Geotechnical Data Report – Revision 1

Proposed PCA Artifact Storage Facility
at 555 Avenue des Entreprises,
Gatineau, QC

Prepared for:
Public Works and Government Services Canada
340 rue Albert Street, Ottawa, ON K1A 0S5

Prepared by:
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Project No. 121622309
R.089317.001

December 2019

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1.0 INTRODUCTION

Public Works and Government Services Canada (PWGSC) has retained Stantec Consulting Ltd. (Stantec) to provide geotechnical services including a geotechnical investigation and recommendations for the proposed PCA Artifact Storage Facility located at 555 Avenue des Entreprises in Gatineau, QC. This geotechnical data report (GDR) presents the results of a geotechnical investigation.

The work was carried out in general accordance with the scope of work for a geotechnical investigation as outlined in Stantec's proposal 671177 dated August 21, 2018, and Scope Change dated October 3, 2018.

This report has been prepared specifically and solely for the project described herein. It presents the factual results of the investigation and provides geotechnical recommendations for the design and construction of the proposed building.

Limitations associated with this report and its contents are provided in the statement of general conditions included in Appendix A.

2.0 SITE DESCRIPTION AND BACKGROUND

It is understood that the proposed building will have an overall gross area of approximately 6,500 m^2 to 10,000 m^2 with either one or two storeys above grade and up to one level below grade. The building will include a loading dock and a paved parking lot with up to 25 spaces. It is understood that the footprint and dimensions of the building have yet to be finalized.

The location of the site is shown on Drawing No. 1 in Appendix B.

The site is currently a paved parking lot, North of the site is a building with a footprint of approximately 13,700 m^2.

Two previous investigations were completed at the site by John D. Patterson and Associates and by Stantec. The previously completed investigations encountered a deep deposit of high plasticity clay extending to a depth of 23 m to greater than 30 m below ground surface.

The 2009 geotechnical investigation by Stantec included one borehole, five (SCPTu) Seismic Cone Penetration Tests and four test pits. The subsurface conditions included fill over a deposit of high plasticity clay. The undrained shear strengths of the clay ranged from 21 kPa to 98 kPa. The measured Atterberg limits of the clay material indicated a liquid limit between 54 and 74 and a plastic limit between 26 and 27, indicating a clay of high plasticity (CH). The measured moisture contents in the clay material ranged between 36% and 79% for the tested samples. A compact sandy silt till was encountered below the clay at a depth of 23.5 m at the location of the sampled borehole. The SCPTu results indicated that the inferred till was encountered at depths ranging from 17.5 m to greater than 30 m.

Based on geological mapping, the bedrock in the area consists of Precambrian Migmatic rock or Paragneiss. The depth to overburden is anticipated to range from 15 m to 50 m. It is anticipated that the depth to bedrock will be variable across the site. Based on the 2009 investigation, it was estimated that the groundwater level was at an elevation of approximately 101.8 m.

As part of the 2009 investigation, the compressibility of the clay was assessed by carrying out two consolidation tests whose results are summarized below.

Table 2.1: 2009 Consolidation Test Results

Sample	Depth (m)	Sample Elevation (m)	Moisture Content	Overburden Pressure P'_o	Preconsolidation Pressure P'_c	Recompression Index C_r	Compression Index C_c
09-1 ST8	7.8	94.4	72%	58 kPa	110 kPa	0.02	0.74
09-1 ST11	15.2	87.0	50%	106 kPa	150 kPa	0.02	1.24

Based on the above information, the high plasticity clays were found to be soft to stiff with overconsolidation ratio (OCR) values of 1.9 and 1.4 at the depths tested.

3.0 SCOPE OF WORK

The scope of work for this preliminary geotechnical investigation included the following:

- Advance four (4) sampled boreholes throughout the site, two boreholes will be advanced to 12 m and DCPT to refusal and two boreholes will extend through the full thickness of the clay until bedrock is encountered (assumed depth of 35 m). Core bedrock at two locations.
- Advance three (3) Seismic Cone Penetration Tests (SCPTu), one to 35 m and two to 12 m below grade.
- Perform Standard Penetration Tests (SPT) while collecting soil samples at regular intervals within boreholes.
- Collect Shelby tube samples within the clay at selected locations.
- Perform field vane and/or Nilcon vane tests to measure the undrained shear strength and the remoulded shear strength.
- Install one (1) vibrating wire piezometer with a vibrating wire datalogger to measure the groundwater table at the site continuously.
- Install two (2) standpipes at the site for groundwater measurements.
- Characterize the soil and rock with laboratory tests.
- Survey the ground surface elevations at the borehole location using a Trimble GPS unit.
- Prepare a Geotechnical Data Report (GDR) with the results of the geotechnical investigation and a Geotechnical Design Memorandum (GDM) with the design and construction recommendations.

4.0 METHOD OF INVESTIGATION

4.1 GEOTECHNICAL FIELD INVESTIGATION

As a component of our standard procedures and due diligence, Stantec contacted the public utility authorities to clear the locations of both private and public underground utilities.

The field drilling program was carried out from November 6, 2018, to November 12, 2018, and consisted of four boreholes and three CPT holes. SCPTu testing was carried out in general accordance with the American Society for Testing and Materials (ASTM) Methods ASTM D5778-07 Standard Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils. The borehole locations are shown on Drawing No. 2 in Appendix B.

The boreholes were advanced using a truck mounted CME drill rig. The subsurface stratigraphy encountered in each borehole was recorded in the field by experienced Stantec personnel while performing Standard Penetration Tests (SPT) at regular intervals and collecting soil samples. The undrained shear strength of cohesive soil was

determined by conducting in-situ shear vane tests at regular intervals. At the location of CPT18-2, a Nilcon vane was advanced measuring the undrained shear strength at 1 m intervals to a depth of 14.8 m. Dynamic cone penetration tests (DCPT) were performed in boreholes BH18-2 and BH18-4. Six Shelby tube samples were also retrieved in boreholes BH18-1 and BH18-3. Bedrock was cored using NQ size coring equipment in borehole BH18-1. The depth to refusal on inferred bedrock ranged from 19.5 in BH18-1 m to greater than 47.6 m below ground surface in BH18-2.

Table 4.1: Summary of Field Investigation

Borehole	SPT Completed	CPT Completed	Bedrock Coring	Installation
BH18-1	Yes	No	Yes	Standpipe
BH18-2	Yes	No	No	Vibrating Wire Piezometer
BH18-3	Yes	No	Yes*	-
BH18-4	Yes	No	No	Standpipe
CPT18-1	No	Yes	No	-
CPT18-2	No	Yes	No	-
CPT18-3	No	Yes	No	-

*Coring was completed in borehole BH18-3. It was determined that the rock being cored was a layer of cobbles and boulders and not bedrock

The boreholes and CPT holes were backfilled with the augered material. One vibrating wire piezometer was installed in BH18-2 and standpipes were installed within BH18-1 and BH18-4. The standpipes each consisted of a 50 mm diameter rigid pipe with 1.5 m screen at the bottom. The standpipes were backfilled with silica sand, sealed with bentonite and covered with a flushmount well cap. One vibrating wire piezometer with an electronic datalogger was installed in borehole BH18-2. The vibrating wire piezometer was installed to a depth of 12.1 m below ground surface, the calibration sheets are provided in Appendix C. The datalogger was programmed to automatically record the water level every hour. The water level data will be downloaded three times during the year.

All recovered soil samples, Shelby tubes and rock cores were stored and transported to either the Stantec Laval laboratory or Ottawa laboratory for detailed geotechnical classification and testing.

4.2 SURVEYING

The ground surface elevation at each borehole was surveyed using a Trimble GPS unit with decimeter accuracy. Accuracy may be affected by satellite coverage at the time of survey. Geodetic elevations at the borehole locations are shown in the table below and on the Borehole Records in Appendix C.

Table 4.2: Summary of Survey Results

Borehole	Elevation (m)	Northing	Easting
BH18-1	101.83	5040042.708	449066.872
BH18-2	101.92	5040067.459	449114.155
BH18-3	101.69	5040096.493	449154.298
BH18-4	101.80	5040056.266	449157.804
CPT18-1	101.70	5040079.173	449062.793
CPT18-2	101.62	5040096.618	449109.742
CPT18-3	102.10	5040033.975	449110.209

Survey results are displayed in UTM zone 18T (NAD 83)

4.3 LABORATORY TESTING

All samples returned to the laboratory were subjected to detailed visual examination and classification by a geotechnical engineer. Moisture content determination was undertaken on all recovered samples. Grain size analyses and Atterberg Limit determination were conducted on select samples. Three Shelby tube samples were submitted for consolidation testing and unconfined compressive strength testing. Selected rock core samples were tested for intact rock core strength. Four soil samples were submitted to Paracel Laboratories Ltd. to measure pH, resistivity, chlorides and sulphate content.

The results of the laboratory tests are discussed in the text of this report and are provided on the Borehole Records in Appendix C and the figures included in Appendix D.

Soil samples will be stored for six (6) months after the issuance of the final report unless directed by the client.

5.0 RESULTS OF INVESTIGATION

The location of the site is shown on Drawing No. 1 in Appendix B. At the time of the investigation, the site for the proposed building was a paved parking lot.

5.1 SUBSURFACE INFORMATION

In general, the subsurface profile at this site consisted of asphalt over fill over a deposit of clay underlain by a thin layer of till followed by cobbles and boulders over bedrock. The depth to inferred bedrock was variable throughout the site with the depth to bedrock generally decreasing towards the western limit of the site.

5.1.1 Surficial Material

Asphalt was encountered at ground surface in all boreholes, the thickness of asphalt ranged from 75 mm to 150 mm.

5.1.2 Fill

Fill was encountered beneath the asphalt in all boreholes. The thickness of the fill ranged from 0.6 m (bottom elevation 101.2 m) to 0.7 m (bottom elevation 101.0 m).

Standard Penetration Test ‘N’ values for the fill material ranged from 7 to 20 indicating a loose to compact state. The fill material was described as well-graded sand with silt and gravel (SW-SM).

The moisture content of this material ranged from 4% to 7%. One representative sample of this material was submitted for grain size analysis testing, the lab testing yielded the following results:

- Gravel: 39%
- Sand: 50%
- Silt: 8%
- Clay: 3%

According to the Unified Soil Classification System (USCS), this material can be classified as well-graded sand with silt and gravel (SW-SM). The gradation results are presented in Figure No. 1 in Appendix D.

5.1.3 Clay

Clay was encountered beneath the fill in all boreholes. The clay thickness ranged from 17.5 m (BH18-1) to 42.1 m (BH18-3). The clay is a marine clay from the Champlain Sea.

The undrained shear strength measured with the field vane ranged from 33 kPa to 110 kPa, indicating a firm to very stiff consistency. The field vane remoulded shear strengths ranged from 0 kPa to 35 kPa. The undrained shear strength measured by the nilcon vane ranged from 41 kPa to 152 kPa, indicating a firm to very stiff consistency. The nilcon remoulded shear strengths ranged from 1 kPa to 22 kPa.

The undrained shear strength profiles presented in Appendix C and developed based on the results of the static cone penetration tests in CPT 18-1, 18-2 and 18-3 suggests the undrained shear strength within the upper 2 m (elevation 98 m to 100 m) typically ranged from 100 kPa to 175 kPa, this upper zone is typically referred to as the clay crust. Below the clay crust, the undrained shear strength ranged from 10 kPa to 50 kPa in CPT18-1, 25 kPa to 100 kPa in CPT18-2 and 30 kPa to 125 kPa in CPT18-3.

Dynamic cone penetration tests (DCPT) were performed in boreholes BH18-2 and BH18-4, the blow counts ranged from 0 to 79 in BH18-2 and 0 to 18 in BH18-4.

Profiles of sensitivity versus depth estimated based on the results of CPT18-1, 18-2 and 18-3 and the field vane values are presented in Appendix C. This profile suggests that the sensitivity ranged from 3 to approximately 20 and would be classified as medium sensitivity to quick clay in accordance with the Canadian Foundation Engineering Manual.

The moisture content of this material ranged from 9% to 76%. Fifteen representative samples of clay were submitted for grain size analysis testing, nineteen samples were submitted for Atterberg Limit testing and three Shelby Tube samples were submitted for consolidation testing. The lab testing yielded the following results:

- Gravel: 0-2%
- Sand: 0-15%
- Silt: 22–39%
- Clay: 57–78%
- Liquid Limit: 29-76
- Plastic Limit: 16-27
- Plasticity Index: 13-49
- Liquidity Index: 0.2-2.2

Table 5.1: Laboratory Results on Clay

Sample Nº	Average Depth (m)	Average Elevation (m)	Moisture Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Classification (USCS)
BH18-1 SS-4	2.6	99.2	52.6	64	27	37	0.7	CH
BH18-1 SS-6	6.4	95.4	65.2	76	27	49	0.8	CH
BH18-1 SS-8	9.1	92.7	63.7	64	26	38	1.0	CH

Sample Nº	Average Depth (m)	Average Elevation (m)	Moisture Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Classification (USCS)
BH18-2 SS-2	1.1	100.8	34.5	63	26	37	0.2	CH
BH18-2 SS-4	3.4	98.5	48.4	62	27	35	0.6	CH
BH18-2 SS-6	6.4	95.5	48.4	58	27	31	0.7	CH
BH18-2 SS-9	11.0	90.9	72.8	57	27	30	1.5	CH
BH18-3 SS-3	1.8	99.9	48.6	66	26	40	0.6	CH
BH 18-3 ST-1	5.5	96.2	52.3	55	24	31	0.9	CH
BH18-3 SS-7	7.9	93.8	73.2	63	26	37	1.3	CH
BH 18-3 ST-2	11.3	90.4	76.4	48	25	23	2.2	CL
BH18-3 SS-10	14.0	87.7	59.4	47	26	21	1.6	CL
BH 18-3 ST-3	15.5	86.2	70.8	49	26	23	1.9	CL
BH18-3 SS-14	27.7	74.0	62.1	52	25	27	1.4	CH
BH18-3 SS-18	42.4	59.3	36.8	29	16	13	1.6	CL
BH18-4 SS-2B	1.1	100.7	33.5	54	24	30	0.3	CH
BH18-4 SS-5	4.9	96.9	47.9	58	26	32	0.7	CH
BH18-4 SS-7	7.9	93.9	49.6	55	26	29	0.8	CH
BH18-4 SS-9	11.0	90.8	72.3	57	26	31	1.5	CH

Notes: Where Liquidity Index values range between 1.0 and 1.4, the clays are very sensitive; where they exceed 1.4, they are quick and behave as a liquid when remoulded. Where IL exceeds 1.2, the clays are considered prone to large retrogressive failures if they form part of a tall slope.

According to the Unified Soil Classification System (USCS), this material can be classified as clay of high plasticity (CH) and silty clay (CL). The gradation results and Atterberg Limits are presented in Figures 2 and 3 in Appendix D.

The results of the consolidation tests carried out on three clay samples is summarized below.

Table 5.2: Summary of Consolidation Test Results

Sample Location	BH18-3 ST1	BH18-3 ST2	BH18-3 ST3
Sample Depth (m)	5.2 – 5.8	11.0 – 11.6	15.2 – 15.8
Moisture Content (%)	52	76	71
P'_o (kPa) Effective Overburden Pressure	47	83	109
P_c' (kPa) Pre-consolidation Pressure	145	135	155
Overconsolidation Ratio (OCR)	2.4	1.3	1.3
C_c; Compression Index	0.591	2.03	1.71
C_r; Recompression Index	0.028	0.022	0.021
e_o; Void Ratio	0.849	1.287	1.259
Specific Gravity, G	2.78	2.78	2.78
Unit Weight (kN/m^3)	16.8	15.0	15.4

5.1.4 Till

Glacial till was encountered beneath the clay and a 0.5 m thick layer of cobbles and boulders in borehole BH18-1. The till consisted of brown silty sand with gravel. The thickness of the till was 0.6 m. The moisture content of this material was 12%.

The Standard Penetration Test 'N' value for the till material was 18 indicating a compact state. The till material was described as silty sand with gravel (SM).

The glacial till of the Ottawa-Gatineau area is usually crowded with cobbles and boulders set in a matrix of finer-grained material (gravel, sand, silt and clay); large boulders in excess of 1.0 m are common. It is unsorted and without stratification, but in places contains discontinuous layers or irregular shaped masses of sand and silt. Where glacial till deposits are identified, cobbles and boulders are present and permeable layers of sand and silt may randomly be present; due to the unsorted and unstratified nature of the glacial till, it is possible to advance boreholes while encountering only matrix material.

5.1.5 Cobbles and Boulders

Refusal was encountered at a depth of 17.8 m (elevation 84.0 m) and again at 18.9 m (elevation 82.9 m) in borehole BH18-1 and a depth of 42.9 m (elevation 58.8 m) in borehole BH18-3. Rock was cored using NQ size coring equipment, the thickness of the layer of cobbles and boulders in BH18-1 was 0.5 m followed by a 0.6 m layer of till and another 0.6 m of cobbles and boulders, the thickness of the layer in BH18-3 was 1.8 m, the rock was determined to be a layer of cobbles and boulders.

The rock type identified from the cobbles and boulders was granite and gneiss.

The Rock Core Recovery (REC) values ranged from 18% to 42%.

5.1.6 Bedrock

Bedrock was encountered at a depth of 19.5 m (elevation 82.2 m) in borehole BH18-1 with corresponding elevation 81.1 m. Bedrock was not encountered within the three remaining boreholes (BH18-2, 18-3 and 18-4), borehole depths varied from 41.6 m (elevation 60.2 m) to 47.6 m (elevation 54.4 m). Rock was cored in BH18-3 from a depth

of 42.9 m to 44.7 m, the cored rock was determined to be boulders, it is expected that bedrock was beneath the layer of boulders similar to BH18-1.

The depth to bedrock is variable across the site, Drawing No. 3 in Appendix B provides a subsurface profile using the available information.

CPT refusal was encountered within the till in CPT18-3, the refusal elevations are not considered good indications of the anticipated bedrock elevations.

The bedrock encountered consisted of grey gneiss. The bedrock was described as fresh to slightly weathered, the Rock Quality Designation (RQD) values ranged from 80% to 91% indicating a good to excellent rock quality.

Four samples of rock core were submitted for unconfined compressive strength testing. The unconfined compressive strength of the rock ranged from 99.4 MPa to 145.6 MPa indicating a very strong intact rock strength. The results are summarized in Table 5.3.

Table 5.3: Unconfined Compressive Strength of Rock Cores

Borehole	Depth (m)	Unconfined Compressive Strength (MPa)
BH18-1	19.8 – 19.9	125.1
BH18-1	20.4 – 20.5	99.4
BH18-1	20.7 – 20.8	145.6
BH18-1	21.0 – 21.1	107.0

5.2 GROUNDWATER

A site visit was carried out June 7, 2019 and June 13, 2019 to measure the water levels in the standpipes, the results are presented below.

Table 5.4: Standpipe Water Level Readings

Borehole	Borehole Elevation (m)	Depth to Water Level (m)	Water Level Elevation (m)	Water Level Reading Date
BH18-1	101.8	8.8 – 9.1	93.0	June 7 & 13, 2019
BH18-4	101.8	2.2	99.6	June 7 &13, 2019

One electronic datalogger was installed with the vibrating wire piezometer in borehole BH18-2, the datalogger was programmed to automatically record the water level every hour. The vibrating wire piezometer was installed to an approximate depth of 12.1 m below ground surface (within the clay deposit). A summary of the groundwater levels is presented in the table below.

Table 5.5: Groundwater Level Results Summary – November 11, 2018 to January 29, 2019

Borehole	Ground Surface Elevation (m)	Maximum Groundwater Elevation (m)	Minimum Groundwater Elevation (m)	Average Groundwater Elevation (m)	Average Groundwater Depth (m)
BH18-2	101.9	99.5	98.7	99.2	2.7

5.3 SHEAR WAVE VELOCITY

In 2009, shear wave velocity was measured from elevation 100.0 m to 78.1 m, the shear wave velocity values ranged from 34 m/s to 354 m/s. Shear wave velocity profiles are presented in Appendix E.

5.4 CEMENT TYPE AND CORROSION POTENTIAL

Four representative soil samples were submitted to Paracel Laboratories Limited in Ottawa, Ontario for resistivity, pH, sulphate and chloride testing. The results of the testing are as follows:

Table 5.6: Results of Chemical Analysis

Borehole	Sample	Depth (m)	pH	Sulphate (µg/g)	Chloride (µg/g)	Resistivity (Ohm-m)
BH18-1	SS-3	1.5 – 2.1	7.77	145	104	22.9
BH18-2	SS-1B	0.2 – 0.8	7.98	176	5	36.7
BH18-3	SS-3	1.5 – 2.1	7.77	73	13	44.1
BH18-4	SS-2B	0.8 – 1.4	7.61	140	8	47.1

6.0 CLOSURE

Use of this report is subject to the Statement of General Conditions provided in Appendix A. It is the responsibility of Public Works and Government Services Canada, who is identified as "the Client" within the Statement of General Conditions, and its agents to review the conditions and to notify Stantec Consulting Ltd. should any of these not be satisfied. The Statement of General Conditions addresses the following:

- Use of the report
- Basis of the report
- Standard of care
- Interpretation of site conditions
- Varying of unexpected site conditions
- Planning, design or construction

This report has been prepared by Katurah Firdawsi and reviewed by Chris McGrath and Raymond Haché.

Respectfully submitted,

STANTEC CONSULTING LTD.

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APPENDIX A

Statement of General Conditions

STATEMENT OF GENERAL CONDITIONS

USE OF THIS REPORT: This report has been prepared for the sole benefit of the Client or its agent and may not be used by any third party without the express written consent of Stantec Consulting Ltd. and the Client. Any use which a third party makes of this report is the responsibility of such third party.

BASIS OF THE REPORT: The information, opinions, and/or recommendations made in this report are in accordance with Stantec Consulting Ltd.'s present understanding of the site specific project as described by the Client. The applicability of these is restricted to the site conditions encountered at the time of the investigation or study. If the proposed site specific project differs or is modified from what is described in this report or if the site conditions are altered, this report is no longer valid unless Stantec Consulting Ltd. is requested by the Client to review and revise the report to reflect the differing or modified project specifics and/or the altered site conditions.

STANDARD OF CARE: Preparation of this report, and all associated work, was carried out in accordance with the normally accepted standard of care in the state or province of execution for the specific professional service provided to the Client. No other warranty is made.

INTERPRETATION OF SITE CONDITIONS: Soil, rock, or other material descriptions, and statements regarding their condition, made in this report are based on site conditions encountered by Stantec Consulting Ltd. at the time of the work and at the specific testing and/or sampling locations. Classifications and statements of condition have been made in accordance with normally accepted practices which are judgmental in nature; no specific description should be considered exact, but rather reflective of the anticipated material behavior. Extrapolation of in situ conditions can only be made to some limited extent beyond the sampling or test points. The extent depends on variability of the soil, rock and groundwater conditions as influenced by geological processes, construction activity, and site use.

VARYING OR UNEXPECTED CONDITIONS: Should any site or subsurface conditions be encountered that are different from those described in this report or encountered at the test locations, Stantec Consulting Ltd. must be notified immediately to assess if the varying or unexpected conditions are substantial and if reassessments of the report conclusions or recommendations are required. Stantec Consulting Ltd. will not be responsible to any party for damages incurred as a result of failing to notify Stantec Consulting Ltd. that differing site or sub-surface conditions are present upon becoming aware of such conditions.

PLANNING, DESIGN, OR CONSTRUCTION: Development or design plans and specifications should be reviewed by Stantec Consulting Ltd., sufficiently ahead of initiating the next project stage (property acquisition, tender, construction, etc), to confirm that this report completely addresses the elaborated project specifics and that the contents of this report have been properly interpreted. Specialty quality assurance services (field observations and testing) during construction are a necessary part of the evaluation of sub-subsurface conditions and site preparation works. Site work relating to the recommendations included in this report should only be carried out in the presence of a qualified geotechnical engineer; Stantec Consulting Ltd. cannot be responsible for site work carried out without being present.

APPENDIX B

Key Plan

Borehole Location Plan

Subsurface Profile

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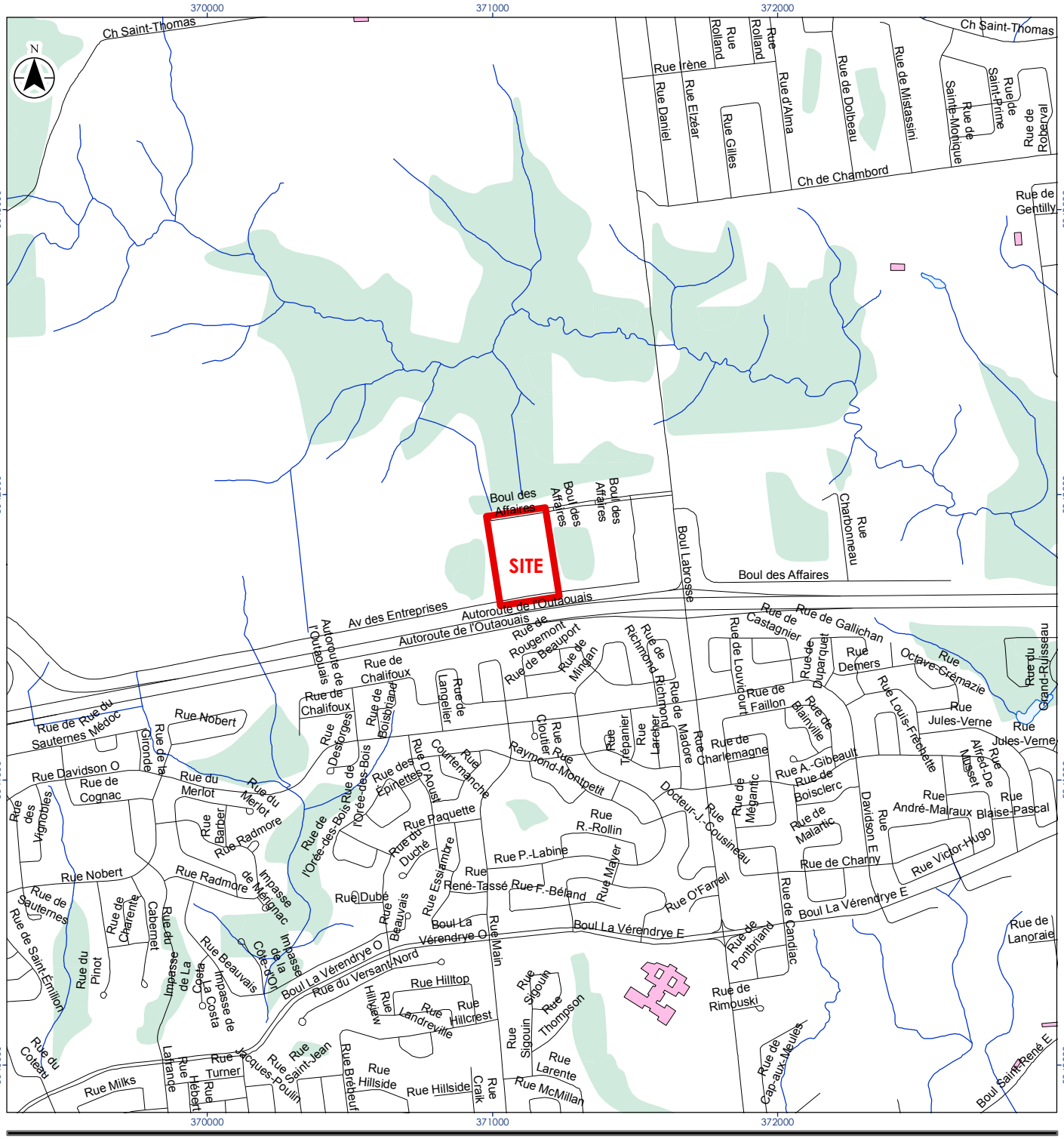


Legend

- Road
- Trail
- Railway
- Watercourse
- Building Area
- Wooded Area

0 400 800 metres

1:20,000 (at original document size of 8.5x11)

Notes

1. Coordinate System: NAD 1983 MTM 9.
2. Base features from Canvec, 2018.
3. Imagery provided by Esri, 2019.

Stantec

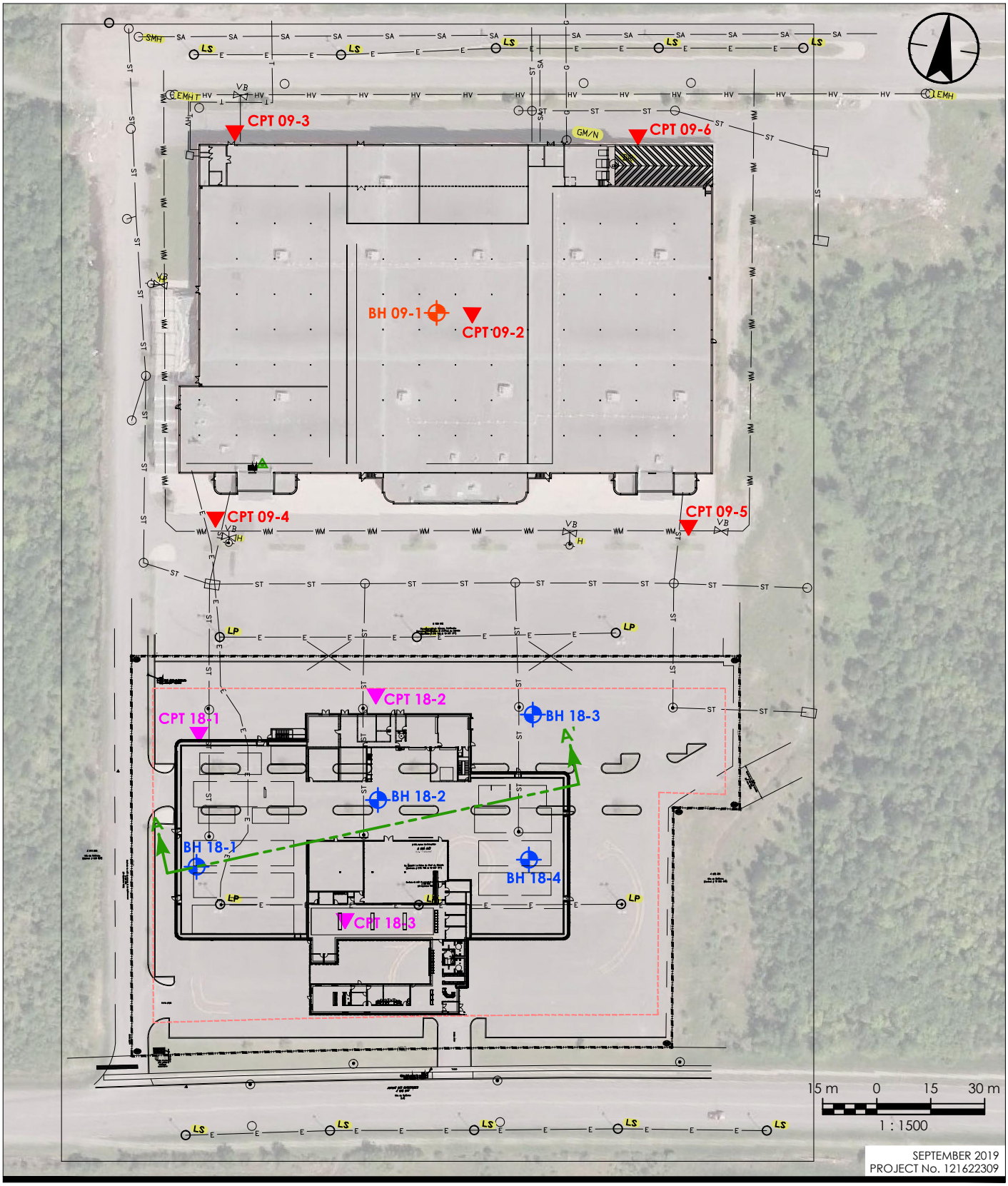
Project Location
555 Avenue Des Enterprises
Gatineau, QC

Project No. 121622309
Prepared by Gliceria Briones
on 2019-01-18

Client/Project
PWGSC
GEOTECHNICAL INVESTIGATION
PARKING LOT SOUTH OF 555 AVENUE DES ENTERPRISES

Drawing No.
1

Title
Key Plan



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SEPTEMBER 2019
PROJECT No. 121622309

LEGEND

BH 18 — BOREHOLE (2018)
BH 09 — BOREHOLE (2009)
CTT 18 — CPT (2018)
CPT 09 — CPT (2009)
A A' — CROSS SECTION LINE (REFER TO DWG. No. 3)

NOTES

1. COORDINATE SYTEM: NAD 1983 MTM ZONE 9N.
2. BASE FEATURES PROVIDE BY PSPC, PLAN No. NCA-1 8-3314, DATED JUNE 7, 2018 .
3. IMAGERY: FIRST BASE SOLUTIONS, 2018.

