WT: 2.0 m / 6.6 ft	T(50): 2423.2 s
Depth: 10.675 m / 35.023 ft	u Max: 61.5 m	Ueq: 8.7 m	Ir: 100
Duration: 2940.0 s	u Final: 34.0 m	U(50): 35.07 m	Ch: 0.3 cm²/min

ConeTec

Stantec

Job No: 24-05-27609
Date: 2024-05-10 14:49
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-WAPP02
Cone: 729:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 24-05-27609_SP-WA-02.PPF2
Depth: 3.050 m / 10.006 ft
Duration: 2010.0 s

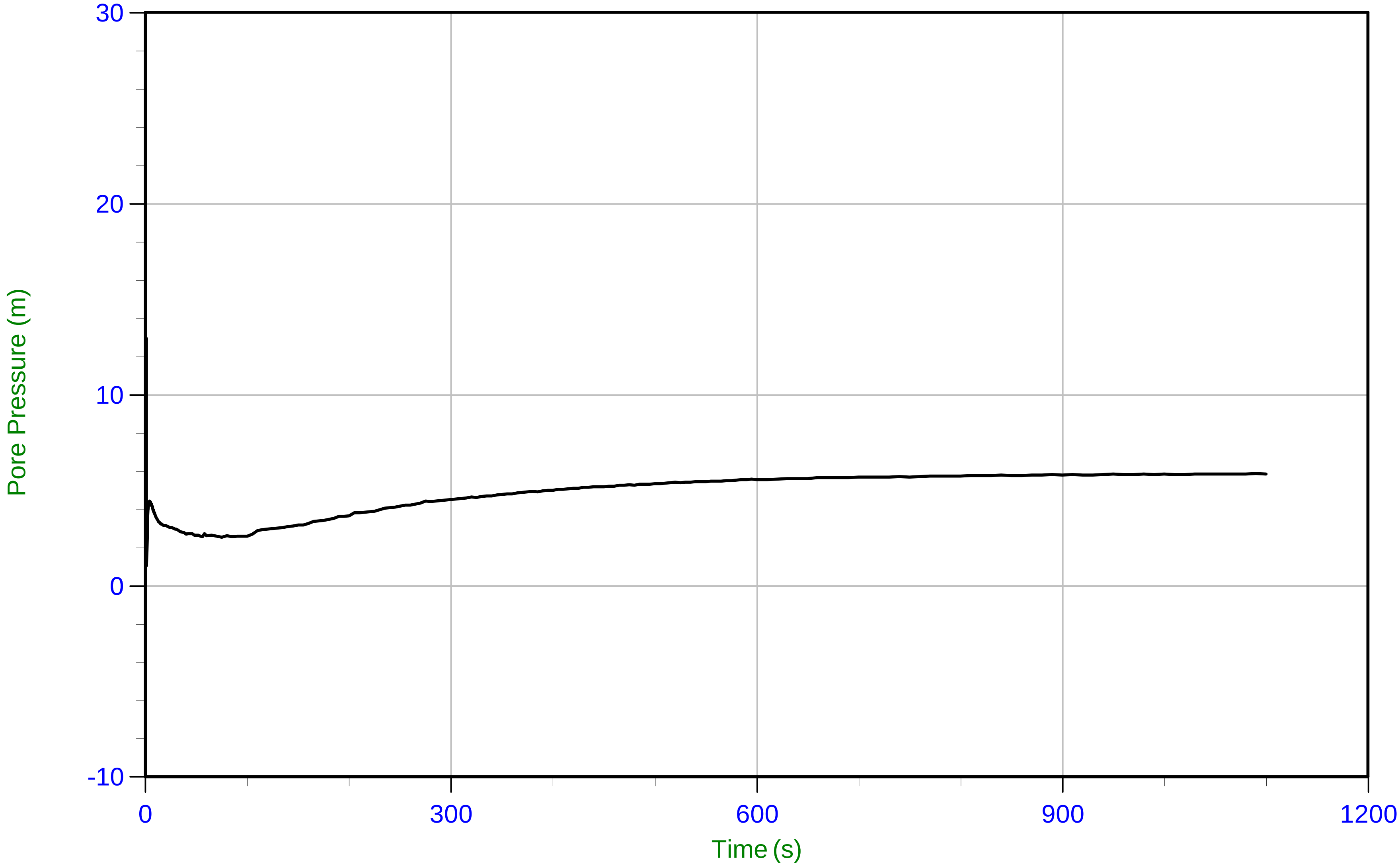
u Min: 31.5 m
u Max: 99.6 m
u Final: 49.9 m

WT: 1.8 m / 6.0 ft
Ueq: 1.2 m
U(50): 50.41 m

T(50): 1785.6 s
Ir: 100
Ch: 0.4 cm²/min

ConeTec

Stantec	Job No: 24-05-27609	Sounding: SCPT24-WAPP02
	Date: 2024-05-10 14:49	Cone: 729:T1500F15U35 Area=15 cm²
	Site: HWY 3, St.Thomas, ON	



Trace Summary:

Filename: 24-05-27609_SP-WA-02.PPF2
Depth: 7.625 m / 25.016 ft
Duration: 1100.0 s

u Min: 1.1 m
u Max: 13.1 m
u Final: 5.8 m

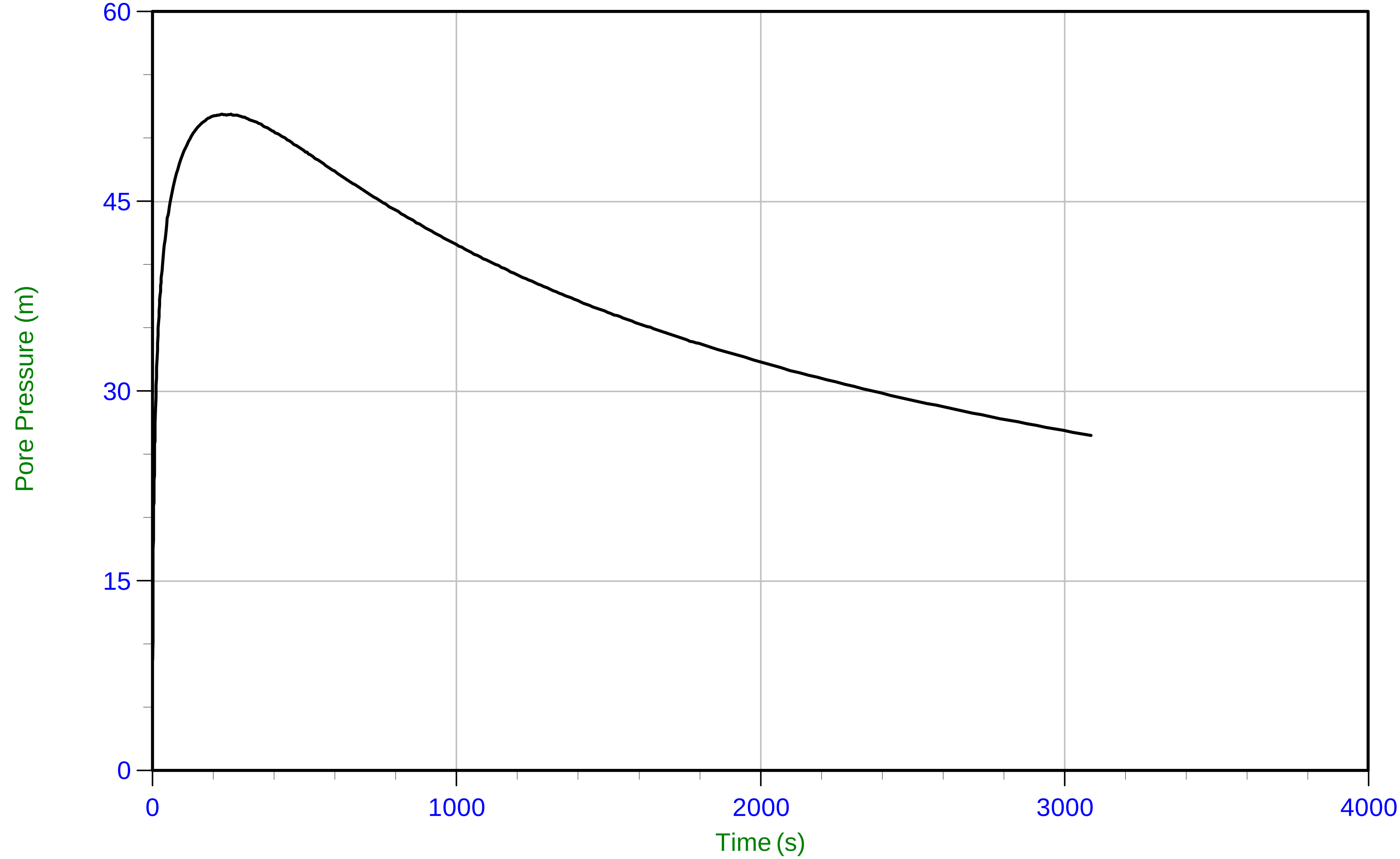
WT: 1.8 m / 6.0 ft
Ueq: 5.8 m

CONETEC

Stantec

Job No: 24-05-27609
Date: 2024-05-09 16:43
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-CNREMB08
Cone: 729:T1500F15U35 Area=15 cm²



Trace Summary:

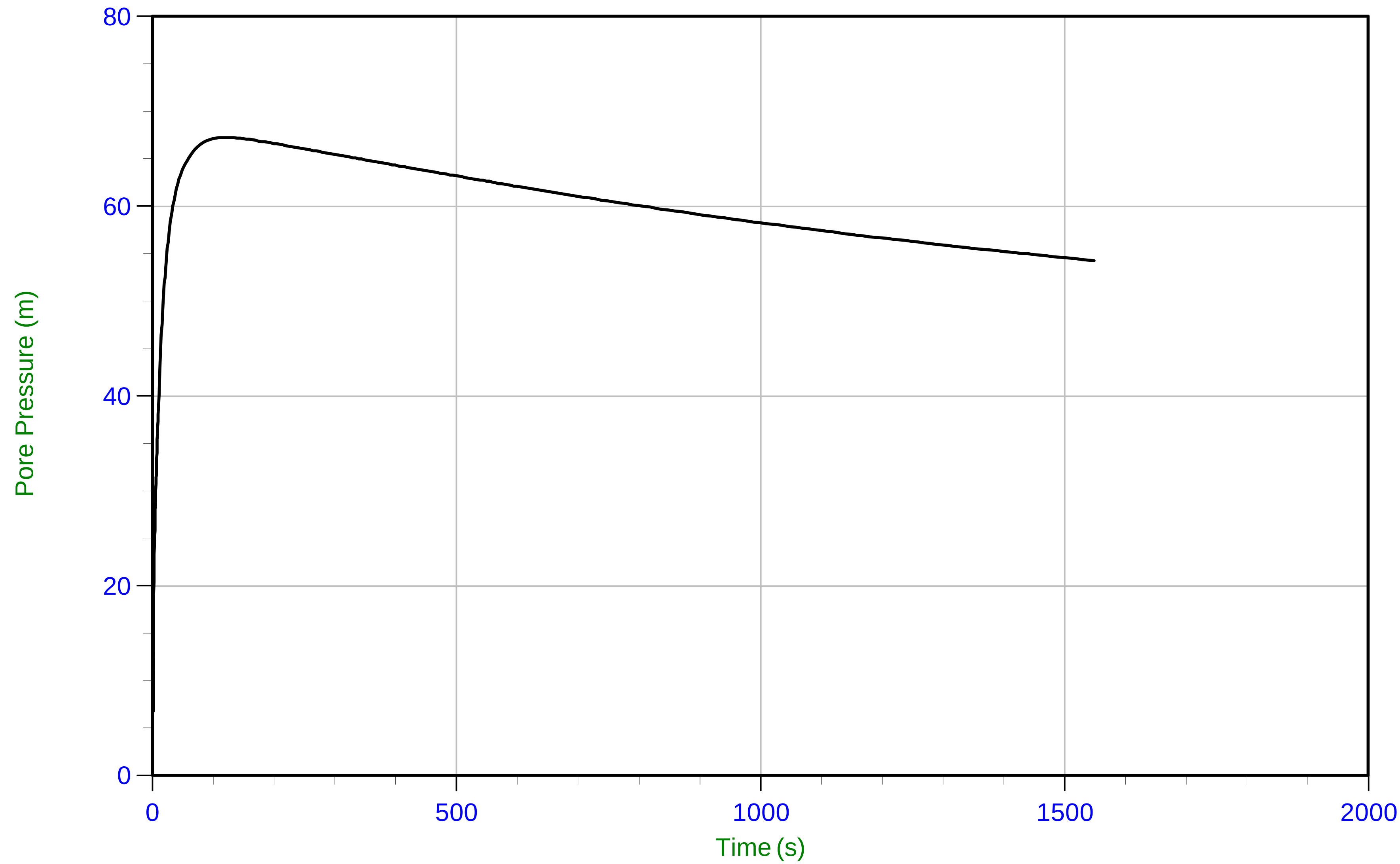
Filename: 24-05-27609_SP-CN-08.PPF2
Depth: 3.050 m / 10.006 ft
Duration: 3090.0 s

u Min: 8.7 m
u Max: 51.9 m
u Final: 26.5 m

WT: 1.5 m / 4.9 ft
Ueq: 1.6 m
U(50): 26.72 m

T(50): 2772.8 s
Ir: 100
Ch: 0.3 cm²/min

ConeTec	Job No: 24-05-27609	Sounding: SCPT24-CNREMB08
Stantec	Date: 2024-05-09 16:43	Cone: 729:T1500F15U35 Area=15 cm²
	Site: HWY 3, St.Thomas, ON	

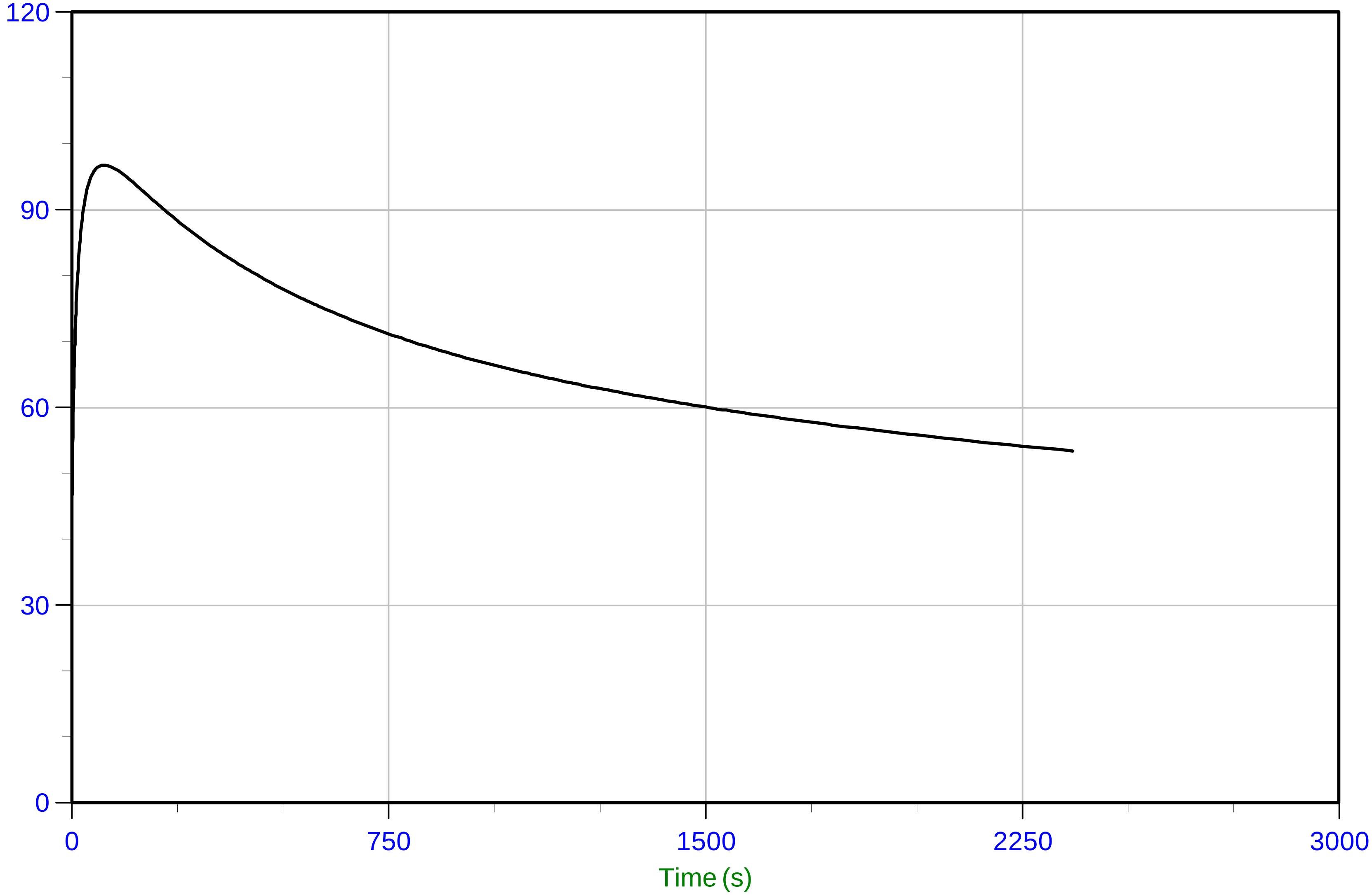


Trace Summary:

Filename: 24-05-27609_SP-CN-08.PPF2
Depth: 7.625 m / 25.016 ft
Duration: 1550.0 s

u Min: 6.7 m
u Max: 67.2 m
u Final: 54.3 m

ConeTec	Stantec	Job No: 24-05-27609 Date: 2024-05-09 16:43 Site: HWY 3, St.Thomas, ON
		Sounding: SCPT24-CNREMB08 Cone: 729:T1500F15U35 Area=15 cm²

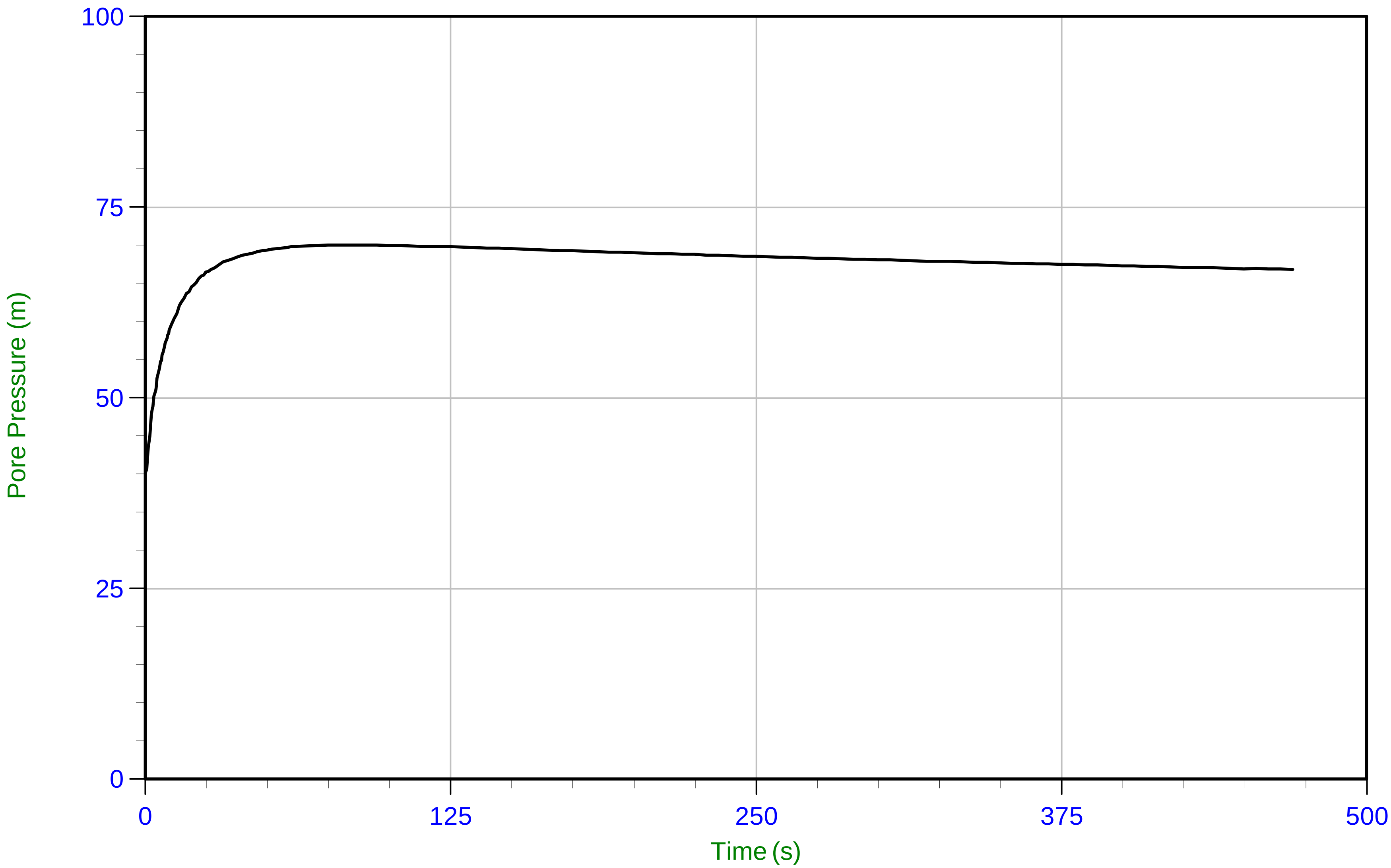


Trace Summary:

Filename: 24-05-27609_SP-CN-08.PPF2
Depth: 10.675 m / 35.023 ft
Duration: 2370.0 s

u Min: 46.6 m
u Max: 96.8 m
u Final: 53.4 m

Stantec	Job No: 24-05-27609 Date: 2024-05-09 16:43 Site: HWY 3, St.Thomas, ON	Sounding: SCPT24-CNREMB08 Cone: 729:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 24-05-27609_SP-CN-08.PPF2
Depth: 20.100 m / 65.944 ft
Duration: 470.0 s

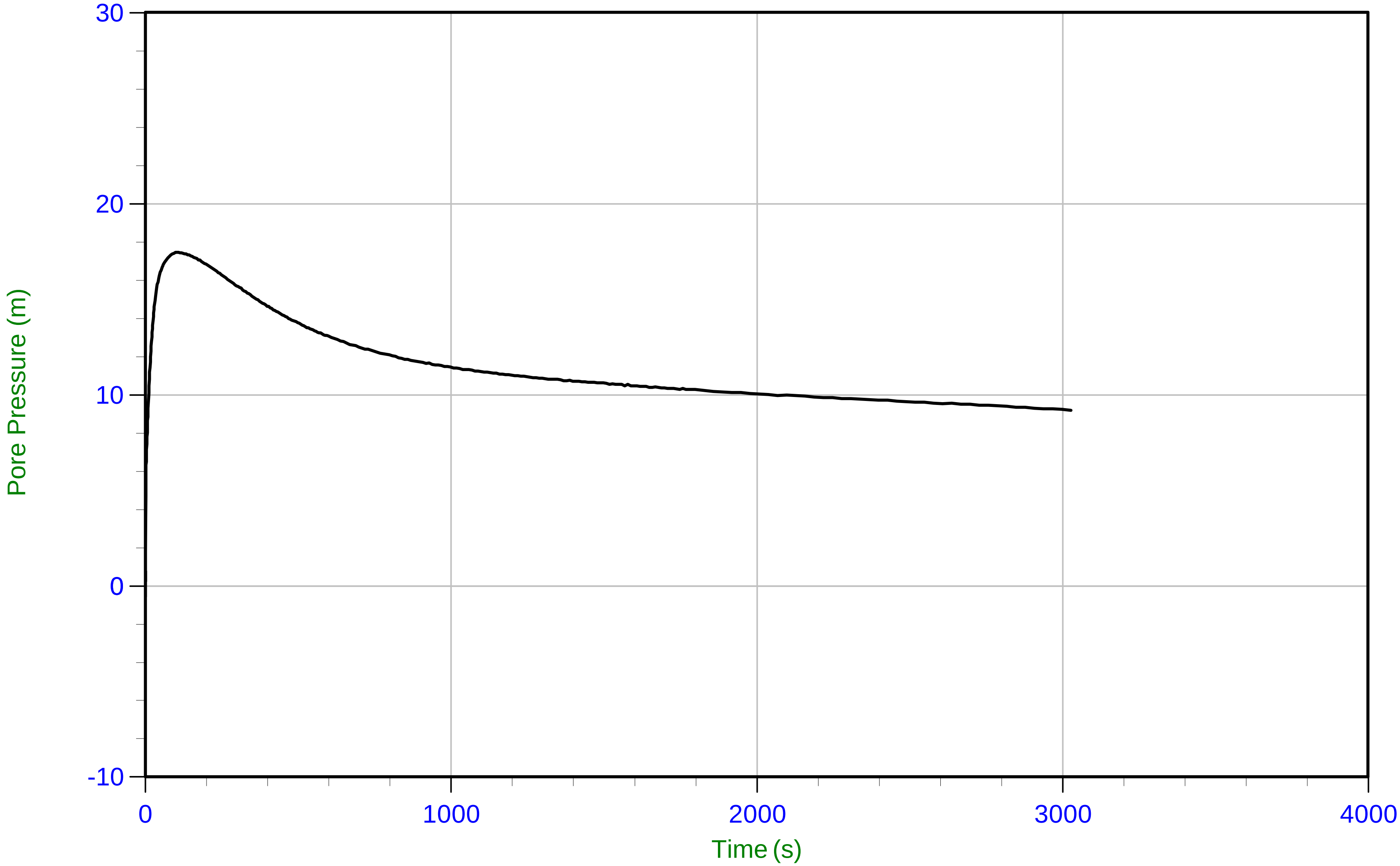
u Min: 40.1 m
u Max: 70.1 m
u Final: 66.8 m

CONETEC

Stantec

Job No: 24-05-27609
Date: 2024-05-10 06:58
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-CNREMB10
Cone: 729:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 24-05-27609_SP-CN-10.PPF2
Depth: 3.050 m / 10.006 ft
Duration: 3030.0 s

u Min: -0.6 m
u Max: 17.5 m
u Final: 9.2 m

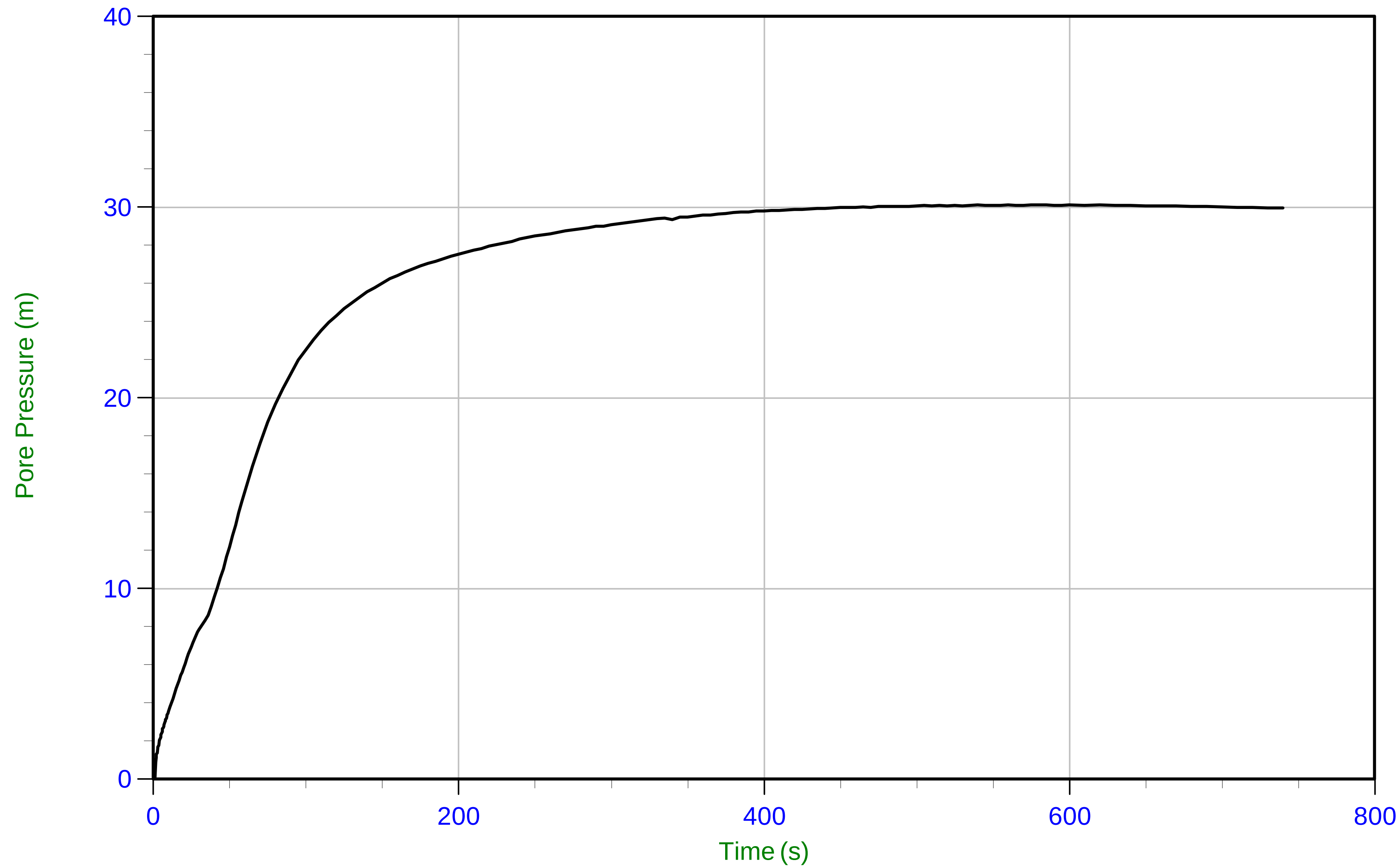
WT: 2.0 m / 6.6 ft
Ueq: 1.1 m
U(50): 9.26 m

T(50): 2879.9 s
Ir: 100
Ch: 0.2 cm²/min

Stantec

Job No: 24-05-27609
Date: 2024-05-10 06:58
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-CNREMB10
Cone: 729:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 24-05-27609_SP-CN-10.PPF2
Depth: 7.625 m / 25.016 ft
Duration: 740.0 s

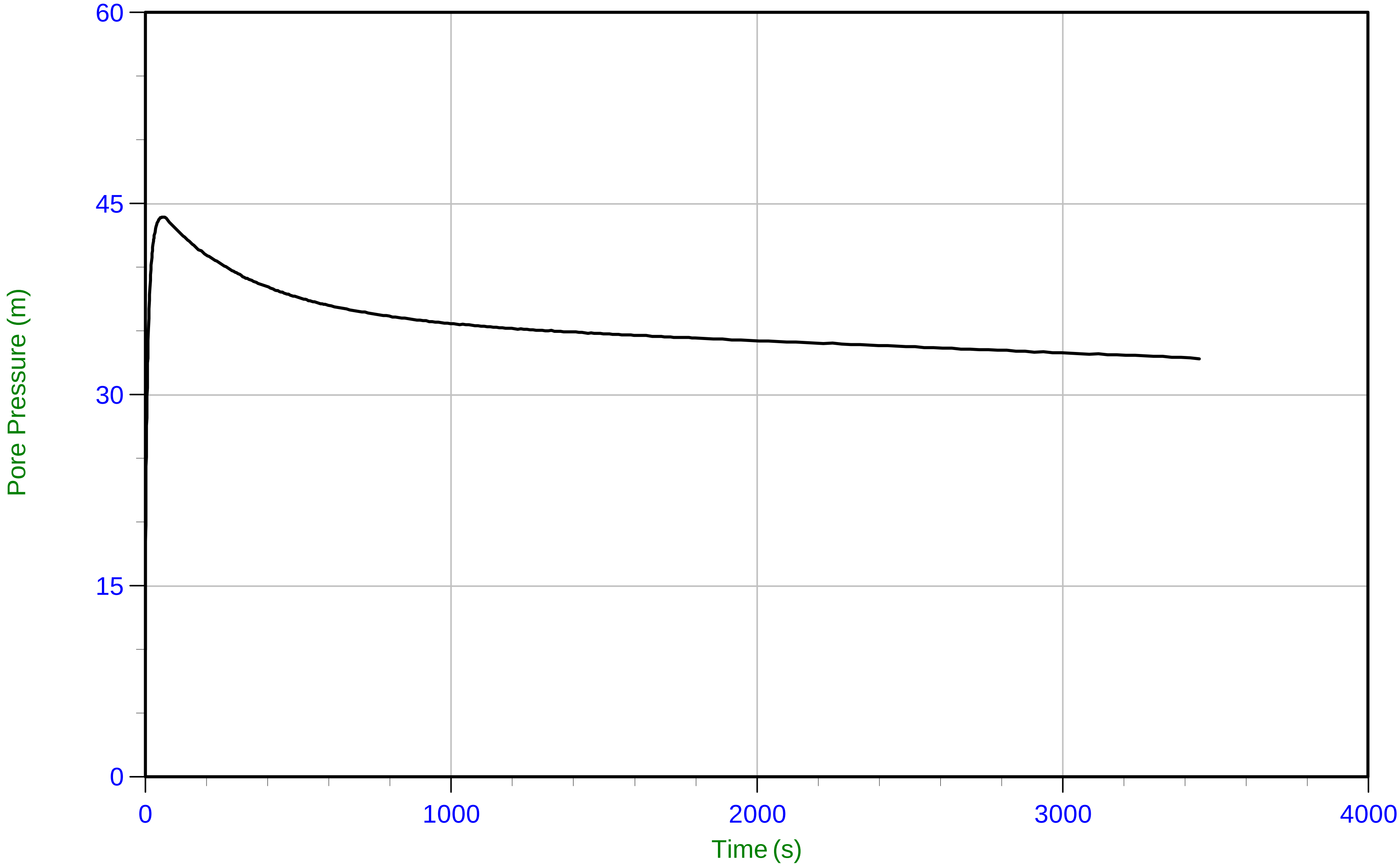
u Min: -0.6 m
u Max: 30.1 m
u Final: 30.0 m

ConeTec

Stantec

Job No: 24-05-27609
Date: 2024-05-10 06:58
Site: HWY 3, St.Thomas, ON

Sounding: SCPT24-CNREMB10
Cone: 729:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 24-05-27609_SP-CN-10.PPF2
Depth: 10.675 m / 35.023 ft
Duration: 3450.0 s

u Min: 10.0 m
u Max: 44.0 m
u Final: 32.8 m

Description of Methods for Calculated CPT Geotechnical Parameters

ConeTec

CALCULATED CPT GEOTECHNICAL PARAMETERS

A Detailed Description of the Methods Used in ConeTec's CPT Geotechnical Parameter Calculation and Plotting Software

Revision SZW-Rev 18

Revised February 10, 2023

Prepared by Jim Greig, M.A.Sc, P.Eng (BC, AB, ON)

CONETEC

Limitations

The geotechnical parameter output was prepared specifically for the site and project named in the accompanying report subject to objectives, site conditions and criteria provided to ConeTec by the client. The output may not be relied upon by any other party or for any other site without the express written permission of ConeTec Group (ConeTec) or any of its affiliates. For this project, ConeTec has provided site investigation services, prepared factual data reporting and produced geotechnical parameter calculations consistent with current best practices. No other warranty, expressed or implied, is made.

To understand the calculations that have been performed and to be able to reproduce the calculated parameters the user is directed to the basic descriptions for the methods in this document and the detailed descriptions and their associated limitations and appropriateness in the technical references cited for each parameter.

BETTER INFORMATION, **BETTER DECISIONS**

ConeTec's Calculated CPT Geotechnical Parameters as of February 10, 2023.

ConeTec's CPT parameter calculation and plotting routine provides a tabular output of geotechnical parameters based on current published CPT correlations and is subject to change to reflect the current state of practice. Due to drainage conditions and the basic assumptions and limitations of the correlations, not all geotechnical parameters provided are considered applicable for all soil types. The results are presented only as a guide for geotechnical use and should be carefully examined for consideration in any geotechnical design. Reference to current literature is strongly recommended. ConeTec does not warranty the correctness or the applicability of any of the geotechnical parameters calculated by the program and does not assume liability for any use of the results in any design or review. For verification purposes we recommend that representative hand calculations be done for any parameter that is critical for design purposes. The end user of the parameter output should also be fully aware of the techniques and the limitations of any method used by the program. The purpose of this document is to inform the user as to which methods were used and to direct the end user to the appropriate technical papers and/or publications for further reference.

The geotechnical parameter output was prepared specifically for the site and project named in the accompanying report subject to objectives, site conditions and criteria provided to ConeTec by the client. The output may not be relied upon by any other party or for any other site without the express written permission of ConeTec Group (ConeTec) or any of its affiliates.

The CPT calculations are based on values of tip resistance, sleeve friction and pore pressures considered at each data point or averaged over a user specified layer thickness (e.g., 0.20 m). Note that q_t is the tip resistance corrected for pore pressure effects and q_c is the recorded tip resistance. The corrected tip resistance (corrected using u_2 pore pressure values) is used for all calculations. Since all ConeTec cones have equal end area friction sleeves pore pressure corrections to sleeve friction, f_s, are not performed.

Corrected tip resistance: $q_t = q_c + (1\text{-}a) \cdot u_2$ (consistent units are required)

where: q_t is the corrected tip resistance
q_c is the recorded tip resistance
u_2 is the recorded dynamic pore pressure from behind the tip (u_2 position)
a is the Net Area Ratio for the cone (typically 0.80 for ConeTec cones)

The total stress calculations are based on soil unit weight values that have been assigned to the Soil Behavior Type (SBT) zones, from a user defined unit weight profile, by using a single uniform value throughout the profile, through unit weight estimation techniques described in various technical papers or from a combination of these methods. The parameter output files indicate the method(s) used.

Effective vertical overburden stresses are calculated using the total stress and equilibrium pore pressure (u_{eq} or u_o) values derived from an assumed hydrostatic distribution of pore pressures below the water table or from a user defined equilibrium pore pressure profile (typically obtained from CPT dissipation tests) or a combination of the two. For over water projects the stress effects of the column of water above the mudline are taken into account as is the appropriate unit weight of water. How this is done depends on where the instruments are zeroed (i.e. on deck or at the mudline). The parameter output files indicate the method(s) used.

A majority of parameter calculations are derived from or driven by results based on material types as determined by the various soil behavior type charts depicted in Figures 1 through 6. The parameter output files indicate the method(s) used.

The Soil Behavior Type classification chart shown in Figure 1 is the classic non-normalized SBT Chart developed at the University of British Columbia and reported in Robertson, Campanella, Gillespie and Greig (1986). Figure 2 shows the original normalized (linear method) SBTn chart developed by Robertson (1990). The Bq classification charts shown in Figures 3a and 3b incorporate pore pressures into the SBT classification and are based on the methods described in Robertson (1990). Many of these charts have been summarized in Lunne, Robertson and Powell (1997). The Jefferies and Davies SBT chart shown in Figure 3c is based on the techniques discussed in Jefferies and Davies (1993) which introduced the concept of the Soil Behavior Type Index parameter, I_c. Take note that the I_c parameter developed by Robertson and Fear (1995) and Robertson and Wride (1998) is similar in concept but uses a slightly different calculation method than that defined by Jefferies and Davies (1993) as the latter incorporates pore pressure in their technique through the use of the Bq parameter. The normalized Qtn SBT chart shown in Figure 4 is based on the work by Robertson (2009) utilizing a variable stress ratio exponent, n, for normalization based on a slightly modified redefinition and iterative approach for I_c. The boundary curves drawn on the chart are based on the work described in Robertson (2010).

Figure 5 shows a revised 1986 SBT Chart presented to CPT'10 by Robertson (2010b). It is known as the Updated non-normalized Soil Behavior Chart (also referred to as the Rev SBT Chart (PKR2010) in our output files). This chart was produced to be more in line with all post-1986 Robertson charts having the same 9 soil type zones, a $\log_{10}$ axis for friction ratio, R_f in this case, and a unitless tip resistance axis.

Figure 6 shows a revised behavior based chart by Robertson (2016) depicting contractive-dilative zones. As the zones represent material behavior rather than soil gradation ConeTec has chosen a set of zone colors that are less likely to be confused with material type colors from previous SBT charts. These colors differ from those used by Dr. Robertson. A green palette was selected for the dilative (desirable) side of the chart and a red palette for the contractive side of the chart.

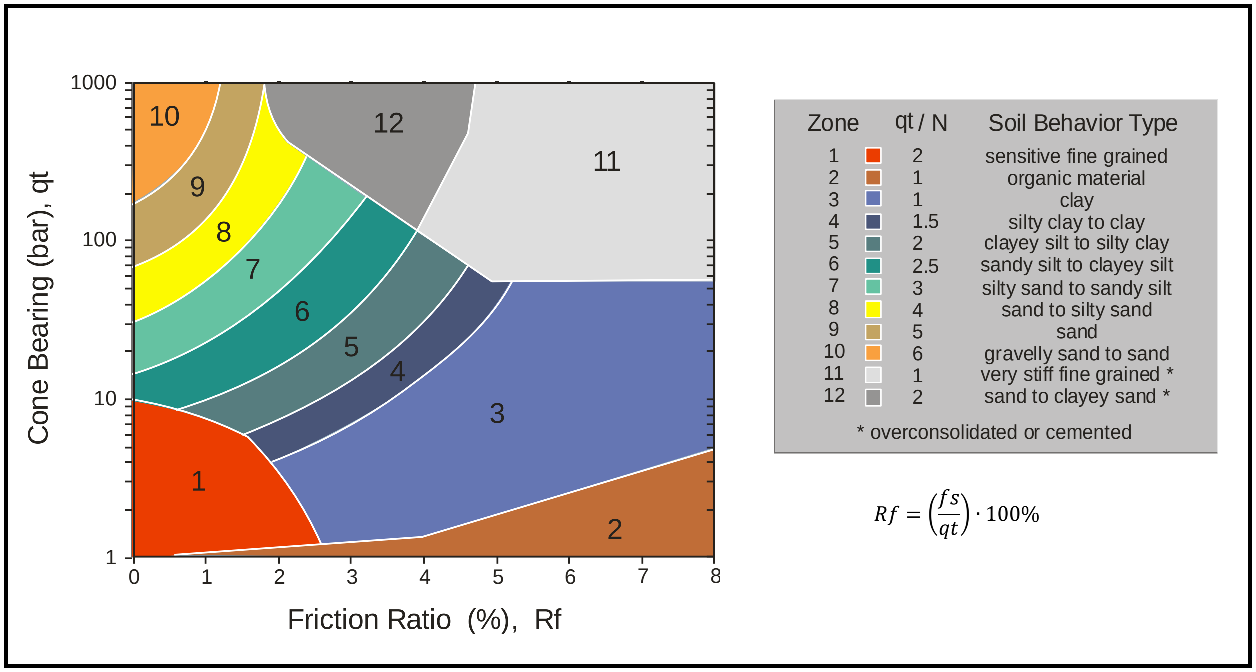


Figure 1. Non-normalized Soil Behavior Type Classification Chart (SBT)

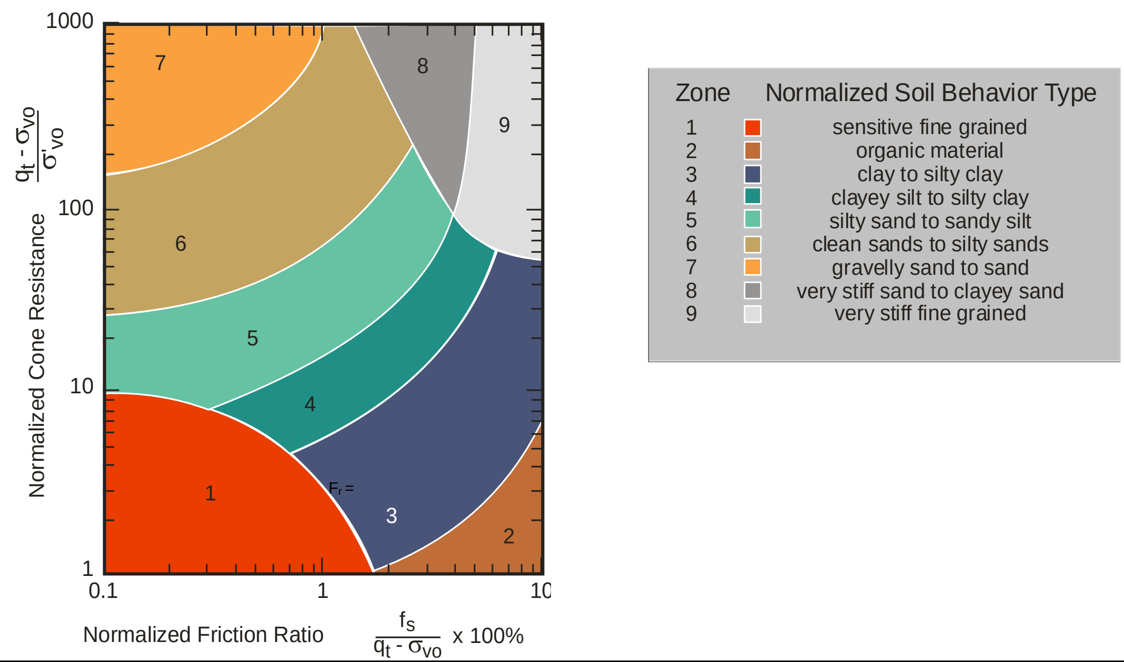


Figure 2. Normalized Soil Behavior Type Classification Chart (SBTn)