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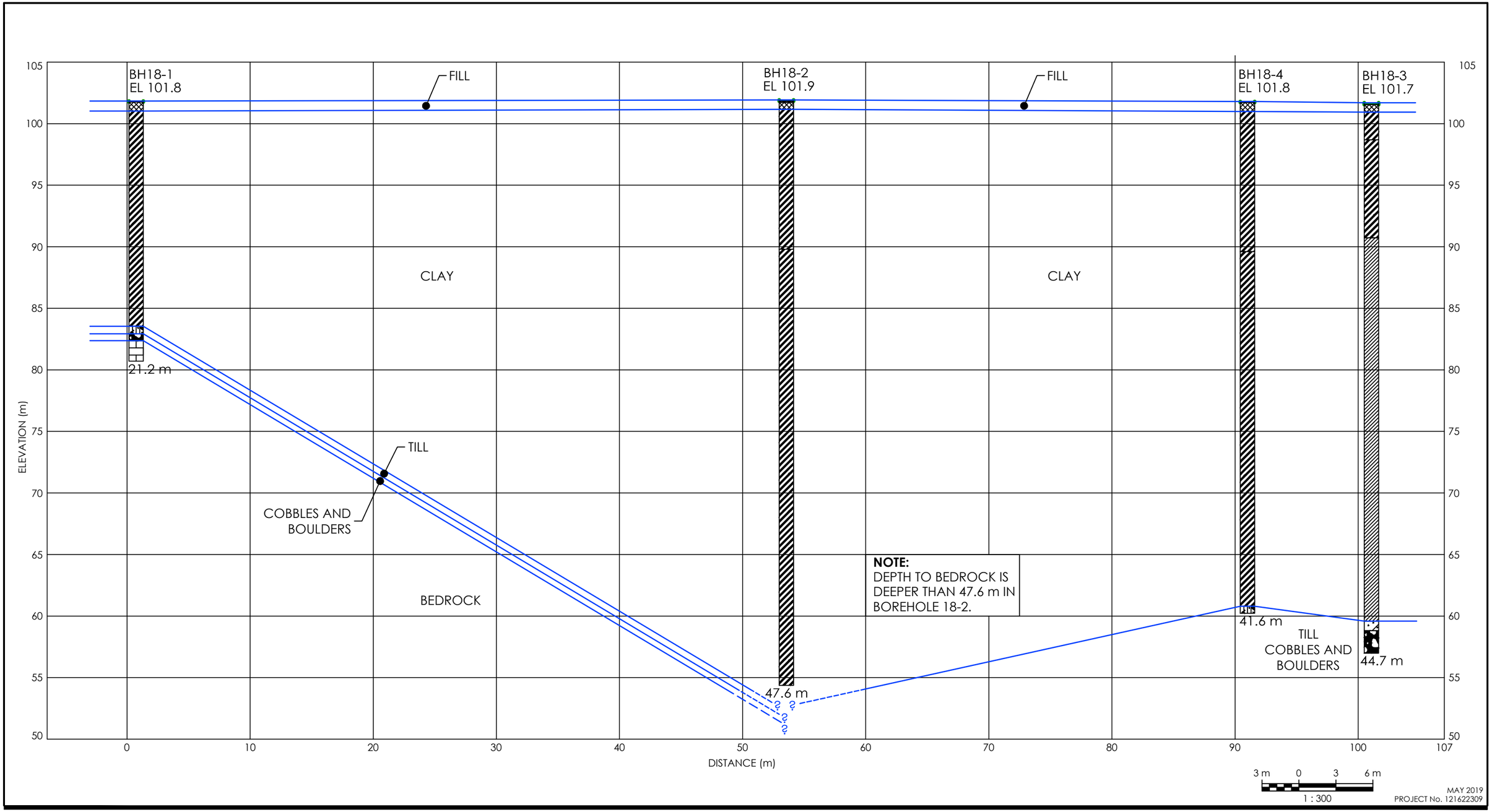
Client/Project
PWGSC, GEOTECHNICAL INVESTIGATION
PARKING LOT SOUTH OF 555 AVENUE DES ENTREPRISES, GATINEAU, QC

Drawing No.
2

Title
BOREHOLE LOCATION PLAN



MAY 2019
PROJECT No. 121622309

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2019/05/31 9:53 AM By: Briones, Gliceria

SOIL AND ROCK KEY

BOULDERS, COBBLES & GRAVELS
SAND & GRAVEL
SAND
SILTY SAND
SILT
CLAY
SILTY CLAY
TILL
FILL
ORGANICS
SHALE BEDROCK
LIMESTONE BEDROCK
SANDSTONE BEDROCK

Stantec
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Client/Project
PWGSC
GEOTECHNICAL INVESTIGATION - PARKING LOT
SOUTH OF 555 AVENUE DES ENTERPRISES, GATINEAU, QC

Drawing No.
3

Title
SUBSURFACE PROFILE

APPENDIX C

Symbols and Terms Used on Borehole and Test Pit Records

Borehole Records

Field Bedrock Core Logs

Rock Core Photographs

Nilcon Vane Results

CPT Results

Vibrating Wire Calibration Sheet

2009 Stantec Borehole Record

2009 CPT Results

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

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BOREHOLE RECORD

N: 5 040 043 E: 449 067

BH18-1

CLIENT Public Works and Government Services Canada — BOREHOLE No. BH18-1

LOCATION 555 Avenue des Entreprises, Gatineau, Quebec — PROJECT No. 121622309

DATES: BORING November 7, 2018 WATER LEVEL June 7, 2019 — DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N-VALUE OR RQD
0	**101.83**							
	101.8	75 mm ASPHALT			SS	1	330	9
	101.0	FILL: brown well-graded sand with silt and gravel (SW-SM)						
1		Firm to very stiff brown CLAY of high plasticity (CH)			SS	2	584	4
2					SS	3	610	5
3					SS	4	610	3
4					SS	5	610	3
5				▽	ST	1		
6					SS	6	610	0
7								
8					SS	7	610	0
9				▼	SS	8	610	0
10								
11					ST	2		
12					SS	9	610	0
13								
14					SS	10	610	0
15								

UNDRAINED SHEAR STRENGTH - kPa

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m ★

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90

▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

□ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

Stantec

BOREHOLE RECORD

N: 5 040 043 E: 449 067

BH18-1

CLIENT Public Works and Government Services Canada — BOREHOLE No. BH18-1

LOCATION 555 Avenue des Entreprises, Gatineau, Quebec — PROJECT No. 121622309

DATES: BORING November 7, 2018 WATER LEVEL June 7, 2019 — DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N-VALUE OR RQD
15		*continued* Firm to very stiff brown CLAY of high plasticity (CH)			ST	3		
16								
17								
18	84.0							
	83.5	Cobbles and Boulders - granite and gneiss			NQ	11	42%	
	82.9	Compact brown silty sand with gravel (SM) TILL			SS	12	229	18
19	82.4	Cobbles and Boulders - granite and gneiss			NQ	13	18%	
20		Good to excellent quality GNEISS BEDROCK - strong to very strong intact rock strength - extremely close spaced fractures - orientation 0 to 20 degrees (flat) - fresh to slightly weathered (Refer to Field Bedrock Core Log)			NQ	14	95%	80%
21	80.7				NQ	15	100%	91%
22		End of Borehole						
23		Standpipe Installed: 19.6 m - 18.8 m (Bentonite) 18.8 m - 17.3 m (Screen) 18.8 m - 17.0 m (Sand) 17.0 m - 0 m (Bentonite/Cuttings) Stick-up Well Cap						
24		Water level was measured at 8.8 m on June 7, 2019 and 9.1 m on June 13, 2019						
25								
26								
27								
28								
29								
30								

UNDRAINED SHEAR STRENGTH - kPa

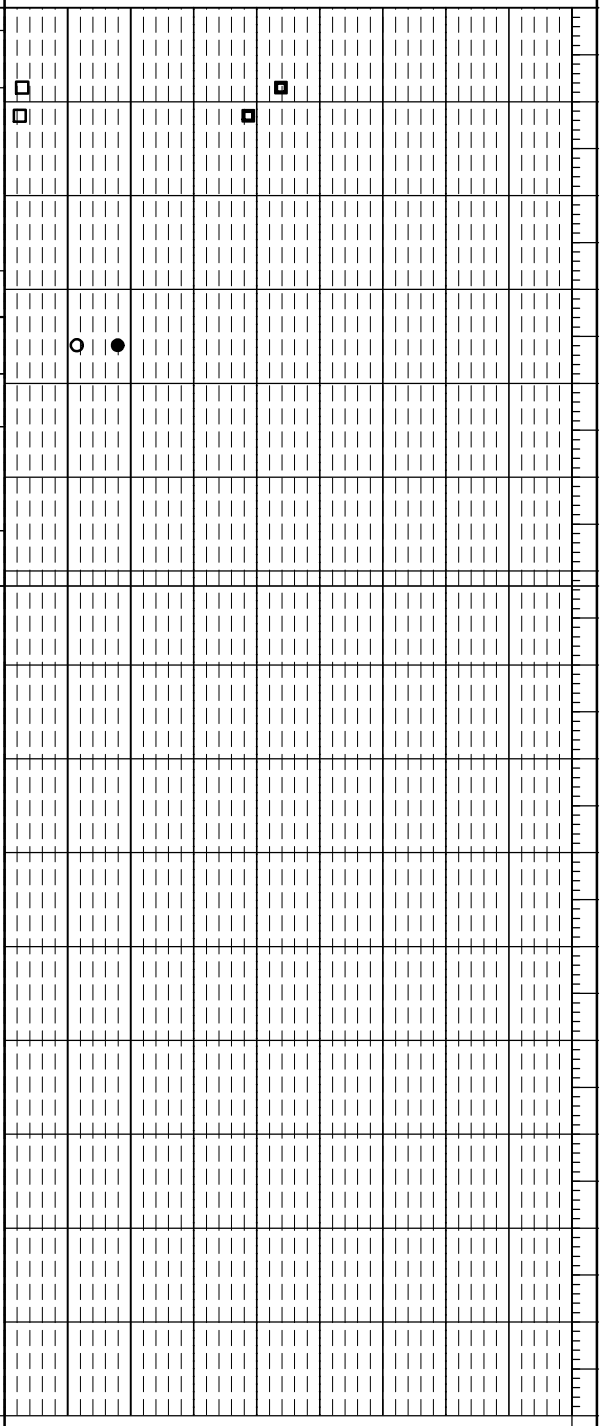
50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m

STANDARD PENETRATION TEST, BLOWS/0.3m

10 20 30 40 50 60 70 80 90



▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

□ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

STN13-STAN-GEO 121622309 - PCA ARTIFACT FACILITY.GPJ SMART.GDT 6/14/19

Stantec

BOREHOLE RECORD

N: 5 040 067 E: 449 114

BH18-2

CLIENT Public Works and Government Services Canada — BOREHOLE No. BH18-2

LOCATION 555 Avenue des Entreprises, Gatineau, Quebec — PROJECT No. 121622309

DATES: BORING November 6, 2018 — WATER LEVEL — DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N-VALUE OR RQD
0	**101.92**							
	101.8	100 mm ASAPHALT			SS	1	279	20
	101.7	FILL: Grey-brown well-graded sand with silt and gravel (SW-SM)			SS	2	508	4
	101.2	FILL: Brown well-graded sand with silt and gravel (SW-SM)						
2		Firm to very stiff grey CLAY of high plasticity (CH) - moist - traces of sand at 0.76 m			SS	3	610	3
3				▽	SS	4	610	1
4								
5					SS	5	610	2
6								
					SS	6	610	0
7								
8					SS	7	610	0
9								
					SS	8	610	0
10								
11					SS	9	610	0
12	89.8	Start of Dynamic Cone Penetration Test (DCPT) (Inferred CLAY from 12 m to 47.6 m)						
13								
14								
15								

UNDRAINED SHEAR STRENGTH - kPa

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m ★

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90

▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

□ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

Stantec

BOREHOLE RECORD

N: 5 040 067 E: 449 114

BH18-2

CLIENT Public Works and Government Services Canada — BOREHOLE No. BH18-2

LOCATION 555 Avenue des Entreprises, Gatineau, Quebec — PROJECT No. 121622309

DATES: BORING November 6, 2018 — WATER LEVEL — DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: RECOVERY (mm)	SAMPLES: N-VALUE OR RQD
15		*continued* (Inferred CLAY from 12 m to 47.6 m)						

UNDRAINED SHEAR STRENGTH - kPa

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m ★

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90

16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

■ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

Stantec

BOREHOLE RECORD

N: 5 040 067 E: 449 114

BH18-2

CLIENT Public Works and Government Services Canada — BOREHOLE No. BH18-2

LOCATION 555 Avenue des Entreprises, Gatineau, Quebec — PROJECT No. 121622309

DATES: BORING November 6, 2018 — WATER LEVEL — DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: RECOVERY (mm)	SAMPLES: N-VALUE OR RQD
30		*continued* (Inferred CLAY from 12 m to 47.6 m)						
31								
32								
33								
34								
35								
36								
37								
38								
39								
40								
41								
42								
43								
44								
45								

UNDRAINED SHEAR STRENGTH - kPa

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m ★

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90

▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

■ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

Stantec

BOREHOLE RECORD

N: 5 040 067 E: 449 114

BH18-2

CLIENT Public Works and Government Services Canada — BOREHOLE No. BH18-2

LOCATION 555 Avenue des Entreprises, Gatineau, Quebec — PROJECT No. 121622309

DATES: BORING November 6, 2018 WATER LEVEL — DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: RECOVERY (mm)	SAMPLES: N-VALUE OR RQD
45		*continued* (Inferred CLAY from 12 m to 47.6 m)						
46								
47	54.4							
48		End of Borehole Vibrating Wire Piezometer Installed to 12.1 m below ground surface						
49								
50								
51								
52								
53								
54								
55								
56								
57								
58								
59								
60								

UNDRAINED SHEAR STRENGTH - kPa

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m ★

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90

▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

■ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

Stantec

BOREHOLE RECORD

N: 5 040 096 E: 449 154

BH18-3

CLIENT Public Works and Government Services Canada — BOREHOLE No. BH18-3

LOCATION 555 Avenue des Entreprises, Gatineau, Quebec — PROJECT No. 121622309

DATES: BORING November 9, 2018 — WATER LEVEL — DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR RQD
	101.69							
0	101.5	150 mm ASPHALT			SS	1	127	13
	100.9	FILL: brown well-graded sand with silt and gravel (SW-SM)			SS	2	406	5
1		Very stiff brown CLAY of high plasticity (CH)						
2					SS	3	610	5
3	98.7			▽				
		Firm to stiff CLAY of high plasticity (CH) - wet			SS	4	610	0
4								
5					SS	5	610	0
					ST	1		
6					SS	6	610	0
7								
8					SS	7	610	0
9					SS	8	610	
10								
	90.7							
11		Firm to very stiff silty CLAY (CL) - wet			ST	2		
12					SS	9	610	0
13								
14					SS	10	610	0
15								

UNDRAINED SHEAR STRENGTH - kPa

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m ★

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90

▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

□ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

Stantec

BOREHOLE RECORD

N: 5 040 096 E: 449 154

BH18-3

CLIENT Public Works and Government Services Canada — BOREHOLE No. BH18-3

LOCATION 555 Avenue des Entreprises, Gatineau, Quebec — PROJECT No. 121622309

DATES: BORING November 9, 2018 — WATER LEVEL — DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N-VALUE OR RQD
15		*continued* Firm to very stiff silty CLAY (CL) - wet			ST	3		
16								
17								
18					SS	11	610	0
19								
20								
21					SS	12	508	0
22								
23								
24					SS	13	330	0
25								
26								
27		- higher plasticity clay in sample SS14			SS	14	610	0
28								
29								
30								

UNDRAINED SHEAR STRENGTH - kPa

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m

STANDARD PENETRATION TEST, BLOWS/0.3m

10 20 30 40 50 60 70 80 90

▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

□ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

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Stantec

BOREHOLE RECORD

N: 5 040 096 E: 449 154

BH18-3

CLIENT Public Works and Government Services Canada — BOREHOLE No. BH18-3

LOCATION 555 Avenue des Entreprises, Gatineau, Quebec — PROJECT No. 121622309

DATES: BORING November 9, 2018 — WATER LEVEL — DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N-VALUE OR RQD
30		*continued* Firm to very stiff silty CLAY (CL) - wet			SS	15	610	0
31								
32								
33								
34					SS	16	610	1
35								
36								
37								
38					SS	17	610	4
39								
40								
41								
42	59.6							
		Very stiff brown sandy silty CLAY (CL)			SS	18	610	17
	58.8							
43		Cobbles and Boulders - granite and gneiss						
44					NQ	19	36%	
	57.0							
45		End of Borehole						

UNDRAINED SHEAR STRENGTH - kPa

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m ★

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90

▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

■ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

Stantec

BOREHOLE RECORD

N: 5 040 056 E: 449 158

BH18-4

CLIENT Public Works and Government Services Canada — BOREHOLE No. BH18-4

LOCATION 555 Avenue des Entreprises, Gatineau, Quebec — PROJECT No. 121622309

DATES: BORING November 11, 2018 — WATER LEVEL June 7, 2019 — DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N-VALUE OR RQD
	101.80							
0	101.7	75 mm ASPHALT			SS	1	229	7
	101.0	FILL: brown well-graded sand with silt and gravel (SW-SM)			SS	2	330	5
1		Stiff to very stiff grey CLAY of high plasticity (CH) - moist - trace sand						
2				▼	SS	3	610	3
3				▽	SS	4	610	2
4								
5					SS	5	610	1
6								
					SS	6	610	1
7								
8					SS	7	610	0
9								
					SS	8	610	0
10								
11					SS	9	610	0
12	89.6	Start of Dynamic Cone Penetration Test (DCPT) (Inferred CLAY from 12 m to 41 m)						
13								
14								
15								

UNDRAINED SHEAR STRENGTH - kPa

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m ★

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90

▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

■ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

STN13-STAN-GEO 121622309 - PCA ARTIFACT FACILITY.GPJ SMART.GDT 6/14/19

Stantec

BOREHOLE RECORD

N: 5 040 056 E: 449 158

BH18-4

CLIENT Public Works and Government Services Canada — BOREHOLE No. BH18-4

LOCATION 555 Avenue des Entreprises, Gatineau, Quebec — PROJECT No. 121622309

DATES: BORING November 11, 2018 — WATER LEVEL June 7, 2019 — DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: RECOVERY (mm)	SAMPLES: N-VALUE OR RQD
15		*continued* (Inferred CLAY from 12 m to 41 m)						
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								

UNDRAINED SHEAR STRENGTH - kPa

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m ★

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90

▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

■ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

Stantec

BOREHOLE RECORD

N: 5 040 056 E: 449 158

BH18-4

CLIENT Public Works and Government Services Canada — BOREHOLE No. BH18-4

LOCATION 555 Avenue des Entreprises, Gatineau, Quebec — PROJECT No. 121622309

DATES: BORING November 11, 2018 — WATER LEVEL June 7, 2019 — DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: RECOVERY (mm)	SAMPLES: N-VALUE OR RQD
30		*continued* (Inferred CLAY from 12 m to 41 m)						
31								
32								
33								
34								
35								
36								
37								
38								
39								
40								
41	60.8							
	60.2	- Inferred transition to TILL						
42		End of Borehole DCPT Refusal at 41.6 m Standpipe Installed: 12.2 m - 10.7 m (Screen) 12.2 m - 10.4 m (Sand) 10.4 m - 0 m (Bentonite/Cuttings) Stick-up Well Cap						
43								
44								
45								

UNDRAINED SHEAR STRENGTH - kPa

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m ★

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90

100

▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

■ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

STN13-STAN-GEO 121622309 - PCA ARTIFACT FACILITY.GPJ SMART.GDT 6/14/19

Stantec

BOREHOLE RECORD

N: 5 040 056 E: 449 158

BH18-4

CLIENT Public Works and Government Services Canada — BOREHOLE No. BH18-4

LOCATION 555 Avenue des Entreprises, Gatineau, Quebec — PROJECT No. 121622309

DATES: BORING November 11, 2018 WATER LEVEL June 7, 2019 — DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: RECOVERY (mm)	SAMPLES: N-VALUE OR RQD
45		Water level was measured at 2.2 m on June 7, 2019 June 13, 2019						
46								
47								
48								
49								
50								
51								
52								
53								
54								
55								
56								
57								
58								
59								
60								

UNDRAINED SHEAR STRENGTH - kPa

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m ★

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90

▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

■ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

STN13-STAN-GEO 121622309 - PCA ARTIFACT FACILITY.GPJ SMART.GDT 6/14/19

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Field Bedrock Core Log

Client:	Public Works and Government Services Canada (PWGSC)	**Project No.:**	121622309 T200
Project:	PCA Artifact Storage Facility	**Date:**	17-Dec-18
Contractor:	Downing Drilling	**Borehole No.:**	BH18-01
		Logger:	FBP

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING		
17.8	11	42	N/A	18.3	Cobbles and Boulders : granite and gneiss	N/A	N/A	N/A								
18.9	13	18	N/A	19.46	Cobbles : granite and gneiss	N/A	N/A	N/A								
19.46	14	95	80	20.57	Gneiss, some angled fractures at the beginning of the run, oxidation present at the level of the fractures (weak layers)	R4-R5	W2	1	FOL	F	EC	3		T		
20.57	15	100	91	21.16	Gneiss, some horizontal fractures, no oxidation at the level of fractures (weak layers)	R5	W1	1	FOL	F	EC	3		T		

STRENGTH (MPa)

Grade/Classification	Est. Strength (MPa)
R0 Extremely Week	0.25 - 1.0
R1 Very Weak	1.0 - 5.0
R2 Weak	5.0 - 25.0
R3 Medium Strong	25.0 - 50.0
R4 Strong	50.0 - 100.0
R5 Very Strong	100.0 - 250.0
R6 Extremely Strong	>250.0

JOINT TYPE

BD = Bedding
JN = Joint
FOL = Foliation
CON = Contact
FLT = Fault
VN = Vein

ORIENTATION

F = Flat = 0-20^0
D = Dipping = 20-50^0
V = n-Vertical = >50^0

FILLING

T = Tight, Hard
O = Oxidized
SA = Slightly Altered, Clay Free
S = Sandy, Clay Free
Si = Sandy, Silty, Minor Clay
NC = Non-softening Clay
SC = Swelling, Soft Clay

WEATHERING

Grade/Classification	Description
W1 Fresh	No Visible Signs of Weathering
W2 Slightly	Discoloration, Weathering on Discontinuities
W3 Moderately	<50% of Rock Material is Decomposed, Fresh Core Stones
W4 Highly	>50% Decomposed to soil: Fresh Core Stones
W5 Completely	100% Decomposed to Soil: Original Structure Intact
W6 Residual Soil	All Rock Converted to Soil, Structure and Fabric Destroyed

DISCONTINUITY SPACING

Spacing (mm)	
EW = >6000	Extremely Wide
VW = 2000 - 6000	Very Wide
W = 600 - 2000	Wide
M = 200 - 600	Moderate
C = 60 - 200	Close
VC = 20 - 60	Very Close
EC = <20	Extremely Close

JOINT ROUGHNESS

Jr	Description
4	DJ = Discontinuous Joints
3	RU = Rough, Irregular, Undulating
1.5	SU = Smooth, Undulating
1.5	LU = Slickensided, Undulating
1.0	RP = Rough or Irregular, Planar
0.5	SP = Smooth, Planar
2	LP = Slickensided, Planar

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Stantec	Project No. 121622309.200 Project: PCA Artifact Storage Facility	Rock Core Photographs

Photo No.: 1	Borehole: BH18-01	Depth : 17.81 – 21.16 m

Photo No.: 2	Borehole: BH18-01	Depth: 17.81 – 21.16m

Stantec	Project No. 121622309.200 Project: PCA Artifact Storage Facility	Rock Core Photographs

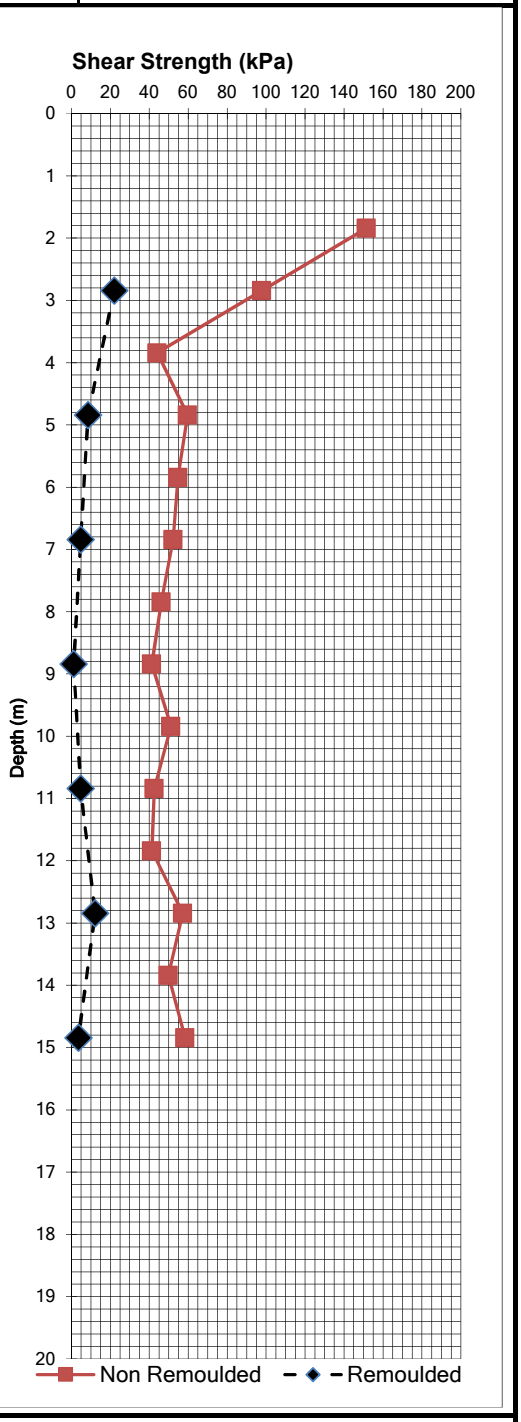
Photo No.: 3	Borehole: BH18-03	Depth : 42.87 – 44.70 m

Photo No.: 4	Borehole: BH18-03	Depth : 42.87 – 44.70m

Stantec

Project No. : 121622509 T200		Elevation (m)
Borehole No. : CPT18-02	"K" factor: **1.203** kg.m/cm	Depth to top of clay (m)
Date: **11-12-2018**	Size used:	Depth to bottom of clay (m)
Completed by: FBP	Small ☐ Medium ∨ Large ☐	

Depth (m)	Vane		Shear Strength								Sensitivity
			Intact				Remould				
	Type (p, m, g)	c	as (mm)	af (mm)	as-af (mm)	cu (kPa)	as (r) (mm)	af (r) (mm)	as-af (r) (mm)	cur (kPa)	cu/cur
1.8	p	0.207	67	5	62	**152**	0	0			
2.8	p	0.207	43	3	40	**98**	11	2	9	**22**	**4.4**
3.8	p	0.207	22	4	18	**44**	0	0			
4.8	m	0.103	55	6	49	**60**	11	4	7	**9**	**7.0**
5.8	m	0.103	51	6	45	**55**	0	0			
6.8	m	0.103	52	9	43	**52**	12	8	4	**5**	**10.8**
7.8	m	0.103	48	10	38	**46**	0	0			
8.8	m	0.103	44	10	34	**41**	11	10	1	**1**	**34.0**
9.8	m	0.103	53	11	42	**51**	0	0			
10.8	m	0.103	44	9	35	**43**	13	9	4	**5**	**8.7**
11.8	m	0.103	45	11	34	**41**	0	0			
12.8	m	0.103	57	10	47	**57**	22	12	10	**12**	**4.7**
13.8	m	0.103	52	11	41	**50**	0	0			
14.8	m	0.103	59	11	48	**58**	12	9	3	**4**	**16.0**



Refusal depth:

cu = 9.82 C K (as - af)

as : maximum radial distance from the point (mm)

af : radial distance during test (mm)

Vane information		
Size	dim. (cm)	C
Small (p)	5 X 11	0.207
Medium (m)	6,5 X 13	0.103
Large (g)	8 X 17	0.052

Comments:

Note: The calculated Cu must be corrected according to the plasticity index of the deposit.

Calculated by : Fannie Beaudry-Potvin Date : **11-12-2018** Checked by : Ie :

Terminology Used on SCPTu and CPTu Records

Key Terminology and Principles

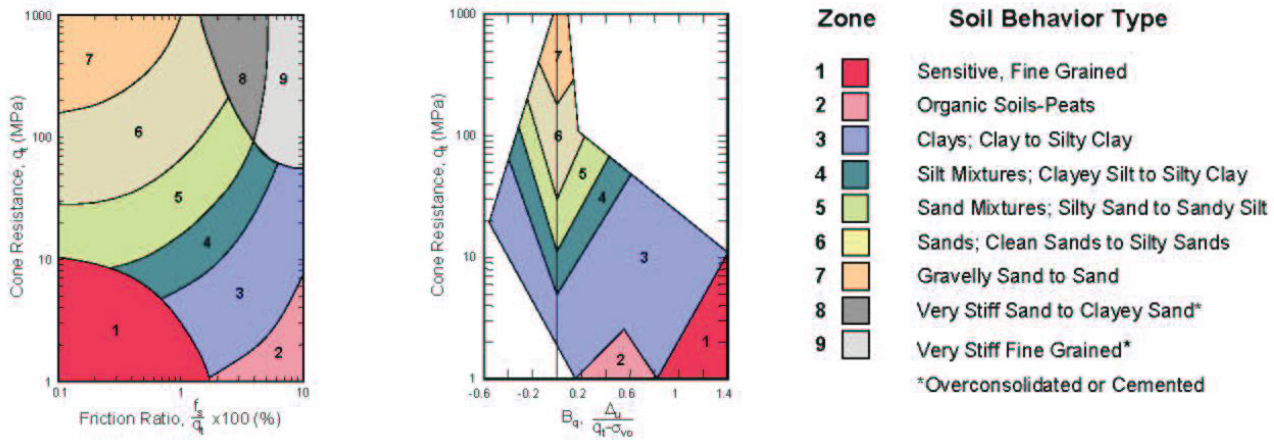
SCPTu:
- Seismic Piezocone (SCPTu);
- A piezocone (CPTu) is an enhanced cone penetration test (CPT) probe that is able to measure porewater pressure (u);
- A seismic piezocone (SCPTu) is further enhanced to measure surface generated compression and shear waves at depth; used to define the shear wave velocity of soils.

Equipment Type and Governing Standard:
- 10 cm^2 seismic piezocone;
- 150 cm^2 friction sleeve;
- manufactured by Applied Research Associates, Inc.;
- ASTM Specification D3441.

SCPTu Investigation Objectives:
- evaluate soil type and soil stratigraphy;
- estimate the relative density of granular soils and in situ undrained shear strength of cohesive soils.

Soil Behavior Type (SBT):
- The SBT is selected based on a soil's response to cone penetration, which is different from an explicit soil type defined by specified laboratory testing procedures, but is normally what the geotechnical engineer requires for design purposes.
- The SBT can be classified on the basis of the soil friction ratio, F_r; ratio between the side shear on the friction sleeve and cone tip resistance.
- The SBT can also be classified on the basis of the normalized pore pressure, B_q; a function of the pore water response to penetration and the cone tip resistance.
- The "CPTu Soil Behavior Type Legend" used for this project is presented below.