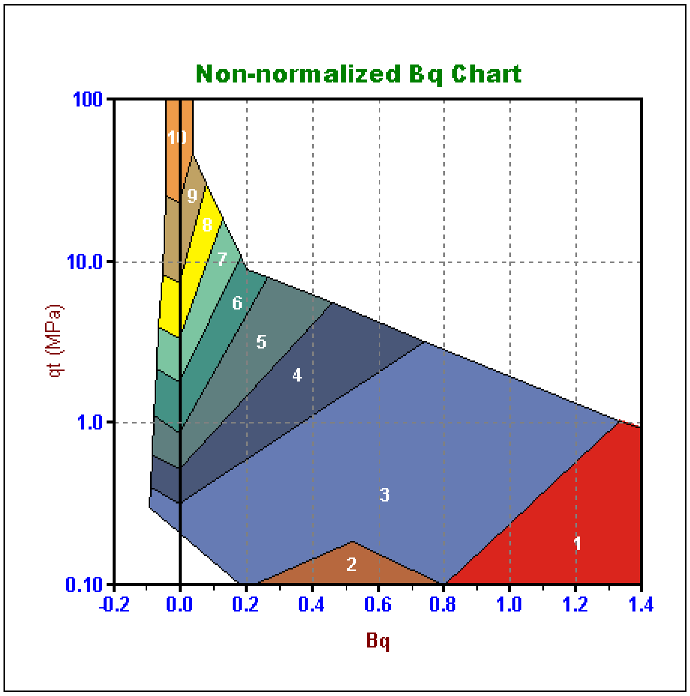


Figure 3a. Alternate Soil Behavior Type Chart (SBT Bq): q_t - B_q

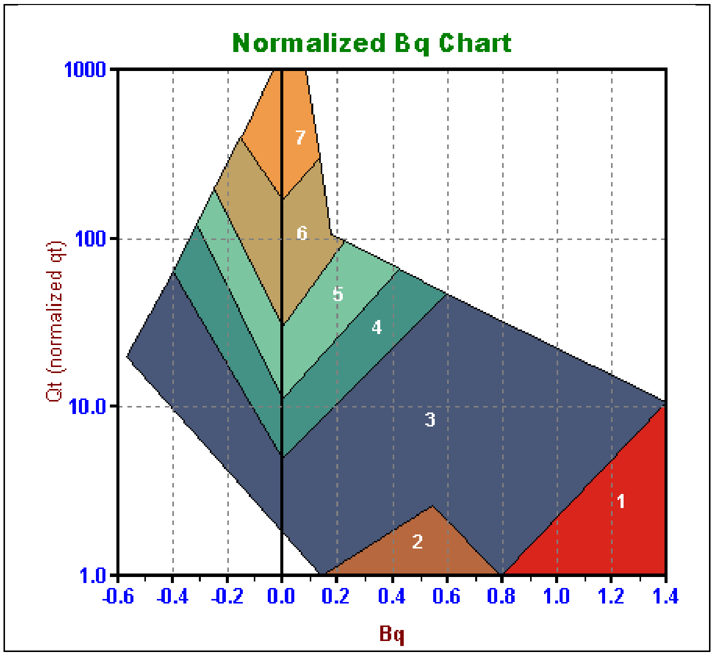


Figure 3b. Alternate Soil Behavior Type Charts (SBT Bqn): Q_t-B_q

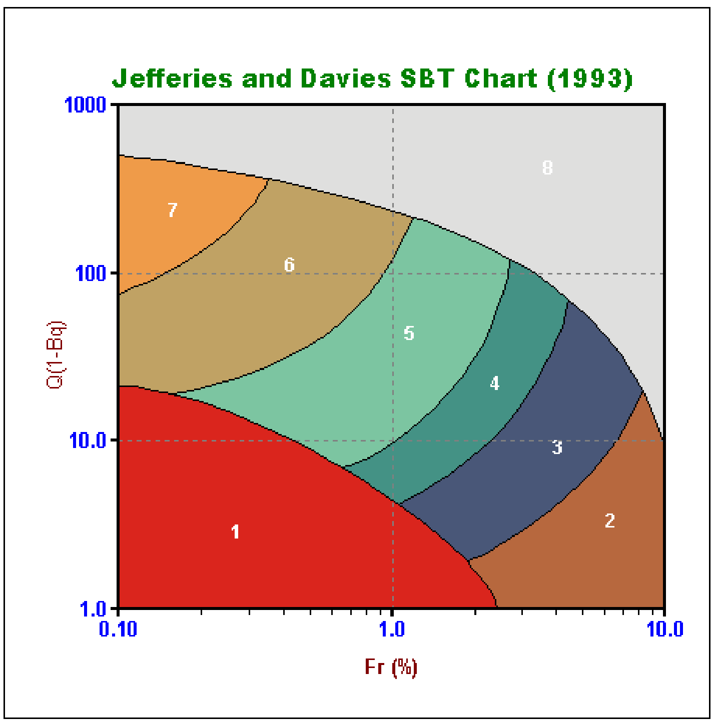


Figure 3c. Alternate Soil Behavior Type Charts: $Q(1-B_q)$ - F_r

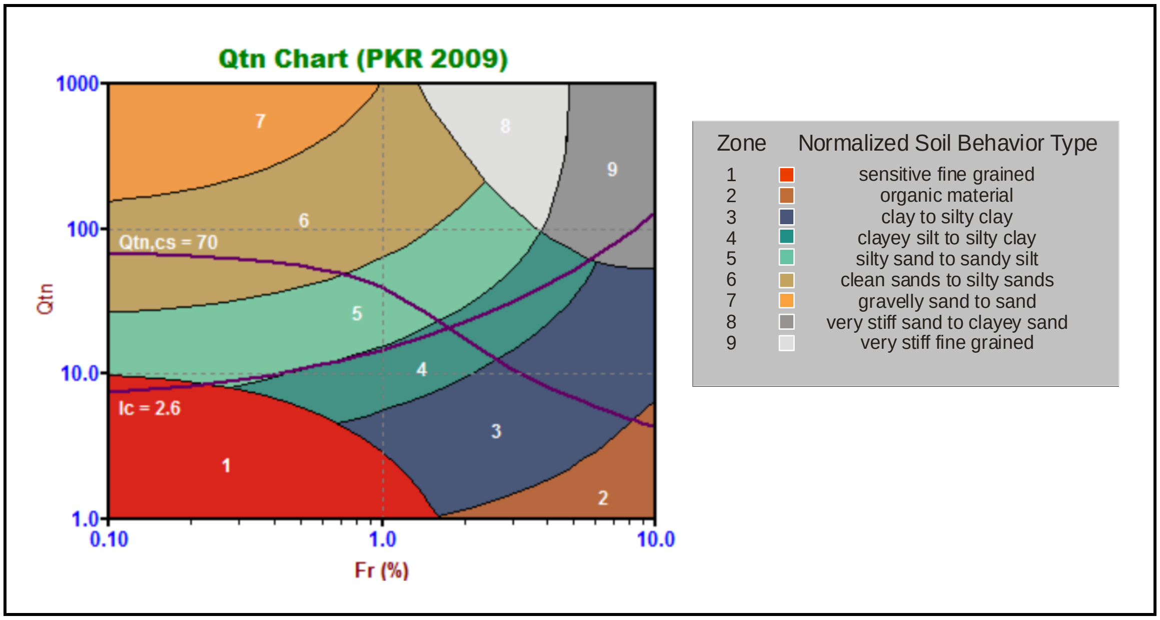


Figure 4. Normalized Soil Behavior Type Chart using Q_{tn} (SBT Qtn)

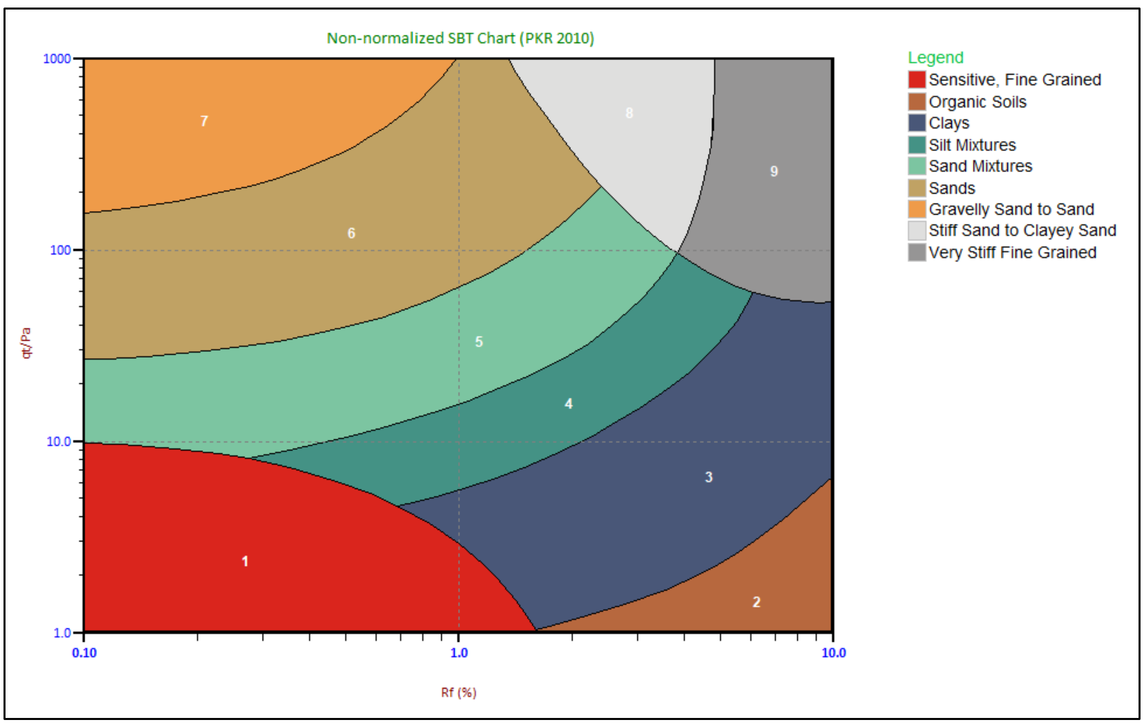


Figure 5. Non-normalized Soil Behavior Type Chart (2010)

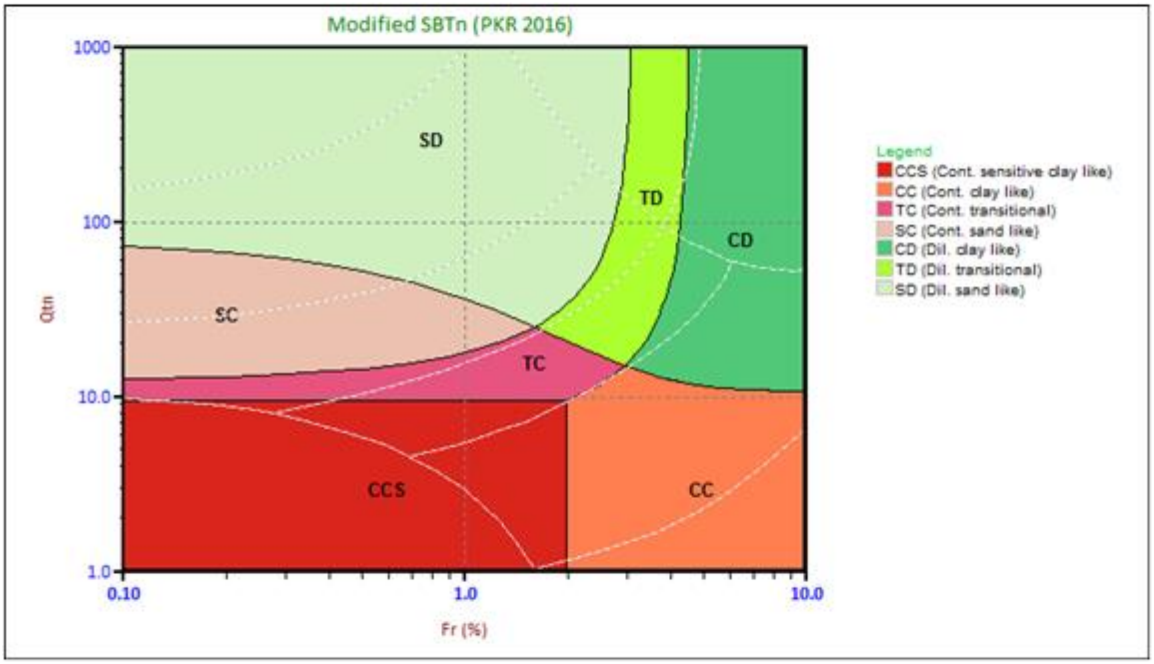


Figure 6. Modified SBTn Behavior Based Chart

Details regarding the geotechnical parameter calculations are provided in Tables 1a and 1b. The appropriate references cited are listed in Table 2. Non-liquefaction specific parameters are detailed in Table 1a and liquefaction specific parameters are detailed in Table 1b.

Where methods are based on charts or techniques that are too complex to describe in this summary, we recommend that the user refer to the cited material. Specific limitations for each method are described in the cited material.

Where the results of a calculation/correlation are deemed *'invalid'* the value will be represented by the text strings "-9999", "-9999.0", the value 0.0 (Zero) or an empty cell. Invalid results will occur because of (and not limited to) one or a combination of:

1. Invalid or undefined CPT data (e.g., drilled out section or data gap).

2. Where the calculation method is inappropriate, for example, drained parameters in a material behaving in an undrained manner (and vice versa).

3. Where input values are beyond the range of the referenced charts or specified limitations of the correlation method.

4. Where pre-requisite or intermediate parameter calculations are invalid.

The parameters selected for output from the program are often specific to a particular project. As such, not all of the calculated parameters listed in Tables 1and 1a may be included in the output files delivered with this report.

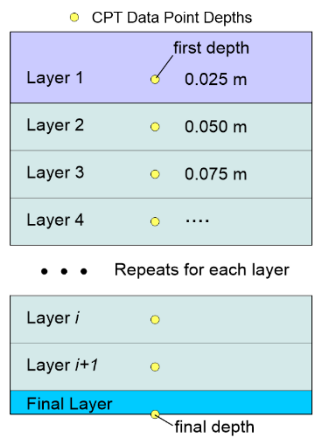
The output files are typically provided in Microsoft Excel XLS, XLSX or CSV format. The ConeTec software has several options for output depending on the number or types of calculated parameters desired or those specifically contracted for by the client. Each output file is named using the original file base name (from the .COR file) followed by a three or four character indicator of the output set selected (e.g. BSC, TBL, NLI, NL2, IFI, IFI2, IFI3) and possibly followed by an operator selected suffix identifying the characteristics of the particular calculation run.

Table 1a. CPT Parameter Calculation Methods – Non liquefaction Parameters

Reference Notes: CK* - Common Knowledge, U* - Unpublished

Calculated Parameter	Description	Equation	Ref
Depth	Mid Layer Depth *(where calculations are done at each point then Mid Layer Depth = Recorded Depth)*	*[Depth (Layer Top) + Depth (Layer Bottom)]/ 2.0*	CK*
Elevation	Elevation of Mid Layer is based on the sounding collar elevation supplied by the client or through a site survey In Sweden a variation of elevation is used where the elevation increases with depth. We refer to this as inverse elevation.	Elevation = Collar Elevation – Depth InverseElevation = Collar Elevation + Depth	CK* N/A
Avg qc	Averaged recorded tip value (q_c)	$Avgqc = \frac{1}{n}\sum_{i=1}^{n} q_c$ *n=1 when calculations are done at each point*	CK*
Avg qt	Averaged corrected tip (q_t) where: $q_t = q_c + (1 - a) \cdot u_2$ Averaged q_t is not calculated using the average q_c and averaged u values. Averaged q_t is based on the average of the q_t values calculated at each data point.	$Avgqt = \frac{1}{n}\sum_{i=1}^{n} q_t$ *n=1 when calculations are done at each point*	1
Avg fs	Averaged sleeve friction (f_s) No pore pressure corrections are applied to f_s.	$Avgfs = \frac{1}{n}\sum_{i=1}^{n} fs$ *n=1 when calculations are done at each point*	CK*
Avg Rf	Averaged friction ratio (R_f) where friction ratio is defined as: $R_f = 100\% \cdot \frac{fs}{q_t}$	$AvgRf = 100\% \cdot \frac{Avgfs}{Avgqt}$ *not an average of individual R_f values*	CK*
Avg u	Averaged dynamic pore pressure *(u)*	$Avgu = \frac{1}{n}\sum_{i=1}^{n} u_i$ *n=1 when calculations are done at each point*	CK*
Avg Res	Averaged Resistivity (this data is not always available since it is a specialized test requiring an additional module)	$AvgRes = \frac{1}{n}\sum_{i=1}^{n} Resistivity_i$ *n=1 when calculations are done at each point*	CK*
Avg UVIF	Averaged UVIF ultra-violet induced fluorescence (this data is not always available since it is a specialized test requiring an additional module)	$AvgUVIF = \frac{1}{n}\sum_{i=1}^{n} UVIF_i$ *n=1 when calculations are done at each point*	CK*
Avg Temp	Averaged Temperature (this data is not always available)	$AvgTemp = \frac{1}{n}\sum_{i=1}^{n} Temperature_i$ *n=1 when calculations are done at each point*	CK*
Avg Gamma	Averaged Gamma Counts (this data is not always available since it is a specialized test requiring an additional module)	$AvgGamma = \frac{1}{n}\sum_{i=1}^{n} Gamma_i$ *n=1 when calculations are done at each point*	CK*
SBT	Soil Behavior Type as defined by Robertson et al 1986 (often referred to as Robertson and Campanella, 1986)	See Figure 1	1, 5
SBTn	Normalized Soil Behavior Type as defined by Robertson 1990 (linear normalization using Q_t, now referred to as Q_{t1})	See Figure 2	2, 5

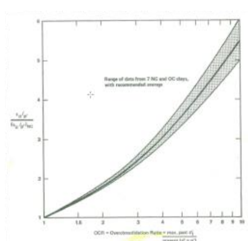
Calculated Parameter	Description	Equation	Ref
SBT-Bq	Non-normalized Soil Behavior type based on non-normalized tip resistance and the B_q parameter	See Figure 3a	1, 2, 5
SBT-Bqn	Normalized Soil Behavior type based on normalized tip resistance (Q_t, now called Q_{t1}) and the B_q parameter	See Figure 3b	2, 5
SBT-JandD	Soil Behavior Type as defined by Jeffries and Davies	See Figure 3c	7
SBT Qtn	Soil Behavior Type as defined by Robertson (2009) using a variable stress ratio exponent for normalization based on $I_{c\ (PKR\ 2009)}$	See Figure 4	15
Modified Non-normalized SBT Chart SBT (PKR2010)	This is a revised version of the simple 1986 non-normalized SBT chart (presented at CPT '10). The revised version has been reduced from 12 zones to 9 zones to be similar to the normalized Robertson charts. Other updates include a dimensionless tip resistance normalized to atmospheric pressure, q_t/P_a, on the vertical axis and a log scale for non-normalized friction ratio, R_f, along the horizontal axis.	See Figure 5	33
Modified SBTn (contractive /dilative)	Modified SBTn chart as defined by Robertson (2016) indicating zones of contractive/dilative behavior. Note that ConeTec displays the chart with colors different from Robertson. ConeTec's colors were chosen to avoid confusion with soil type descriptions.	See Figure 6	30
Unit Wt.	Unit Weight of soil determined from one of the following user selectable options: 1) uniform value 2) value assigned to each SBT zone 3) value assigned to each SBTn zone 4) value assigned to SBTn zone as determined from Robertson and Wride (1998) based on q_{c1n} 5) values assigned to SBT Qtn zones 6) values based on Robertson updated non-normalized Soil Behavior Type Chart (2010b) 6) Mayne f_s (sleeve friction) method 7) Robertson and Cabal 2010 method 8) user supplied unit weight profile The last option may co-exist with any of the other options.	See references	3, 5, 15, 21, 24, 29, 33

Calculated Parameter	Description	Equation	Ref
TStress σ_v	Total vertical overburden stress at Mid Layer Depth *A layer is defined as the averaging interval specified by the user where depths are reported at their respective mid-layer depth.* For data calculated at each point layers are defined using the recorded depth as the mid-point of the layer. Thus, a layer starts half-way between the previous depth and the current depth unless this is the first point in which case the layer start is at zero depth. The layer bottom is half-way from the current depth to the next depth unless it is the last data point. Defining layers affects how stresses are calculated since the unit weight attributed to a data point is used throughout the entire layer. This means that to calculate the stresses the total stress at the top and bottom of a layer are required. The stress at mid layer is determined by adding the incremental stress from the layer top to the mid-layer depth. The stress at the layer bottom becomes the stress at the top of the subsequent layer. Stresses are NOT calculated from mid-point to mid-point. For over-water work the total stress due to the column of water above the mud line is taken into account where appropriate.	$TStress = \sum_{i=1}^{n} \gamma_i h_i$ *where* γ_i is layer unit weight h_i is layer thickness 	CK*
EStress σ_v'	Effective vertical overburden stress at mid-layer depth.	$\sigma_v' = \sigma_v - u_{eq}$	CK*
Equil u u_{eq} or u_0	Equilibrium pore pressures are determined from one of the following user selectable options: 1) hydrostatic below the water table 2) user supplied profile 3) combination of those above When a user supplied profile is used/provided a linear interpolation is performed between equilibrium pore pressures defined at specific depths. If the profile values start below the water table then a linear transition from zero pressure at the water table to the first defined pointed is used. Equilibrium pore pressures may come from dissipation tests, adjacent piezometers or other sources. Occasionally, an extra equilibrium point ("assumed value") will be provided in the profile that does not come from a recorded value to smooth out any abrupt changes or to deal with material interfaces. These "assumed" values will be indicated on our plots and in tabular summaries.	For the hydrostatic option: $u_{eq} = \gamma_w \cdot (D - D_{wt})$ where u_{eq} is equilibrium pore pressure γ_w is the unit weight of water D is the current depth D_{wt} is the depth to the water table	CK*
K_0	Coefficient of earth pressure at rest, K_0.	$K_o = (1 - \sin\Phi')\ OCR^{\sin\Phi'}$	17
C_n	Overburden stress correction factor used for $(N_1)_{60}$ and older CPT parameters.	$C_n = (P_a/\sigma_v')^{0.5}$ where $0.0 < C_n < 2.0$ *(user adjustable, typically ranging from 1.7 to 2.0)* P_a *is atmospheric pressure (100 kPa)*	4, 12

Calculated Parameter	Description	Equation	Ref
C_q	Overburden stress normalizing factor.	$C_q = 1.8 / [0.8 + (\sigma_v'/P_a)]$ where *$0.0 < C_q < 2.0$ (user adjustable)* *P_a is atmospheric pressure (100 kPa)* *Robertson and Wride define C_q to be the same as C_n. The Olson definition above is used in the program.*	3, 12
N_{60}	SPT N value at 60% energy calculated from q_t/N ratios assigned to each SBT zone. This method has abrupt N value changes at zone boundaries.	*See Figure 1*	5
$(N_1)_{60}$	SPT N_{60} value corrected for overburden pressure.	$(N_1)_{60} = C_n \bullet N_{60}$	4
$N_{60}I_c$	SPT N_{60} values based on the I_c parameter, as defined by Robertson and Wride 1998 (3), or by Robertson 2009 (15).	$(q_t/P_a)/ N_{60} = 8.5 (1 - I_c/4.6)$ $(q_t/P_a)/ N_{60} = 10^{(1.1268 - 0.2817Ic)}$ P_a being atmospheric pressure	3, 5 15, 31
$(N_1)_{60}I_c$	SPT N_{60} value corrected for overburden pressure (using N_{60} I_c). User has 3 options.	1) $(N_1)_{60}Ic = C_n \bullet (N_{60} I_c)$ 2) $q_{c1n}/ (N_1)_{60}I_c = 8.5 (1 - I_c/4.6)$ 3) $(Q_{tn})/ (N_1)_{60}I_c = 10^{(1.1268 - 0.2817Ic)}$	4 5 15, 31
S_u or S_u (N_{kt})	Undrained shear strength based on q_t S_u factor N_{kt} is user selectable.	$Su = \frac{qt - \sigma_v}{N_{kt}}$	1, 5
S_u or S_u (N_{du}) or S_u ($N_{\Delta u}$)	Undrained shear strength based on pore pressure S_u factor $N_{\Delta u}$ is user selectable.	$Su = \frac{u_2 - u_{eq}}{N_{\Delta u}}$	1, 5
D_r	Relative Density determined from one of the following user selectable options: 1) Ticino Sand 2) Hokksund Sand 3) Schmertmann (1978) 4) Jamiolkowski (1985) - All Sands 5) Jamiolkowski et al (2003) (various compressibilities, K_o)	See reference (methods 1 through 4) Jamiolkowski et al (2003) reference	5 14
PHI ϕ	Friction Angle determined from one of the following user selectable options (methods 1 through 4 are for sands and method 5 is for silts and clays): 1) Campanella and Robertson 2) Durgunoglu and Mitchel 3) Janbu 4) Kulhawy and Mayne 5) NTH method (clays and silts)	See appropriate reference	5 5 5 11 23
Delta U/q_t $\Delta u/q_t$ du/q_t	Differential pore pressure ratio (older parameter used before B_q was established)	$= \frac{\Delta u}{qt}$ *where:* $\Delta u = u - u_{eq}$ *and* *u = dynamic pore pressure* *u_{eq} = equilibrium pore pressure*	39

Calculated Parameter	Description	Equation	Ref
B_q	Pore pressure parameter	$Bq = \frac{\Delta u}{qt - \sigma_v}$ where: $\Delta u = u - u_{eq}$ *and* *u = dynamic pore pressure* *u_{eq} = equilibrium pore pressure*	1, 2, 5
Net q_t or qtNet	Net tip resistance (used in many subsequent correlations)	$qt - \sigma_v$	36
q_e or qE or q_E	Effective tip resistance (using the dynamic pore pressure u_2 and not equilibrium pore pressure)	$q_t - u_2$	36
qeNorm	Normalized effective tip resistance	$\frac{qt - u_2}{\sigma'_v}$	36
Q_t or Norm: Qt or Q_{t1}	Normalized q_t for Soil Behavior Type classification as defined by Robertson (1990) using a linear stress normalization. Note this is different from Q_{tn}. This parameter was renamed to Q_{t1} in Robertson, 2009. Without normalization limits this parameter calculates to very high unrealistic values at low stresses.	$Qt = \frac{qt - \sigma_v}{\sigma'_v}$	2, 5, 15
F_r or Norm: Fr	Normalized Friction Ratio for Soil Behavior Type classification as defined by Robertson (1990)	$Fr = 100\% \cdot \frac{fs}{qt - \sigma_v}$	2, 5
$Q(1\text{-}B_q)$ $Q(1\text{-}B_q) + 1$	$Q(1\text{-}B_q)$ grouping as suggested by Jefferies and Davies for their classification chart and the establishment of their I_c parameter. Later papers added the +1 term to the equation.	$Q \cdot (1 - Bq)$ $Q \cdot (1 - Bq) + 1$ *where Bq is defined as above and Q is the same as the normalized tip resistance, Q_{t1}, defined above*	6, 7, 34
q_{c1}	Normalized tip resistance, q_{c1}, using a fixed stress ratio exponent, n (this method has stress units)	$q_{c1} = q_t \cdot (Pa/\sigma_v')^{0.5}$ where: P_a = atmospheric pressure	21
q_{c1} (0.5)	Normalized tip resistance, q_{c1}, using a fixed stress ratio exponent, n (this method is unit-less)	$q_{c1}(0.5) = (q_t/P_a) \cdot (Pa/\sigma_v')^{0.5}$ where: P_a = atmospheric pressure	5
q_{c1} (C_n)	Normalized tip resistance, q_{c1}, based on C_n (this method has stress units)	$q_{c1}(Cn) = C_n * q_t$	5, 12
q_{c1} (C_q)	Normalized tip resistance, q_{c1}, based on C_q (this method has stress units)	$q_{c1}(Cq) = C_q * q_t$ (some papers use q_c)	5, 12
q_{c1n}	normalized tip resistance, q_{c1n}, using a variable stress ratio exponent, n (where n=0.0, 0.70, or 1.0) (this method is unit-less)	$q_{c1n} = (q_t / P_a)(P_a/\sigma_v')^n$ where: P_a = atm. Pressure and n varies as described below	3