CPTu Soil Behavior Type Legend (Robertson et al. 1990)



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Terminology and Key Engineering Relationships

Parameter	Description	Symbol/Equation
Depth/Elevation	Measured at the centroid of the sensor	
Sleeve Stress	Measured friction stress on the friction sleeve located above the cone tip	f_s
Tip Stress, Uncorrected	Measured compression stress on the cone tip surface	q_c
Corrected Tip Stress	Tip stress, corrected for probe geometry	$q_t = q_c + u_2 \cdot (1-a)$ *where a is a geometry based ratio relating the diameters of the inner load cell and the cone*
Ratio (%)	Friction ratio	$R_f = \frac{f_s}{q_t} \cdot 100\,\%$
In situ Pore Pressure	In situ equilibrium or static value	u_0
Measured Pore Pressure	Penetration pore pressure value	u_2
Overburden Stress		σ_{vo}
Effective Overburden Stress		$\sigma'_{vo} = \sigma_{vo} - u_o$
Normalized Tip Stress		$Q_t = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}}$
Normalized Friction Ratio		$F_r = \frac{f_s}{q_t - \sigma_{vo}}$
Normalized Pore Pressure		$B_q = \frac{\Delta u}{q_t - \sigma_{vo}}$ *where* $\Delta u = u_2 - u_0$

Key References:

T. Lunne, P.K. Robertson, and J.J.M. Powell (1997). "Cone Penetration Testing in Geotechnical Practice"; Spon Press.

P.W. Mayne (1986). "CPT indexing of in situ OCR in Clays"; Proceedings of the ASCE Specialty Conference In Situ '86: Use of In Situ Tests in Geotechnical Engineering, Blacksburg, 780-93, ASCE.

P.K. Robertson and R.G. Campanella (1988). "Guidelines for geotechnical design using CPT and CPTU"; University of British Columbia, Vancouver, Department of Civil Engineering, Soil Mechanics Series 120.

P.K. Robertson (1990) "Soil classification using the cone penetration test", Canadian Geotechnical Journal, Vol. 27, No. 1, pp. 151-158.

STATIC SCPT$_u$ Interpreter

Calculation Methods

SCPTu Measured Data - Non Modified Measurements

f_s = sleeve stress

q_c = tip stress

u_2 = pore pressure (position 2)

q_t - corrected tip stress (geometric cor. calculated by Vertek software based on Net Area Ratio)

$q_t = q_c + u_2*(1 - a)$ — Lunne et al. p25-26

a = 0.83 (Net Area Ratio stated in the Vertek user guide)

R_f - Friction Ratio (calculated by Vertek software)

$R_f = f_s/q_t$ — Lunne et al. p36

F_r - Normalized Friction Ratio

$F_r = f_s/(q_t - \sigma_{vo})$ — Lunne et al. p53

B_q - Pore Pressure Ratio

$B_q = \Delta u_2/(q_t - \sigma_{vo})$ — Lunne et al. p53

Q_t - Normalized Cone Resistance

$Q_t = (q_t - \sigma_{vo})/\sigma'_{vo}$ — Lunne et al. p53

I_c - Soil Behaviour Type Index

$I_c = [(\log F_r + 1.22)^2 + (3.47 - \log Q_t)^2]^{0.5}$ — Lunne et al. p151

S_u - Undrained Shear Strength (caculated only when $I_c > 2.6$)

$S_u = (q_t - \sigma_{vo})/N_{kt}$ based on corrected tip stress (preferred method) — Lunne et al. p65

$S_u = (q_c - \sigma_{vo})/N_k$ based on un-corrected tip stress (use when u_2 is suspect) — Lunne et al. p64

$S_u = \Delta u/N_{\Delta u}$ based on excess pore pressure (use when q_c is suspect) — Lunne et al. p67

$\Delta u = u_2 - u_o$ uo based on static groundwater level

N_{kt}, N_k, $N_{\Delta u}$ are soil specific cone factor values applicable to each method

S_t - Sensitivity of Cohesive Soils (calculated only when $I_c > 2.6$)

$S_t = S_u/f_s$ S_u based on N_{kt} used in calculations — Lunne et al. p68

P'_c - Effective Preconsolidation Pressure

$P'_c = (q_t - P'_o)/N_{st}$ — ConTec Guide p12

N_{st} is a soil specific cone factor value

$P'_c = S_u / (0.2+0.0024*I_p)$

(S_u based on N_{kt} as a check for marine clays only)

OCR - Overconsolidation Ratio

$OCR = k*[(q_t - \sigma_{vo})/\sigma'_{vo}]$ — Lunne et al. p60

$k = 1/N_{st}$

N_{60} - equivalent 60% energy efficient field N-value

$(q_c/p_a)/N_{60} = 8.5*[1 - (I_c/4.6)]$ — Lunne et al. p151

p_a = 101.3 kPa; atmospheric pressure

ϕ' = effective angle of internal friction (calculated only when $I_c < 2.6$)

$\tan\phi' = [\log(q_c/\sigma'_{vo}) + 0.29]/2.68$ — ConTec Guide p15

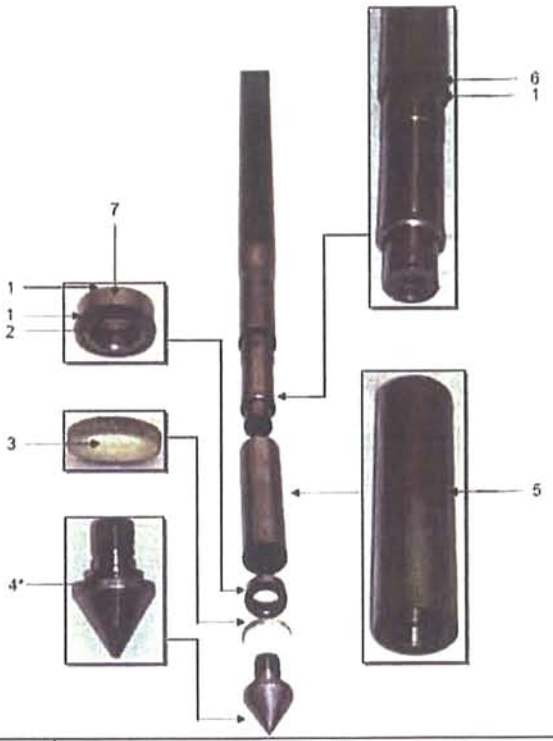
FC% = fines content in percent

$FC\% = 1.75*I_c^3 - 3.7$ — Lunne et al. p169

CPT Equipment and Details

Stantec Limited's standard method for cone penetration testing (CPT) uses a Vertek 4579 Digital Piezocone (serial number 2659.109) with a cone area of 10 cm^2 (1.5 in^2) and a mass of 14500 kg (32,000 lb). It is capable of recording the following parameters:

- Tip Resistance, q_c
- Sleeve Friction, f_s (Side Friction)
- Pore Water Pressure, u_2
- Shear Wave Arrival Time
- Compression Wave Arrival Time
- Inclination
- Temperature



Item	Description
1	O-Ring
2	O-Ring
3	Piezo filter, saturated in de-aired silicone oil
4	Piezo tip
*	Standard tip (For use without piezo filter)
5	Friction Sleeve
6	X-Ring
7	Retainer Ring

Stantec

The CPTu unit can be used to interpret subsurface stratigraphy. The piezocone is pushed at a rate of 2 cm/s, with a drill rig providing the thrust and reaction force. The piezocone measures force in two locations – at the tip of the penetrometer, as well as along the sleeve. The tip load cell, which measures tip resistance (q_c) has a range of 100 kN (22,000 lb) and an accuracy of 0.2%. Other penetrometer specifications include:

- Cone Area: 10 cm^2
- Net Area Ratio: 0.83
- Zero Drift: 0.006 %FS/degF
- Linearity: 0.10%FS (max)
- Overload Cap (%): 150

A load cell along the sleeve measures sleeve friction (f_s) with a range of 20 kN (4,400 lb) and an accuracy of 0.2%. Further specifications include:

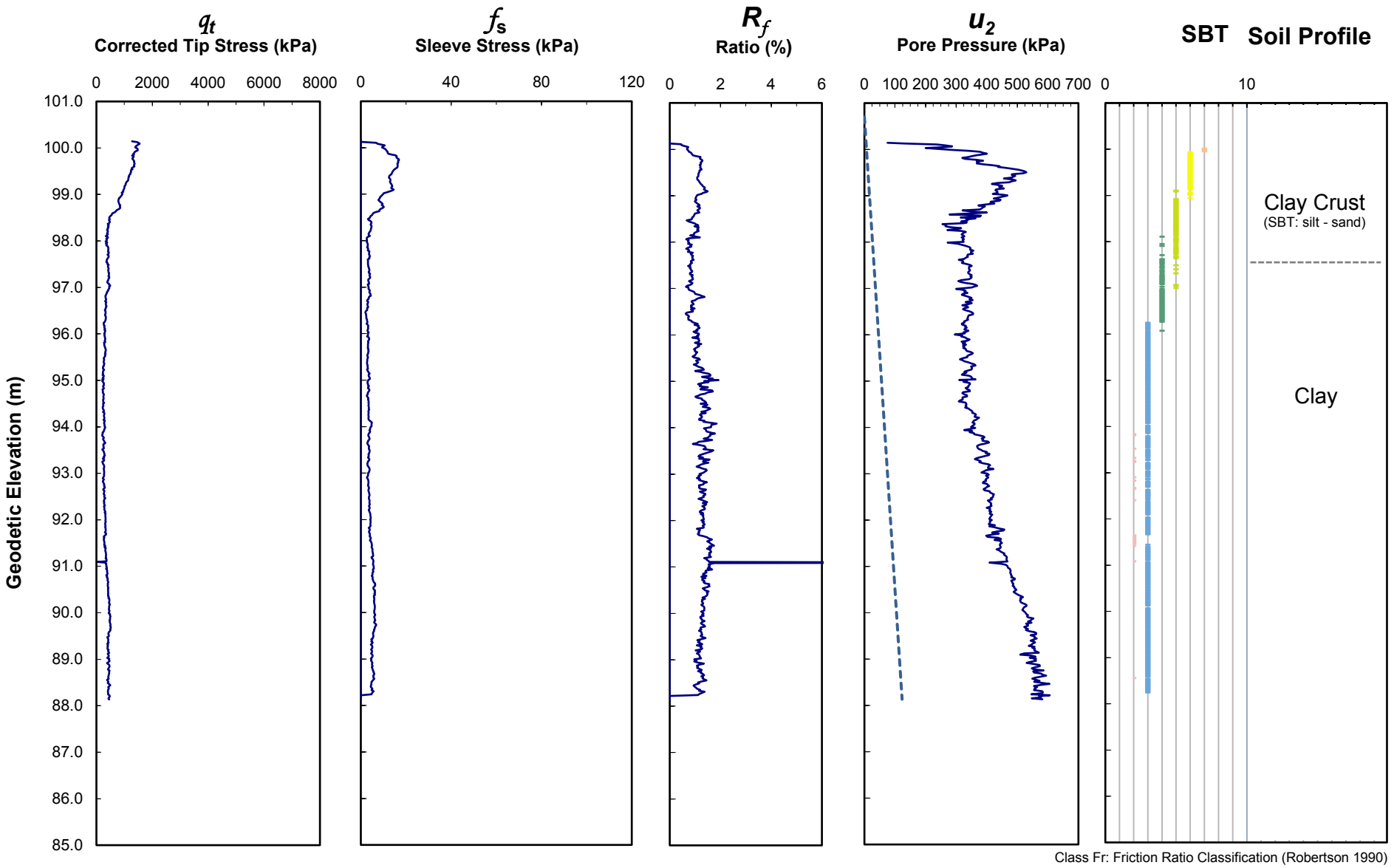
- Sleeve Area: 150 cm^2
- Net Area Ratio: 1.00
- Zero Drift: 0.003 %FS/degF
- Linearity: 0.25 %FS (max)
- Overload Cap (%) 150

A piezofilter, saturated in de-aired silicone oil, acts as a pore pressure transducer. This instrument, which is situated behind the cone of the penetrometer (commonly referred to as position u_2), has a standard range of 3.5 MPA (500 psi) and an accuracy of 0.5%. Further specifications are as follows:

- Burst Pressure: 150 %
- Rise Time (10-90%) <1 ms
- Zero Drift: 0.03 %FS/degF
- Static Error Band: 0.03 %FS (max)

The built-in inclinometer has a range of ± 15°, and an accuracy of 1°.

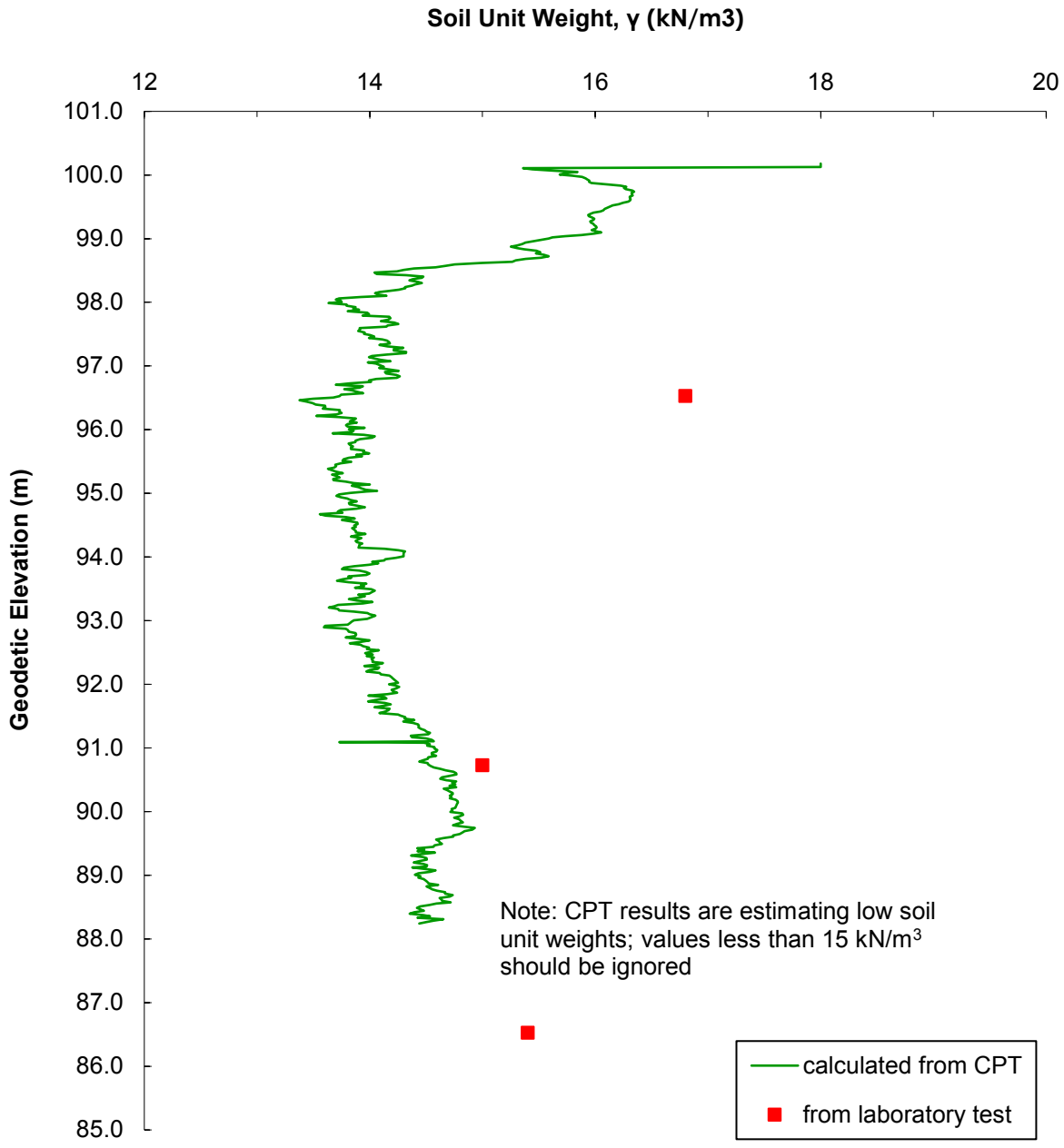
Stantec	Elevation: 101.70 m SCPTu Start Elevation: 100.18 m Groundwater Elevation: 100.70 m	Date : November 5, 2018 Project Number: 121622309	CPT18-1
	Client : Public Works and Government Services Canada (PWGSC) Projet : PCA Artifact Storage Facility - 555 Avenue des Entreprises, Gatineau, QC		



Class Fr: Friction Ratio Classification (Robertson 1990)

SCPTu Results

Soil Unit Weight, γ



Project No. 121622309
CPT18-1

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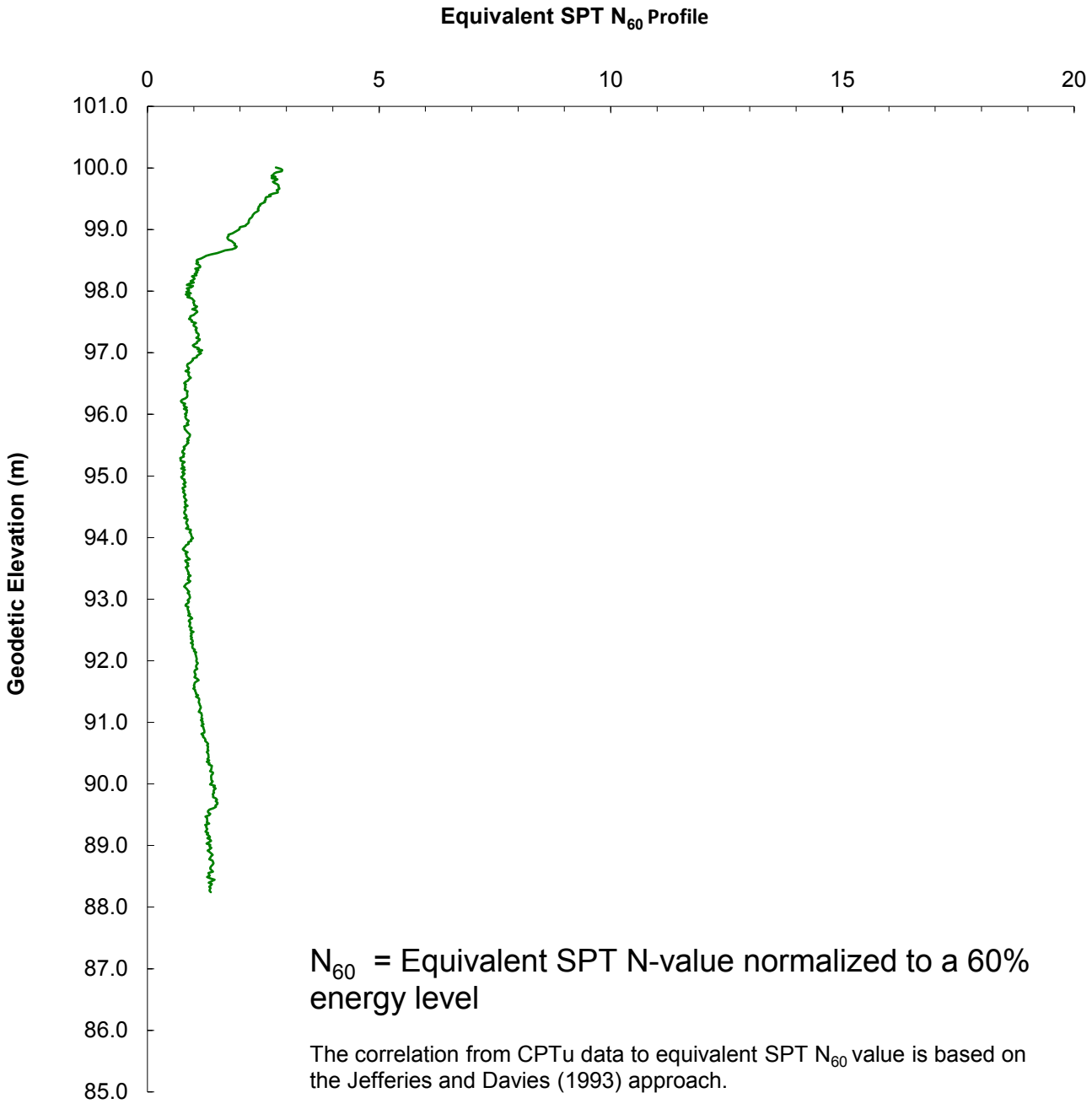
SCPTu Results

SCPTu N_{60} Values



N_{60} = Equivalent SPT N-value normalized to a 60% energy level

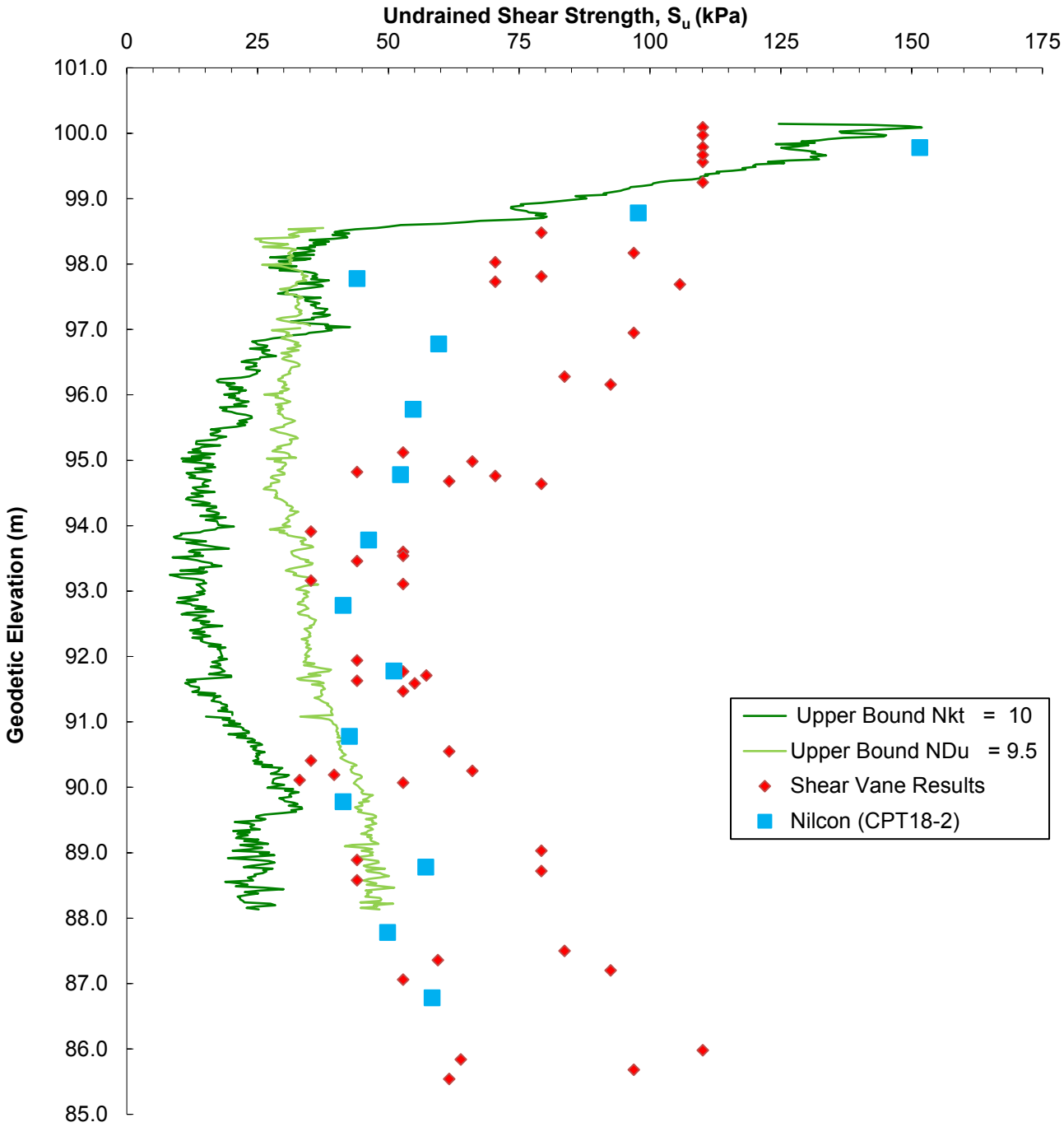
The correlation from CPTu data to equivalent SPT N_{60} value is based on the Jefferies and Davies (1993) approach.