Calculated Parameter	Description	Equation	Ref
I_c or Ic (RW1998)	Soil Behavior Type Index as defined by Robertson and Wride (1997, 1998) for estimating grain size characteristics and providing smooth gradational changes across the SBTn chart. Ic(RW1998) is different from that of Jefferies and Davies (7) and is different from Ic(PKR2009).	$I_c = [(3.47 - \log_{10}Q)^2 + (\log_{10} Fr + 1.22)^2]^{0.5}$ *Where:* $Q = \left(\frac{qt - \sigma_v}{P_a}\right)\left(\frac{P_a}{\sigma_v'}\right)^n$ *Or* $Q = q_{c1n} = \left(\frac{qt}{P_a}\right)\left(\frac{P_a}{\sigma_v'}\right)^n$ *depending on the iteration in determining* I_c *And* *Fr is in percent* P_a *= atmospheric pressure* *n has the following distinct values:* *0.5, 0.75 and 1.0* *and is determined in an iterative manner based on the resulting* I_c *in each iteration* *Note that NCEER replaced 0.75 with 0.70*	3, 4, 5 10
I_c (PKR 2009)	Soil Behavior Type Index, I_c (PKR 2009) is based on a variable stress ratio exponent n, which itself is based on I_c (PKR 2009). An iterative calculation is required to determine I_c (PKR 2009) and its corresponding n (PKR 2009).	I_c *(PKR 2009) =* $[(3.47 - \log_{10}Q_{tn})^2 + (1.22 + \log_{10}F_r)^2]^{0.5}$	15
n (PKR 2009)	Stress ratio exponent n, based on I_c (PKR 2009). An iterative calculation is required to determine n (PKR 2009) and its corresponding I_c (PKR 2009).	*n (PKR 2009) =* $0.381 (I_c) + 0.05 (\sigma_v'/P_a) - 0.15$	15
Q_{tn} (PKR 2009)	Normalized tip resistance using a variable stress ratio exponent based on I_c (PKR 2009) and n (PKR 2009). An iterative calculation is required to determine Q_{tn} (PKR 2009).	$Q_{tn} = [(qt - \sigma_v)/P_a](P_a/\sigma_v')^n$ *where* P_a *= atmospheric pressure (100 kPa)* *n = stress ratio exponent described above*	15
FC	Apparent fines content (%)	$FC=1.75(Ic^{3.25}) - 3.7$ $FC=100$ *for* $I_c > 3.5$ $FC=0$ *for* $I_c < 1.26$ $FC = 5\%$ *if* $1.64 < I_c < 2.6$ *AND* $F_r<0.5$	3
I_c Zone	This parameter is the Soil Behavior Type zone based on the I_c parameter (valid for zones 2 through 7 on SBTn or SBT Qtn charts)	$I_c < 1.31$ Zone = 7 $1.31 < I_c < 2.05$ Zone = 6 $2.05 < I_c < 2.60$ Zone = 5 $2.60 < I_c < 2.95$ Zone = 4 $2.95 < I_c < 3.60$ Zone = 3 $I_c > 3.60$ Zone = 2	3
CD	The contractive / dilative boundary on Robertson's Modified SBTn (contractive/dilative) Chart shown in Figure 6 above. The boundary is marked as CD = 70 on the chart in the relevant paper. Similar to the $Q_{tn,cs}$ = 70 line in Figure 4.	$CD = 70 = (Q_{tn} - 11)(1 + 0.06F_r)^{17}$ lower bound of CD = 60: $CD = 60 = (Q_{tn} - 9.5)(1 + 0.06F_r)^{17}$	30

Calculated Parameter	Description	Equation	Ref
I_B	Hyperbolic fit defining the boundary between SBT soil types proposed by Schneider as a better fit than the I_c circles. I_B = 32 represents the boundary for most sand like soils. I_B = 22 represents the upper boundary for most clay like soils. The region between I_B=22 and I_B=32 is the "transitional soil" zone.	$I_B = 100\ (Q_{tn} + 10) / (70 + Q_{tn}\ F_r)$	30
State Param or State Parameter or ψ	The state parameter index, ψ, is defined as the difference between the current void ratio, e, and the critical void ratio, e_c. Positive ψ - contractive soil Negative ψ - dilative soil This is based on the work by Been and Jefferies (1985) and Plewes, Davies and Jefferies (1992) This method uses mean normal stresses based on a uniform value of K_0 or a calculated K_0 using methods described elsewhere in this document	See reference	6, 8
Yield Stress σ_p'	Yield stress is calculated using the following methods 1) General method 2) 1st order approximation using q_tNet (clays) 3) 1st order approximation using Δu_2 (clays) 4) 1st order approximation using q_e (clays) 5) Based on Vs	All stresses in kPa 1) $\sigma_p' = 0.33 \cdot (q_t - \sigma_v)^{m'}\ (\sigma_{atm}/100)^{1-m'}$ where $m' = 1 - \frac{0.28}{1 + (I_c/2.65)^{25}}$ 2) $\sigma_p' = 0.33 \cdot (q_t - \sigma_v)$ 3) $\sigma_p' = 0.54 \cdot (\Delta u_2)$ $\Delta u_2 = u_2 - u_0$ 4) $\sigma_p' = 0.60 \cdot (q_t - u_2)$ 5) $\sigma_p' = (Vs/4.59)^{1.47}$	19 20 20 20 18
OCR OCR(JS1978) YSR(Mayne2014) YSR (qtNet) YSR (deltaU) YSR (qe) YSR (Vs) OCR (PKR2015)	Over Consolidation Ratio based on 1) Schmertmann (1978) method involving a plot plot of S_u/σ_v' /($S_u/\sigma_v')_{NC}$ and OCR  2) based on Yield stresses described above 3) approximate version based on qtNet 4) approximate version based on Δu 5) approximate version based on effective tip, q_e 6) approximate version based on shear wave velocity, V_s and σ_v' 7) based on Qt	1) requires a user defined value for NC Su/P_c' ratio 2 through 5) *based on yield stresses* 6) YSR (Vs) = $\sigma_p'(Vs) / \sigma_v'$ 7) OCR = $0.25 \cdot (Qt)^{1.25}$	9 19 20 20 20 18 32
Es/qt	Intermediate parameter for calculating Young's Modulus, E, in sands. It is the Y axis of the reference chart. Note that Figured 5.59 from reference 5, Lunne, Robertson and Powell, (LRP) has an error. The X axis values are too high by a factor of 10. The plot is based on Baldi's (not Bellotti as cited in	Based on Figure 5.59 in the reference	5, 37

Calculated Parameter	Description	Equation	Ref
	LRP) original Figure 3 where the X axis is: $\frac{q_c}{\sqrt{\sigma_v'}}$ (both in kPa) with a range of 200 to 3000. Figure 5.59 from LRP shows a dimensionless form of the equation, q_{c1}, displaying the same range of values. Figure 5.59's X axis uses $q_{c1} = \left(\frac{q_c}{P_a}\right)\left(\frac{P_a}{\sigma_v'}\right)^{0.5}$ The two expressions are not the same: they differ by a factor of $\frac{\sqrt{P_a}}{P_a}$. With P_a taken to be 100 kPa the factor is 1/10. Substituting typical values of 200 bar (20000 kPa) for q_c and 225 kPa for σ_v' one gets: 20000 / 15 = 1333.33 for Bellotti's axis and $(200/1)(100/225)^{0.5}$ = 200 * (10/15) = 133.3 for LRP's axis (noting that P_a = 1 bar) showing a factor of 10 difference.		
Es or E_s Young's Modulus E	Young's Modulus based on the work done in Italy. There are three types of sands considered in this technique. The user selects the appropriate type for the site from: a) OC Sands b) Aged NC Sands c) Recent NC Sands Each sand type has a family of curves that depend on mean normal stress. The program calculates mean normal stress and linearly interpolates between the two extremes provided in the E_s/q_t chart. E_s is evaluated for an axial strain of 0.1%.	Mean normal stress is evaluated from: $\sigma_m' = \frac{1}{3}(\sigma_v' + \sigma_h' + \sigma_h')$ where σ_v'= vertical effective stress σ_h'= horizontal effective stress *and* $\sigma_h = K_o \cdot \sigma_v'$ with K_o assumed to be 0.5	5
Delta U/TStress Δu / σ_v	Differential pore pressure ratio with respect to total stress	$= \frac{\Delta u}{\sigma_v}$ *where:* $\Delta u = u - u_{eq}$	39
Delta U/EStress, P Value, Excess Pore Pressure Ratio $\Delta u/\sigma_v'$	Differential pore pressure ratio with respect to effective stress. Key parameter (P, Normalized Pore Pressure Parameter, Excess Pore Pressure Ratio) in the Winckler et. al. static liquefaction method.	$= \frac{\Delta u}{\sigma_v'}$ *where:* $\Delta u = u - u_{eq}$	25, 25a
Su/EStress S_u/σ_v'	Undrained shear strength ratio with respect to vertical effective overburden stress using the S_u (N_{kt}) method	= *Su* (N_{kt}) / σ_v'	9, 23
Vs or V_s	Recorded shear wave velocities (not estimated). The shear wave velocities are typically collected over 1 m depth intervals. Each data point over the relevant depth range is assigned the same V_s value.	recorded data	27
Vp or V_p	Recorded compression wave (or P wave) velocities (not estimated). The P wave velocities are typically collected over 1 m depth intervals. Each data point over the relevant depth range is assigned the same V_p value.	recorded data	27

Calculated Parameter	Description	Equation	Ref
V_{s30} V_{s100}	The average shear wave velocity of the near surface materials to a depth of 30 m (100 ft). It is based on the sum of all travel times through all layers in the top 30m (100 ft). V_{s100} is the same calculation as V_{s30} except down to a depth of 100 feet.	$V_{s30} = \frac{total\ thickness\ of\ all\ layers\ to\ 30\ m}{\Sigma\left(\frac{layer\ thickness}{layer\ shear\ wave\ velocity}\right)}$ $V_{s30} = \frac{total\ thickness\ of\ all\ layers\ to\ 30\ m}{\Sigma\,(layer\ travel\ times)}$	38
G_{max}	G_{max} determined from SCPT shear wave velocities (not estimated values). Note that seismic data (V_s) is collected over set depth intervals (typically 1 meter). Each data point over the test segment is assigned the same V_s value. Since soil density changes with depth, slightly different G_{max} values may be calculated over the test depth interval.	$G_{max} = \rho V_s^2$ where ρ is the mass density of the soil determined from the estimated unit weights at each test depth	27
qtNet/G_{max}	Net tip resistance ratio with respect to the small strain modulus G_{max} determined from SCPT shear wave velocities (not estimated values)	$= (qt - \sigma_v) / G_{max}$ where $G_{max} = \rho V_s^2$ and ρ is the mass density of the soil determined from the estimated unit weights at each test depth	15, 28, 30
qUlt	A site specific and client specific parameter for estimating the limiting stress for "crane walk" accessibility	$q_{ult} = CraneWalkFactor \cdot S_u$ Where: *CraneWalkFactor* is client provided	U*
Estimated G_o	Estimated value for small strain shear modulus	$G_o = 0.0188[10^{(0.55Ic + 1,68)}](q_t - \sigma_v)$	15
Estimated E_{25}	Estimated value for Young's Modulus, E, at a 25% working load	$E_{25} = \alpha_E$ (qtNet) where $\alpha_E = 0.015[10^{(0.55Ic + 1,68)}]$	15
k_{SBT}	Estimated soil permeability derived from Soil Behavior Type (SBT) Chart I_c values.	For $1.0 < I_c \leq 3.27$: $k = 10^{(0.952 - 3.04Ic)}$ in m/s For $3.27 < Ic < 4.0$: $k = 10^{(-4.52 - 1.37Ic)}$ in m/s	35
M or D' Constrained Modulus	Constrained Modulus based on 1) Robertson, M 2) Mayne, D'	1) Robertson $M = \alpha_M (q_t - \sigma_v)$ $I_c > 2.2$ (fine grained) $\alpha_M = Qt$ when $Qt < 14$ $\alpha_M = 14$ when $Qt > 14$ $Ic < 2.2$ (coarse grained) $\alpha_M = 0.0188\ [10^{(0.55Ic + 1.68)}]$ $D' = \alpha_D (qt - \sigma_v)$ where $\alpha_D = 5$	32 23

Table 1b. CPT Parameter Calculation Methods – Liquefaction Parameters

Calculated Parameter	Description	Equation	Ref
K_{SPT} or K_s	Equivalent clean sand factor for $(N_1)60$	$K_{SPT} = 1 + ((0.75/30) \bullet (FC - 5))$	10
K_{CPT} or K_C (RW1998)	Equivalent clean sand correction for q_{c1N}	$K_{cpt} = 1.0$ for $I_c \leq 1.64$ $K_{cpt} = f(I_c)$ for $I_c > 1.64$ (see reference) $K_c = -0.403 I_c^4 + 5.581 I_c^3 - 21.63 I_c^2 + 33.75 I_c - 17.88$	3, 10
K_C (PKR 2010)	Clean sand equivalent factor to be applied to Q_{tn}	$K_c = 1.0$ for $I_c \leq 1.64$ $K_c = -0.403 I_c^4 + 5.581 I_c^3 - 21.63 I_c^2 + 33.75 I_c - 17.88$ for $I_c > 1.64$	16
$(N_1)_{60cs}I_c$	Clean sand equivalent SPT $(N_1)_{60}I_c$. User has 3 options.	1) $(N_1)_{60cs}Ic = \alpha + \beta((N_1)_{60}I_c)$ 2) $(N_1)_{60cs}Ic = K_{SPT} * ((N_1)_{60}I_c)$ 3) $(q_{c1ncs})/ (N_1)_{60cs}I_c = 8.5 (1 - I_c/4.6)$ FC ≤ 5%: $\alpha = 0$, $\beta=1.0$ FC ≥ 35% $\alpha = 5.0$, $\beta=1.2$ 5% < FC < 35% $\alpha = exp[1.76 - (190/FC^2)]$ $\beta = [0.99 + (FC^{1.5}/1000)]$	10 10 5
q_{c1ncs}	Clean sand equivalent q_{c1n}	$q_{c1ncs} = q_{c1n} \bullet K_{cpt}$	3
$Q_{tn,cs}$ (PKR 2010)	Clean sand equivalent for Q_{tn} described above - Q_{tn} being the normalized tip resistance based on a variable stress exponent as defined by Robertson (2009)	$Q_{tn,cs} = Q_{tn} \cdot K_c$ (PKR 2016)	16
Su(Liq)/ESv or $S_u(Liq)/\sigma_v'$	Liquefied shear strength ratio as defined by Olson and Stark	$\frac{S_u(Liq)}{\sigma_v'} = 0.03 + 0.0143(q_{c1})$ Note: σ_v' and s_v' are synonymous	13
Su(Liq)/ESv or $S_u(Liq)/\sigma_v'$ (PKR 2010)	Liquefied shear strength ratio as defined by Robertson (2010)	$\frac{S_u(Liq)}{\sigma_v'}$ Based on a function involving $Q_{tn,cs}$	16
S_u (Liq) (PKR 2010)	Liquefied shear strength derived from the liquefied shear strength ratio and effective overburden stress	$S_u(Liq) = \sigma_v' \cdot \left(\frac{S_u(Liq)}{\sigma_v'}\right)$	16
Cont/Dilat Tip	Contractive / Dilative q_{c1} Boundary based on $(N_1)_{60}$	$(\sigma_v')_{boundary} = 9.58 \times 10^{-4} [(N_1)_{60}]^{4.79}$ q_{c1} is calculated from specified q_t(MPa)/N ratio	13
CRR	Cyclic Resistance Ratio (for Magnitude 7.5)	$q_{c1ncs} < 50$: $CRR_{7.5} = 0.833 [q_{c1ncs}/1000] + 0.05$ $50 \leq q_{c1ncs} < 160$: $CRR_{7.5} = 93 [q_{c1ncs}/1000]^3 + 0.08$	10
Kg or K_g	Small strain Stiffness Ratio Factor, K_g	$[G_{max}/q_t]/[q_{c1n}^{-m}]$ m = empirical exponent, typically 0.75	26

Calculated Parameter	Description	Equation	Ref
K_g*	Revised K_g factor extended to fine grained soils (Robertson).	$K_g^* = (G_o / q_n)(Q_{tn})^{0.75}$ where q_n is the net tip resistance = $q_t - \sigma_v$	30
SP Distance	State Parameter Distance, Winckler static liquefaction method	Perpendicular distance on Q_{tn} chart from plotted point to state parameter $\Psi = -0.05$ curve	25
URS NP Fr	Normalized friction ratio point on $\Psi = -0.05$ curve used in SP distance calculation		25
URS NP Q_{tn}	Normalized tip resistance (Q_{tn}) point on $\Psi = -0.05$ curve used in SP Distance calculation		25

Table 2. References

No.	Reference
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4	Robertson, P.K. and Wride, C.E., 1997, "Cyclic Liquefaction and its Evaluation Based on SPT and CPT", NCEER Workshop Paper, January 22, 1997.
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No.	Reference
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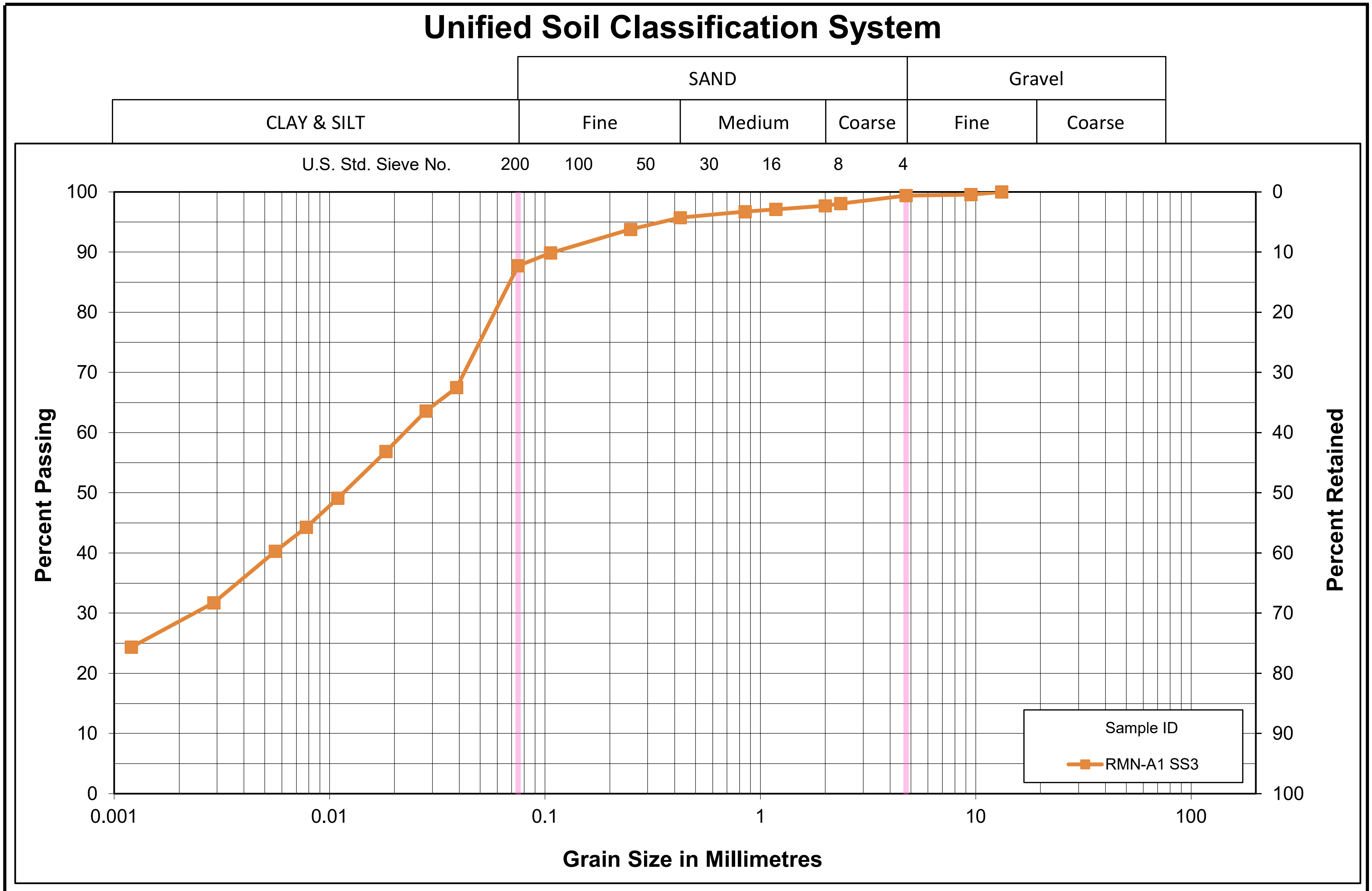
APPENDIX D

D.1 GRAIN SIZE DISTRIBUTION PLOTS AND PLASTICITY CHARTS (FIGURES D1-D6)

D.2 CONSOLIDATION TESTS

D.3 TRIAXIAL TEST RESULTS

D.4 CORROSIVITY TEST RESULTS



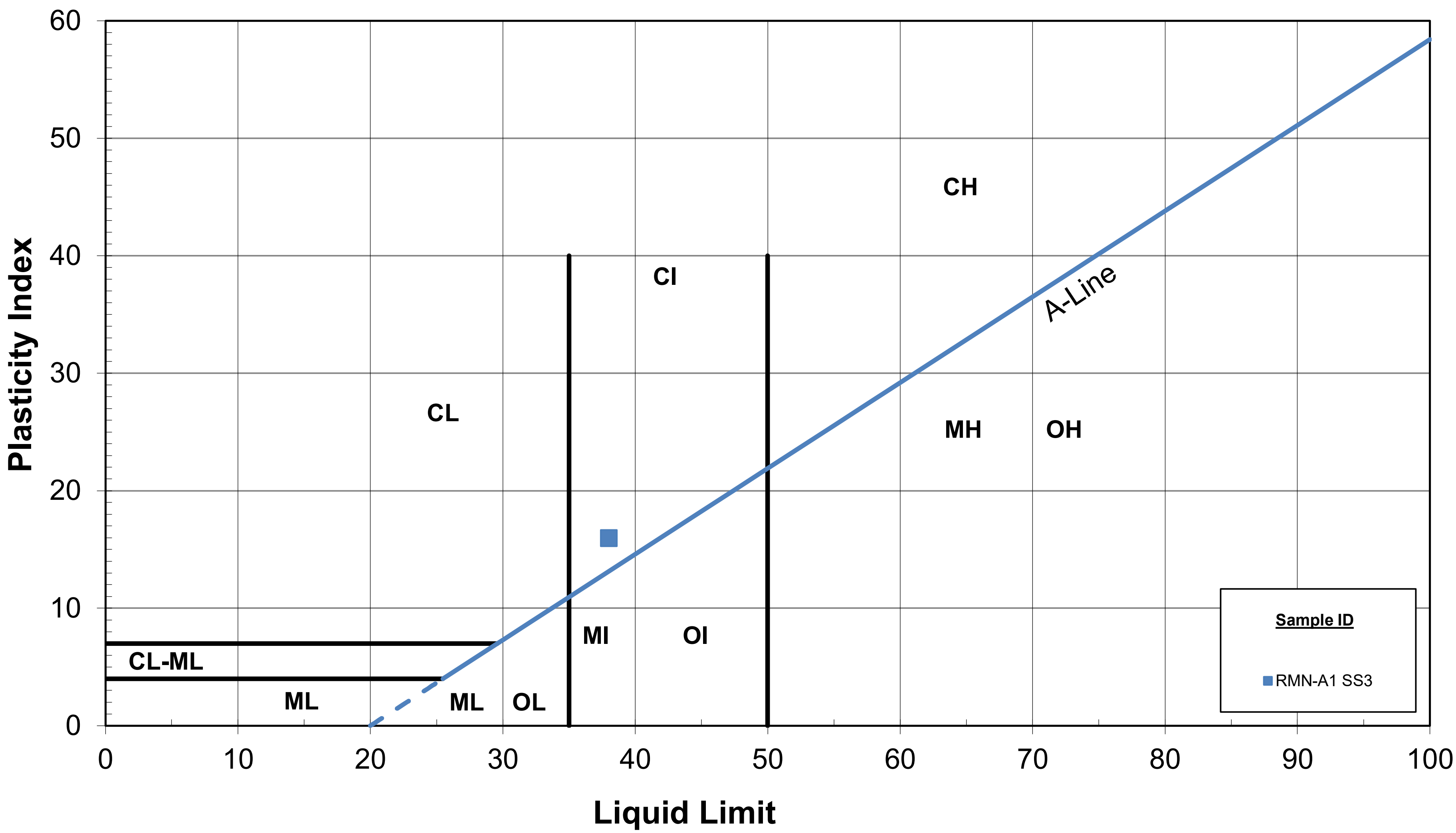
FILL: SILTY CLAY (CI)