Project No. 121622309

CPT18-1

SCPTu Results

Undrained Shear Strength, S_u

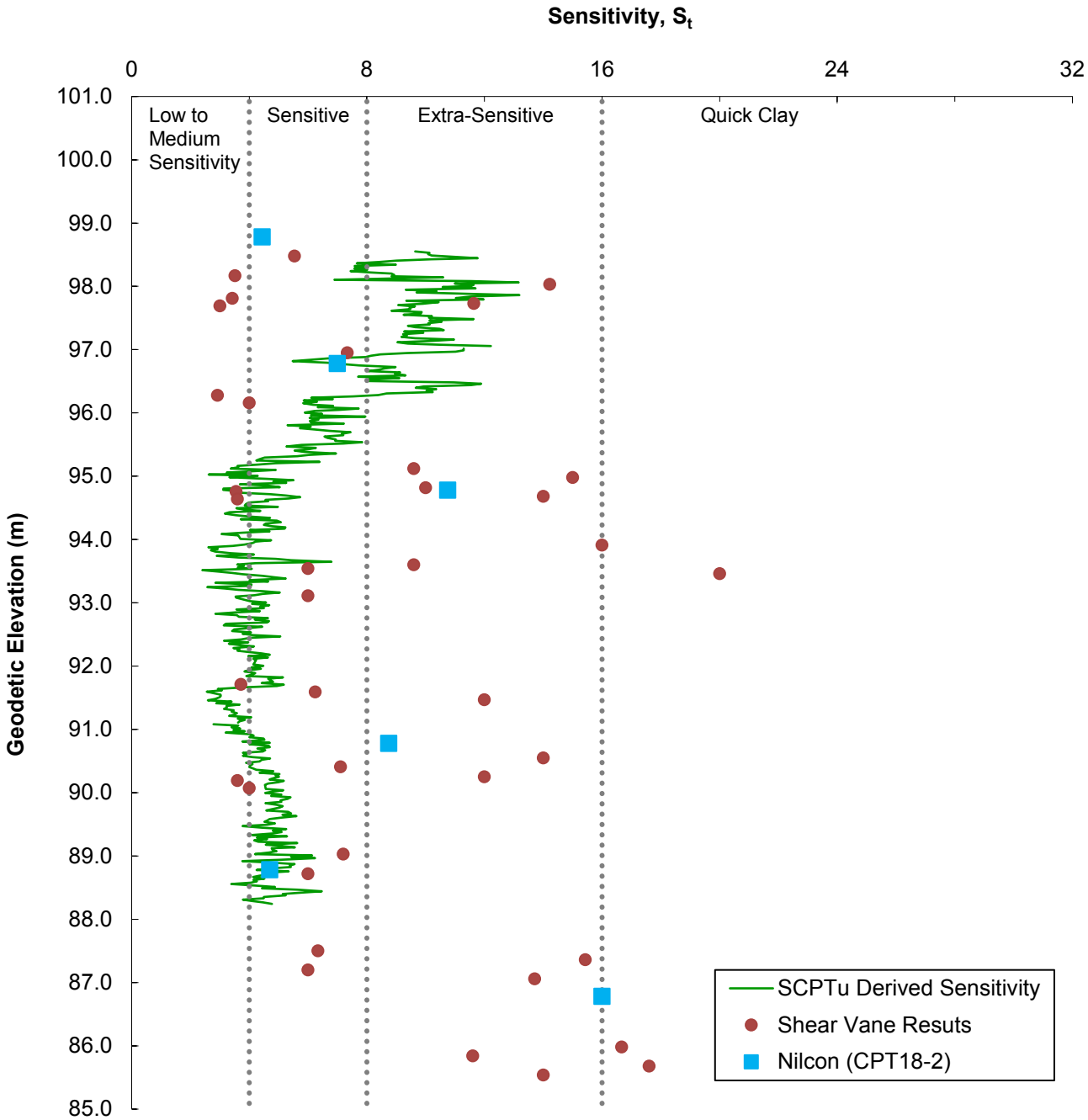


Project No. 121622309

CPT18-1

SCPTu Results

Sensitivity S_t

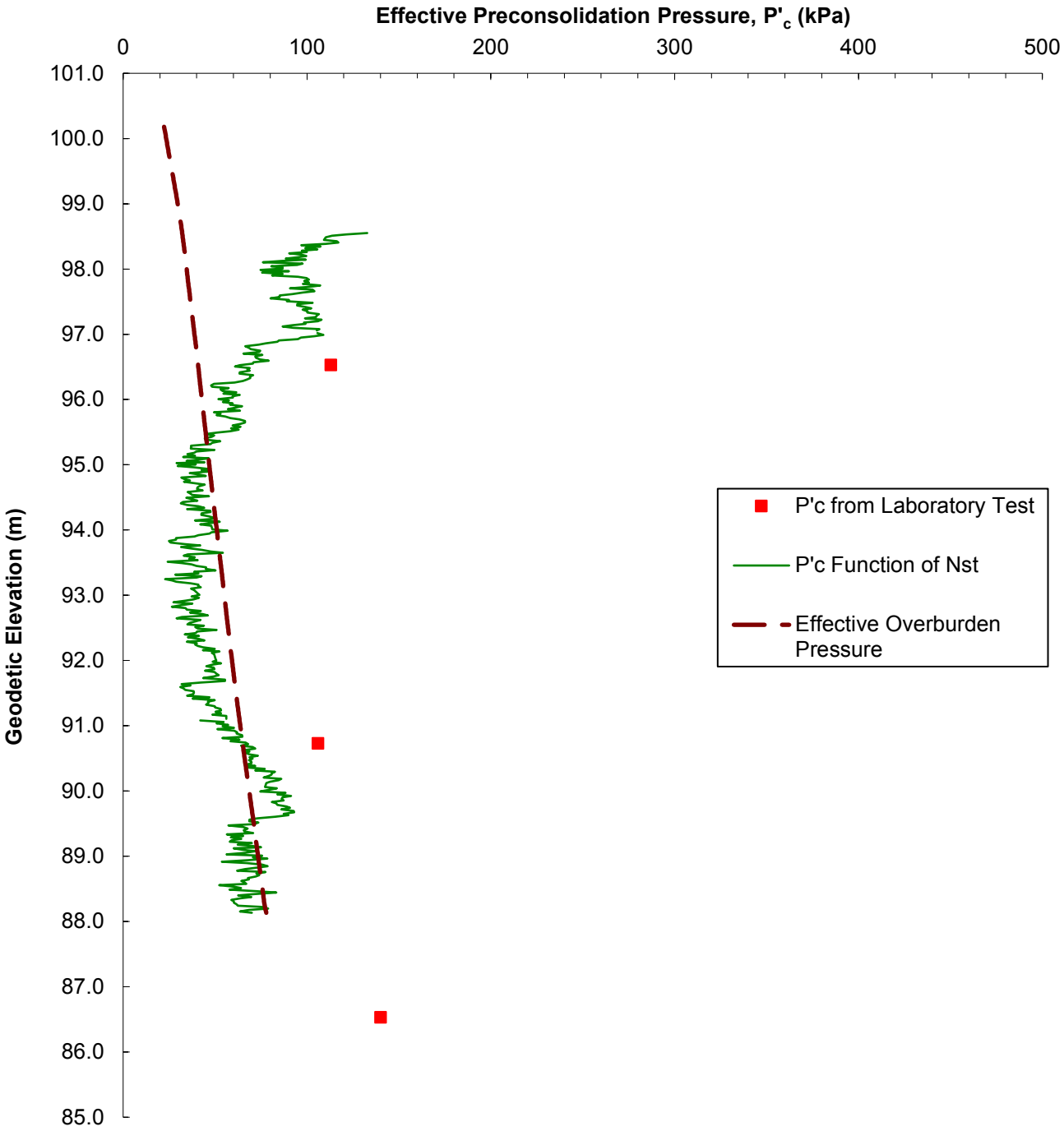


Project No. 121622309

CPT18-1

SCPTu Results

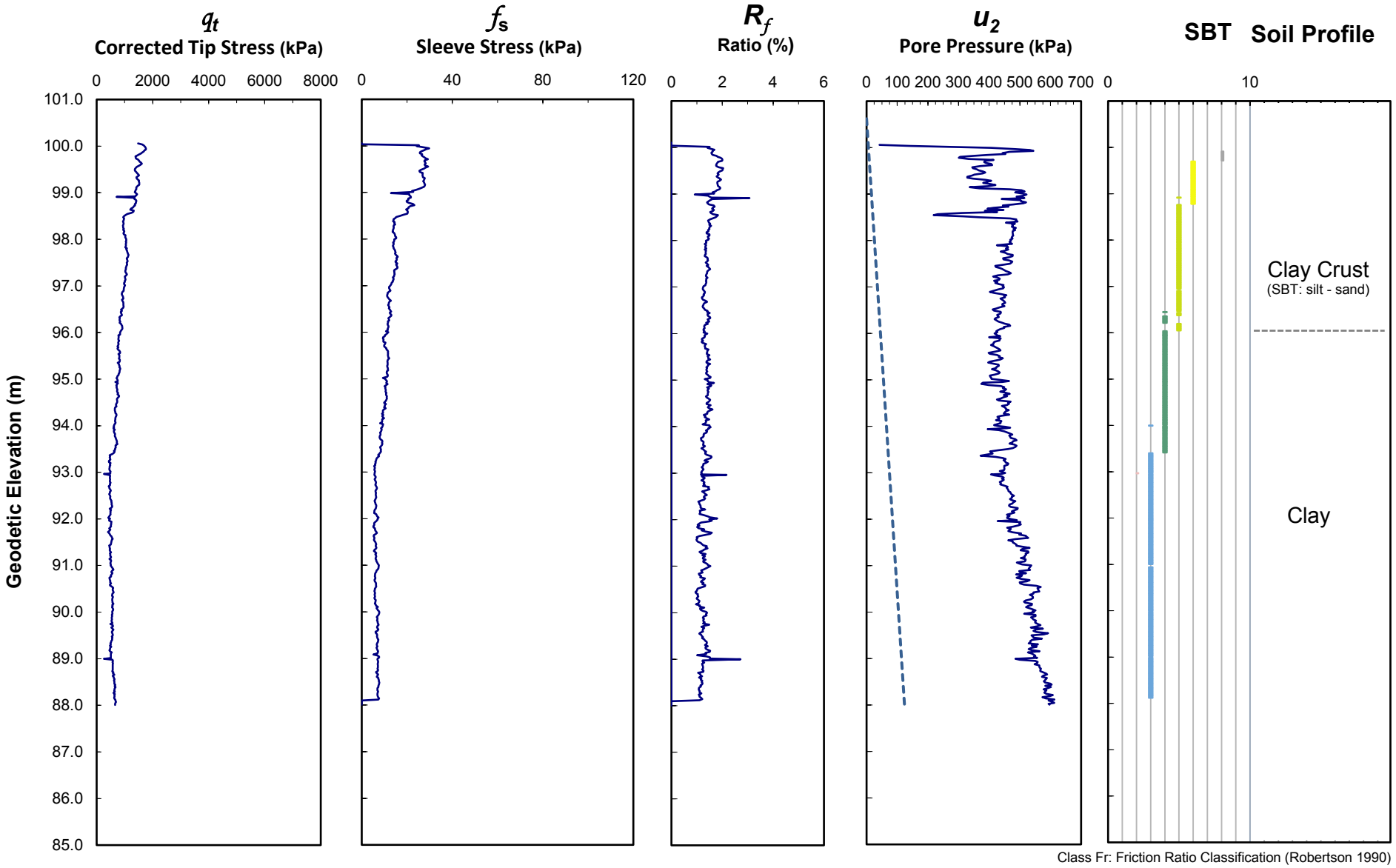
Preconsolidation Pressure, P'_c



Project No. 121622309

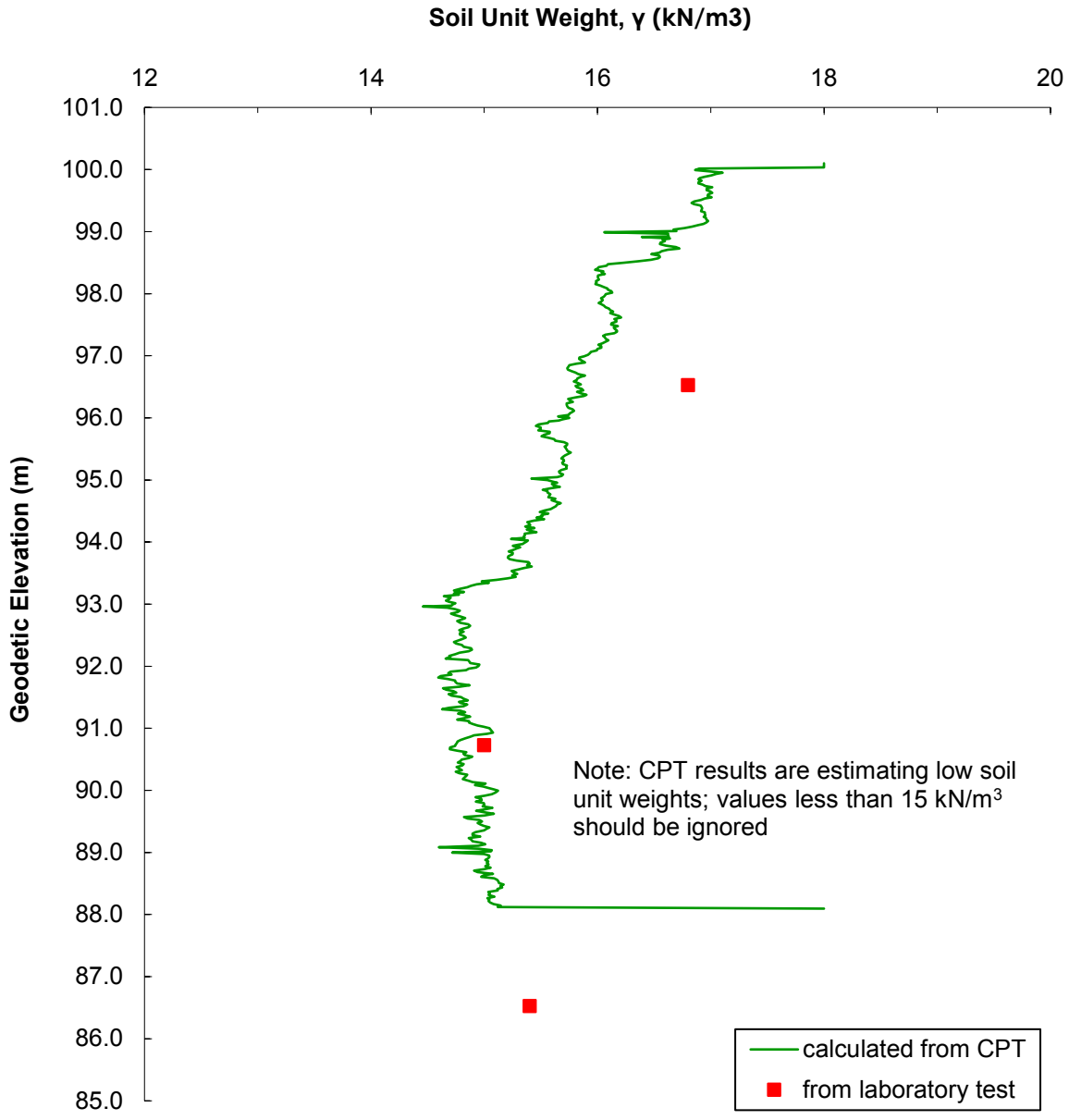
CPT18-1

Stantec	Elevation: 101.62 m SCPTu Start Elevation: 100.10 m Groundwater Elevation: 100.62 m	Date : November 5, 2018 Project Number: 121622309	CPT18-2
	Client : Public Works and Government Services Canada (PWGSC) Projet : PCA Artifact Storage Facility - 555 Avenue des Entreprises, Gatineau, QC		



SCPTu Results

Soil Unit Weight, γ

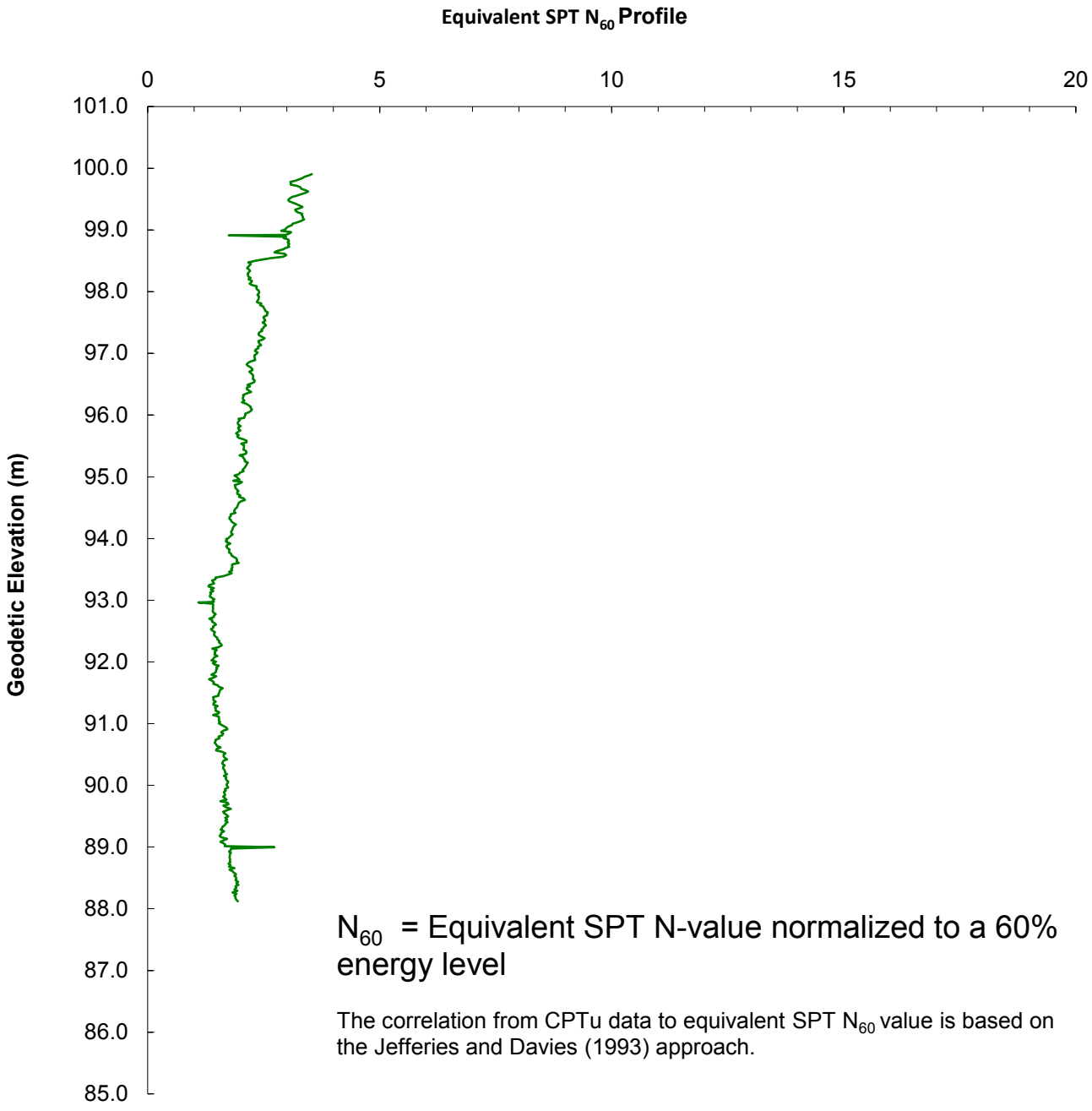


Project No. 121622309

CPT18-2

SCPTu Results

SCPTu N_{60} Values



N_{60} = Equivalent SPT N-value normalized to a 60% energy level

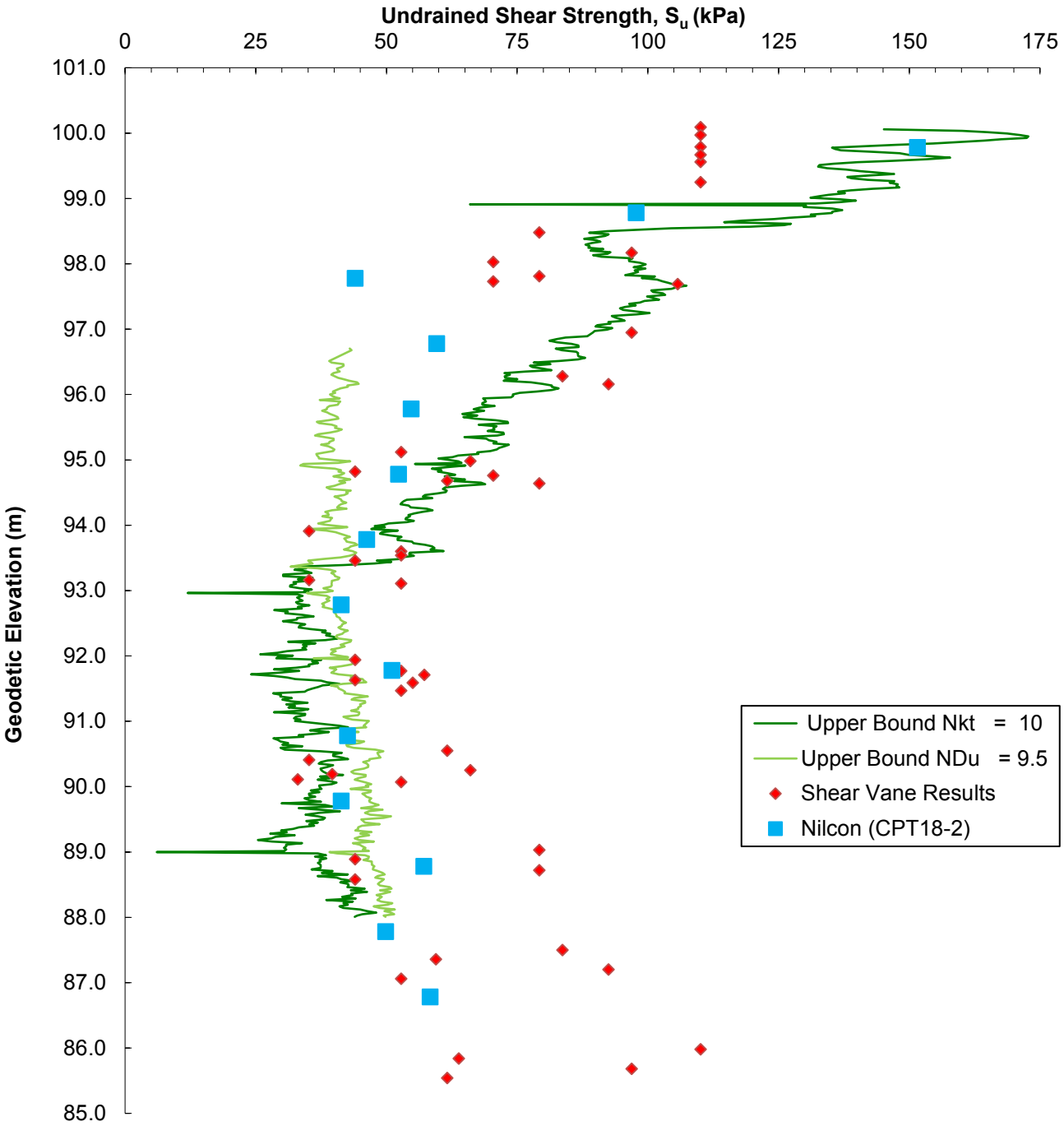
The correlation from CPTu data to equivalent SPT N_{60} value is based on the Jefferies and Davies (1993) approach.

Project No. 121622309

CPT18-2

SCPTu Results

Undrained Shear Strength, S_u

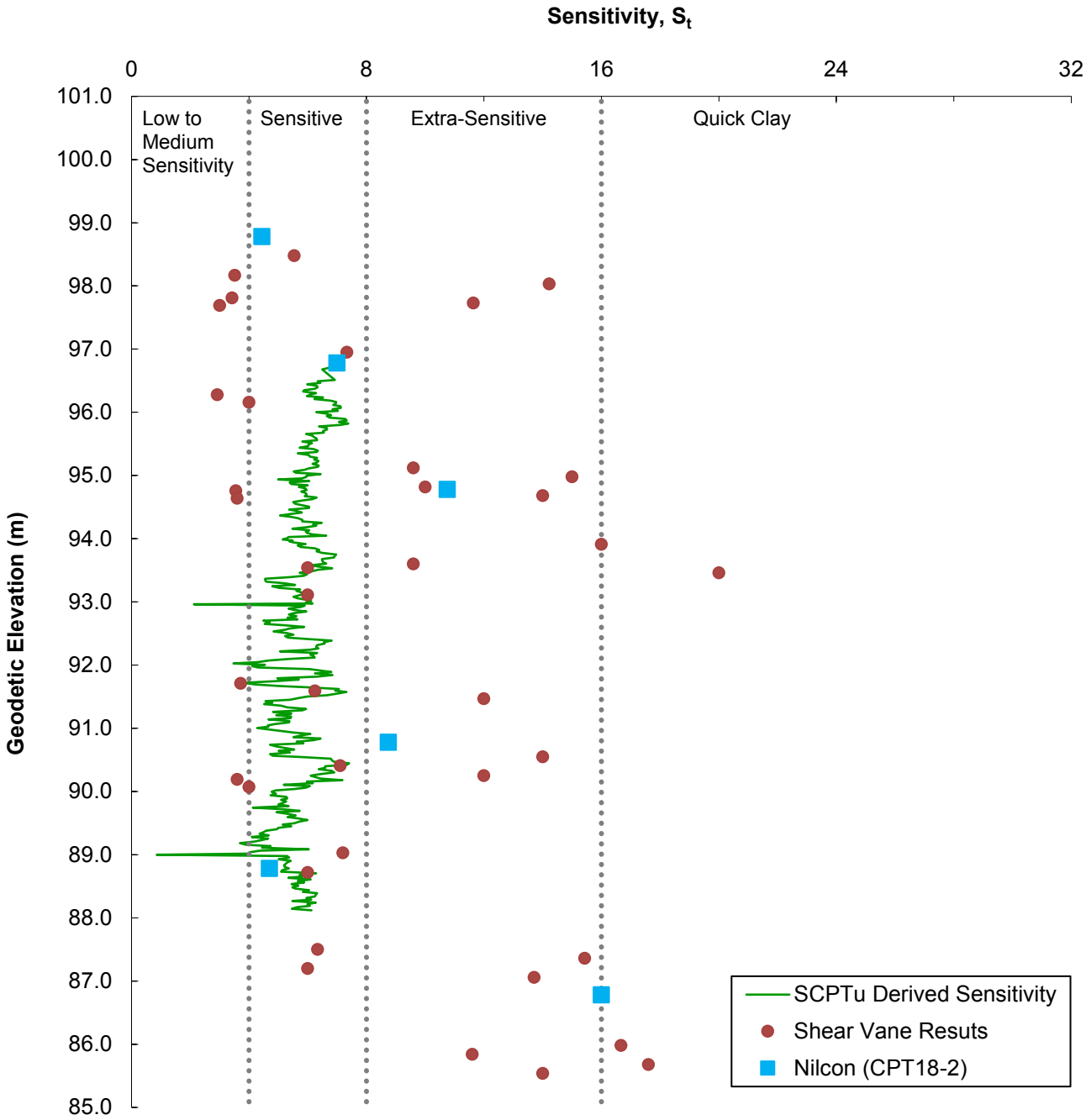


Project No. 121622309

CPT18-2

SCPTu Results

Sensitivity S_t

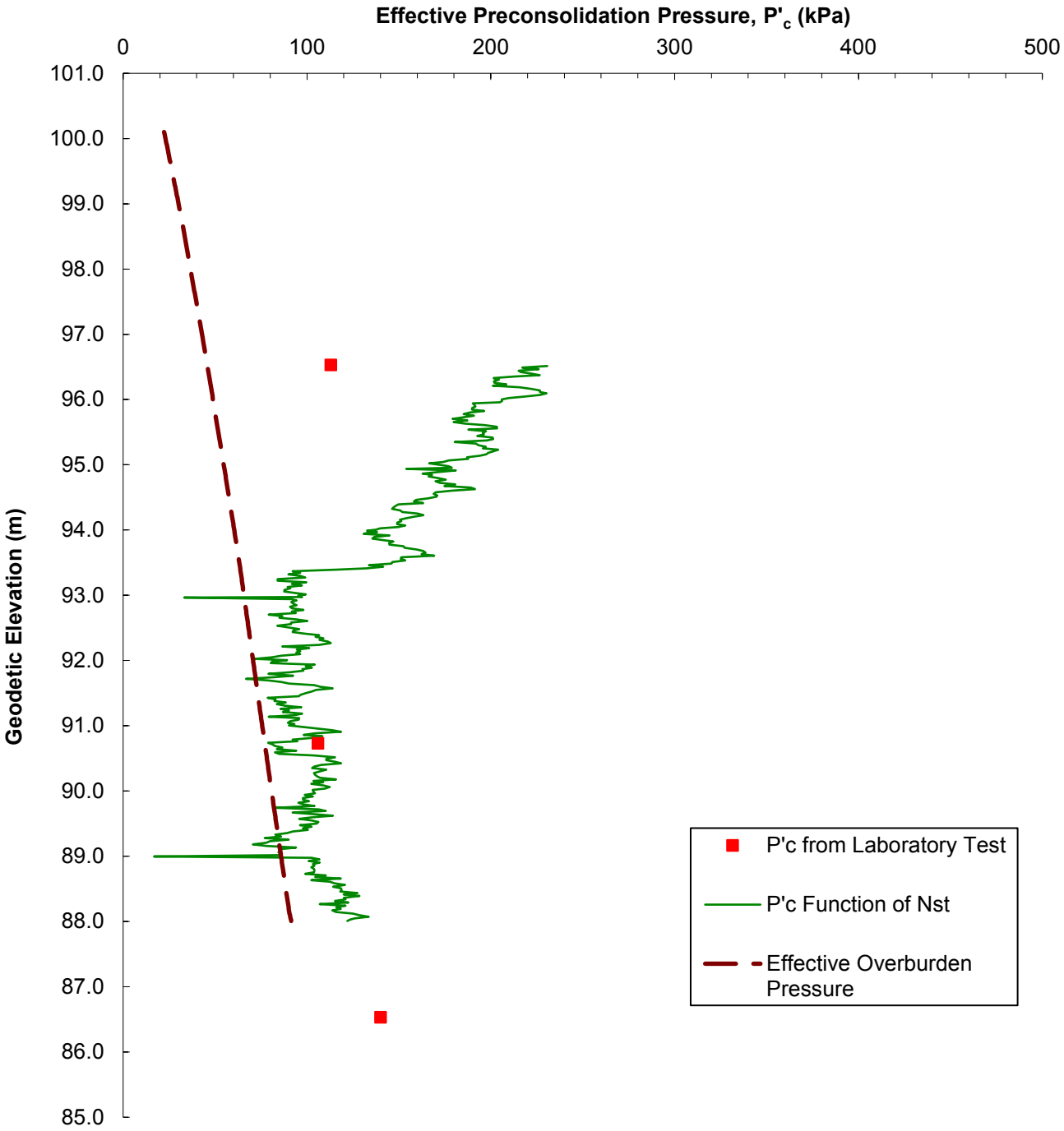


Project No. 121622309

CPT18-2

SCPTu Results

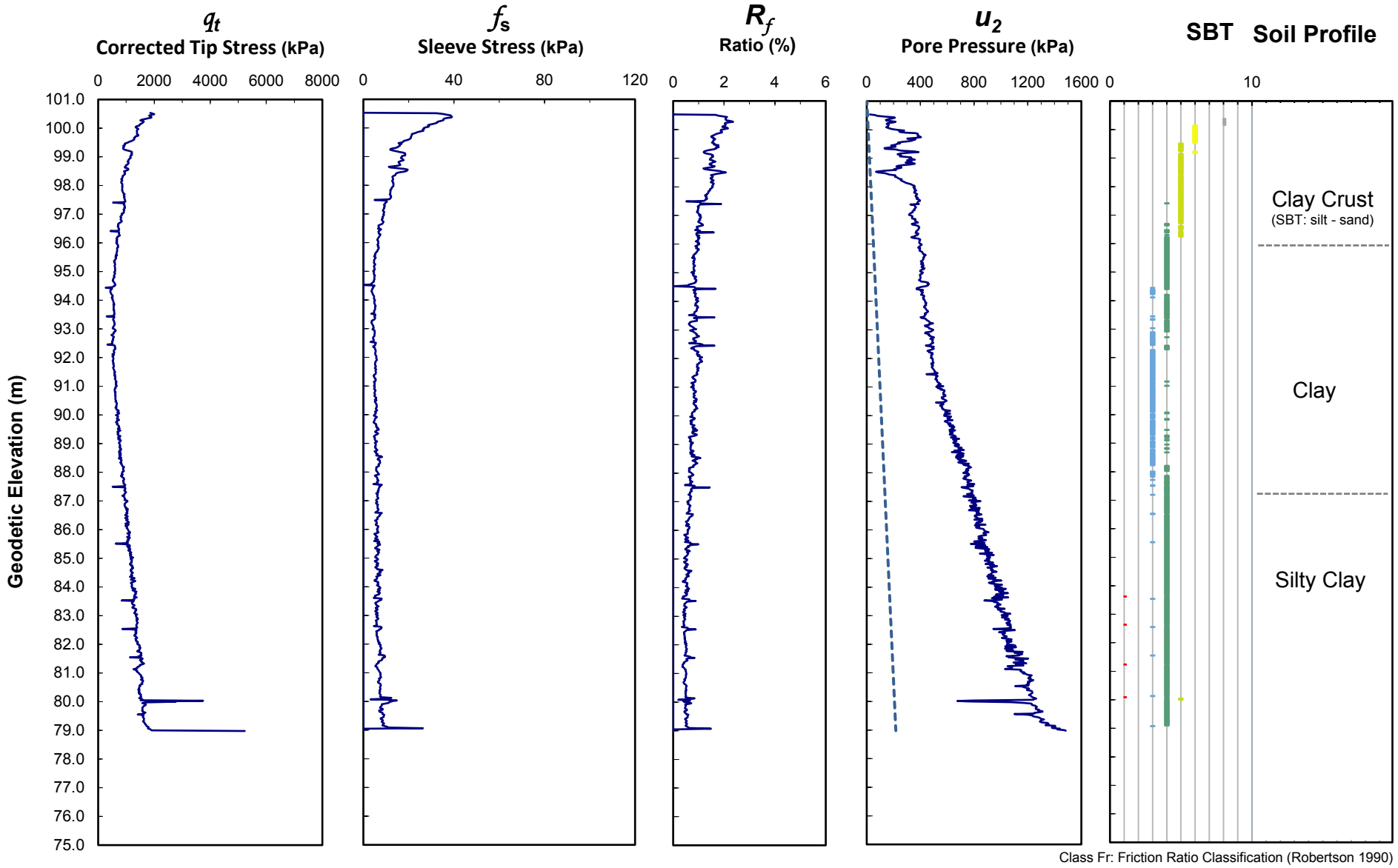
Preconsolidation Pressure, P'_c



Project No. 121622309

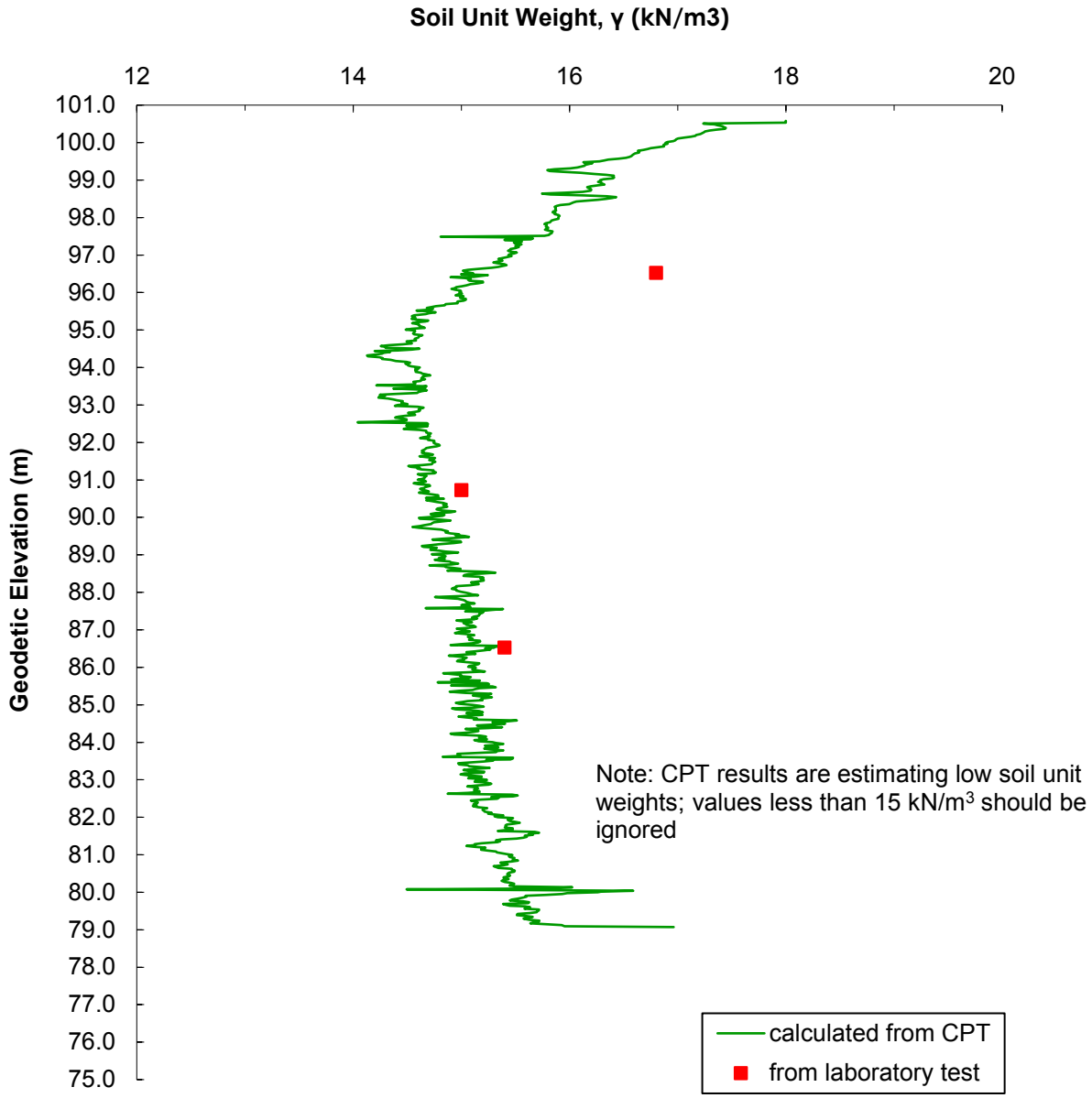
CPT18-2

Stantec	Elevation: 102.10 m SCPTu Start Elevation: 100.58 m Groundwater Elevation: 101.10 m	Date : November 5, 2018 Project Number: 121622309	CPT18-3
	Client : Public Works and Government Services Canada (PWGSC) Projet : PCA Artifact Storage Facility - 555 Avenue des Entreprises, Gatineau, QC		