Ministry of Transportation (MTO)

Talbotville Bypass - Ron McNeil Line Overpass

Figure No. D1

Project No. 165001308



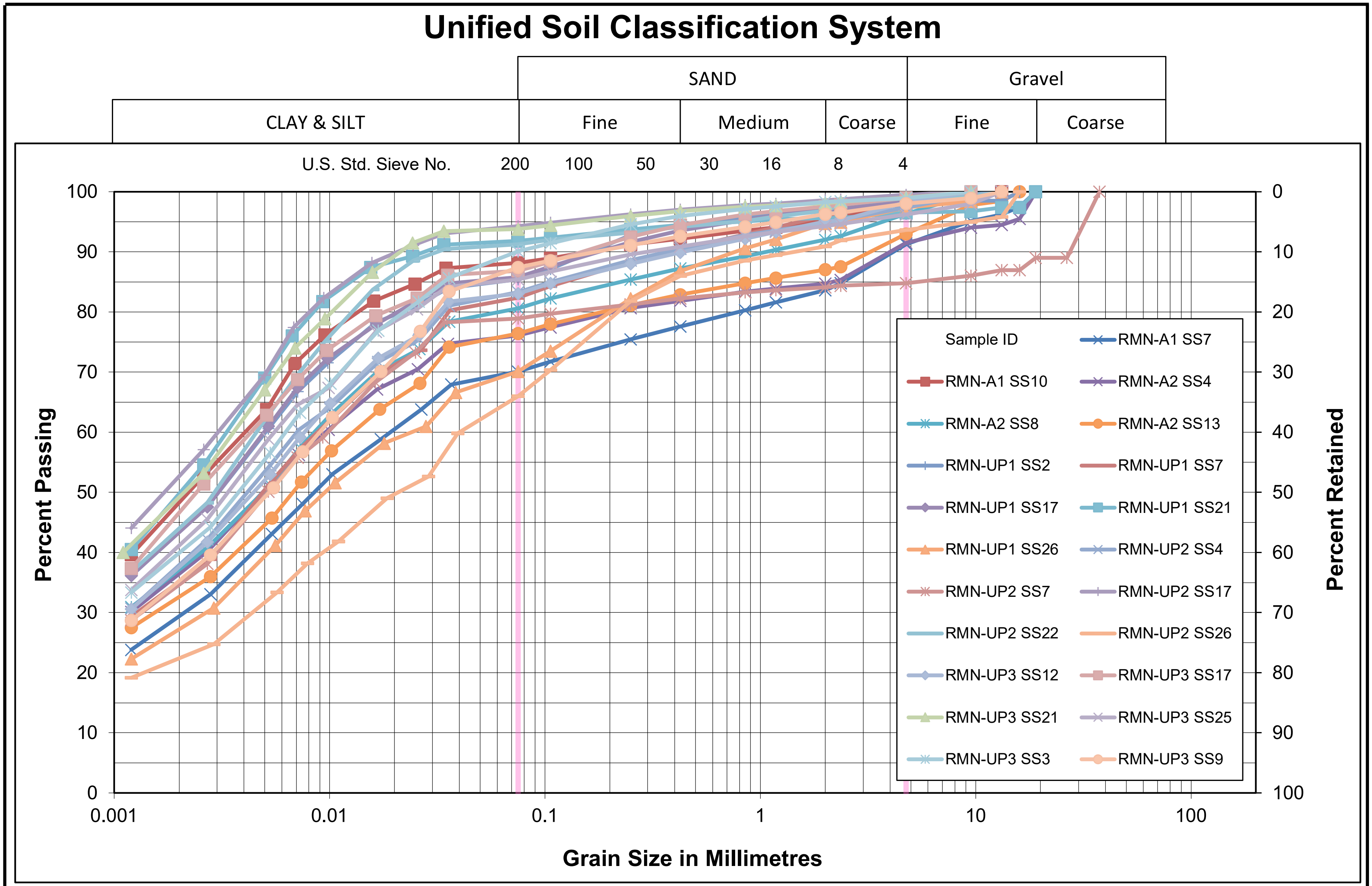
FILL: SILTY CLAY (CI)

Ministry of Transportation (MTO)

Talbotville Bypass - Ron McNeil Overpass

Figure No. D2

Project No. 165001308



Stantec

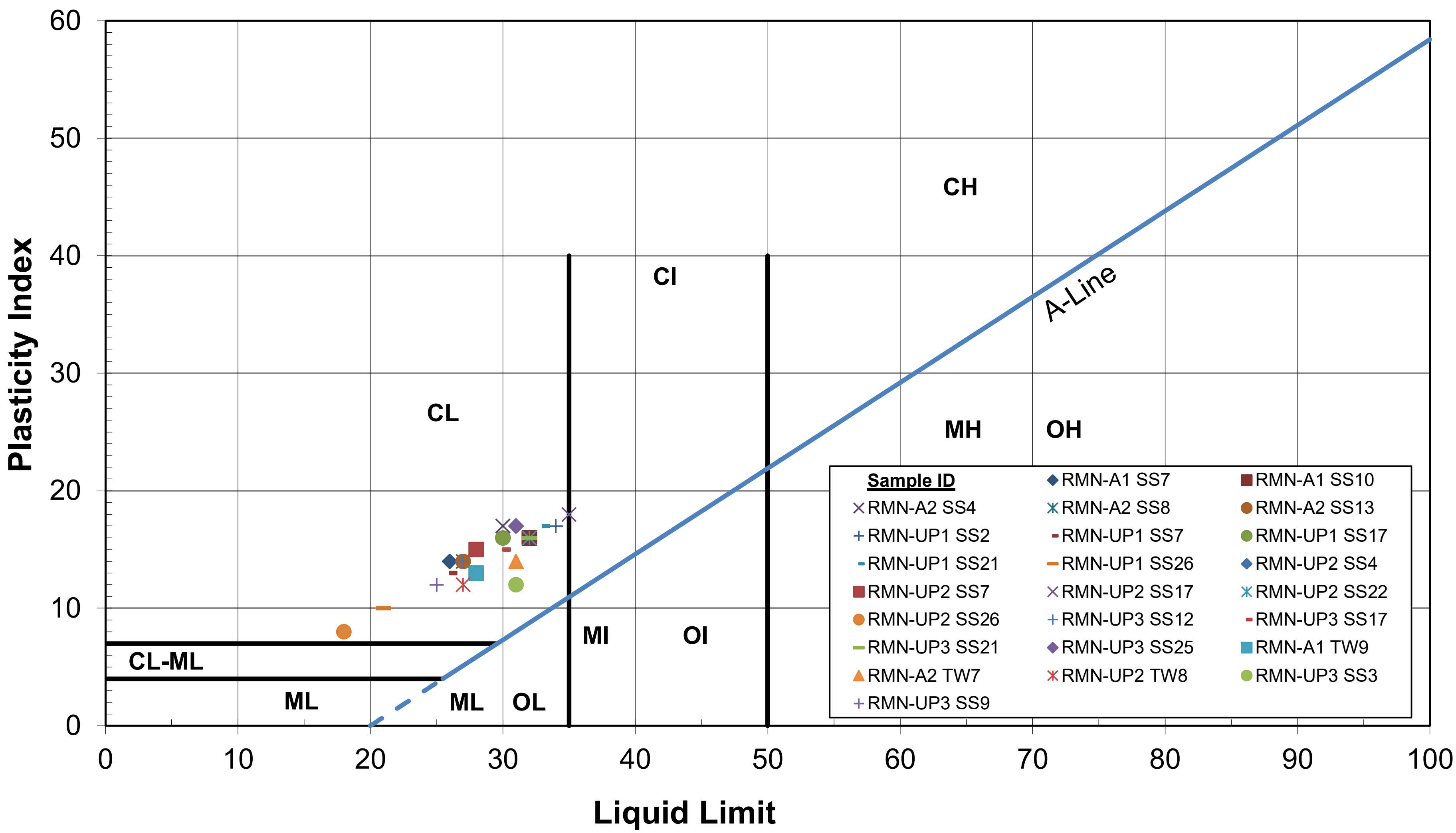
TILL: Clayey SILT (CL)

Ministry of Transportation (MTO)

Talbotville Bypass - Ron McNeil Line Overpass

Figure No. D3

Project No. 165001308



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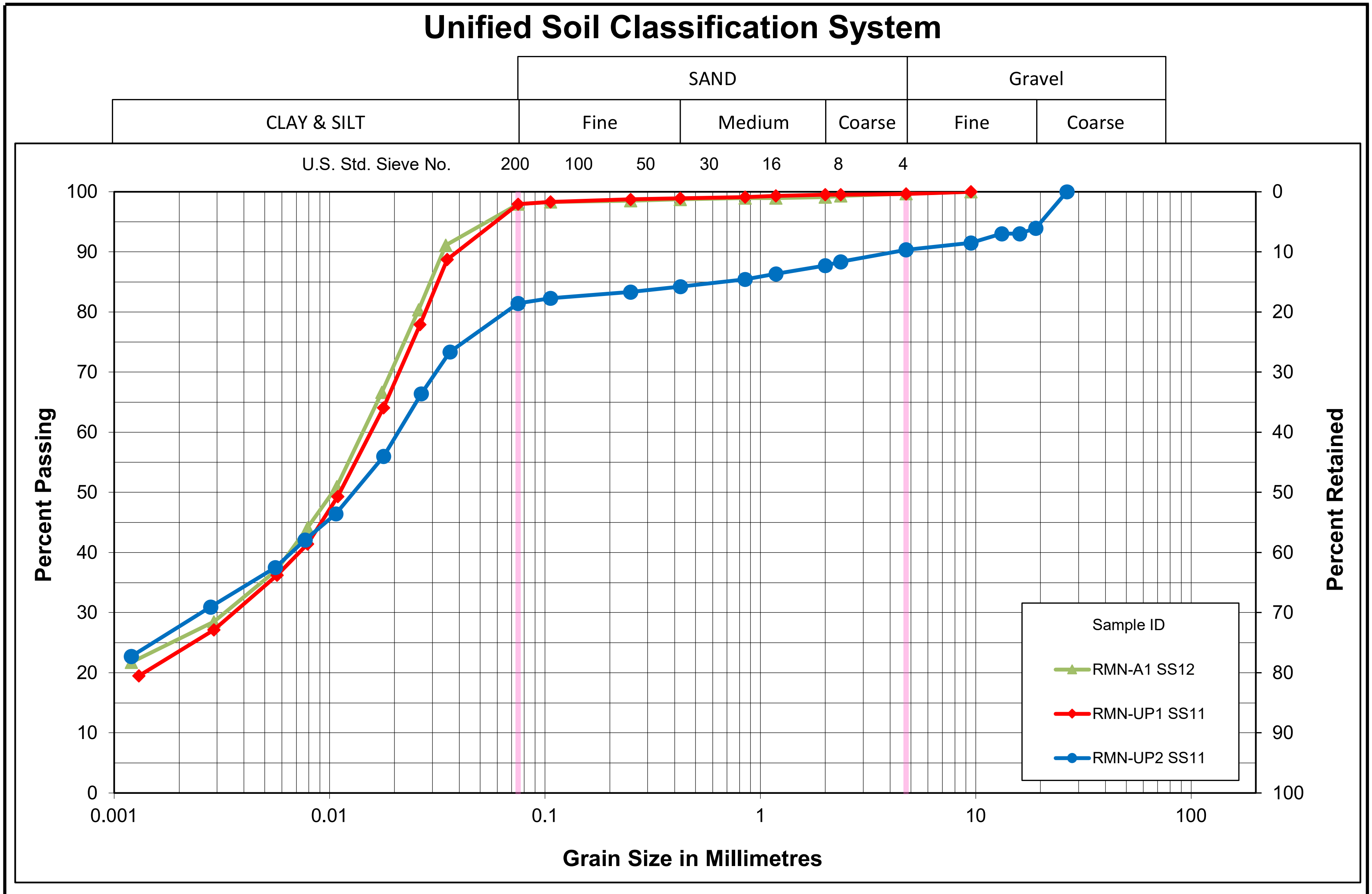
TILL: Clayey SILT (CL)

Ministry of Transportation (MTO)

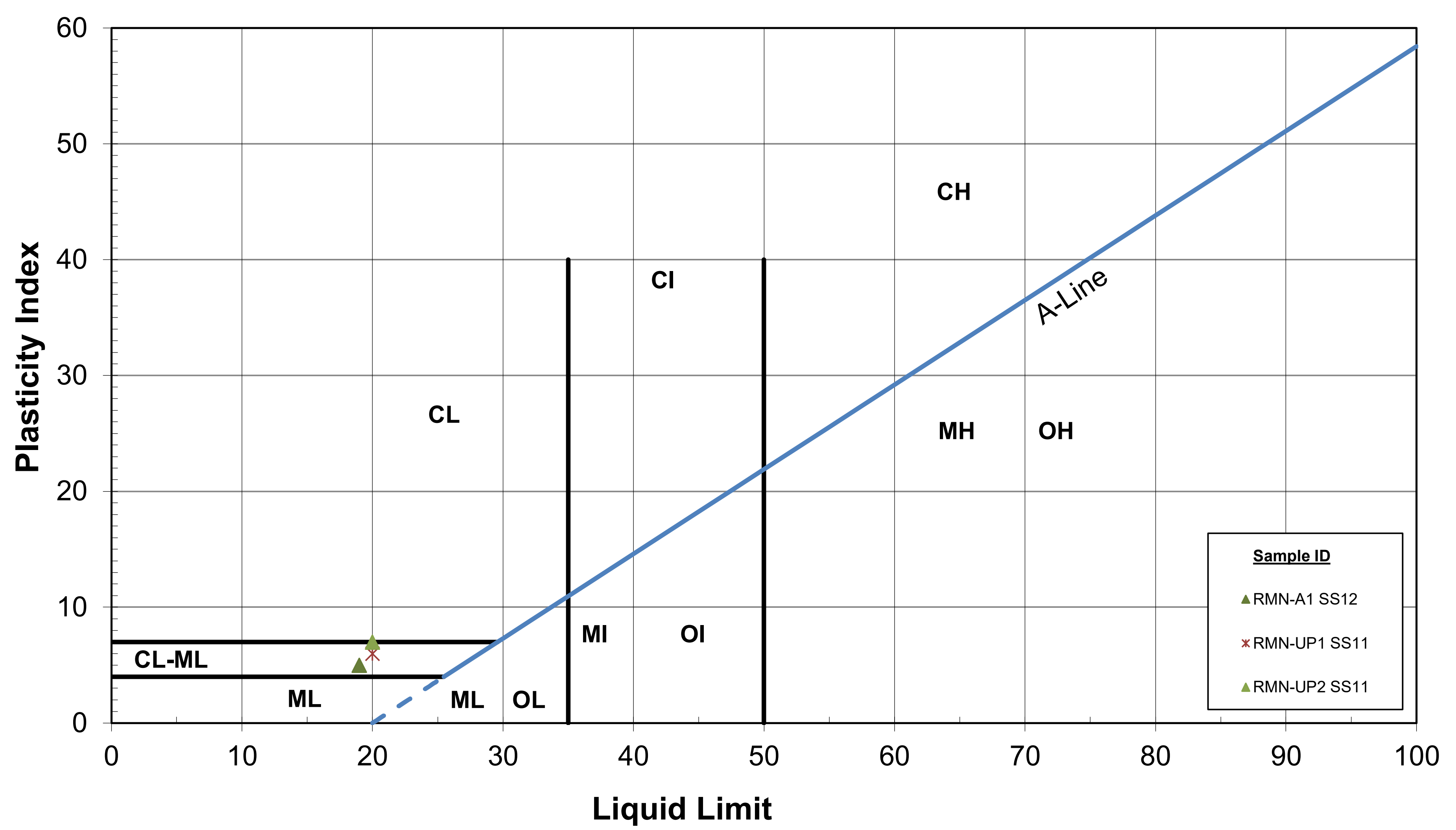
Talbotville Bypass - Ron McNeil Underpass

Figure No. D4

Project No. 165001308



Stantec	**Clayey SILT (CL-ML)** **Ministry of Transportation (MTO)** **Talbotville Bypass - Ron McNeil Line Overpass**	Figure No. D5 Project No. 165001308



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Clayey SILT (CL-ML)

Ministry of Transportation (MTO)

Talbotville Bypass - Ron McNeil Underpass

Figure No. D6

Project No. 165001308

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST (ASTM D2850)

Tables 1-4

MTO Hwy 3 Talbotville Bypass
SPECIMEN IDENTIFICATION

Borehole/Sample No.:	BH RMN UP2, TW8	Sample Type:	Intact
Sample Depth (ft):	17.7-19.5	Soil Classification:	CL
Liquid Limit:	27.4%	Specific Gravity:	2.764
Plastic limit:	14.8%		

Soil Description & Classification: *Lean clay of low plasticity, stiff to very stiff, brown, moist, CL*

INITIAL SPECIMEN DIMENSIONS AND PROPERTIES

Test No	3	4
Specimen Height, (mm)	152	152
Specimen Diameter, (mm)	70	70
Natural Water Content (Cuttings), (%)	11.4	17.9
Void Ratio	0.41	0.51
Degree of Saturation, (%)	76.3	96.4
Dry Unit Weight (kN/m^3)	19.12	17.85

SHEARING/FAILURE

Max. Deviator Stress, (σ_1-σ_3), (kPa)	117.1	212.0
Axial Strain At Maximum (σ_1-σ_3), (%)	15.00	15.01
Compressive Strength, Max, (kN)	0.5	1.0
Max Total Principal Stress Ratio,(σ_1/σ_3)	2.2	1.6
Deviator Stress At (σ_1/σ_3) Max, (kPa)	117.1	212.0
Total Major Principal Stress At Failure, σ_1, (kPa)	217.1	551.1
Total Minor Principal Stress At Failure, σ_3, (kPa)	100.0	339.1
Average Rate of Strain, (%/min)	1.00	1.00

Test Notes: ***Top of tube (Tes# 3) is stiff, Bottom of tube (Tes# 4) is very stiff***

Specimen Saturation Method	N/A	N/A
Failure Criterion	15% A. Strain	15% A. Strain
Membrane Thickness Correction Applied, Y/N	Y	Y

Project No.: 165001308.451.200
Date: August 19, 2024

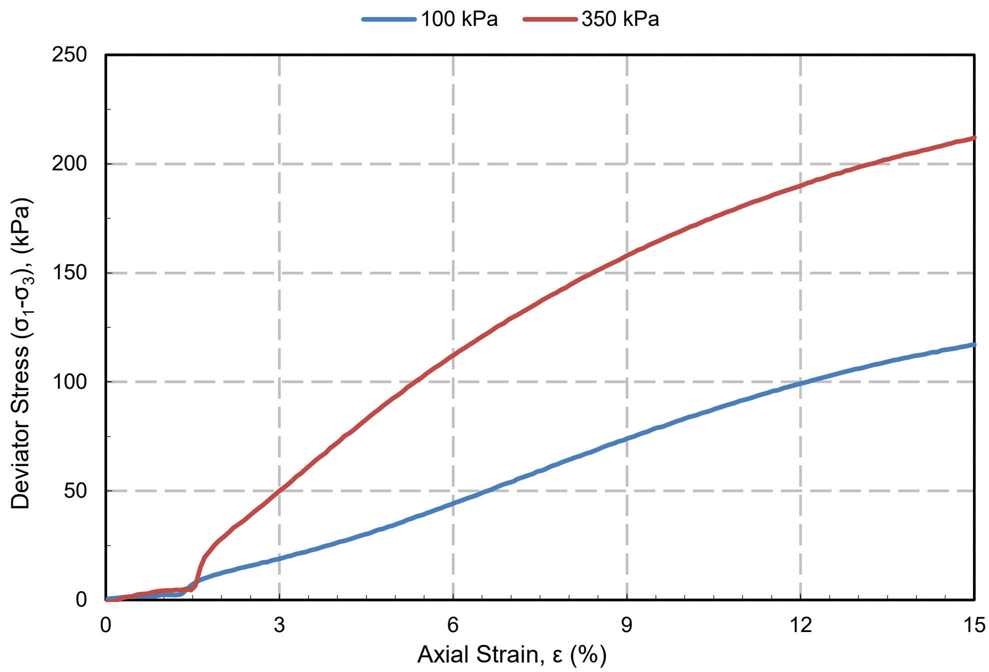
Stantec

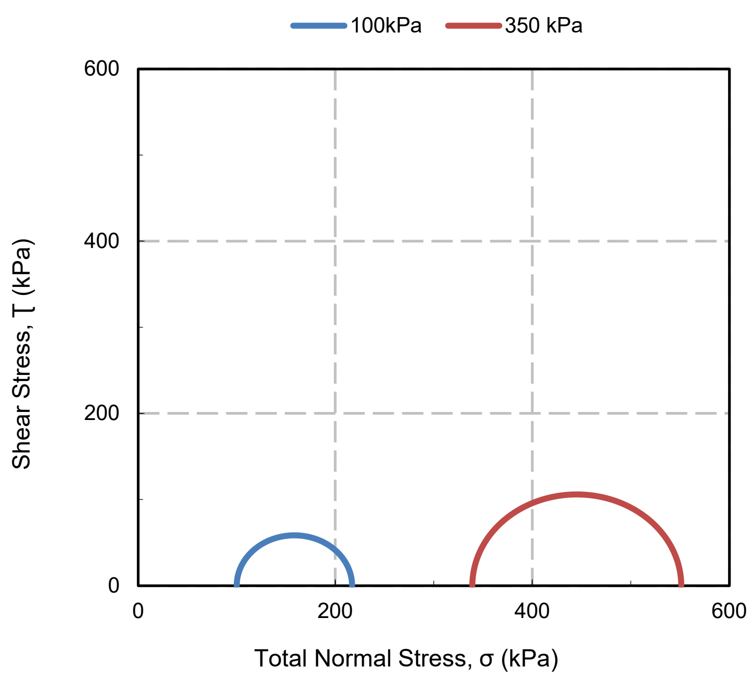
Prepared By : DB
Checked By : RG

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST (ASTM D2850)	Figures 1-2

MTO Hwy 3 Talbotville Bypass

BH RMN UP2, ST1





Project No.: 165001308.451.200
Date: August 19, 2024

Stantec

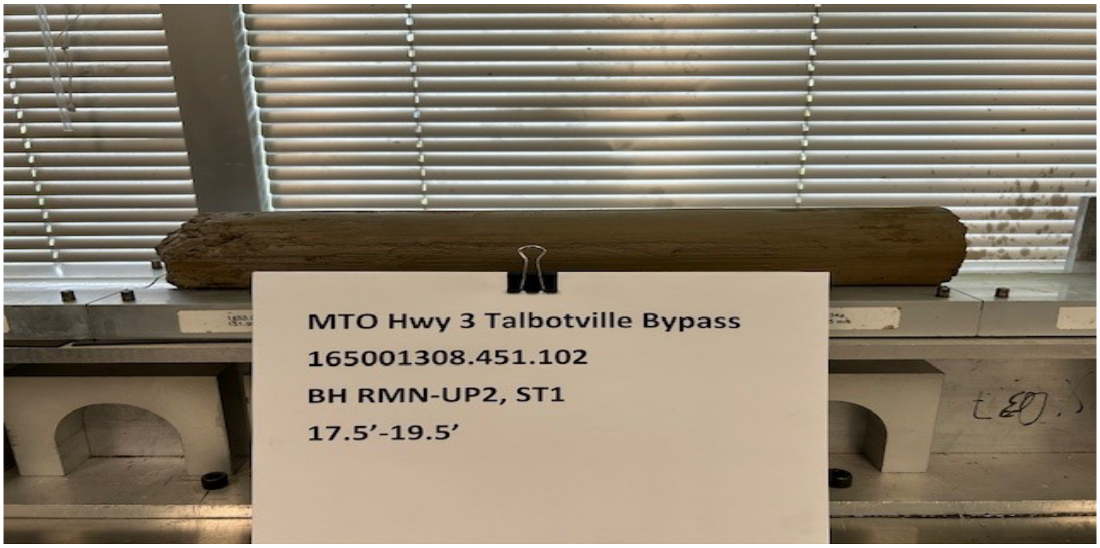
Prepared By : DB
Checked By : RG

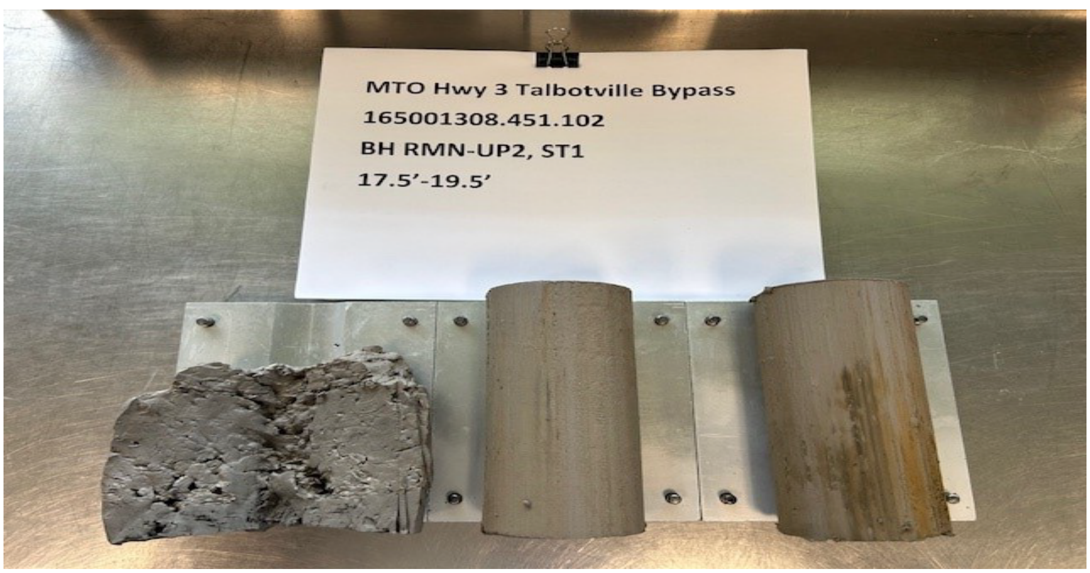
PHOTOGRAPHS OF EXTRUDED/SLICED SPECIMENS	PHOTOS 1-2

MTO Hwy 3 Talbotville Bypass

Lean clay of low plasticity, stiff to very stiff, brown, moist, CL

BH RMN UP2, ST1





Project No. :	165001308.451.200	Stantec	Prepared by :	DB
Date :	August 19, 2024		Checked by :	RG

PHOTOGRAPHS OF FAILED SPECIMENS	PHOTOS 3-4

MTO Hwy 3 Talbotville Bypass

Lean clay of low plasticity, stiff to very stiff, brown, moist, CL

BH RMN UP2, ST1

100 kPa Shearing

350 kPa Shearing

Project No. :	165001308.451.200	Stantec	Prepared by :	DB
Date :	August 19, 2024		Checked by :	RG

CONSOLIDATION TEST SUMMARY

SAMPLE IDENTIFICATION

Borehole No. :	BH RMN-A1	Sample No. :	TW9
		Sample Depth (ft) :	20-21.5

TEST CONDITIONS

Test Type :	ASTM D2435/D2435M	Date Started :	21-Aug-24
Load Duration (hr) :	Method B	Date Completed :	23-Aug-24

SAMPLE DIMENSIONS AND PROPERTIES _ INITIAL

Sample Height (mm) :	20.50	Unit Weight (kN/m^3) :	21.86
Sample Diameter (mm) :	50.00	Dry Unit Weight (kN/m^3) :	19.01
Area (cm^2) :	19.63	Specific Gravity : (Assumed)	2.757
Volume (cm^3) :	40.25	Solid Height (mm) :	14.41
Water Content (%) :	14.98	Volume of Solids (cm^3) :	28.30
Wet Mass (g) :	89.71	Volume of Voids (cm^3) :	11.95
Dry Mass (g) :	78.02	Degree of Saturation (%) :	97.80

TEST COMPUTATIONS

Axial Stress (kPa)	Height (H) (mm)	Corrected Deformation (ΔH) (mm)	Axial Strain (ε_a) (%)	Void Ratio e	t_{90} (sec)	C_v (cm^2/s)	m_v (m^2/kN)	k (m/s)
0	20.5000			0.422				
10	20.3196	0.1804	1.09	0.407	105.83	8.29E-03	1.09E-03	8.90E-09
20	20.1592	0.3408	1.89	0.396	211.89	4.07E-03	7.93E-04	3.17E-09
40	19.9201	0.5799	3.08	0.379	280.29	3.01E-03	5.96E-04	1.76E-09
80	19.6822	0.8178	4.24	0.362	415.70	1.99E-03	2.91E-04	5.67E-10
160	19.4556	1.0444	5.37	0.346	377.65	2.14E-03	1.41E-04	2.96E-10
240	19.2844	1.2156	6.02	0.337	656.02	1.21E-03	8.16E-05	9.67E-11
160			5.99	0.337				
80			5.81	0.340				
160	19.2862	1.2138	5.94	0.338	169.20	4.66E-03	1.60E-05	7.34E-11
240	19.2513	1.2487	6.14	0.335	284.52	2.76E-03	2.51E-05	6.80E-11
480	19.0410	1.4590	7.35	0.318	301.02	2.57E-03	5.05E-05	1.27E-10
960	18.7427	1.7573	8.83	0.297	240.74	3.13E-03	3.08E-05	9.44E-11
1920	18.4125	2.0875	10.48	0.273	209.62	3.47E-03	1.71E-05	5.84E-11
3840	18.0269	2.4731	12.34	0.247	218.55	3.20E-03	9.71E-06	3.05E-11
4800	17.8897	2.6103	12.94	0.238	286.59	2.38E-03	6.21E-06	1.45E-11
1920			12.67	0.242				
480			11.82	0.254				
80			10.12	0.278				
10			8.46	0.302				

SAMPLE DIMENSIONS AND PROPERTIES _ FINAL

Sample Height (mm) :	18.77	Unit Weight (kN/m^3) :	23.44
Sample Diameter (mm) :	50.00	Dry Unit Weight (kN/m^3) :	20.77
Area (cm^2) :	19.63	Specific Gravity (Assumed) :	2.757
Volume (cm^3) :	36.85	Solid Height (mm) :	14.41
Water Content (%) :	12.89	Volume of Solids (cm^3) :	28.30
Wet Mass (g) :	88.08	Volume of Voids (cm^3) :	8.55
Dry Mass (g) :	78.02		

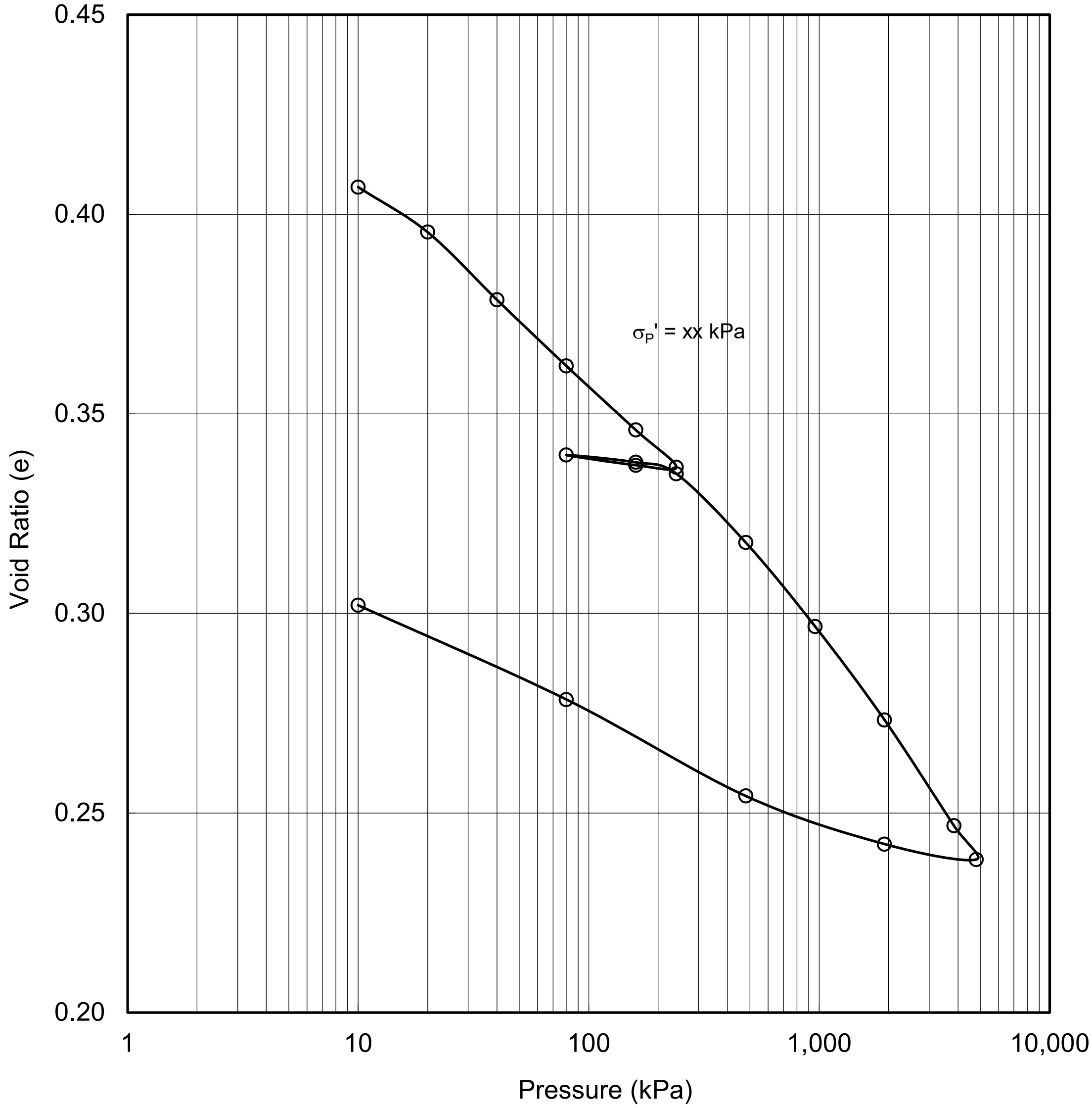
Project No. :	165001308.451.102	Stantec	Prepared By :	DB
Date :	24-Aug-24		Checked By :	RG

CONSOLIDATION TEST	FIGURE 1

MTO Hwy 3 Talbotville Bypass

BH RMN-A1, TW9

Void Ratio vs Pressure



Soil Type :	*Overconsolidated Lean clay of low plasticity, hard, brown, moist, CL*				
e_o =	0.422	w_L =	27.9%	σ_{v0}' =	kPa
w =	15.0%	w_P =	15.3%	σ_P' =	kPa
γ =	21.9 kN/m^3	PI =	12.6%		
Gs =	2.757				

Project No. : 165001308.451.102
Date : 24-Aug-24

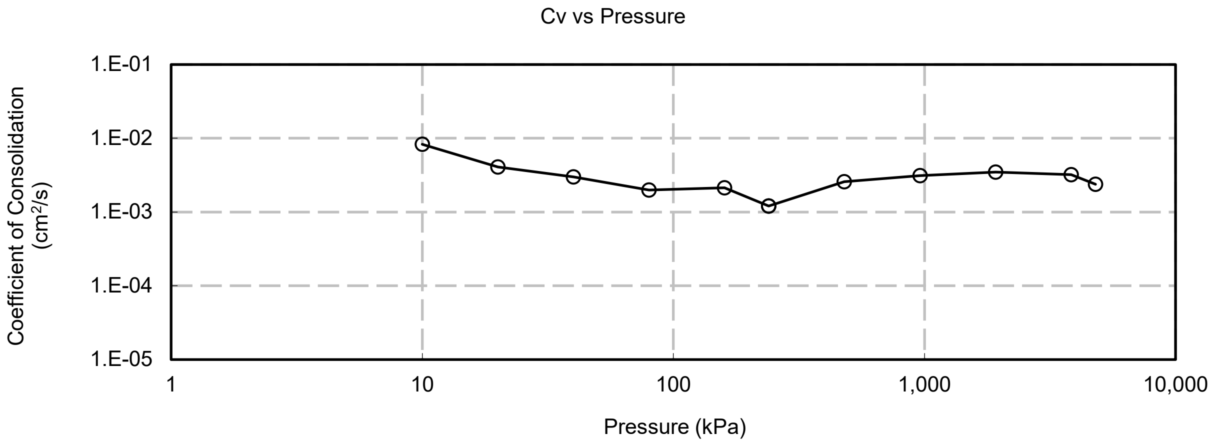
Stantec

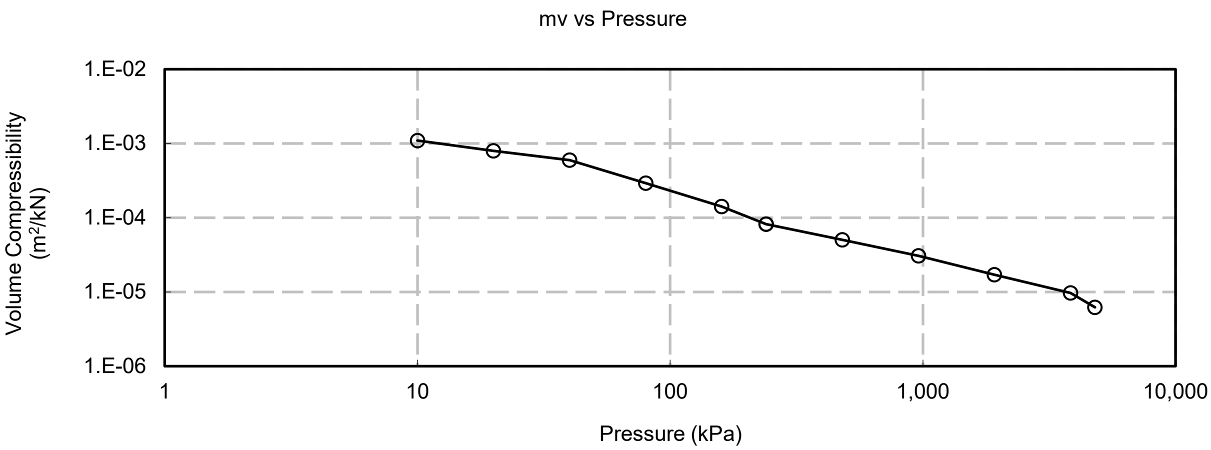
Prepared By : DB
Checked By : RG

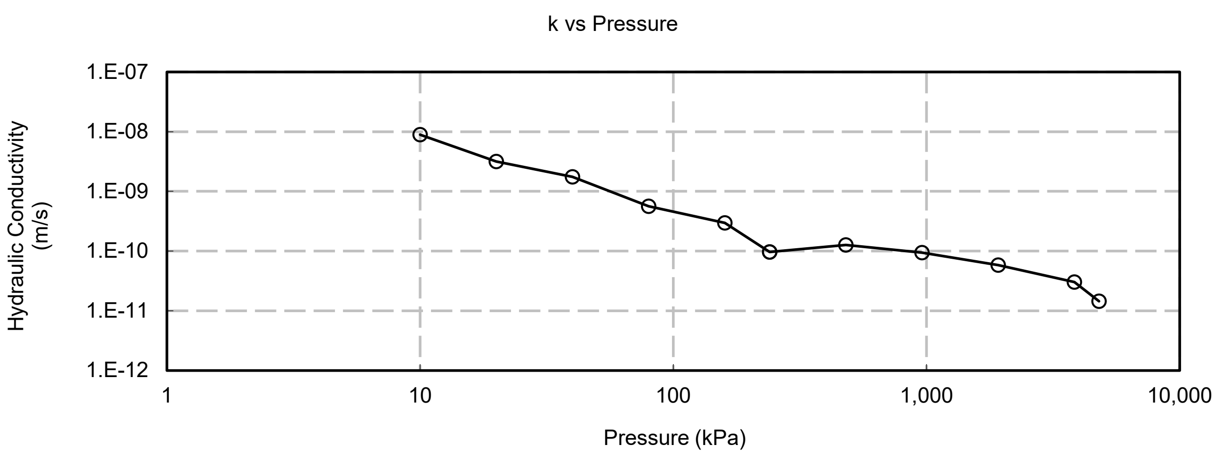
CONSOLIDATION TEST	FIGURES 2, 3 & 4

MTO Hwy 3 Talbotville Bypass

BH RMN-A1, ST1



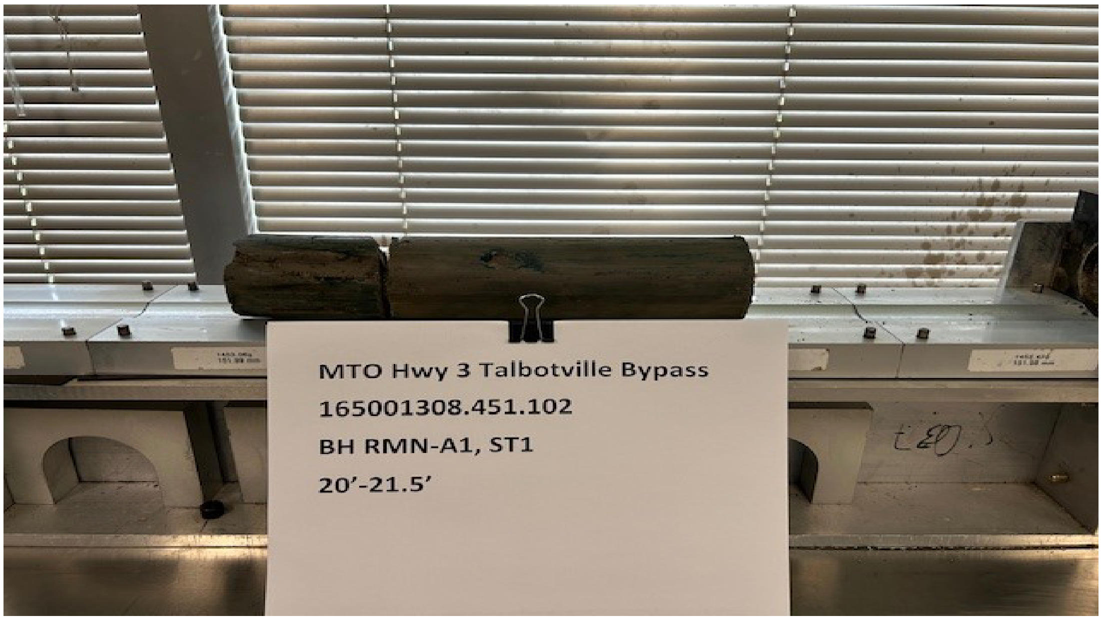




Project No. :	165001308.451.102	Stantec	Prepared By :	DB
Date :	24-Aug-24		Checked By :	RG

MTO Hwy 3 Talbotville Bypass

Overconsolidated Lean clay of low plasticity, hard, brown, moist, CL



BH RMN-A1, ST1

BH RMN-A1, ST1

CONSOLIDATION TEST SUMMARY

SAMPLE IDENTIFICATION

Borehole No. :	BH RMN-A2	Sample No. :	TW7
		Sample Depth (ft) :	15-16.5

TEST CONDITIONS

Test Type :	ASTM D2435/D2435M	Date Started :	21-Aug-24
Load Duration (hr) :	Method B	Date Completed :	23-Aug-24

SAMPLE DIMENSIONS AND PROPERTIES _ INITIAL

Sample Height (mm) :	20.50	Unit Weight (kN/m^3) :	21.42
Sample Diameter (mm) :	50.00	Dry Unit Weight (kN/m^3) :	18.35
Area (cm^2) :	19.63	Specific Gravity : (Assumed)	2.761
Volume (cm^3) :	40.25	Solid Height (mm) :	13.89
Water Content (%) :	16.76	Volume of Solids (cm^3) :	27.28
Wet Mass (g) :	87.93	Volume of Voids (cm^3) :	12.98
Dry Mass (g) :	75.31	Degree of Saturation (%) :	97.26

TEST COMPUTATIONS

Axial Stress (kPa)	Height (H) (mm)	Corrected Deformation (ΔH) (mm)	Axial Strain (ε_a) (%)	Void Ratio e	t_{90} (sec)	C_v (cm^2/s)	m_v (m^2/kN)	k (m/s)
0	20.5000			0.476				
10	20.3736	0.1264	0.65	0.466	106.79	8.25E-03	6.49E-04	5.26E-09
20	20.3343	0.1657	0.87	0.463	297.16	2.95E-03	2.18E-04	6.32E-10
40	20.2510	0.2490	1.33	0.456	338.70	2.57E-03	2.31E-04	5.84E-10
80	20.1172	0.3828	2.03	0.446	435.55	1.98E-03	1.75E-04	3.39E-10
160	19.9207	0.5793	2.98	0.432	566.56	1.49E-03	1.19E-04	1.74E-10
240	19.7944	0.7056	3.61	0.422	400.58	2.08E-03	7.91E-05	1.61E-10
160			3.51	0.424				
80			3.21	0.428				
160	19.8064	0.6936	3.42	0.425	179.93	4.63E-03	2.70E-05	1.23E-10
240	19.7556	0.7444	3.71	0.421	246.83	3.36E-03	3.53E-05	1.16E-10
480	19.5415	0.9585	4.94	0.403	294.62	2.77E-03	5.16E-05	1.40E-10
960	19.1957	1.3043	6.64	0.378	320.48	2.46E-03	3.53E-05	8.53E-11
1920	18.7652	1.7348	8.77	0.346	311.48	2.43E-03	2.22E-05	5.29E-11
3840	18.2609	2.2391	11.24	0.310	234.54	3.07E-03	1.29E-05	3.89E-11
4800	18.0867	2.4133	12.00	0.299	284.38	2.45E-03	7.96E-06	1.91E-11
1920			11.66	0.304				
480			9.93	0.329				
80			7.57	0.364				
10			5.31	0.397				

SAMPLE DIMENSIONS AND PROPERTIES _ FINAL

Sample Height (mm) :	19.41	Unit Weight (kN/m^3) :	22.35
Sample Diameter (mm) :	50.00	Dry Unit Weight (kN/m^3) :	19.38
Area (cm^2) :	19.63	Specific Gravity (Assumed) :	2.761
Volume (cm^3) :	38.11	Solid Height (mm) :	13.89
Water Content (%) :	15.36	Volume of Solids (cm^3) :	27.28
Wet Mass (g) :	86.88	Volume of Voids (cm^3) :	10.84
Dry Mass (g) :	75.31		