SCPTu Results

Soil Unit Weight, γ

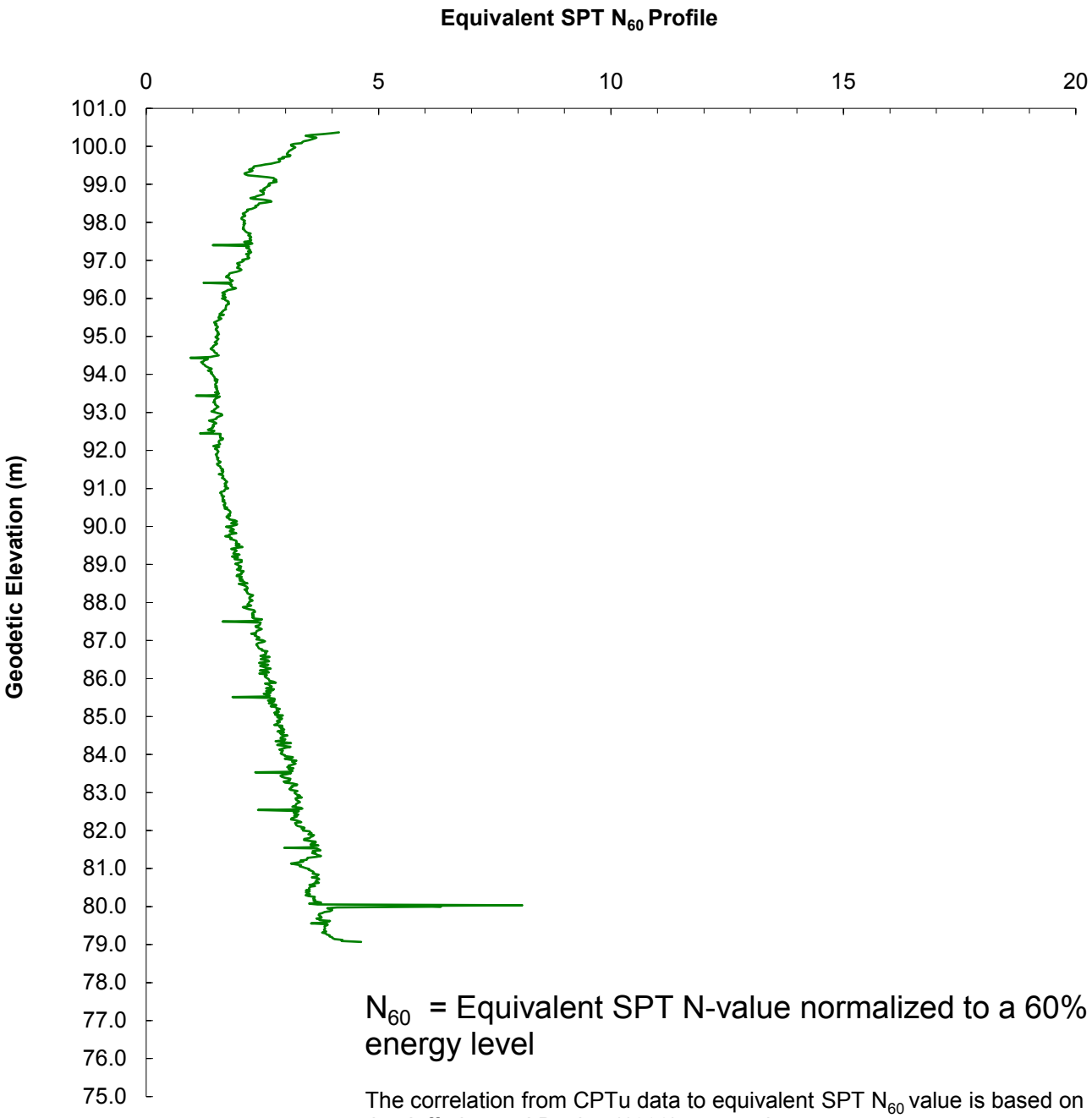


Project No. 121622309

CPT18-3

SCPTu Results

SCPTu N_{60} Values



N_{60} = Equivalent SPT N-value normalized to a 60% energy level

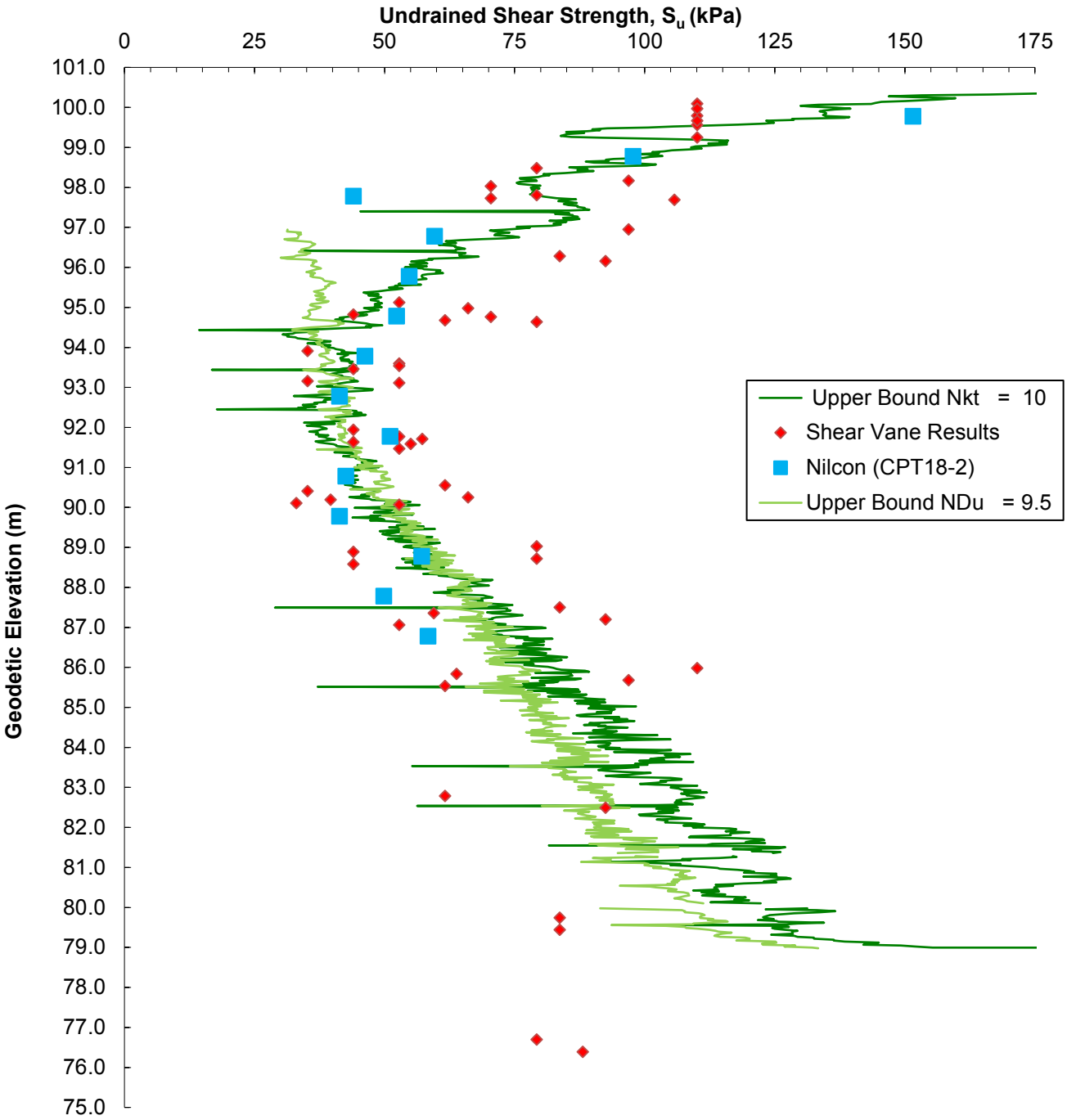
The correlation from CPTu data to equivalent SPT N_{60} value is based on the Jefferies and Davies (1993) approach.

Project No. 121622309

CPT18-3

SCPTu Results

Undrained Shear Strength, S_u

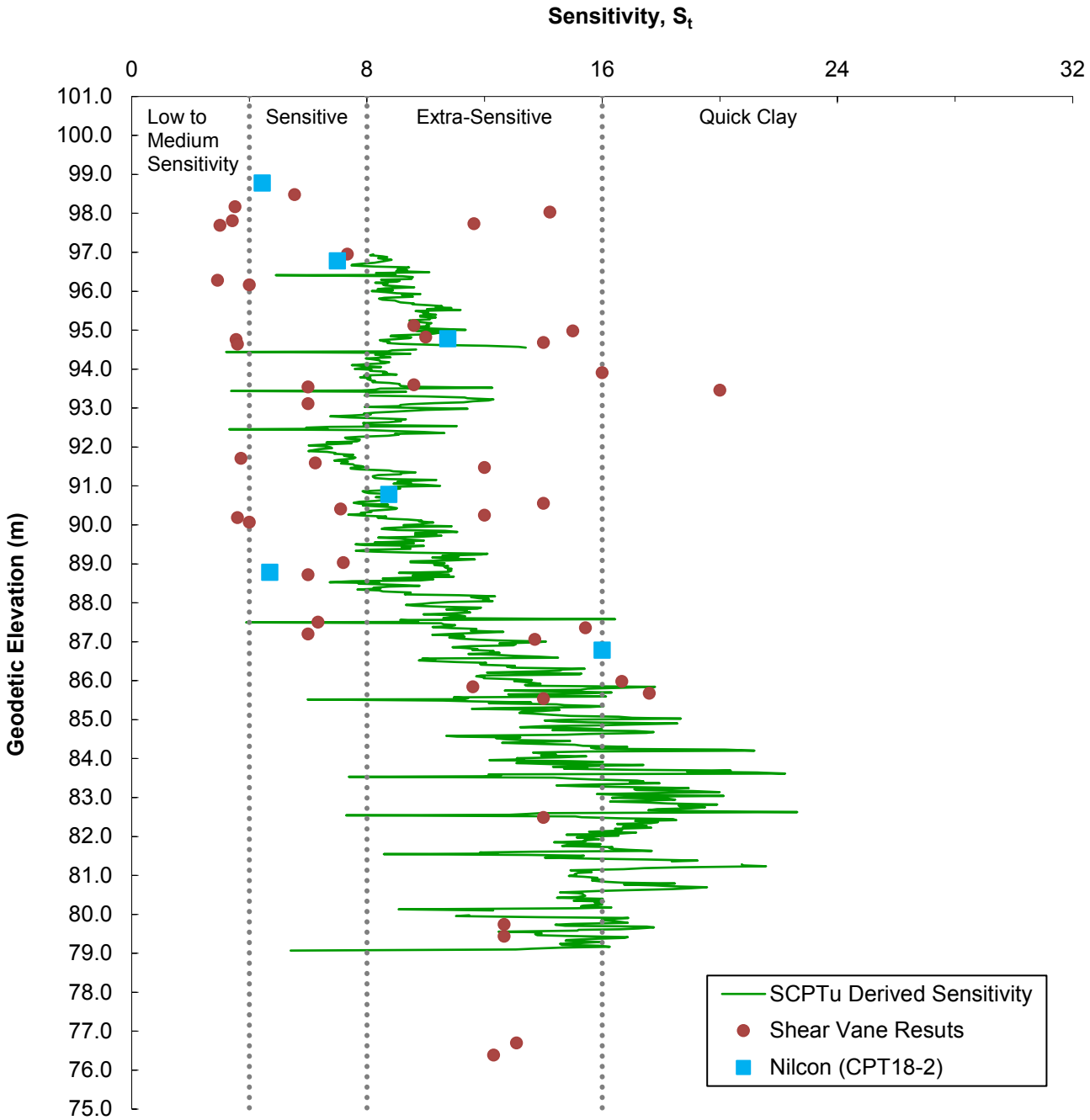


Project No. 121622309

CPT18-3

SCPTu Results

Sensitivity S_t

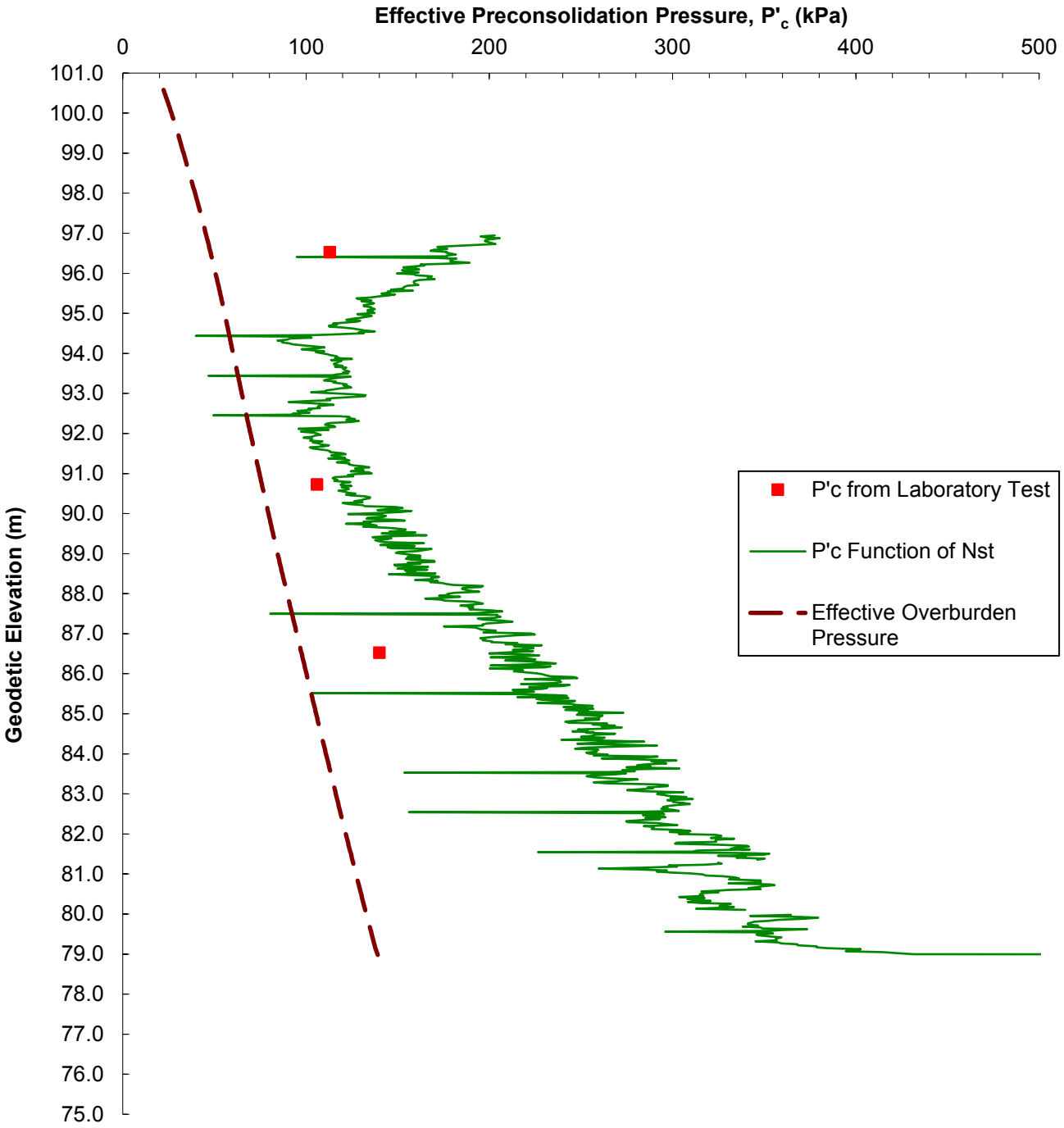


Project No. 121622309

CPT18-3

SCPTu Results

Preconsolidation Pressure, P'_c



Project No. 121622309

CPT18-3

ROCTEST

CALIBRATION DATA SHEET
VIBRATING WIRE PRESSURE TRANSDUCER

Model:	**PWS**
Serial number:	**100D1802554**
Range:	**350 kPa**
Temperature:	**22.2 °C**
Barometric pressure:	**102.6 kPa**
Cable model:	**IRC-41A**
Cable length:	**35 m**
Thermistor type:	**3 kOhms**

Color code: **red & black (coil) green & white (thermistor)**

Applied pressure kPa	Reading linear unit LU	Error linear % FS	Error polynomial % FS
0.50	3959.5	-0.02	-0.01
69.90	3684.1	0.06	0.06
140.00	3404.4	0.04	0.03
210.00	3125.2	0.03	0.01
280.10	2845.5	0.00	0.00
350.00	2566.7	-0.01	0.00
350.10	2566.7	0.02	0.03
279.90	2845.6	-0.05	-0.05
210.00	3124.6	-0.02	-0.03
139.90	3404.0	-0.02	-0.03
70.20	3682.3	0.02	0.02
-0.10	3961.4	-0.06	-0.04
	Maximum error (%):	0.06	0.06

Calculated Pressure:

$$P_c = P - P_T - (S - S_0)$$

P, P_c = Raw pressure and corrected one

P_T = Temperature correction

S_0, S = Barometric pressure at installation and current one

Linear regression	Polynomial regression
$P = C_f (L - L_0)$ $P_T = C_T (T - T_0)$	$P = AL^2 + BL + C'$ (*) $P_T = C_T (T - T_0)$
C_f = -2.5090E-01 kPa / LU C_T = 4.1108E-02 kPa / °C	A = -2.2651E-07 kPa / LU² B = -2.4942E-01 kPa / LU C_T = 4.1108E-02 kPa / °C
L_0 : Initial reading in LU	(*) C' calculation, please refer to instruction manual, § Initial reading
L : Reading in LU ; T_0, T : Temperatures in °C (initial, current)	

Note : LU = Linear Unit with K = 1.0156, use with MB-3TL readout unit

Certificate: 2554,2594.xls

Traceability: TR 12-03

Calibrated by: Dorina Jugureanu

Date: 2018/09/12

ROCTEST

CALIBRATION DATA SHEET
VIBRATING WIRE PRESSURE TRANSDUCER

Model:	**PWS**
Serial number:	**100D1802554**
Range:	**350 kPa**
Temperature:	**22.2 °C**
Barometric pressure:	**102.6 kPa**
Cable model:	**IRC-41A**
Cable length:	**35 m**
Thermistor type:	**3 kOhms**

Color code: **red & black (coil) green & white (thermistor)**

Applied pressure kPa	Reading Frequency Hz	Calculated pressure kPa	Error polynomial % FS
0.50	1974.5	0.53	-0.01
69.90	1904.6	69.68	0.06
140.00	1830.9	139.89	0.03
210.00	1754.2	209.95	0.01
280.10	1673.8	280.11	0.00
350.00	1589.7	349.99	0.00
350.10	1589.7	349.99	0.03
279.90	1673.9	280.08	-0.05
210.00	1754.0	210.11	-0.03
139.90	1830.8	139.99	-0.03
70.20	1904.1	70.14	0.02
-0.10	1975.0	0.05	-0.04
		Erreur maximum (%) :	0.06

Calculated Pressure:

$$P_c = P - P_T - (S-S_0)$$

P, P_c = Raw pressure and corrected one

P_T = Temperature correction

S_0, S = Barometric pressure at installation and current one

Polynomial regression:

$$P = AL^2 + BL + C$$
$$P_T = C_T (T - T_0)$$

A = -2.5749E-04
B = 9.5557E-03
C = 985.54
C_T = 4.1149E-02 (kPa/°C)

L : Reading in Hz ; T_0, T : Temperatures in °C (initial, current)

Note: These calibration factors must be used with Minilogger or Quattrologger

Certificate: 2554,2594_Hz.xls

Traceability: TR 12-03

Calibrated by: Dorina Jugureanu

Date: 2018/09/12

Stantec

BOREHOLE RECORD

BH09-1

CLIENT Public Works and Government Services Canada — BOREHOLE No. BH09-1

LOCATION 555 Avenue des Enterprises, Gatineau, QC — PROJECT No. 1049643

DATES: BORING March 17, 2009 — WATER LEVEL — DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N-VALUE OR RQD
0	**102.20**							
	102.1	145 mm CONCRETE						
	101.8	FILL: Grey crushed gravel		▽	BS	1	---	---
		FILL: Brown sand with silt and gravel						
1	101.2	Very stiff, grey fat CLAY (CH)			SS	2	300	16
					SS	3	500	14
2								
	99.6				SS	4	400	3
		Firm to stiff, grey fat CLAY (CH)						
3								
4					ST	5	610	---
					SS	6	600	2
5								
6					SS	7	600	2
7								
8					ST	8	610	---
9								
10								

UNDRAINED SHEAR STRENGTH - kPa

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m ★

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90

▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

■ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

STN13-STAN-GEO 1049643.GPJ SMART.GDT 1/9/19

Stantec

BOREHOLE RECORD

BH09-1

CLIENT Public Works and Government Services Canada — BOREHOLE No. BH09-1

LOCATION 555 Avenue des Enterprises, Gatineau, QC — PROJECT No. 1049643

DATES: BORING March 17, 2009 — WATER LEVEL — DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N-VALUE OR RQD
10		Soft to firm, grey fat CLAY (CH)						
11					SS	9	600	5
12								
13								
14					SS	10	600	2
15								
16					ST	11	610	---
17								
18								
19					SS	12	600	2
20								

UNDRAINED SHEAR STRENGTH - kPa

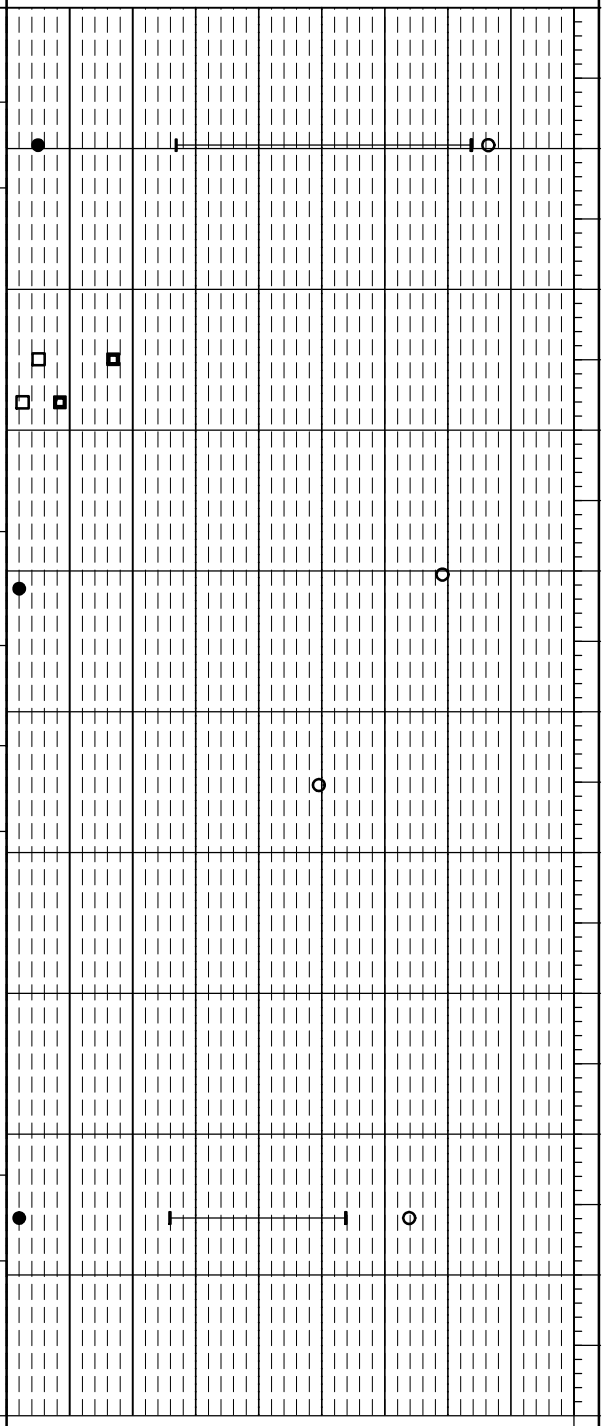
50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m

STANDARD PENETRATION TEST, BLOWS/0.3m

10 20 30 40 50 60 70 80 90



▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

■ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

Stantec

BOREHOLE RECORD

BH09-1

CLIENT Public Works and Government Services Canada — BOREHOLE No. BH09-1

LOCATION 555 Avenue des Enterprises, Gatineau, QC — PROJECT No. 1049643

DATES: BORING March 17, 2009 — WATER LEVEL — DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N-VALUE OR RQD
20		Soft to firm, grey fat CLAY (CH)						
21		- becoming stiff			SS	13	600	12
22								
23	79.3	Compact, grey sandy SILT (ML) with gravel TILL			SS	14	600	16
24	78.7	End of Borehole						
25								
26								
27								
28								
29								
30								

UNDRAINED SHEAR STRENGTH - kPa

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m

STANDARD PENETRATION TEST, BLOWS/0.3m

10 20 30 40 50 60 70 80 90

▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

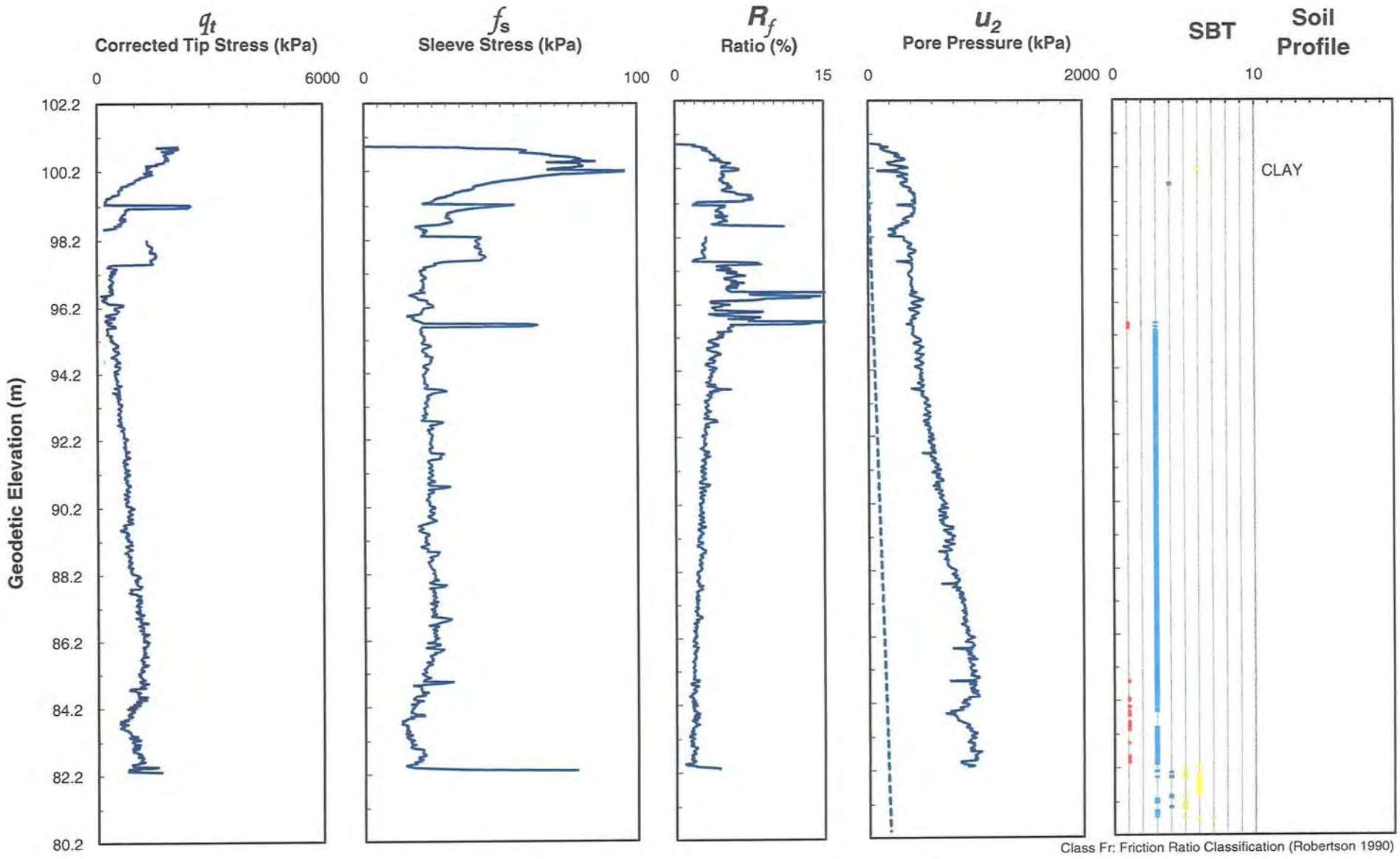
■ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

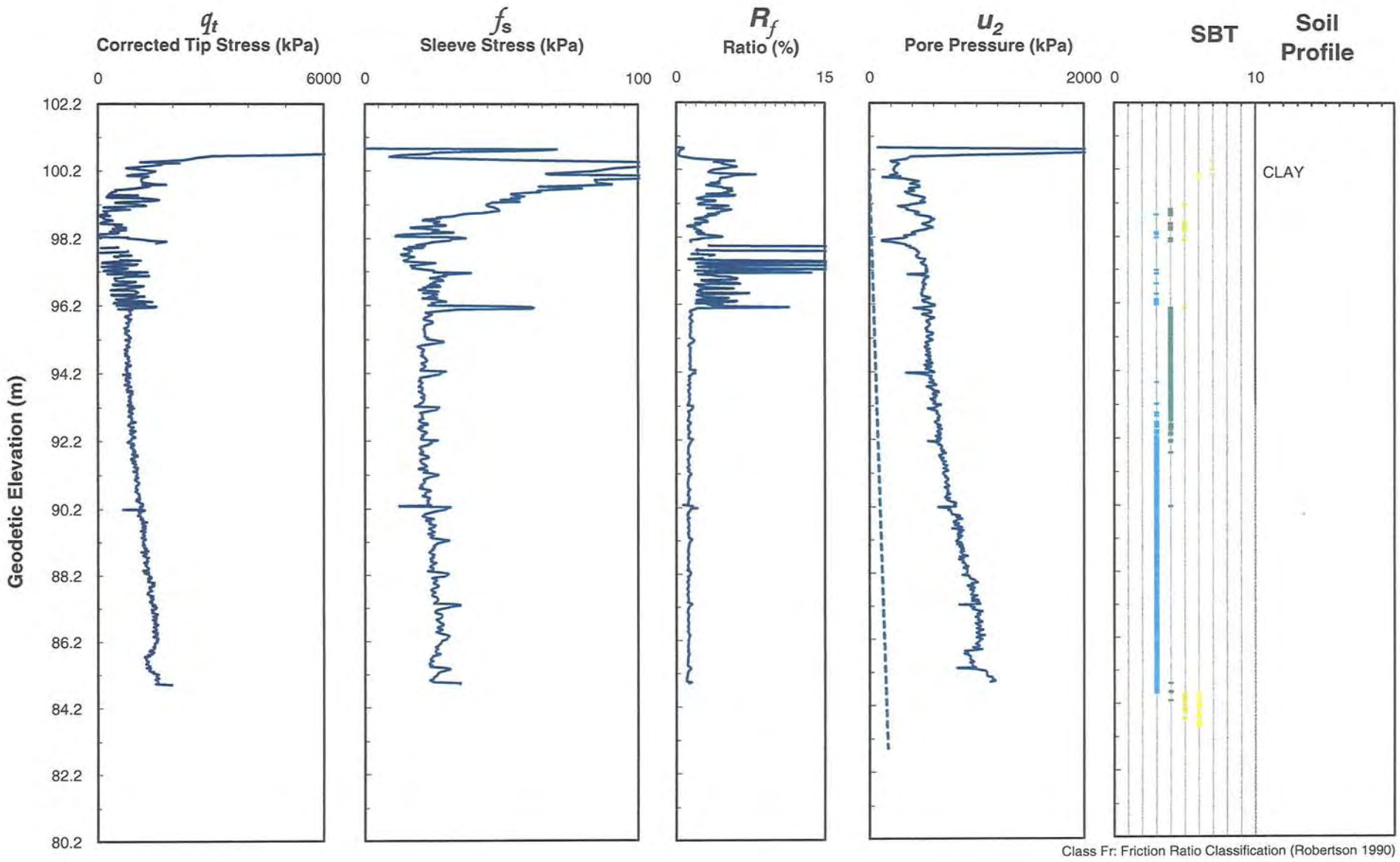
△ Pocket Penetrometer Test, kPa

STN13-STAN-GEO 1049643.GPJ SMART.GDT 1/9/19

Jacques Whitford Stantec Limited	Elevation: 102.20 m SCPTu Start Elevation: 100.98 m Groundwater Elevation: 100.20 m	Test Date: March 18, 2009 Project No. 1049643	CPT09-2
	Client: PWGSC Project: Archives Canada		