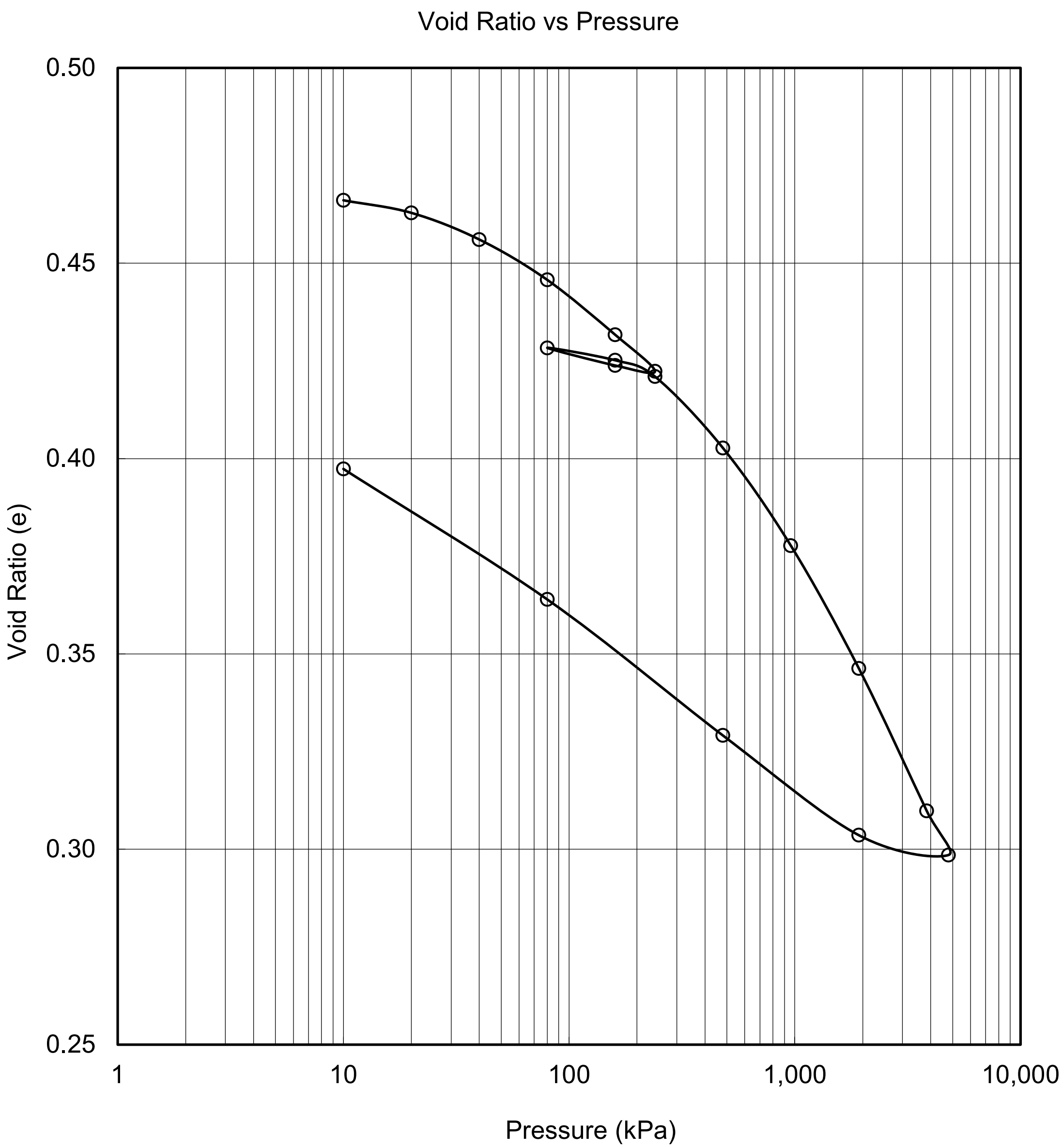
Project No. :	165001308.451.102	Prepared By :	DB
Date :	24-Aug-24	Checked By :	RG

Stantec

CONSOLIDATION TEST	FIGURE 1

MTO Hwy 3 Talbotville Bypass

BH RMN-A2, TW7



Soil Type : *Overconsolidated Lean clay of low plasticity, hard, brown, moist, CL*

e_o =	0.476	w_L =	30.7%	σ_{v0}' =		kPa
w =	16.8%	w_P =	16.6%	σ_P' =		kPa
γ =	21.4 kN/m^3	PI =	14.1%			
Gs =	2.761					

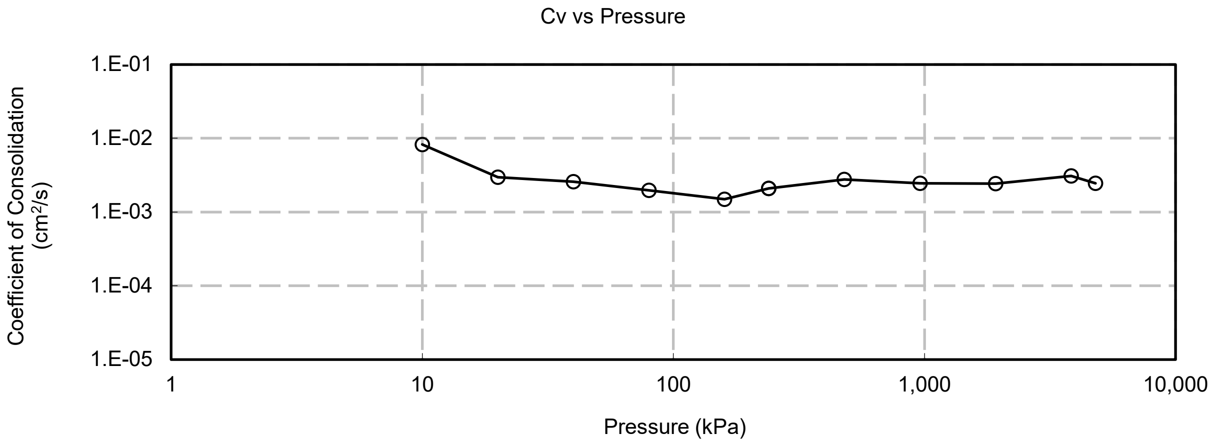
Project No. :	165001308.451.102	Prepared By :	DB
Date :	24-Aug-24	Checked By :	RG

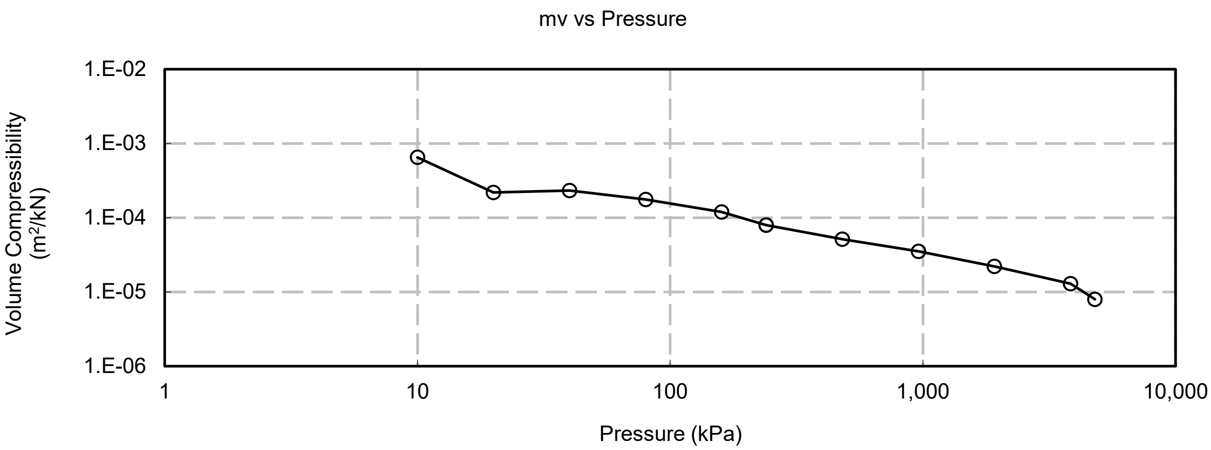
Stantec

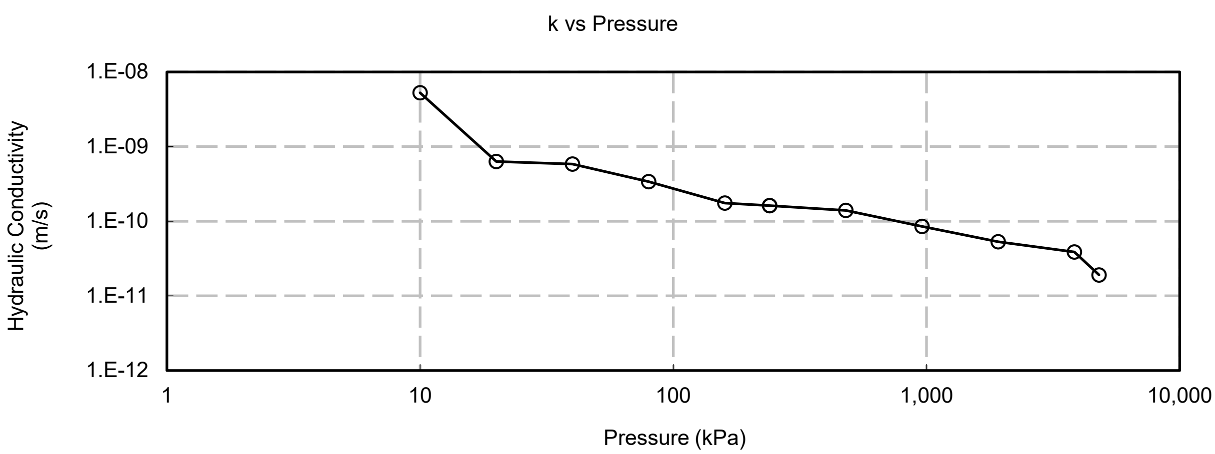
CONSOLIDATION TEST	FIGURES 2, 3 & 4

MTO Hwy 3 Talbotville Bypass

BH RMN-A2, ST1



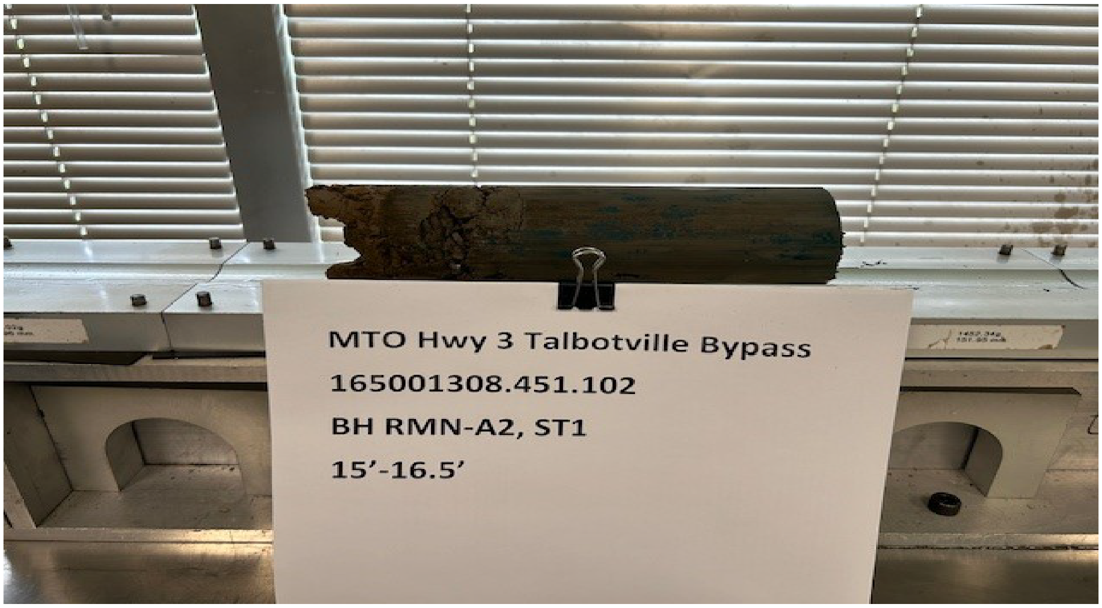




Project No. :	165001308.451.102	Stantec	Prepared By :	DB
Date :	24-Aug-24		Checked By :	RG

MTO Hwy 3 Talbotville Bypass

Overconsolidated Lean clay of low plasticity, hard, brown, moist, CL



BH RMN-A2, ST1

BH RMN-A2, ST1

CONSOLIDATION TEST SUMMARY

SAMPLE IDENTIFICATION

Borehole No. :	BH RMN UP2	Sample No. :	TW8
		Sample Depth (ft) :	17.5-19.5

TEST CONDITIONS

Test Type :	ASTM D2435/D2435M	Date Started :	12-Aug-24
Load Duration (hr) :	Method B	Date Completed :	14-Aug-24

SAMPLE DIMENSIONS AND PROPERTIES _ INITIAL

Sample Height (mm) :	20.50	Unit Weight (kN/m^3) :	20.91
Sample Diameter (mm) :	50.00	Dry Unit Weight (kN/m^3) :	17.76
Area (cm^2) :	19.63	Specific Gravity :	2.764
Volume (cm^3) :	40.25	Solid Height (mm) :	13.43
Water Content (%) :	17.74	Volume of Solids (cm^3) :	26.37
Wet Mass (g) :	85.83	Volume of Voids (cm^3) :	13.88
Dry Mass (g) :	72.90	Degree of Saturation (%) :	93.18

TEST COMPUTATIONS

Axial Stress (kPa)	Height (H) (mm)	Corrected Deformation (ΔH) (mm)	Axial Strain (ε_a) (%)	Void Ratio e	t_{90} (sec)	C_v (cm^2/s)	m_v (m^2/kN)	k (m/s)
0	20.5000	0.0000	0.00	0.526				
5	20.2699	0.2301	1.63	0.501	122.69	7.13E-03	3.26E-03	2.28E-08
10	20.1179	0.3821	2.27	0.491	155.31	5.53E-03	1.28E-03	6.97E-09
20	19.9500	0.5500	3.15	0.478	181.00	4.67E-03	8.72E-04	4.00E-09
40	19.7376	0.7624	4.22	0.462	378.22	2.19E-03	5.39E-04	1.16E-09
80	19.4821	1.0179	5.52	0.442	336.66	2.40E-03	3.24E-04	7.64E-10
160	19.1566	1.3434	6.96	0.420	476.74	1.65E-03	1.80E-04	2.91E-10
320	18.8677	1.6323	8.57	0.395	201.22	3.78E-03	1.00E-04	3.72E-10
160			8.46	0.397				
80			8.24	0.400				
160	18.7889	1.7111	8.38	0.398	134.55	5.57E-03	1.76E-05	9.62E-11
320	18.7222	1.7778	8.76	0.392	247.60	3.01E-03	2.38E-05	7.03E-11
640	18.4622	2.0378	10.26	0.370	345.62	2.11E-03	4.70E-05	9.73E-11
1280	18.0823	2.4177	12.07	0.342	332.50	2.11E-03	2.82E-05	5.85E-11
2560	17.7236	2.7764	13.92	0.314	198.73	3.40E-03	1.45E-05	4.82E-11
640			13.56	0.319				
160			12.74	0.332				
40			11.52	0.350				
10			10.48	0.366				
5			9.93	0.375				

SAMPLE DIMENSIONS AND PROPERTIES _ FINAL

Sample Height (mm) :	18.46	Unit Weight (kN/m^3) :	22.36
Sample Diameter (mm) :	50.00	Dry Unit Weight (kN/m^3) :	19.72
Area (cm^2) :	19.63	Specific Gravity :	2.764
Volume (cm^3) :	36.25	Solid Height (mm) :	13.43
Water Content (%) :	13.40	Volume of Solids (cm^3) :	26.37
Wet Mass (g) :	82.67	Volume of Voids (cm^3) :	9.88
Dry Mass (g) :	72.90		

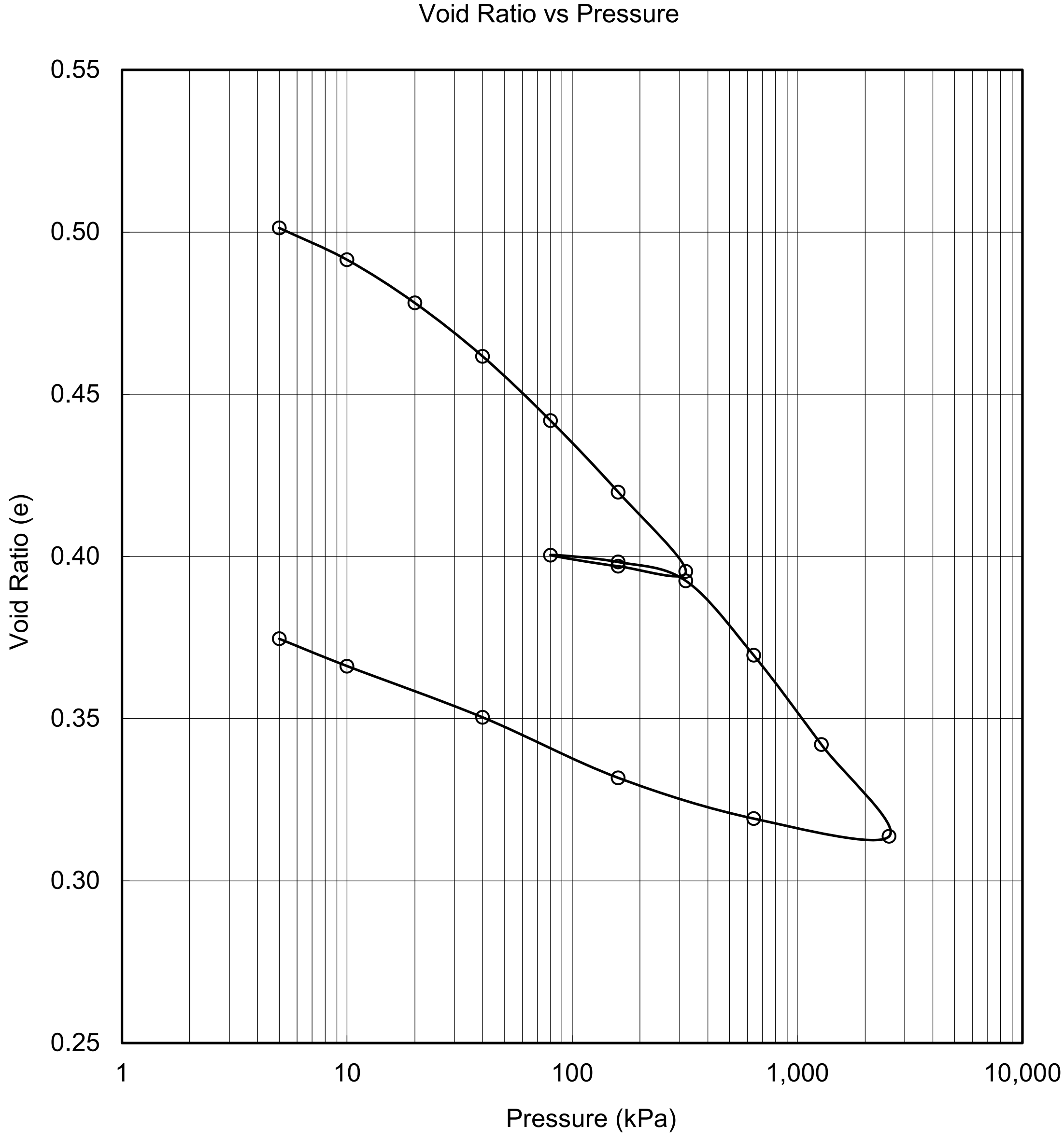
Project No. :	165001308.451.102	Prepared By :	DB
Date :	19-Aug-24	Checked By :	RG

Stantec

CONSOLIDATION TEST	**FIGURE 1**

MTO Hwy 3 Talbotville Bypass

BH RMN UP2, TW8



Soil Type : *Overconsolidated Lean clay of low plasticity , v. stiff to hard, brown, moist, -CL*

e_o =	0.526	w_L =	27.4%	σ_{v0}' =	kPa
w =	17.7%	w_P =	14.8%	σ_P' =	kPa
γ =	20.9 kN/m^3	PI =	12.6%		
Gs =	2.764				

Project No. : 165001308.451.102

Date : 19-Aug-24

Stantec

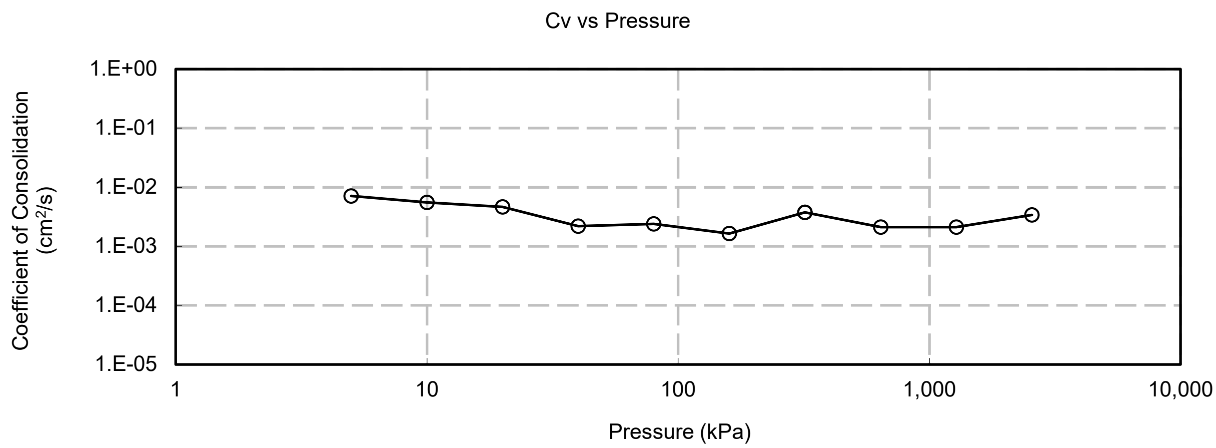
Prepared By : DB

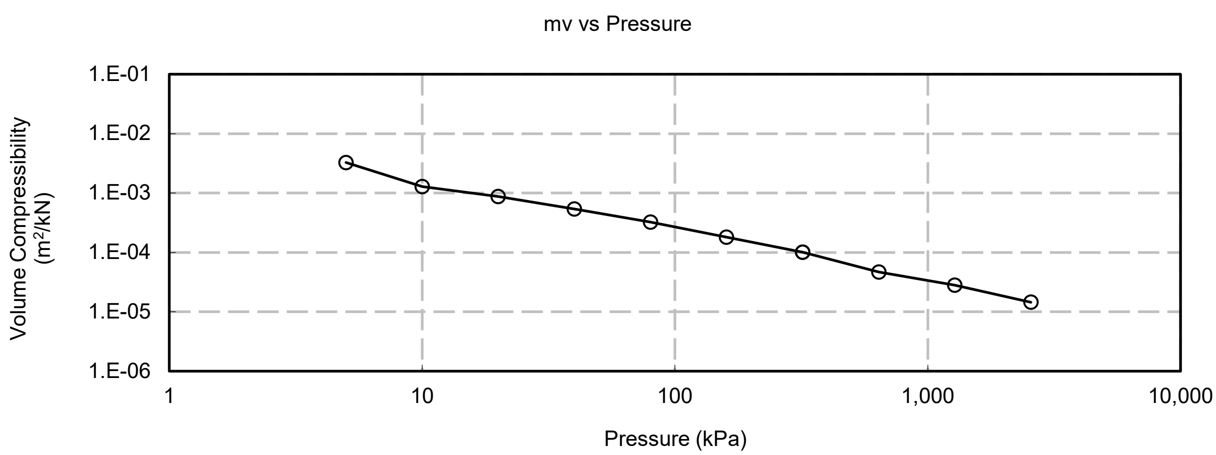
Checked By : RG

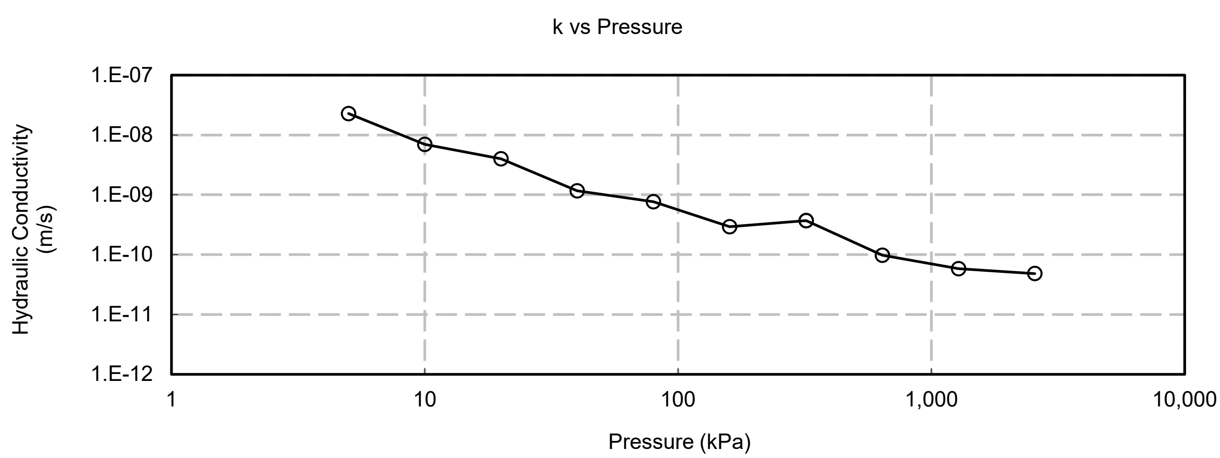
CONSOLIDATION TEST	FIGURES 2, 3 & 4

MTO Hwy 3 Talbotville Bypass

BH RMN UP2, ST1





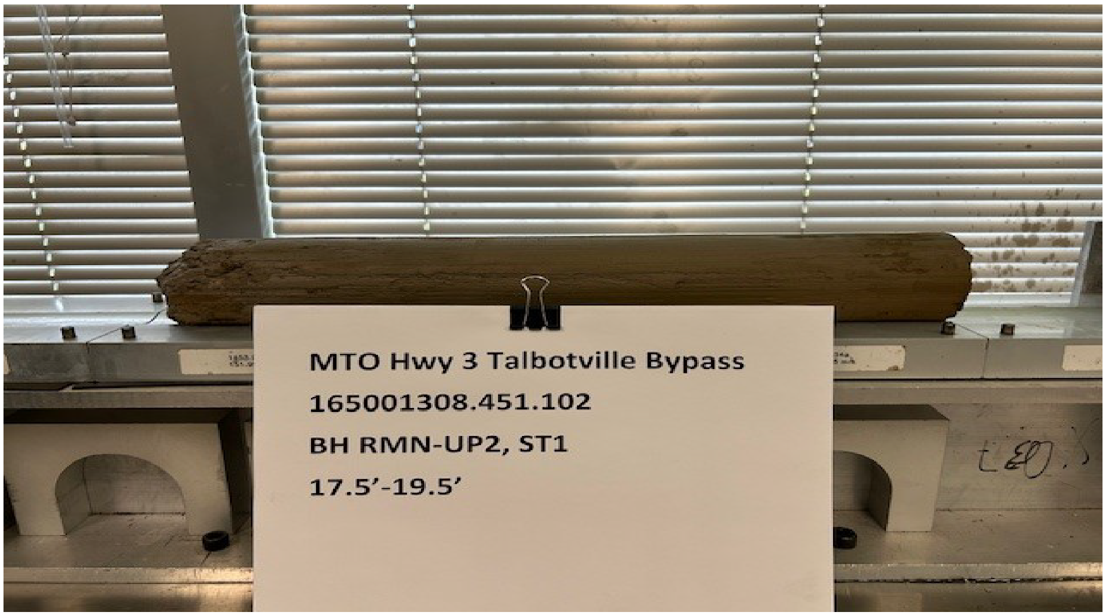


Project No. :	165001308.451.102	Stantec	Prepared By :	DB
Date :	19-Aug-24		Checked By :	RG

MTO Hwy 3 Talbotville Bypass	**PHOTOS 1 & 2**

MTO Hwy 3 Talbotville Bypass

Overconsolidated Lean clay of low plasticity , v. stiff to hard, brown, moist, -CL



BH RMN UP2, ST1

BH RMN UP2, ST1

Project No. :	165001308.451.102	Stantec	Prepared by :	DB
Date :	19-Aug-2024		Checked by :	RG

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
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FAX (403)735-2771
http://www.agatlabs.com

CLIENT NAME: STANTEC CONSULTING LTD
300-675 Cochrane Drive
MARKHAM, ON L3R0B8
(905) 444-7777

ATTENTION TO: Bahram Siavash

PROJECT: 165001308.551.102

AGAT WORK ORDER: 24T167277

ROCK ANALYSIS REVIEWED BY: Jewel Shibu, Lab Supervisor

SOIL ANALYSIS REVIEWED BY: Sukhwinder Randhawa, Inorganic Team Lead

DATE REPORTED: Jul 05, 2024

PAGES (INCLUDING COVER): 7

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (403) 735-2005

*Notes

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AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 24T167277
PROJECT: 165001308.551.102

CLIENT NAME: STANTEC CONSULTING LTD
SAMPLING SITE:

ATTENTION TO: Bahram Siavash
SAMPLED BY:

(284-137) Sulfide (CGY)

DATE RECEIVED: 2024-06-27

DATE REPORTED: 2024-07-05

			SAMPLE DESCRIPTION:	WR-UP3-SS7	RMN-UP3-SS8	CNR-OH1-SS8	CNR-OH2-SS5	CNR-OH3-SS4
			SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil
			DATE SAMPLED:	2024-06-26	2024-06-26	2024-06-26	2024-06-26	2024-06-26
Parameter	Unit	G / S	RDL	5964762	5964839	5964840	5964841	5964842
Sulfide	%		0.01	0.08	0.14	0.16	<0.01	<0.01

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
Analysis performed at AGAT Calgary (unless marked by *)

Certified By: Jewel Shibu

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AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 24T167277

PROJECT: 165001308.551.102

CLIENT NAME: STANTEC CONSULTING LTD

ATTENTION TO: Bahram Siavash

SAMPLING SITE:

SAMPLED BY:

Corrosivity Package

DATE RECEIVED: 2024-06-27

DATE REPORTED: 2024-07-05

Parameter	Unit	G / S	RDL					
			SAMPLE DESCRIPTION:	WR-UP3-SS7	RMN-UP3-SS8	CNR-OH1-SS8	CNR-OH2-SS5	CNR-OH3-SS4
			SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil
			DATE SAMPLED:	2024-06-26	2024-06-26	2024-06-26	2024-06-26	2024-06-26
				5964762	5964839	5964840	5964841	5964842
Chloride (2:1)	µg/g		2	127	7	6	15	16
Sulphate (2:1)	µg/g		2	154	174	194	206	185
pH (2:1)	pH Units		NA	8.33	8.38	8.48	8.30	8.35
Electrical Conductivity (2:1)	mS/cm		0.005	0.516	0.281	0.329	0.297	0.342
Resistivity (2:1) (Calculated)	ohm.cm		1	1940	3560	3040	3370	2920
Redox Potential 1	mV		NA	127	340	305	139	198
Redox Potential 2	mV		NA	120	339	278	137	199
Redox Potential 3	mV		NA	102	318	288	131	199

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

5964762-5964842 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.
Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.
Redox potential measurement in soil is quite variable and non reproducible due in part, to the general heterogeneity of a given soil. It is also related to the introduction of increased oxygen into the sample after extraction. The interpretation of soil redox potential should be considered in terms of its general range rather than as an absolute measurement.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO CHARTERED Sukhwinder Kaur Randhawa CHEMIST

AGAT Laboratories

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Quality Assurance

CLIENT NAME: STANTEC CONSULTING LTD | AGAT WORK ORDER: 24T167277
PROJECT: 165001308.551.102 | ATTENTION TO: Bahram Siavash
SAMPLING SITE: | SAMPLED BY:

Rock Analysis

RPT Date: Jul 05, 2024			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
(284-137) Sulfide (CGY)															
Total Sulfur	5964762	5964762	0.10	0.09	11.4%	< 0.01	108%	80%	120%						
Sulfate	5950778	5950778	0.04	0.04	0.6%	< 0.01	87%	80%	120%						

Comments: RPDs are calculated using raw analytical data and not the rounded duplicate values reported.
Duplicate/ Replicate NA: Results are less than 10X the RDL and RPD will not be calculated

PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Lower	Upper	Recovery	Lower	Upper	Recovery	Lower	Upper
(284-137) Sulfide (CGY)															
Sulfate	5964762	5964762	0.02	0.02	2%	< 0.01		80%	120%						

Comments: RPDs are calculated using raw analytical data and not the rounded duplicate values reported.
Duplicate/ Replicate NA: Results are less than 10X the RDL and RPD will not be calculated

Certified By: Jewel Shibu

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Quality Assurance

CLIENT NAME: STANTEC CONSULTING LTD
PROJECT: 165001308.551.102
SAMPLING SITE:

AGAT WORK ORDER: 24T167277
ATTENTION TO: Bahram Siavash
SAMPLED BY:

Soil Analysis

RPT Date: Jul 05, 2024			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
Corrosivity Package															
Chloride (2:1)	5961472		21	21	0.0%	< 2	101%	70%	130%	96%	80%	120%	95%	70%	130%
Sulphate (2:1)	5961472		77	77	0.0%	< 2	101%	70%	130%	96%	80%	120%	92%	70%	130%
pH (2:1)	5962742		7.86	7.56	3.9%	NA	97%	80%	120%						
Electrical Conductivity (2:1)	5962742		1.67	1.69	1.2%	< 0.005	103%	80%	120%						
Redox Potential 1	5964762					NA	100%	90%	110%						

Comments: NA signifies Not Applicable.
pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Lower	Upper	Recovery	Lower	Upper	Recovery	Lower	Upper
Corrosivity Package															
pH (2:1)	5964762	5964762	8.33	8.00	4.0%	NA	98%	80%	120%						
Electrical Conductivity (2:1)	5964762	5964762	0.516	0.509	1.4%	< 0.005	102%	80%	120%						

Comments: NA signifies Not Applicable.
pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Certified By:

AGAT Laboratories
2910 12TH STREET NE
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CANADA T2E 7P7
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Method Summary

CLIENT NAME: STANTEC CONSULTING LTD
PROJECT: 165001308.551.102
SAMPLING SITE:

AGAT WORK ORDER: 24T167277
ATTENTION TO: Bahram Siavash
SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	modified from EPA 9045D and MCKEAGUE 3.11	PH METER
Electrical Conductivity (2:1)	INOR-93-6075	modified from MSA PART 3, CH 14 and SM 2510 B	PC TITRATE
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION
Redox Potential 1	INOR-93-6066	G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 2	INOR-93-6066	ASTM G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 3	INOR-93-6066	ASTM G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE

5835 Coopers Avenue
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AGAT Laboratories

Chain of Custody Record

Ph.: 905.712.5100 · Fax: 905.712.5122 · Toll Free: 800.856.6261

Laboratory Use Only

Arrival Temperature: 20.4, 20.5, 21.0
AGAT WO #: 24T167277
Lab Temperature:
Notes: no ice, 1 box

Client Information:

Company: Stantec Consulting Ltd.
Contact: Bahram Siavash
Address: 300W-675 Cochran Drive West Tower
Markham, ON L3R 0B8
Phone: 905-479-9345 Fax: 905-474-9889
Project: 165001308.551.102 PO:
AGAT Quotation #:

Please note, if quotation number is not provided, client will be billed full price for analysis.

Regulatory Requirements:

☐ Regulation 153/09 (reg. 511 Amend.)
Table ______ Indicate one
☐ Ind/Com
☐ Res/Park
☐ Agriculture
Soil Texture (check one)
☐ Coarse ☐ Fine

☐ Sewer Use
Region ______ Indicate one
☐ Sanitary
☐ Storm

☐ Regulation 558
☐ CCME
☐ Other (specify)
☐ Prov. Water Quality Objectives (PWQO)
☐ None

Turnaround Time Required (TAT) Required*

Regular TAT
☑ 5 to 7 Working Days

Rush TAT (please provide prior notification)
Rush Surcharges Apply
☐ 3 Working Days
☐ 2 Working Days
☐ 1 Working Day

OR

Date Required (Rush surcharges may apply):

*TAT is exclusive of weekends and statutory holidays

Invoice To:

Same: Yes ☑ No ☐
Company:
Contact:
Address:

Is this a drinking water sample?
(potable water intended for human consumption)
☐ Yes ☐ No
If "Yes", please use the *Drinking Water Chain of Custody Form*

Is this submission for a **Record of Site Condition?**
☐ Yes ☐ No

Legend Matrix

GW Ground Water **O** Oil
SW Surface Water **P** Paint
SD Sediment **S** Soil

Report Information – reports to be sent to:

1. Name: Bahram Siavash
Email: Bahram.Siavash@stantec.com
2. Name: Kirby Lales
Email: kirby.lales@stantec.com

Sample Identification	Date Sampled	Time Sampled	Sample Matrix	# of Containers	Comments Site/Sample Information	Metals and Inorganics	Metal Scan	Hydride Forming Metals	Client Custom Metals	ORPs: ☐ B-HWS ☐ Cl- ☐ CN- ☐ EC ☐ FOC ☐ Cr+6 ☐ SAR ☐ NO_3/NO_2 ☐ N-Total ☐ Hg ☐ pH	Nutrients: ☐ TP ☐ NH_3 ☐ TKN ☐ NO_3 ☐ NO_2 ☐ NO_3/NO_2	VOC: ☐ VOC ☐ THM ☐ BTEX	CCME Fractions 1 to 4	ABNs	PAHs	Chlorophenols	PCBs	Organochlorine Pesticides	TCLP Metals/Inorganics	TCLP:	Sewer Use	Corrosivity Pckg (pH, Redox Potential	sulphates and sulphides contents,	chlorides contents and resistivity)					
WR-UP3 - SS7	26-6-2024			1	15'-17'																	X	X	X					
RMN-UP3 - SS8	26-6-2024			1	20'-22'																	X	X	X					
CNR-OH1 - SS8	26-6-2024			1	17.5'-19.5'																	X	X	X					
CNR-OH2 - SS5	26-6-2024			1	10'-12'																	X	X	X					
CNR - OH3 - SS4	26-6-2024			1	7.5'-9.5'																	X	X	X					

Samples Relinquished by (print name & sign): Date/Time:
Samples Received by (Print name & sign): [signature] Date/Time: Jun 27 11:15 AM
Samples Relinquished by (print name & sign): Date/Time:
Samples Received by (Print name & sign): Date/Time:

Pink Copy – Client
Yellow + Golden Copy – AGAT
White Copy – AGAT

Page ____ of ____
NO:

Date Issued: July 20, 2011

Document ID: DIV-78-1511.006

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CLIENT NAME: STANTEC CONSULTING LTD
300-675 Cochrane Drive
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(905) 444-7777

ATTENTION TO: Bahram Siavash

PROJECT: 165001308.551.102

AGAT WORK ORDER: 24T187247

ROCK ANALYSIS REVIEWED BY: Jewel Shibu, Lab Supervisor

SOIL ANALYSIS REVIEWED BY: Sukhwinder Randhawa, Inorganic Team Lead

DATE REPORTED: Aug 28, 2024

PAGES (INCLUDING COVER): 7

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (403) 735-2005

*Notes

Certificate of Analysis

AGAT WORK ORDER: 24T187247
PROJECT: 165001308.551.102

AGAT Laboratories
2910 12TH STREET NE
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CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
http://www.agatlabs.com

CLIENT NAME: STANTEC CONSULTING LTD
ATTENTION TO: Bahram Siavash
SAMPLING SITE:
SAMPLED BY:

(284-137) Sulfide (CGY)

DATE RECEIVED: 2024-08-20
DATE REPORTED: 2024-08-28

Parameter	Unit	G / S	RDL	CNR-OH4 - SS9	RMN-UP2 - SS7	RMN-UP1 - SS10
SAMPLE TYPE:				Soil	Soil	Soil
DATE SAMPLED:				2024-08-20	2024-08-20	2024-08-20
				6087931	6087963	6087966
Sulfide	%		0.01	0.09	0.14	0.13

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

6087931-6087966 Sulfide is a calculated parameter and is non-accredited. The parameters that are components of the calculation are accredited.

Analysis performed at AGAT Calgary (unless marked by *)

Certified By: Jewel Shibu

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Certificate of Analysis

AGAT WORK ORDER: 24T187247

PROJECT: 165001308.551.102

CLIENT NAME: STANTEC CONSULTING LTD

ATTENTION TO: Bahram Siavash

SAMPLING SITE:

SAMPLED BY:

Corrosivity Package

DATE RECEIVED: 2024-08-20

DATE REPORTED: 2024-08-28

			SAMPLE DESCRIPTION:	CNR-OH4 - SS9	RMN-UP2 - SS7	RMN-UP1 - SS10
			SAMPLE TYPE:	Soil	Soil	Soil
			DATE SAMPLED:	2024-08-20	2024-08-20	2024-08-20
Parameter	Unit	G / S	RDL	6087931	6087963	6087966
Chloride (2:1)	µg/g		2	10	5	6
Sulphate (2:1)	µg/g		2	277	318	272
pH (2:1)	pH Units		NA	8.68	8.46	8.79
Electrical Conductivity (2:1)	mS/cm		0.005	0.412	0.397	0.366
Resistivity (2:1) (Calculated)	ohm.cm		1	2430	2520	2730
Redox Potential 1	mV		NA	201	199	196
Redox Potential 2	mV		NA	186	205	216
Redox Potential 3	mV		NA	195	221	229

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

6087931-6087966 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.
Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.
Redox potential measurement in soil is quite variable and non reproducible due in part, to the general heterogeneity of a given soil. It is also related to the introduction of increased oxygen into the sample after extraction. The interpretation of soil redox potential should be considered in terms of its general range rather than as an absolute measurement.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

Results relate only to the items tested. Results apply to samples as received.

AGAT Laboratories

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
http://www.agatlabs.com

Quality Assurance

CLIENT NAME: STANTEC CONSULTING LTD
PROJECT: 165001308.551.102
SAMPLING SITE:

AGAT WORK ORDER: 24T187247
ATTENTION TO: Bahram Siavash
SAMPLED BY:

Rock Analysis

RPT Date: Aug 28, 2024			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
(284-137) Sulfide (CGY)															
Total Sulfur	6087931	6087931	0.11	0.13	16.8%	< 0.01	105%	80%	120%						
Sulfate	6074983	6074983	<0.01	<0.01	NA	< 0.01	99%	80%	120%						

Comments: RPDs are calculated using raw analytical data and not the rounded duplicate values reported.
Duplicate/ Replicate NA: Results are less than 10X the RDL and RPD will not be calculated

(284-137) Sulfide (CGY)									
Sulfate	6087931	6087931	0.02	0.02	0.2%	< 0.01		80%	120%

Comments: RPDs are calculated using raw analytical data and not the rounded duplicate values reported.
Duplicate/ Replicate NA: Results are less than 10X the RDL and RPD will not be calculated

Certified By: Jewel Shibu

AGAT Laboratories

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Quality Assurance

CLIENT NAME: STANTEC CONSULTING LTD
PROJECT: 165001308.551.102
SAMPLING SITE:

AGAT WORK ORDER: 24T187247
ATTENTION TO: Bahram Siavash
SAMPLED BY:

Soil Analysis

RPT Date: Aug 28, 2024			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
Corrosivity Package															
Chloride (2:1)	6089108		40	40	0.0%	< 2	94%	70%	130%	98%	80%	120%	95%	70%	130%
Sulphate (2:1)	6089108		171	172	0.6%	< 2	98%	70%	130%	101%	80%	120%	100%	70%	130%
pH (2:1)	6089108		8.52	8.34	2.1%	NA	96%	80%	120%						
Electrical Conductivity (2:1)	6089108		0.353	0.364	3.1%	< 0.005	102%	80%	120%						
Redox Potential 1	6087931					NA	100%	90%	110%						

Comments: NA signifies Not Applicable.
pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Certified By:

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Method Summary

CLIENT NAME: STANTEC CONSULTING LTD
AGAT WORK ORDER: 24T187247
PROJECT: 165001308.551.102
ATTENTION TO: Bahram Siavash
SAMPLING SITE:
SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	modified from EPA 9045D and MCKEAGUE 3.11	PH METER
Electrical Conductivity (2:1)	INOR-93-6075	modified from MSA PART 3, CH 14 and SM 2510 B	PC TITRATE
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION
Redox Potential 1	INOR-93-6066	G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 2	INOR-93-6066	ASTM G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 3	INOR-93-6066	ASTM G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE

AGAT Laboratories

5835 Coopers Avenue
Mississauga, Ontario
L4Z 1Y2
www.agatlabs.com · webearth.agatlabs.com

Chain of Custody Record

Ph.: 905.712.5100 · Fax: 905.712.5122 · Toll Free: 800.856.6261

Laboratory Use Only

Arrival Temperature: 21-2, 21-4, 21-7
AGAT WO #: 24T187247
Lab Temperature:
Notes: 1 box, no ice

Client Information:

Company: Stantec Consulting Ltd.
Contact: Bahram Siavash
Address: 300W-675 Cochran Drive West Tower
Markham, ON L3R 0B8
Phone: 905-479-9345 Fax: 905-474-9889
Project: 165001308.551.102 PO:
AGAT Quotation #:

Please note, if quotation number is not provided, client will be billed full price for analysis.

Regulatory Requirements:

☐ Regulation 153/09 (reg. 511 Amend.)
Table ______ *Indicate one*
☐ Ind/Com
☐ Res/Park
☐ Agriculture
Soil Texture *(check one)*
☐ Coarse ☐ Fine

☐ Sewer Use
Region ______ *Indicate one*
☐ Sanitary
☐ Storm

☐ Regulation 558
☐ CCME
☐ Other *(specify)*
☐ Prov. Water Quality Objectives (PWQO)
☐ None

Turnaround Time Required (TAT) Required*

Regular TAT
☑ 5 to 7 Working Days

Rush TAT (please provide prior notification)
Rush Surcharges Apply
☐ 3 Working Days
☐ 2 Working Days
☐ 1 Working Day

OR

Date Required (Rush surcharges may apply):

**TAT is exclusive of weekends and statutory holidays*

Invoice To: Same: Yes ☑ No ☐
Company:
Contact:
Address:

Is this a drinking water sample?
(potable water intended for human consumption)
☐ Yes ☐ No
If "Yes", please use the *Drinking Water Chain of Custody Form*

Is this submission for a **Record of Site Condition?**
☐ Yes ☐ No

Legend Matrix
GW Ground Water **O** Oil
SW Surface Water **P** Paint
SD Sediment **S** Soil

Report Information – reports to be sent to:
1. Name: Kirby Lales
Email: Kirby.Lales@Stantec.com
2. Name: Maged Abdel Mesih
Email: Maged.Abdel-Mesih@stantec.com

Sample Identification	Date Sampled	Time Sampled	Sample Matrix	# of Containers	Comments Site/Sample Information	Metals and Inorganics	Metal Scan	Hydride Forming Metals	Client Custom Metals	ORPs: ☐ B-HWS ☐ Cl- ☐ CN- ☐ EC ☐ Cr+6 ☐ SAR ☐ FOC ☐ Hg ☐ pH ☐ NO_3/NO_2 ☐ N-Total	Nutrients: ☐ TP ☐ NH_3 ☐ TKN ☐ NO_3 ☐ NO_2 ☐ NO_3/NO_2	VOC: ☐ VOC ☐ THM ☐ BTEX	CCME Fractions 1 to 4	ABNs	PAHs	Chlorophenols	PCBs	Organochlorine Pesticides	TCLP Metals/Inorganics	TCLP:	Sewer Use	Corrosivity Pckg (pH, Redox Potential	sulphates and sulphides contents,	chlorides contents and resistivity)
CNR-OH4 - SS9	2024-08-20			1	20'-22'																	X	X	X
RMN-UP2 - SS7	2024-08-20			1	15'-17'																	X	X	X
RMN-UP1 - SS10	2024-08-20			1	25'-27'																	X	X	X

Samples Relinquished by (print name & sign):	Date/Time	Samples Received by (Print name & sign):	Date/Time	Pink Copy – Client	Page ____ of ____
		[signature]	Aug 20 9:45 PM		
Samples Relinquished by (print name & sign):	Date/Time	Samples Received by (Print name & sign):	Date/Time	Yellow + Golden Copy – AGAT White Copy – AGAT	NO:

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