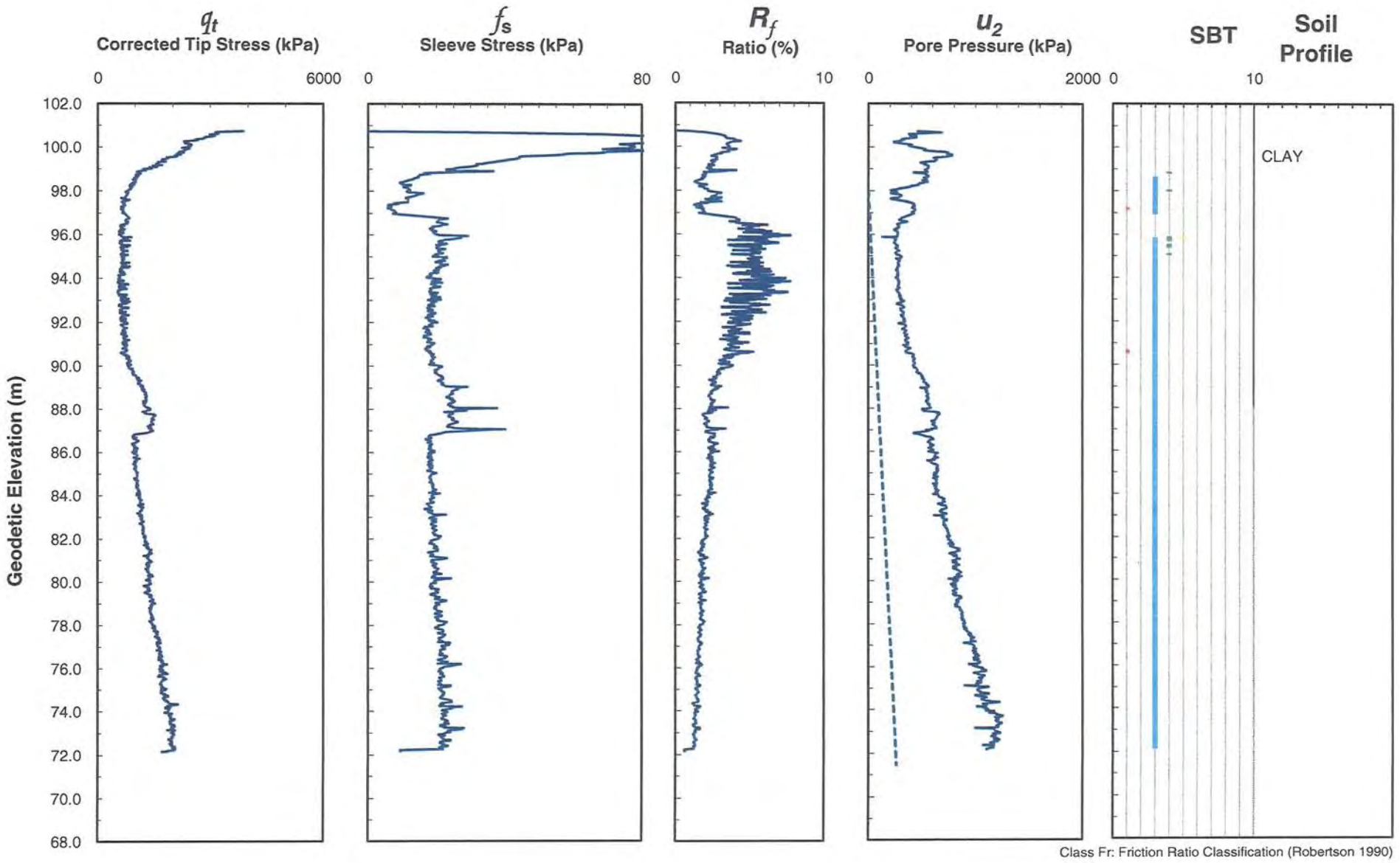


Jacques Whitford Stantec Limited	Elevation: 102.14 m SCPTu Start Elevation: 100.92 m Groundwater Elevation: 100.14 m	Test Date: March 19, 2009 Project No. 1049643	CPT09-3
	Client: PWGSC Project: Archives Canada		



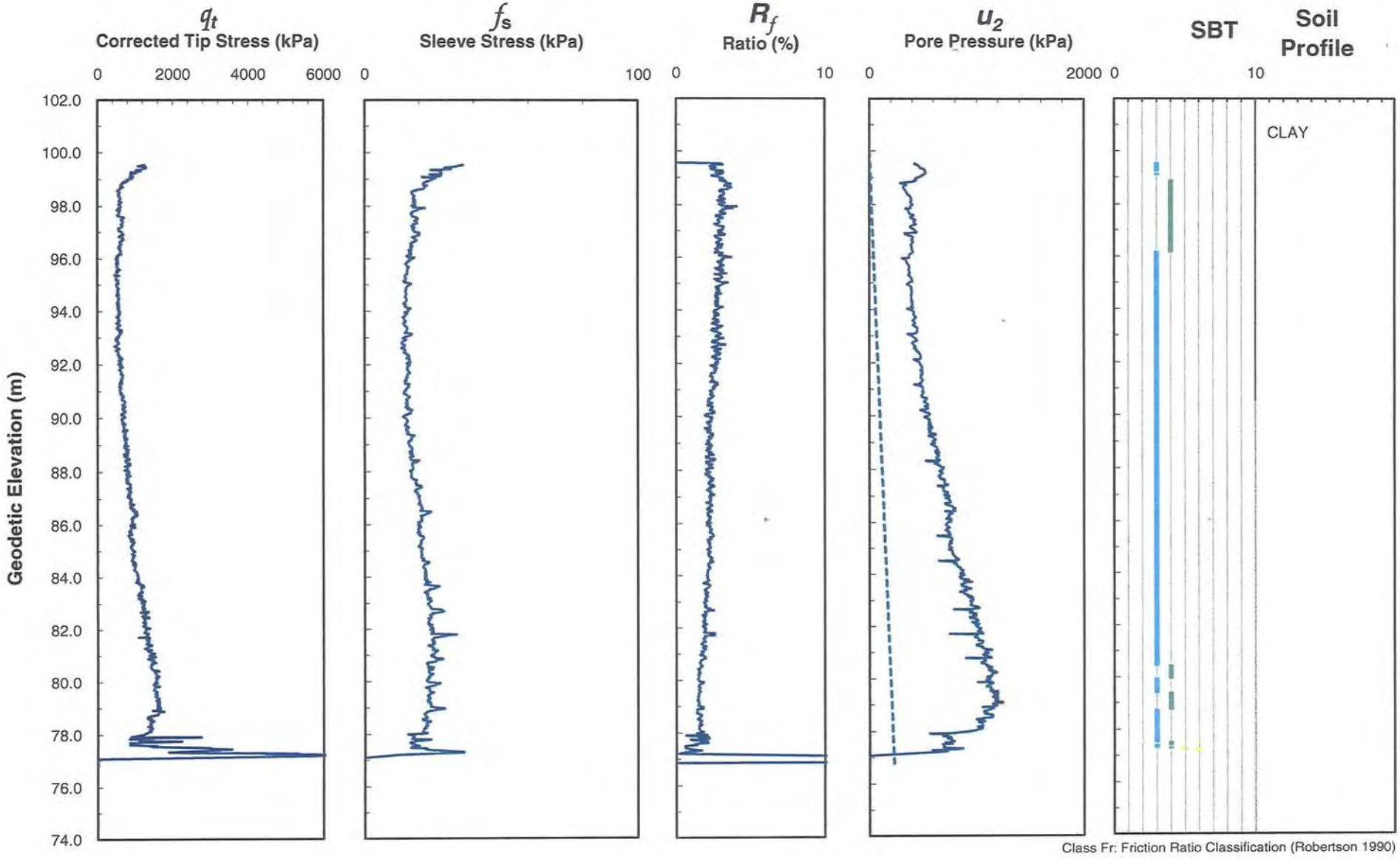
Class Fr: Friction Ratio Classification (Robertson 1990)

Jacques Whitford **Stantec Limited** Stantec	Elevation: 102.01 m SCPTu Start Elevation: 100.79 m Groundwater Elevation: 98.01 m	Test Date: March 18, 2009 Project No. 1049643	CPT09-4
	Client: PWGSC Project: Archives Canada		



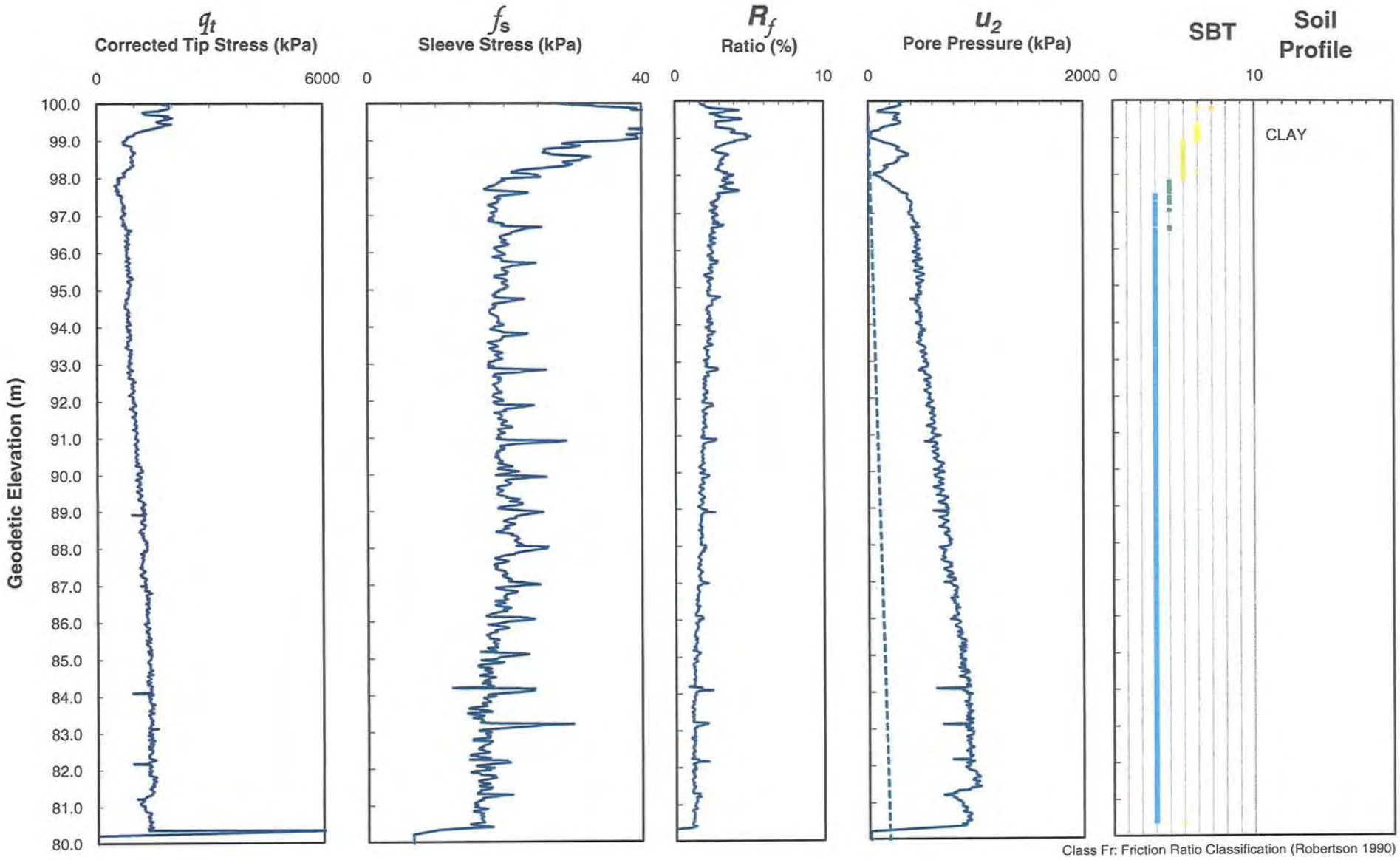
Class Fr: Friction Ratio Classification (Robertson 1990)

Jacques Whitford **Stantec Limited** Stantec	Elevation: 102.04 m SCPTu Start Elevation: 100.82 m Groundwater Elevation: 100.04 m	Test Date: March 18, 2009 Project No. 1049643	CPT09-5
	Client: PWGSC Project: Archives Canada		



Class Fr: Friction Ratio Classification (Robertson 1990)

Jacques Whitford Stantec Limited	Elevation: 101.61 m SCPTu Start Elevation: 100.39 m Groundwater Elevation: 99.61 m	Test Date: March 18, 2009 Project No. 1049643	CPT09-6
	Client: PWGSC Project: Archives Canada		



Stantec

Piezocone Interpretations
Undrained Shear Strength (S_u)

The following are three common relationships used to estimate the undrained shear strength (S_u) of a soil based on piezocone data.

Method 1 (most commonly used)

$$S_u = (q_t - \sigma_{vo}) / N_{kt}$$

Where q_t is the corrected tip pressure
σ_{vo} is the total overburden pressure
$q_t = q_c + u_2 * (1-a)$
q_c = tip stress
u_2 is the pore pressure response to the tip being pushed through the soil

Method 2

$$S_u = (q_c - \sigma_{vo}) / N_k$$

Method 3

$$S_u = (u_2 - u_0) / N_{DU}$$

Where u_0 is the static groundwater pressure

N_{kt}, N_k, and N_{DU} are cone factors which are specific to a site and is locally adjusted to match the S_u values measured while carrying out in situ field vane testing.

N_{kt} Typically ranges between 10 and 20 in Champlain Sea Clays. Stantec has found ranges of 9 to 11 to be typical in the Ottawa to Montreal area.

N_k Lunne and Kleven suggest values of 11 to 19 for normally consolidated marine clays.

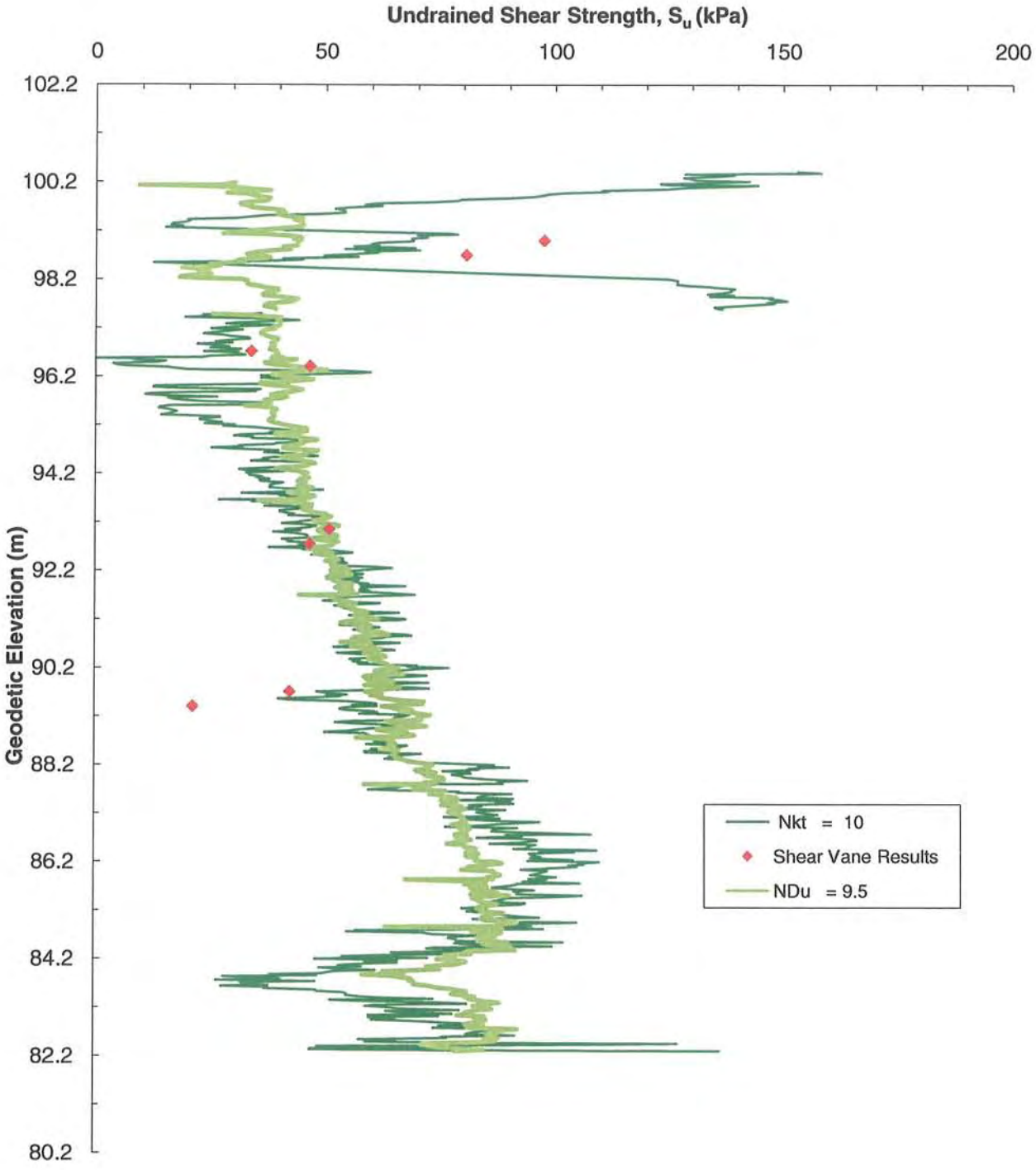
N_{DU} Larochelle et al. suggests 7 to 9 for Canadian Clays if OCR is between 1.2 and 50.

Although Method 1 is most commonly used, Method 2 is frequently used when measured pore pressure u_2 values are suspect. Likewise, Method 3 is frequently used when q_c values are suspect.

Stantec

SCPTu RESULTS

Undrained Shear Strength, S_u



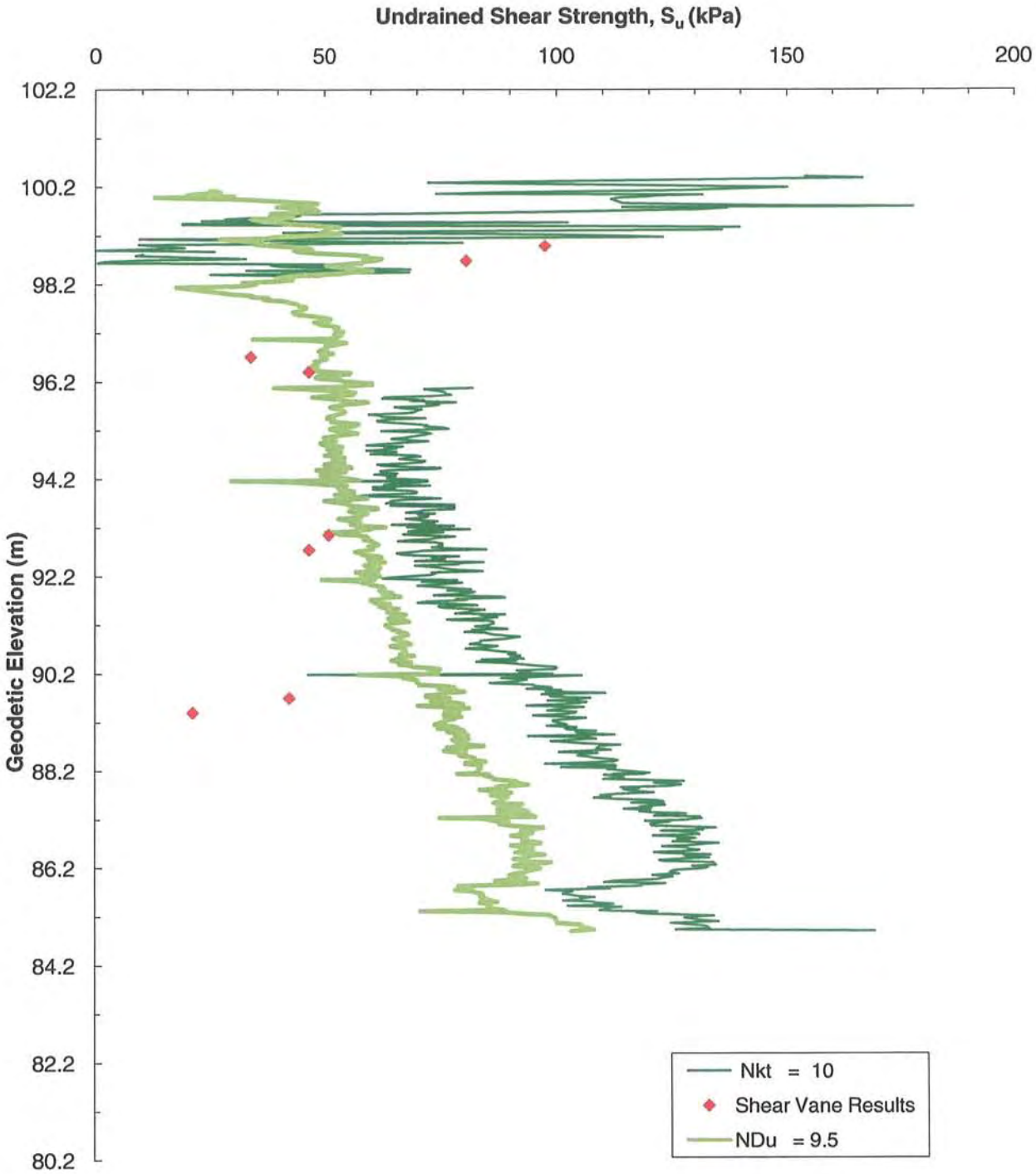
Project No. 1049643

CPT09-2

Stantec

SCPTu RESULTS

Undrained Shear Strength, S_u



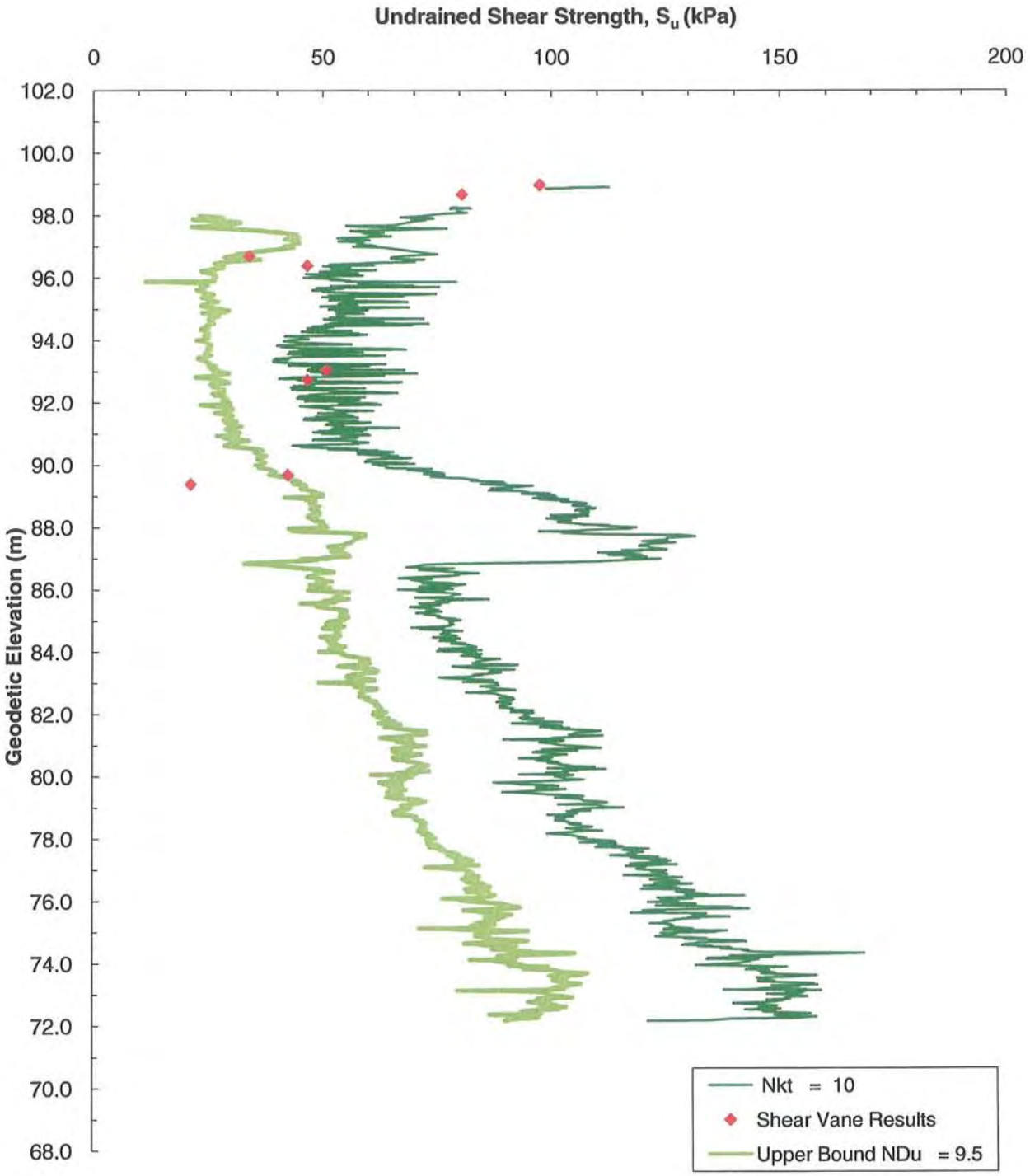
Project No. 1049643

CPT09-3

Stantec

SCPTu RESULTS

Undrained Shear Strength, S_u



Project No. 1049643

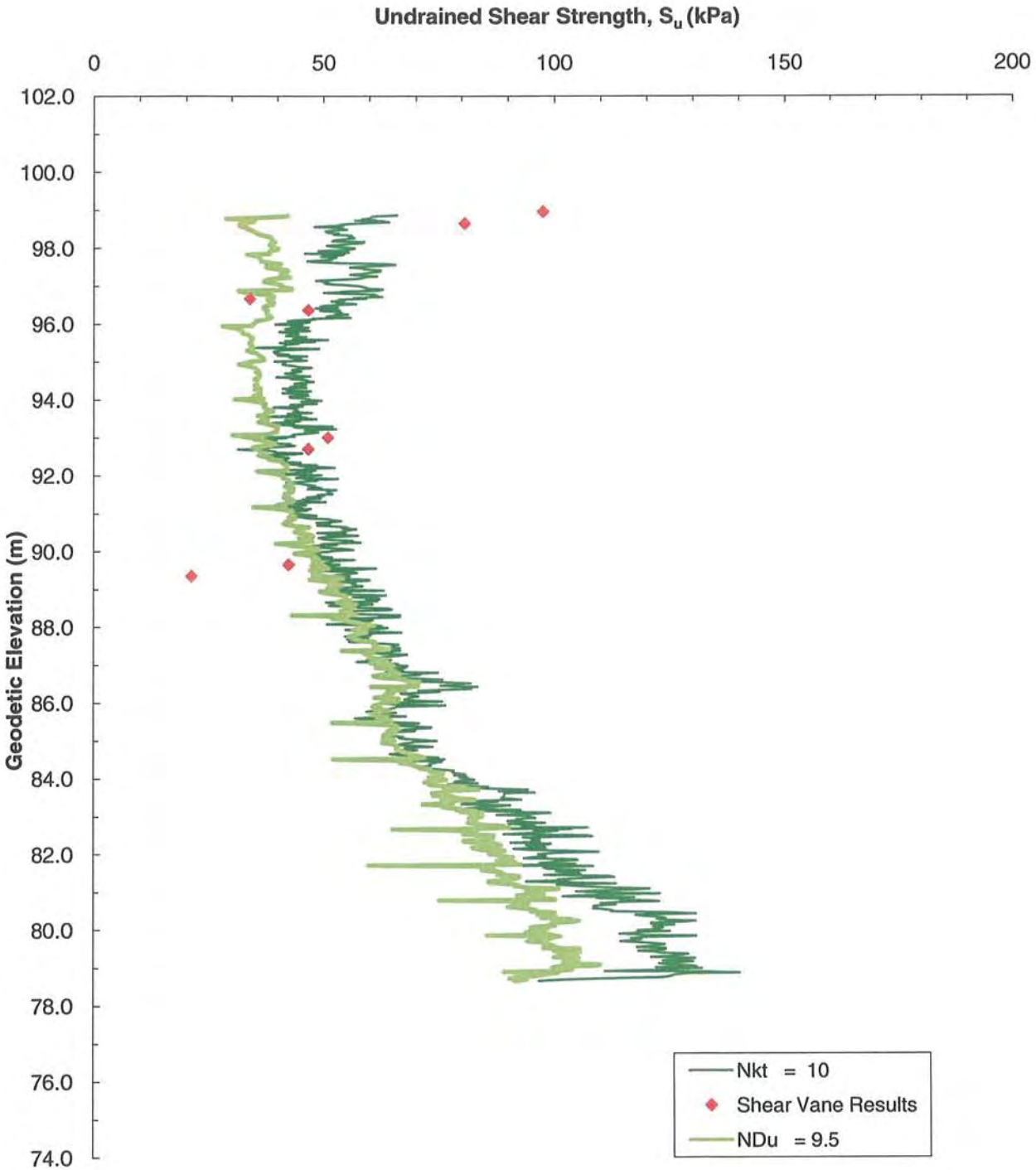
CPT09-4

P:\2009\1049643\CPT\STATIC SCPTu CPT09-4b

Stantec

SCPTu RESULTS

Undrained Shear Strength, S_u



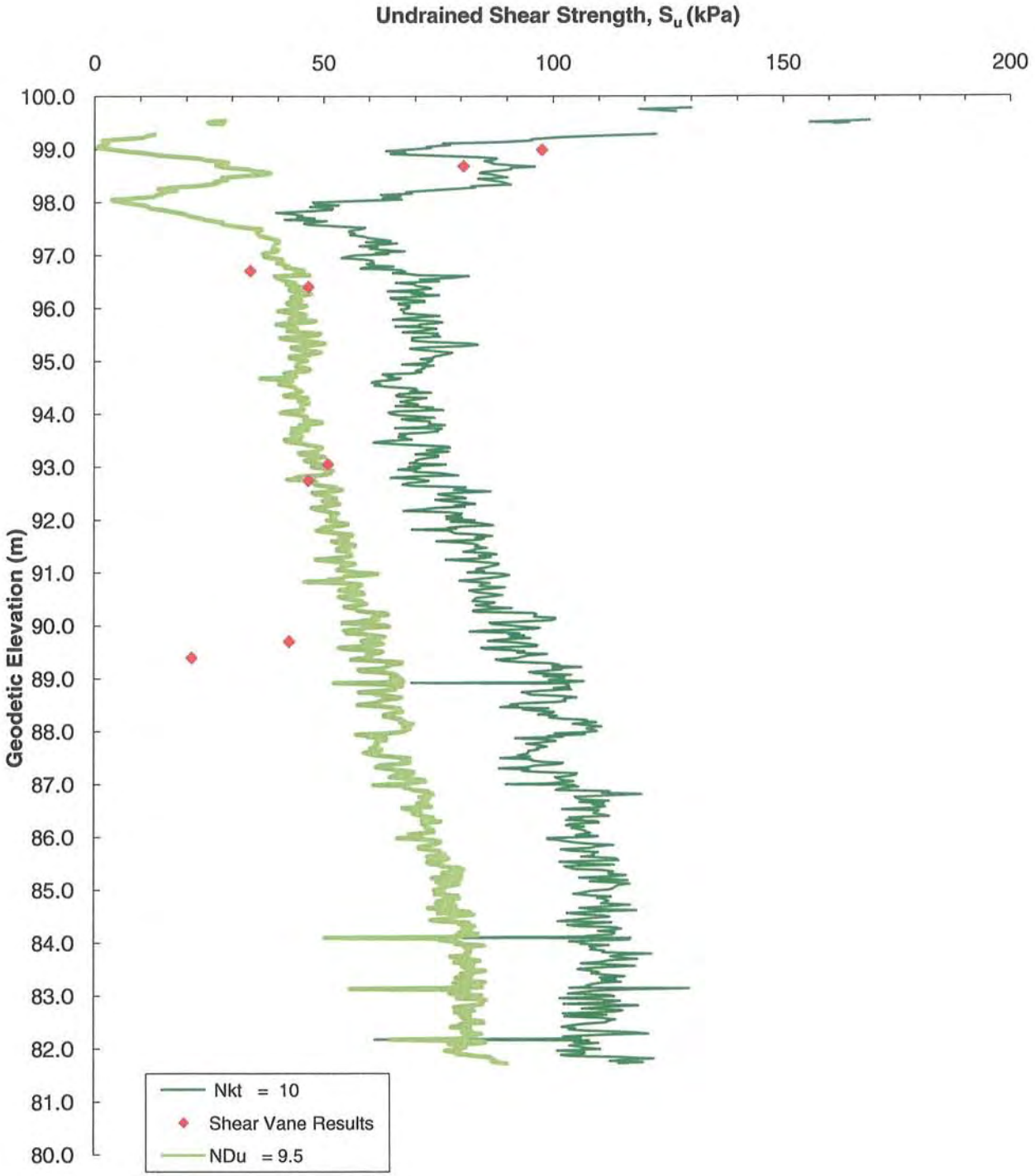
Project No. 1049643

CPT09-5

Stantec

SCPTu RESULTS

Undrained Shear Strength, S_u



Project No. 1049643

CPT09-6

Stantec

Piezocone Interpretations
Sensitivity (S_t) of Clays

The following relationship is used to estimate the sensitivity of clays from piezocone data.

$$S_t = S_u / f_s$$

Where S_u is the piezocone derived undrained shear strength
f_s is the measure piezocone sleeve stress

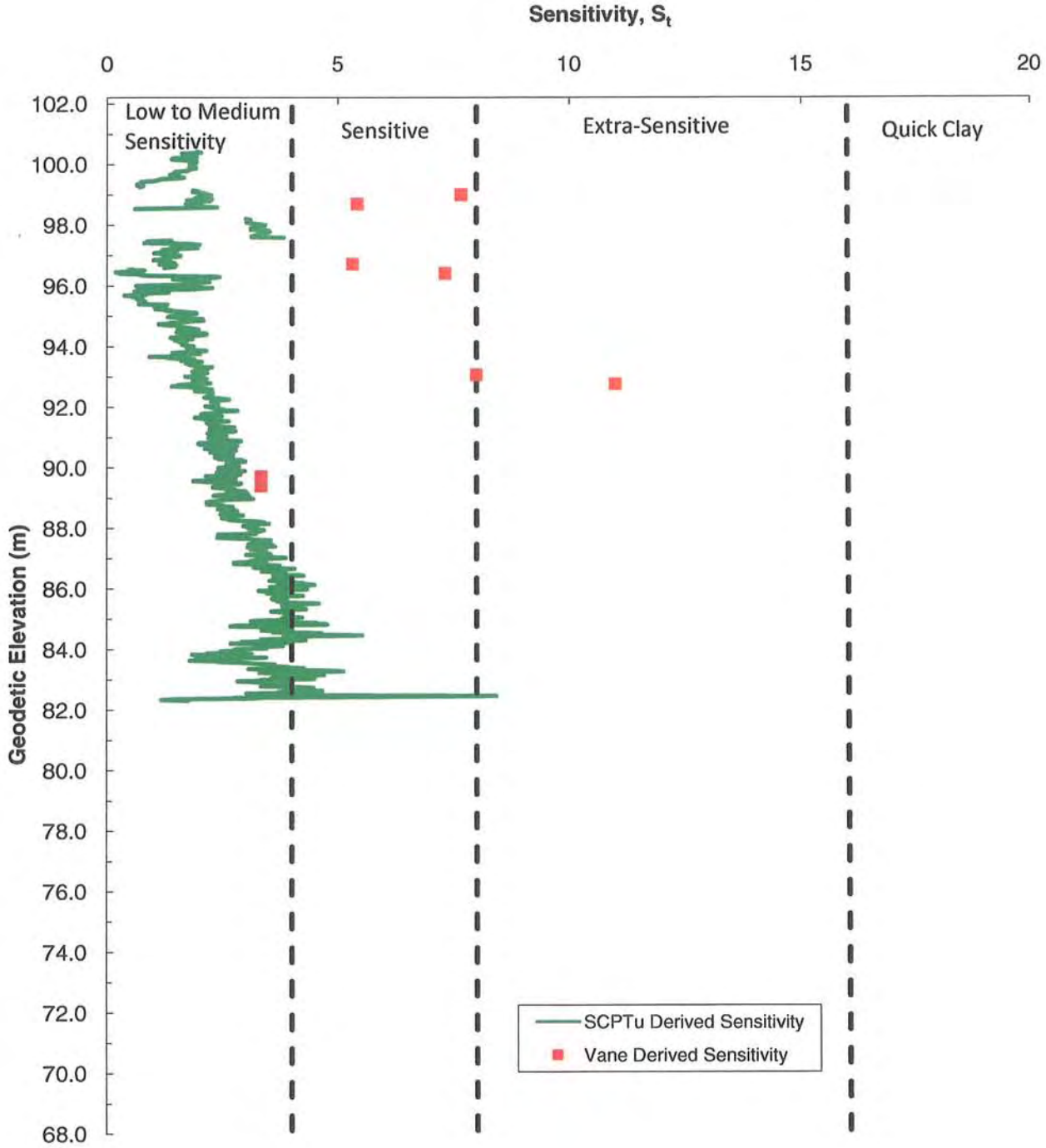
This method of calculating sensitivity is based on the recognition that f_s from an electric piezocone is approximately equal to the remolded shear strength of a clay.

Lunne, Robertson and Powell (1997) states that although the field vane is a better test to measure sensitivity, S_t can be roughly estimated using CPT data.

Stantec

SCPTu RESULTS

Sensitivity S_t



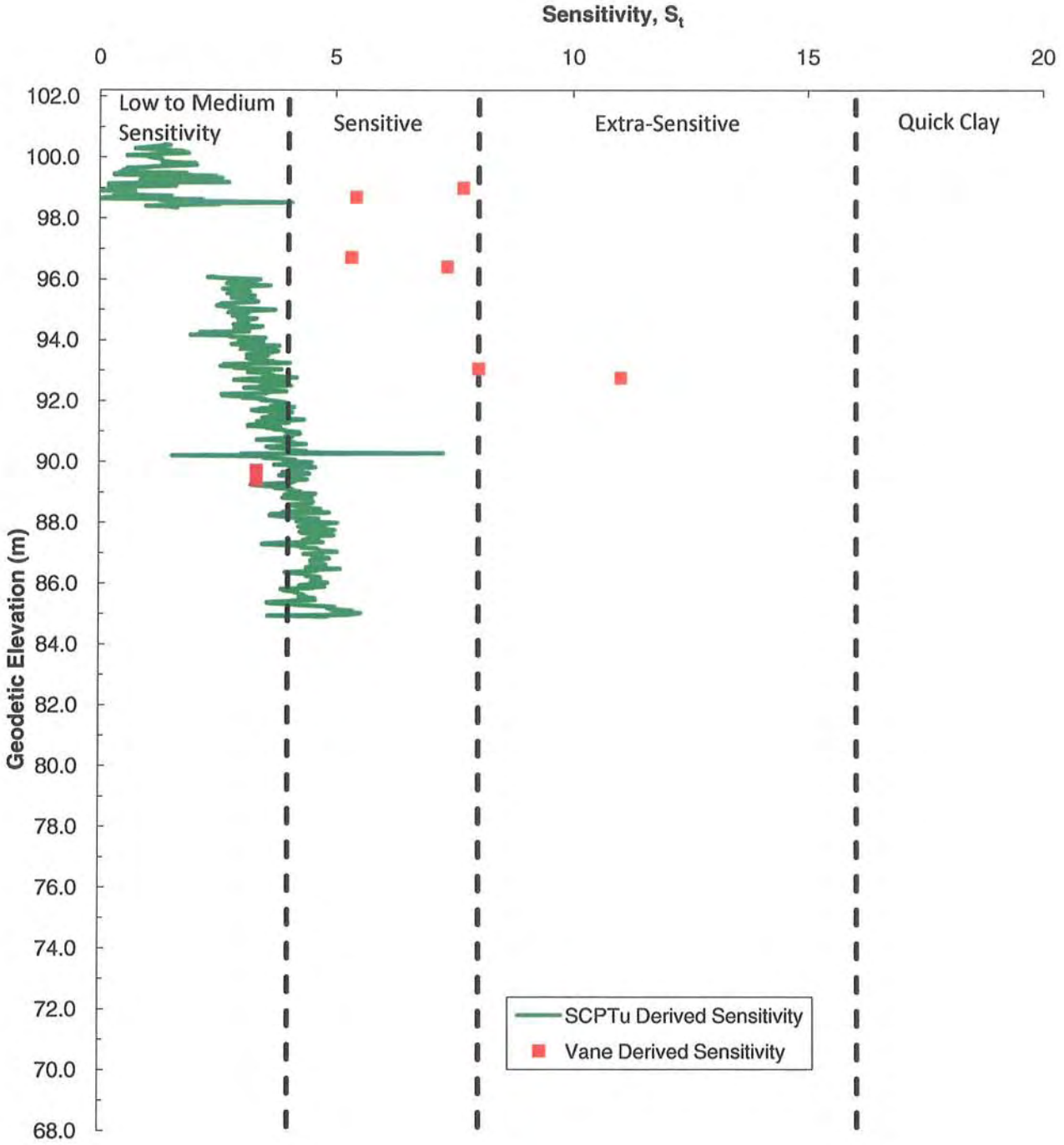
Project No. 1049643

CPT09-2

Stantec

SCPTu RESULTS

Sensitivity S_t



Project No. 1049643

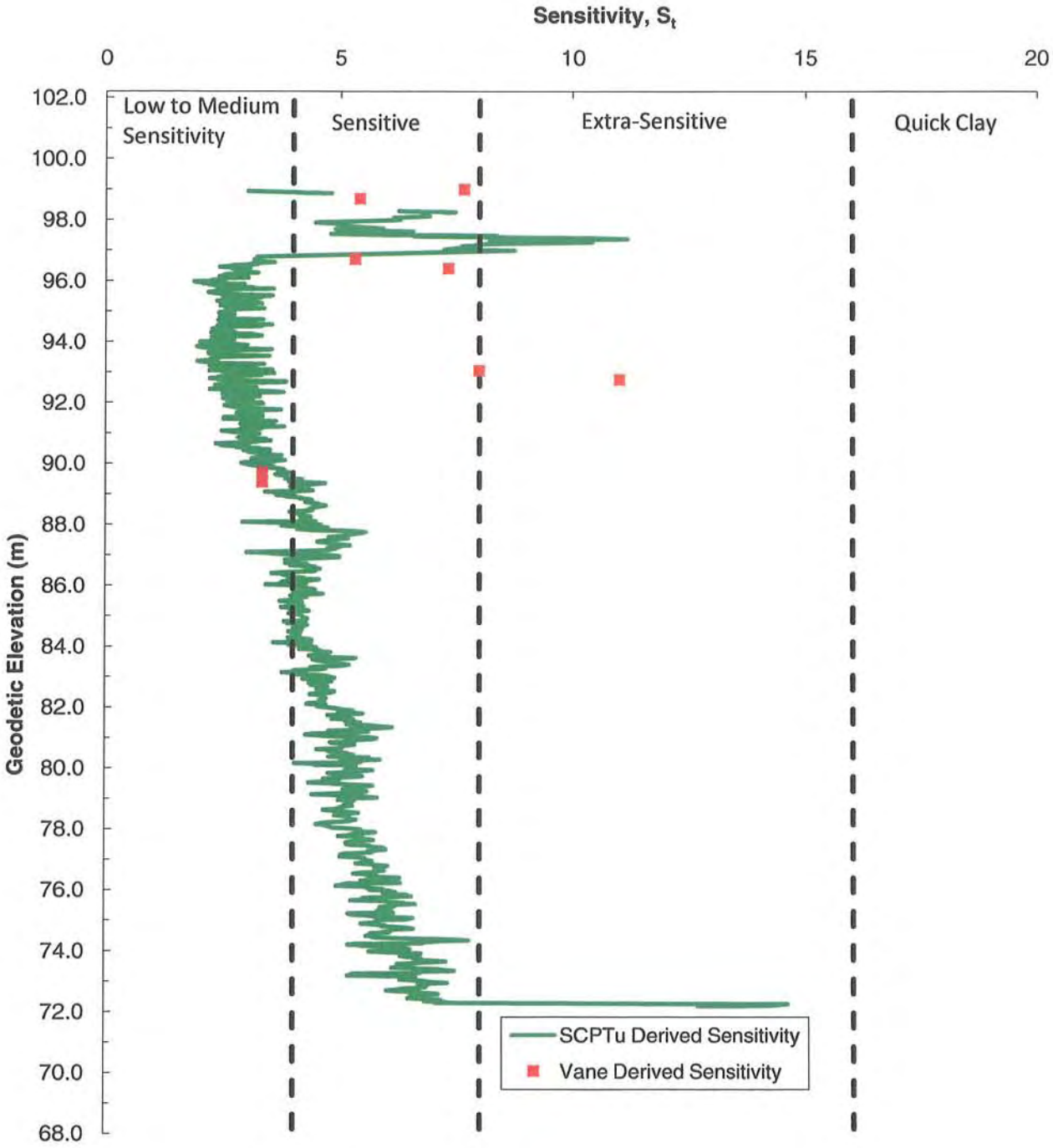
CPT09-3

P:\2009\1049643\CPT\STATIC SCPTu CPT09-3b

Stantec

SCPTu RESULTS

Sensitivity S_t



Project No. 1049643

CPT09-4

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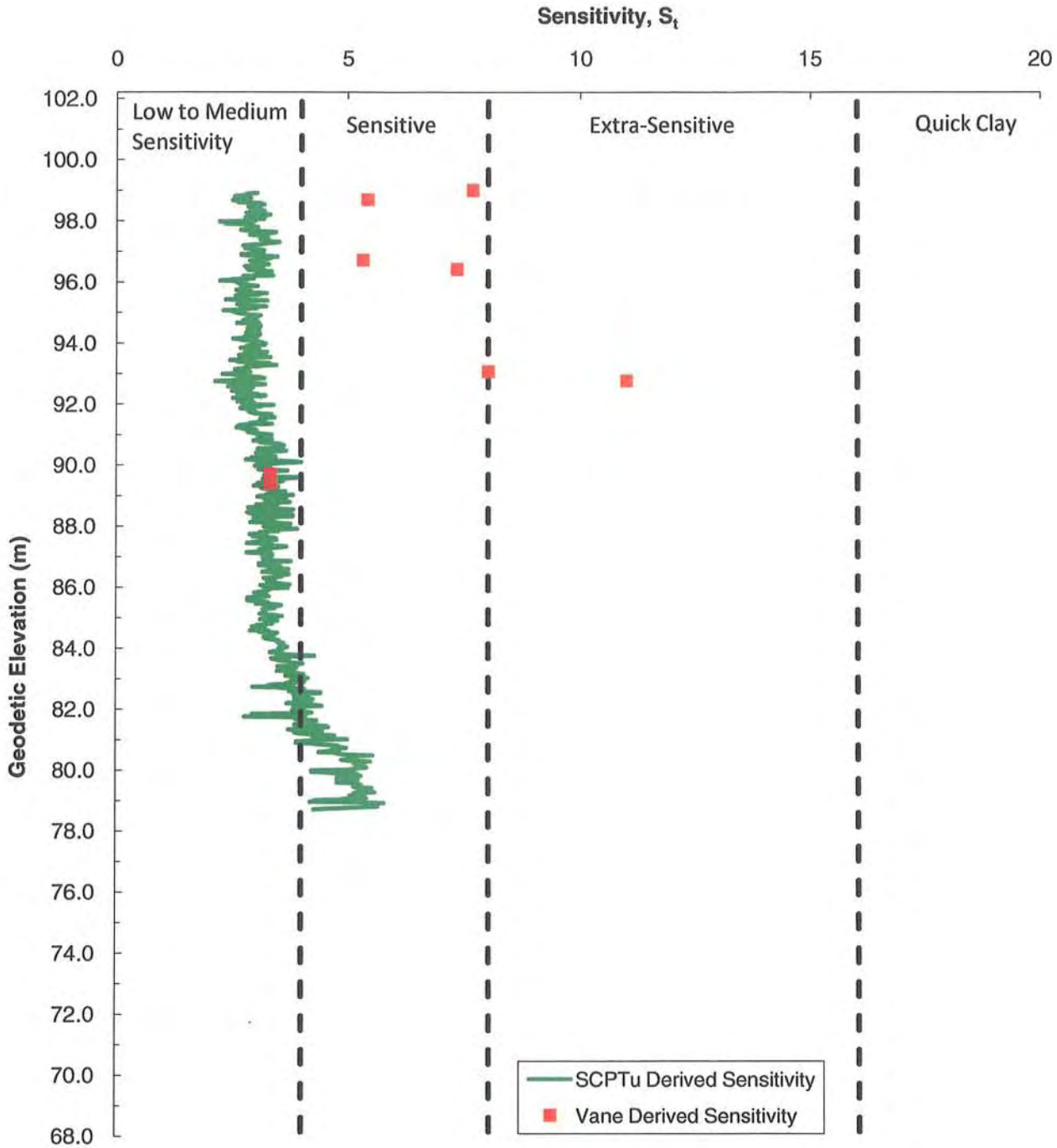
Stantec

SCPTu RESULTS

Sensitivity S_t



Project No. 1049643

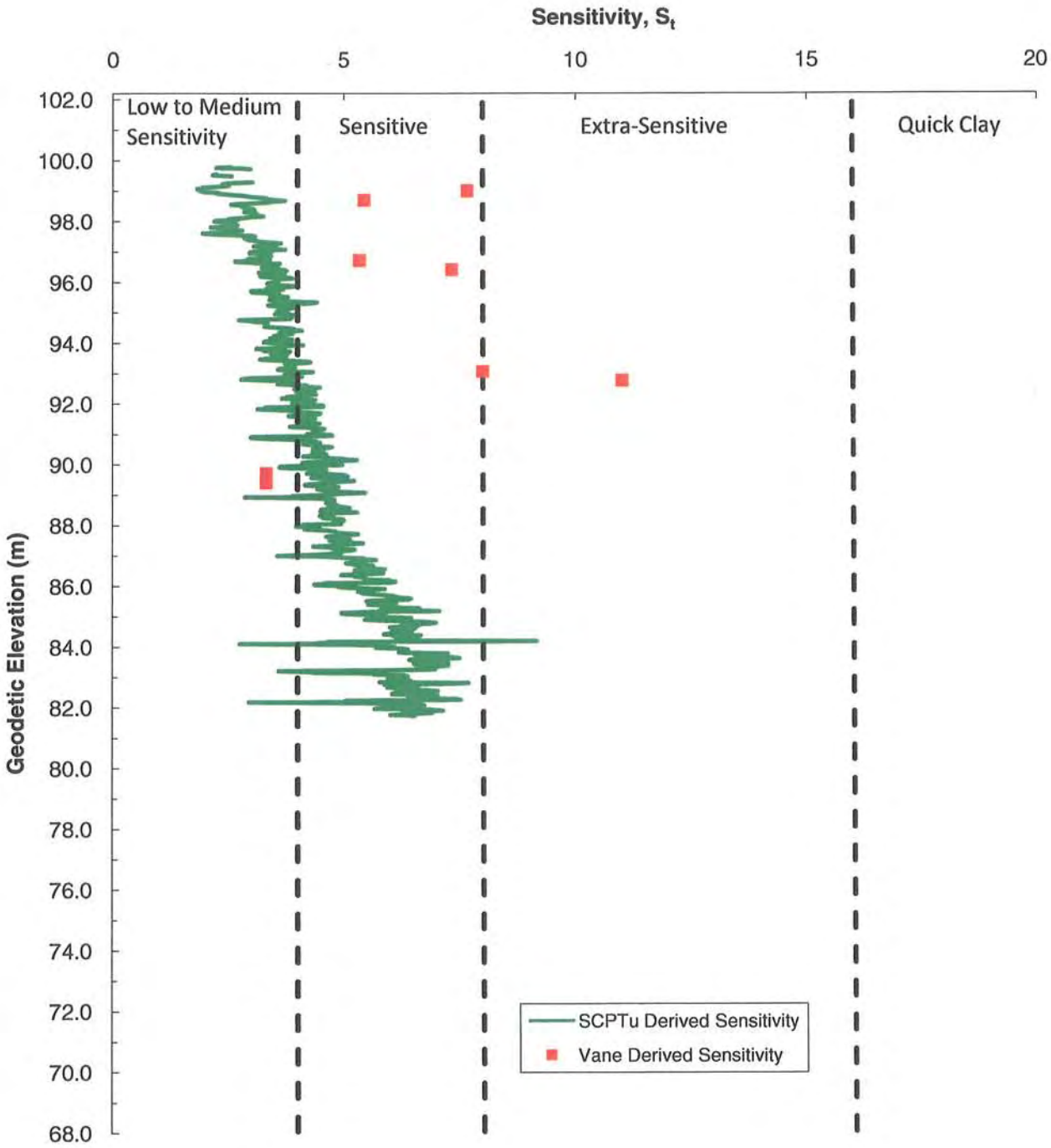
CPT09-5

P:\2009\1049643\CPT\STATIC SCPTu CPT09-5a

Stantec

SCPTu RESULTS

Sensitivity S_t

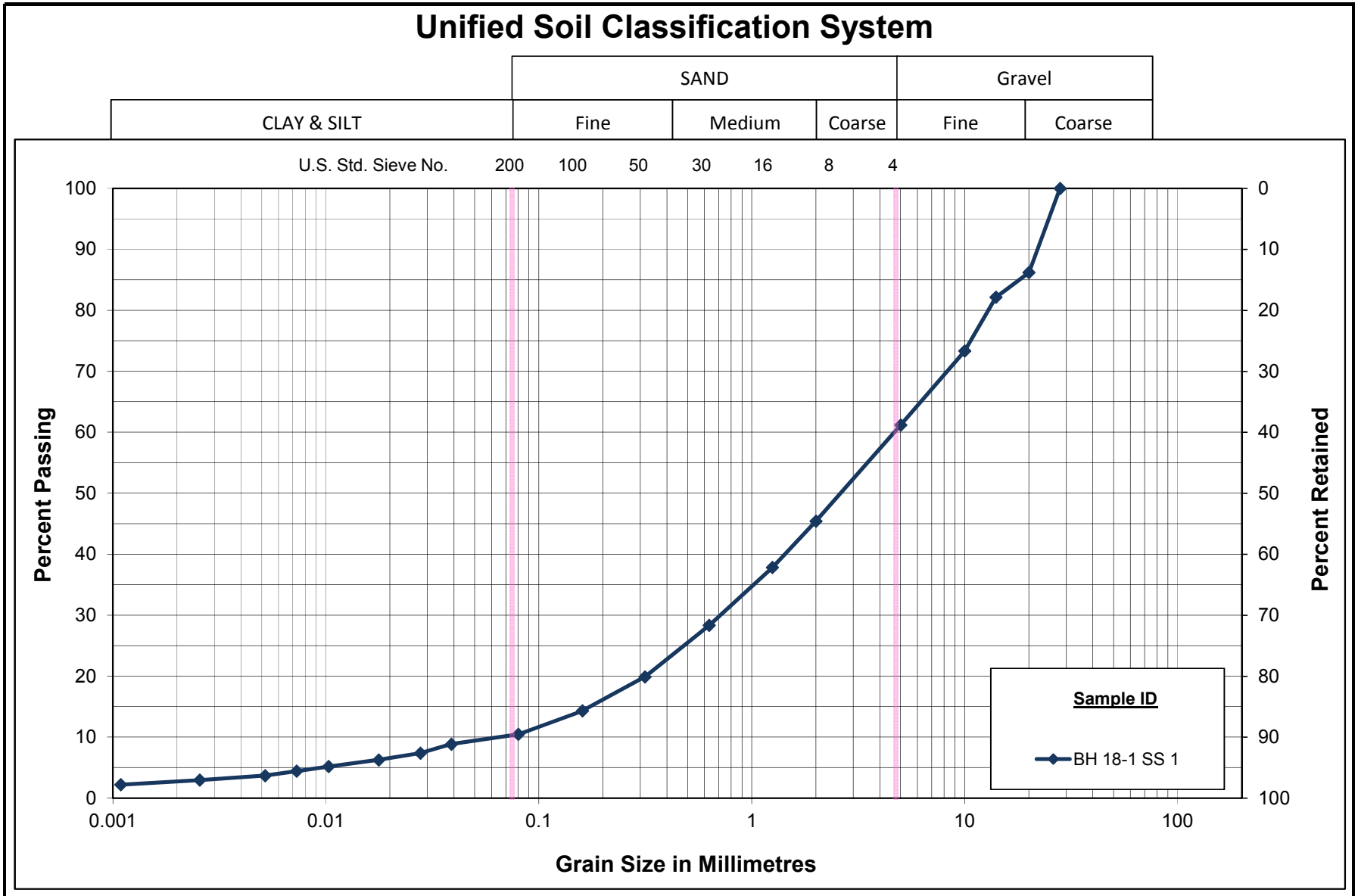


Project No. 1049643

CPT09-6

APPENDIX D

Laboratory Test Results



Stantec

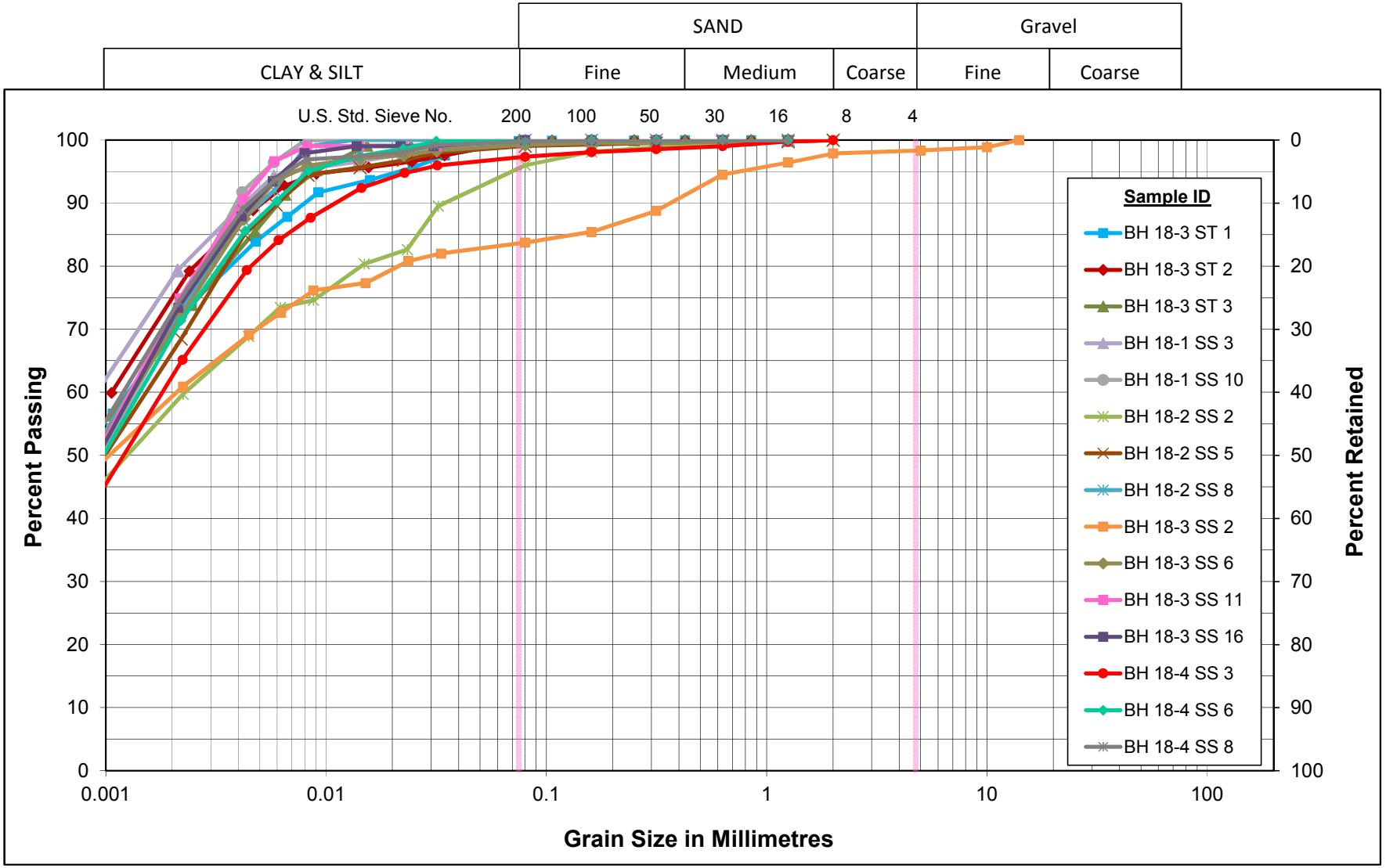
GRAIN SIZE DISTRIBUTION

Well-graded SAND with silt and gravel (SW-SM)

Figure No. 1

Project No. 121622309

Unified Soil Classification System



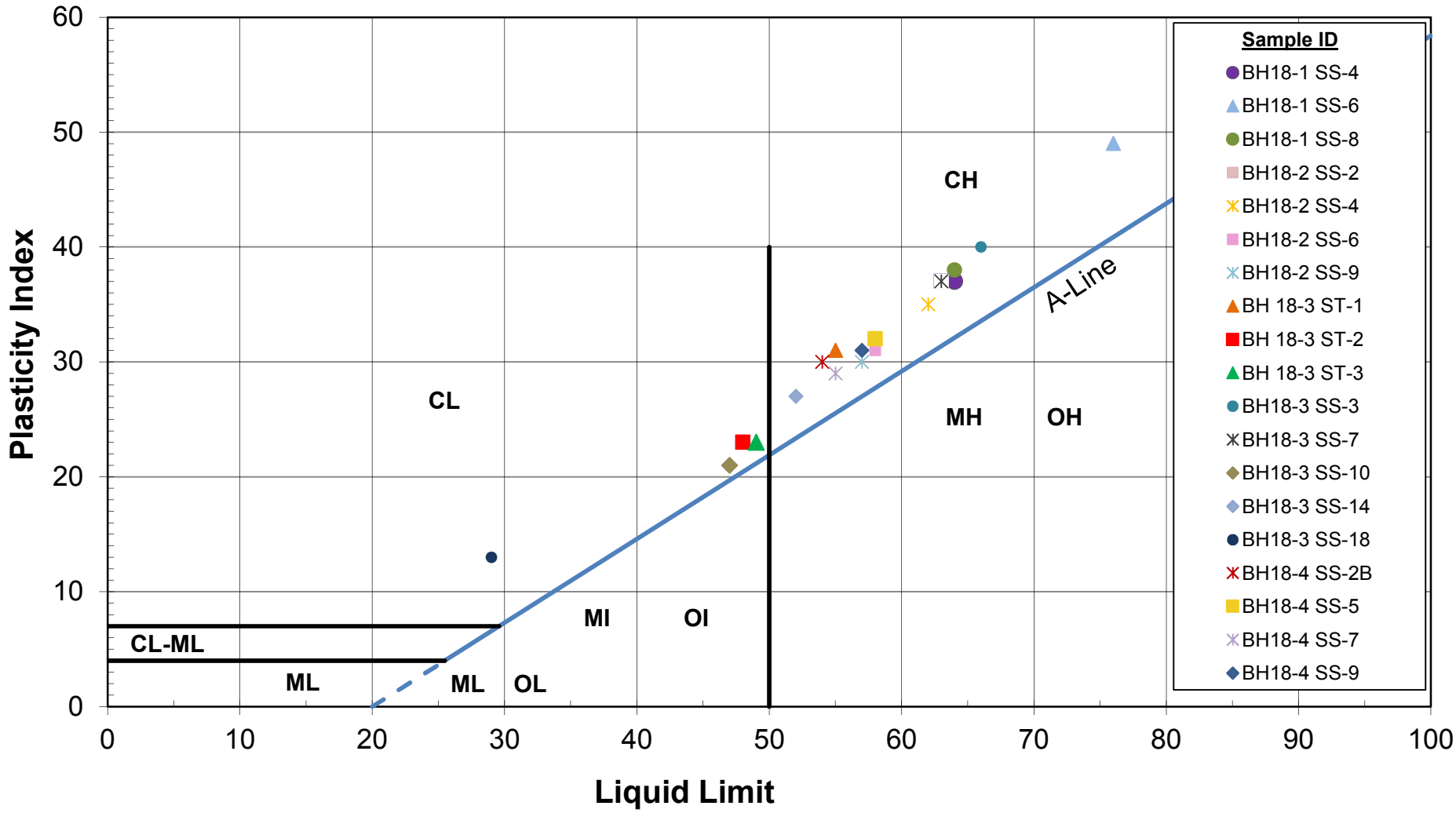
Stantec

GRAIN SIZE DISTRIBUTION

CLAY of High Plasticity (CH) to Silty CLAY (CL)

Figure No. 2

Project No. 121622309



Stantec

PWGSC

PCA Artifact Storage

PLASTICITY CHART

Figure No. 3

Project No. 121622309

Stantec
2273 Michelin Street
Laval QC, H7L 5B8

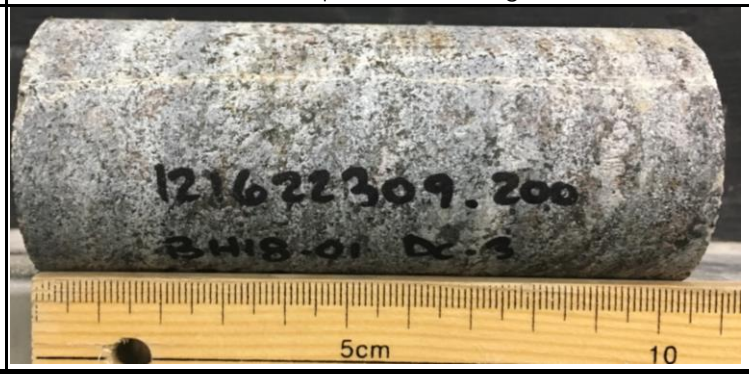
Compressive Strength of Intact Rock Core Specimens, ASTM D 7012, Method C

Client : Public Works & Government Services Canada
Project No : 121622309.200
Project : PCA Artifact Storage Facility
555, Avenue des Entreprises, Gatineau

Borehole No : BH18-01
Sample No : DC-3
Depth : 19,80 - 19,91m
Sampled by : SMD and PP
Date of sampling : November 08, 2018

Apparatus :
Loading Device no : LAV-011
Scale Protractor no : LAV-029
Caliper no : LAV-104
Scale no : LAV-012

Average Length (mm)	Average Diameter (mm)	L/D Ratio	Weigth (Kg)	Volumic Weigth (kg/m³)	Humidity Conditions	Targeted Loading Rate (lbs/sec)	Time to Failure	load at failure (lbs)	Compressive Strenght (MPa)
108,6	47,2	2,3	0,526	2768	Dry	331	2min 20sec	49200	125,1

Description	Sample before testing	Sample after testing
Gneiss		

Remarks :

Tested by : Benoit Cyr
Date : 2018-12-21
Approved by : Benoit Cyr, geo.
Date : 2018-12-21

Stantec
2273 Michelin Street
Laval QC, H7L 5B8

Compressive Strength of Intact Rock Core Specimens, ASTM D 7012, Method C

Client : Public Works & Government Services Canada
Project No : 121622309.200
Project : PCA Artifact Storage Facility
555, Avenue des Entreprises, Gatineau

Borehole No : BH18-01
Sample No : DC-3
Depth : 20,40 - 20,51m
Sampled by : SMD and PP
Date of sampling : November 08, 2018

Apparatus :
Loading Device no : LAV-011
Scale Protractor no : LAV-029
Caliper no : LAV-104
Scale no : LAV-012

Average Length (mm)	Average Diameter (mm)	L/D Ratio	Weigth (Kg)	Volumic Weigth (kg/m³)	Humidity Conditions	Targeted Loading Rate (lbs/sec)	Time to Failure	load at failure (lbs)	Compressive Strenght (MPa)
108,8	47,2	2,3	0,505	2653	Dry	331	1min 50sec	39090	99,4

Description	Sample before testing	Sample after testing
Gneiss		

Remarks :

Tested by : Benoit Cyr
Date : 2018-12-21
Approved by : Benoit Cyr, geo.
Date : 2018-12-21

Stantec
2273 Michelin Street
Laval QC, H7L 5B8

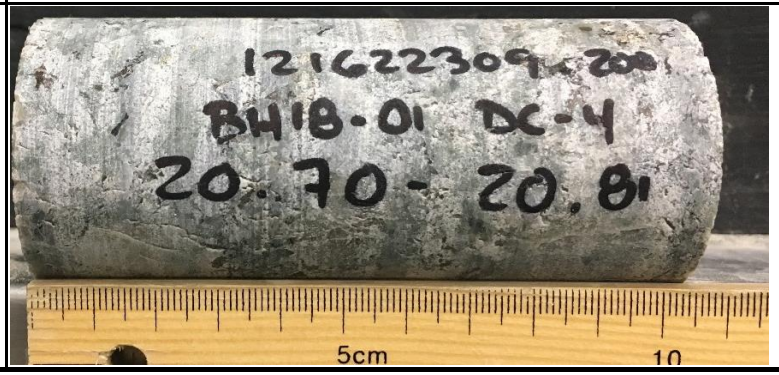
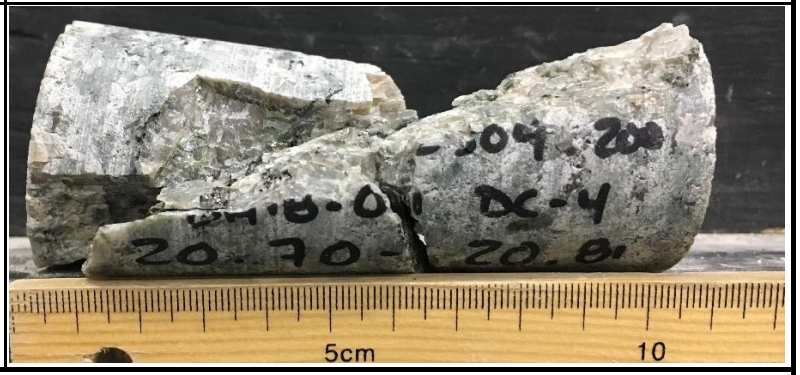
Compressive Strength of Intact Rock Core Specimens, ASTM D 7012, Method C

Client : Public Works & Government Services Canada
Project No : 121622309.200
Project : PCA Artifact Storage Facility
555, Avenue des Entreprises, Gatineau

Borehole No : BH18-01
Sample No : DC-4
Depth : 20,70 - 20,81m
Sampled by : SMD and PP
Date of sampling : November 08, 2018

Apparatus :
Loading Device no : LAV-011
Scale Protractor no : LAV-029
Caliper no : LAV-104
Scale no : LAV-012

Average Length (mm)	Average Diameter (mm)	L/D Ratio	Weigth (Kg)	Volumic Weigth (kg/m³)	Humidity Conditions	Targeted Loading Rate (lbs/sec)	Time to Failure	load at failure (lbs)	Compressive Strenght (MPa)
106,8	47,2	2,3	0,490	2622	Dry	331	2min 05sec	57260	145,6

Description	Sample before testing	Sample after testing
Gneiss		

Remarks :

Tested by : Benoit Cyr
Date : 2018-12-21
Approved by : Benoit Cyr, geo.
Date : 2018-12-21

Stantec
2273 Michelin Street
Laval QC, H7L 5B8

Compressive Strength of Intact Rock Core Specimens, ASTM D 7012, Method C

Client : Public Works & Government Services Canada
Project No : 121622309.200
Project : PCA Artifact Storage Facility
555, Avenue des Entreprises, Gatineau

Borehole No : BH18-01
Sample No : DC-4
Depth : 21,00 - 21,11m
Sampled by : SMD and PP
Date of sampling : November 08, 2018

Apparatus :
Loading Device no : LAV-011
Scale Protractor no : LAV-029
Caliper no : LAV-104
Scale no : LAV-012

Average Length (mm)	Average Diameter (mm)	L/D Ratio	Weigth (Kg)	Volumic Weigth (kg/m³)	Humidity Conditions	Targeted Loading Rate (lbs/sec)	Time to Failure	load at failure (lbs)	Compressive Strenght (MPa)
104,1	47,2	2,2	0,479	2630	Dry	331	1min 50sec	42070	107,0

Description	Sample before testing	Sample after testing
Gneiss		

Remarks :

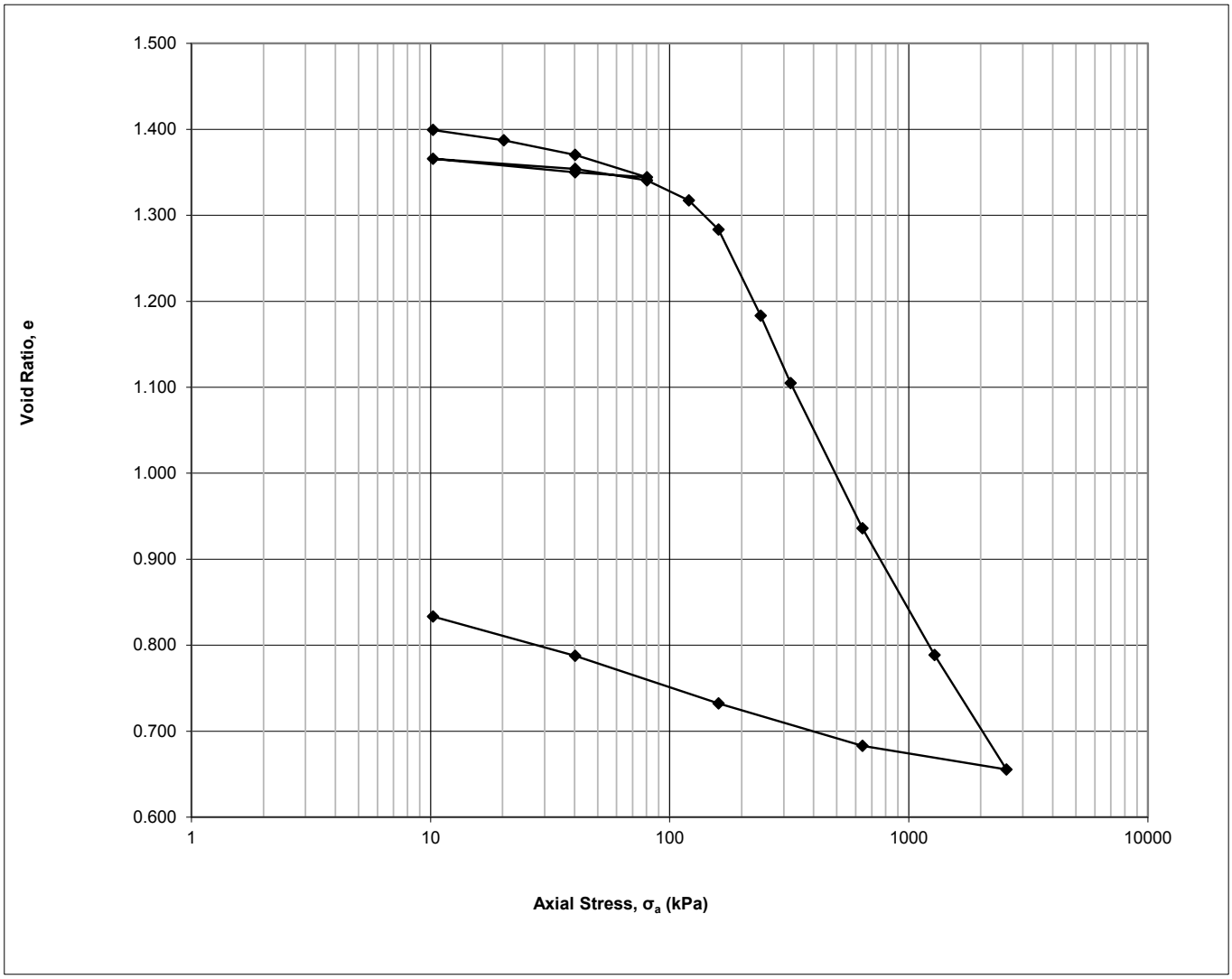
Tested by : Benoit Cyr
Date : 2018-12-21
Approved by : Benoit Cyr, geo.
Date : 2018-12-21

Stantec

One-Dimensional Consolidation Properties of Soils Using Incremental Loading

ASTM D2435/D2435M - 11

Project	**PCA Artifact Storage**
Project No.	**121622309.200**
Borehole No.	**BH 18-03**
Sample No.	**ST 1**
Sample Depth	**17-19 ft.**



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Stantec Consulting Ltd.

One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

Filename: V:\0121\active\121622XX\121622309\03_data\
Checked by: D. Boateng Date: 30-Nov-18
Approved by: R. Hache Date: 30-Nov-18

Specimen Details

Project Name	PCA Artifact Storage
Project Location	Gatineau, Quebec
Borehole	BH 18-03
Sample No.	ST 1
Depth	17-19 ft.
Sample Date	November 9, 2018
Test Number	One
Technician Name	Daniel Boateng

Soil Description & Classification

Silty Clay, Firm, Grey, Friable, Very Moist - CH		
Specific Gravity of Solids		2.780
Liquid Limit	%	55
Plastic Limit	%	24
Plasticity Index	%	31
Average water content of trimmings	%	52
Additional Notes (information source, occurence and size of large isolated particles etc.)		

Initial Specimen Conditions

Height	mm	20.00
Diameter	mm	50.00
Area	mm^2	1963
Volume	mm^3	39270
Mass	g	67.06
Dry Mass	g	44.06
Density	Mg/m^3	1.708
Dry Density	Mg/m^3	1.122
Water Content	%	52.20
Degree of Saturation	%	98.2
Height of Solids	mm	8.07
Initial Void Ratio		1.478

Final Specimen Conditions

Water Content	%	34.52
Final Void Ratio		0.849
Estimated Preconsolidation Stress	kPa	145

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One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

Filename: V:\01216\active\1216223XX\12162230903_data\laboratory\internal\Ottawa Testi
Date: 30-Nov-18
Checked by: D. Boateng Date: 30-Nov-18
Approved by: R. Hache Date:

Specimen Details

Project Name	PCA Artifact Storage
Project Location	Gatineau, Quebec
Borehole	BH 18-03
Sample No.	ST 1
Depth	17-19 ft.
Sample Date	November 9, 2018
Test Number	One
Technician Name	Daniel Boateng

Test Procedure

Date Started		November 23, 2018
Date Finished		November 24, 2018
Machine Number		Frame C
Cell Number		C
Ring Number		C
Trimming Procedure		Trimming Turntable/Cutting Shoe
Moisture Condition		Natural Moisture/Inundated
Axial Stress at Inundation	kPa	10
Water Used		Distilled
Test Method		B
Interpretation Procedure for c_v		2

All Departures from Outlined ASTM D2435/D2435M-11 Procedure

Calculations

Load Increment	Increment Duration min	Axial Stress σ_a kPa	Corrected Deformation ΔH mm	Specimen Height H mm	Axial Strain ε_a %	Void Ratio e
Seating	0.0	10	0.0000	20.0000	0.00	1.478
1	20.0	10	0.6342	19.3658	3.17	1.399
2	21.5	20	0.7309	19.2691	3.65	1.387
3	25.0	40	0.8665	19.1335	4.33	1.370
4	35.0	80	1.0787	18.9213	5.39	1.344
5	18.3	40	1.0301	18.9699	5.15	1.350
6	23.3	10	0.9042	19.0958	4.52	1.366
7	20.0	40	0.9994	19.0006	5.00	1.354
8	25.0	80	1.1069	18.8931	5.53	1.341
9	53.3	120	1.2940	18.7060	6.47	1.317
10	95.0	160	1.5686	18.4314	7.84	1.283
11	180.5	240	2.3772	17.6228	11.89	1.183
12	162.3	320	3.0113	16.9887	15.06	1.105
13	135.8	640	4.3722	15.6278	21.86	0.936
14	117.5	1280	5.5624	14.4376	27.81	0.789
15	97.3	2560	6.6373	13.3627	33.19	0.655
16	25.0	640	6.4147	13.5853	32.07	0.683
17	52.0	160	6.0173	13.9827	30.09	0.732
18	94.0	40	5.5699	14.4301	27.85	0.788
19	121.3	10	5.2004	14.7996	26.00	0.833
20	77.5	5.2	5.0777	14.9223	25.39	0.849

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One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

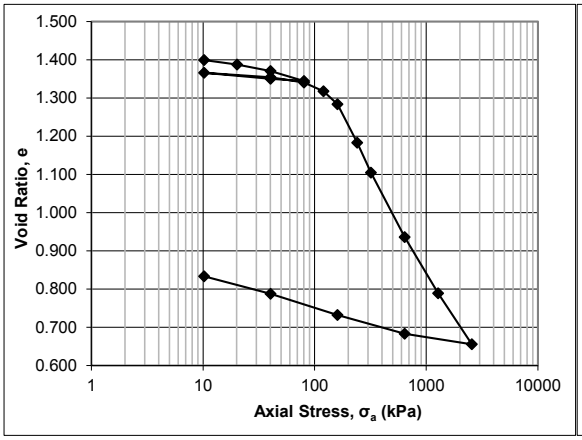
Filename: V:\01216\active\1216223XX\121622309\03_data\laboratory\internal\Ottawa Testing
Date: 30-Nov-18
Checked by: D. Boateng Date: 30-Nov-18
Approved by: R. Hache Date:

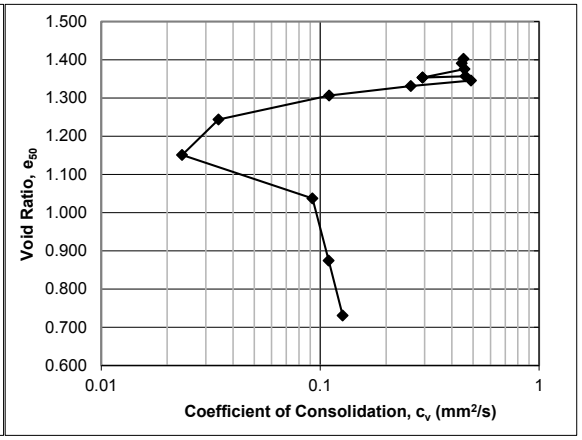
Specimen Details

Project Name	PCA Artifact Storage
Project Location	Gatineau, Quebec
Borehole	BH 18-03
Sample No.	ST 1
Depth	17-19 ft.
Sample Date	November 9, 2018
Test Number	One
Technician Name	Daniel Boateng

Calculations

		Calculated using Interpretation Procedure 2				Interpretation Procedure 1		Interpretation Procedure 2	
Load Increment	Axial Stress $\sigma_{a,\ average}$ kPa	Corrected Deformation ΔH_{50} mm	Specimen Height H_{50} mm	Axial Strain $\varepsilon_{a,50}$ %	Void Ratio e_{50}	Time t_{50} sec	Coeff. Consol. c_v mm^2/s	Time t_{90} sec	Coeff. Consol. c_v mm^2/s
Seating	5								
1	10	0.6068	19.3932	3.03	1.403			177	4.52E-01
2	15	0.7037	19.2963	3.52	1.391			178	4.44E-01
3	30	0.8243	19.1757	4.12	1.376			170	4.57E-01
4	60	1.0051	18.9949	5.03	1.353			260	2.94E-01
5	60	1.0398	18.9602	5.20	1.349				
6	25	0.9360	19.0640	4.68	1.362				
7	25	0.9770	19.0230	4.88	1.357			166	4.62E-01
8	60	1.0665	18.9335	5.33	1.346			156	4.89E-01
9	100	1.1815	18.8185	5.91	1.331			289	2.60E-01
10	140	1.3808	18.6192	6.90	1.307			669	1.10E-01
11	200	1.8887	18.1113	9.44	1.244			2025	3.43E-02
12	280	2.6375	17.3625	13.19	1.151			2729	2.34E-02
13	480	3.5584	16.4416	17.79	1.037			622	9.21E-02
14	960	4.8698	15.1302	24.35	0.874			443	1.10E-01
15	1920	6.0294	13.9706	30.15	0.731			326	1.27E-01
16	1600	6.4718	13.5282	32.36	0.676				
17	400	6.1712	13.8288	30.86	0.713				
18	100	5.7610	14.2390	28.81	0.764				
19	25	5.5596	14.4404	27.80	0.789				
20	8	5.1748	14.8252	25.87	0.837				





Stantec	Project No.: 121622309.200	Photo Log
	Project Name: PCA Artifact Storage	

Photo No.: 1	Borehole: BH 18-03, ST 1	Depth: 17 – 19 ft.

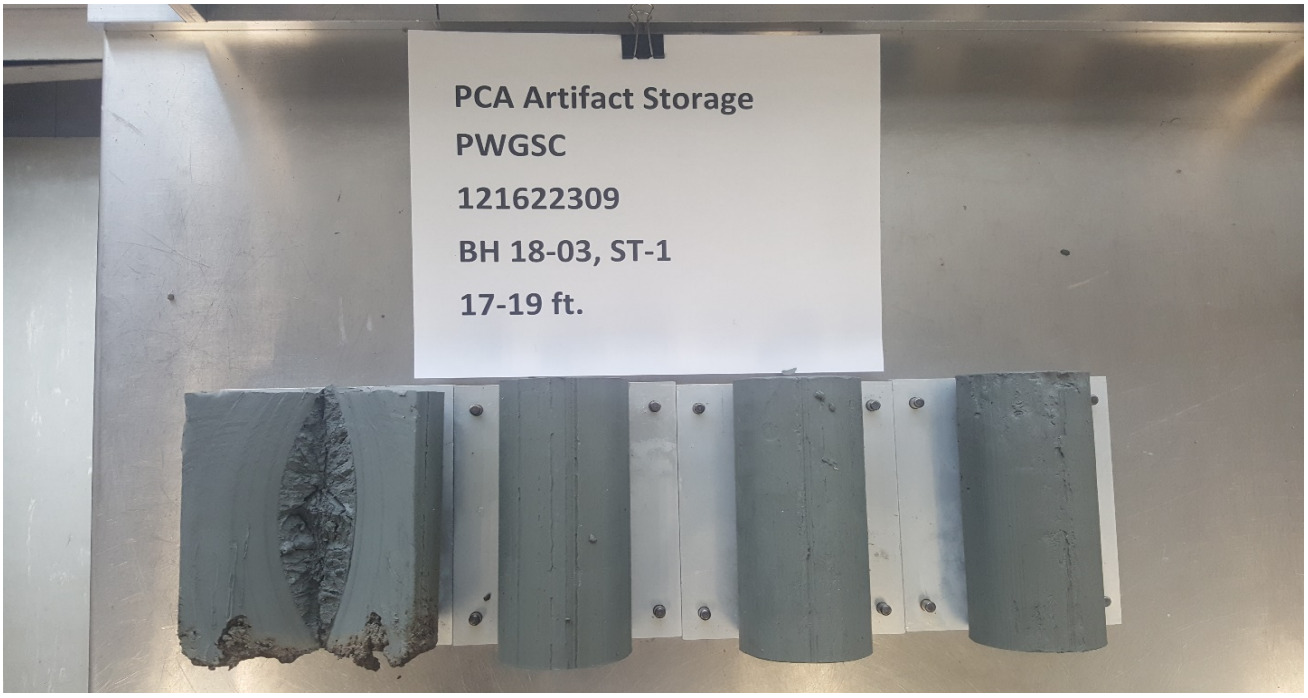


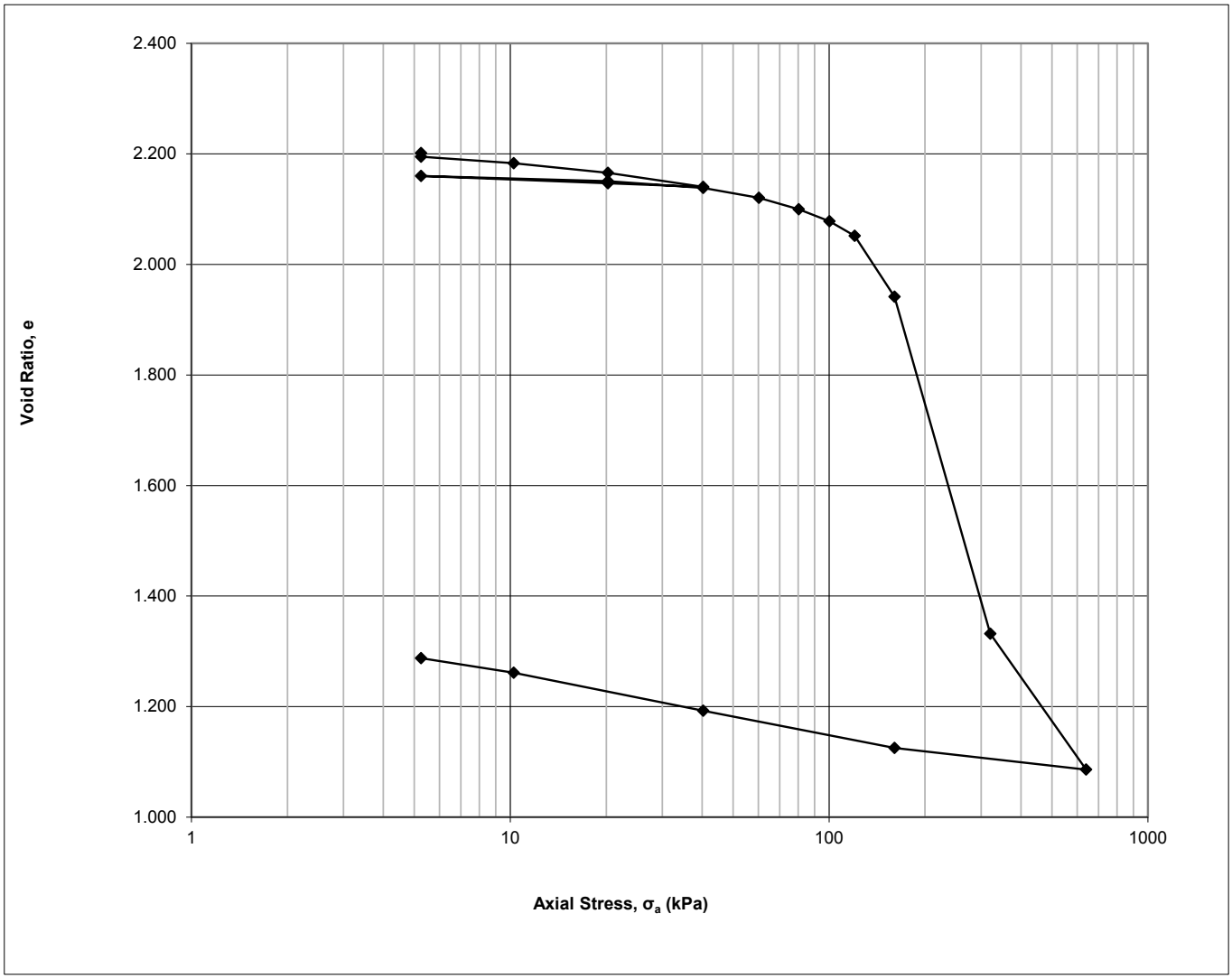
Photo No.: 2	Borehole: BH 18-03, ST 1	Depth: 17 – 19 ft.

Stantec

One-Dimensional Consolidation Properties of Soils Using Incremental Loading

ASTM D2435/D2435M - 11

Project	**PCA Artifact Storage**
Project No.	**121622309.200**
Borehole No.	**BH 18-03**
Sample No.	**ST 2**
Sample Depth	**35-37 ft.**



Stantec

Stantec Consulting Ltd.

One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

Filename: V:\0121 6\active\121 6223XX\121 62309\03_data\

Checked by: D. Boateng Date: 3-Dec-18

Approved by: R. Hache Date: 3-Dec-18

Specimen Details

Project Name	PCA Artifact Storage
Project Location	Gatineau, Quebec
Borehole	BH 18-03
Sample No.	ST 2
Depth	35-37 ft.
Sample Date	November 9, 2018
Test Number	Two
Technician Name	Daniel Boateng

Soil Description & Classification

Silty Clay, Soft, Grey, Friable, Wet - CI		
Specific Gravity of Solids		2.780
Liquid Limit	%	48
Plastic Limit	%	25
Plasticity Index	%	23
Average water content of trimmings	%	76
Additional Notes (information source, occurence and size of large isolated particles etc.)		
Specific Gravity of Solids Assumed		

Initial Specimen Conditions

Height	mm	20.00
Diameter	mm	50.00
Area	mm^2	1963
Volume	mm^3	39270
Mass	g	60.06
Dry Mass	g	34.10
Density	Mg/m^3	1.529
Dry Density	Mg/m^3	0.868
Water Content	%	76.13
Degree of Saturation	%	96.1
Height of Solids	mm	6.25
Initial Void Ratio		2.201

Final Specimen Conditions

Water Content	%	49.64
Final Void Ratio		1.287
Estimated Preconsolidation Stress	kPa	135

Stantec

Stantec Consulting Ltd.

One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

Filename: V:\01216\active\1216223XX\12162230903_data\laboratory\internal\Ottawa Testi
Date: 3-Dec-18
Checked by: D. Boateng Date: 3-Dec-18
Approved by: R. Hache Date:

Specimen Details

Project Name	PCA Artifact Storage
Project Location	Gatineau, Quebec
Borehole	BH 18-03
Sample No.	ST 2
Depth	35-37 ft.
Sample Date	November 9, 2018
Test Number	Two
Technician Name	Daniel Boateng

Test Procedure

Date Started		November 23, 2018
Date Finished		November 24, 2018
Machine Number		Frame D
Cell Number		D
Ring Number		D
Trimming Procedure		Trimming Turntable/Cutting Shoe
Moisture Condition		Natural Moisture/Inundated
Axial Stress at Inundation	kPa	5
Water Used		Distilled
Test Method		B
Interpretation Procedure for c_v		2

All Departures from Outlined ASTM D2435/D2435M-11 Procedure

Calculations

Load Increment	Increment Duration min	Axial Stress σ_a kPa	Corrected Deformation ΔH mm	Specimen Height H mm	Axial Strain ε_a %	Void Ratio e
Seating	0.0	5	0.0000	20.0000	0.00	2.201
1	18.3	5	0.0404	19.9596	0.20	2.195
2	23.3	10	0.1146	19.8854	0.57	2.183
3	24.8	20	0.2240	19.7760	1.12	2.166
4	29.8	40	0.3810	19.6190	1.91	2.140
5	15.0	20	0.3415	19.6585	1.71	2.147
6	21.5	5	0.2588	19.7412	1.29	2.160
7	18.3	20	0.3177	19.6823	1.59	2.151
8	20.0	40	0.3944	19.6056	1.97	2.138
9	28.3	60	0.5058	19.4942	2.53	2.121
10	43.3	80	0.6362	19.3638	3.18	2.100
11	50.0	100	0.7697	19.2303	3.85	2.078
12	73.3	120	0.9337	19.0663	4.67	2.052
13	267.5	160	1.6239	18.3761	8.12	1.942
14	235.0	320	5.4329	14.5671	27.16	1.332
15	142.8	640	6.9686	13.0314	34.84	1.086
16	31.8	160	6.7241	13.2759	33.62	1.125
17	73.8	40	6.3014	13.6986	31.51	1.193
18	112.8	10	5.8740	14.1260	29.37	1.261
19	99.3	5	5.7099	14.2901	28.55	1.287

Stantec

Stantec Consulting Ltd.

One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

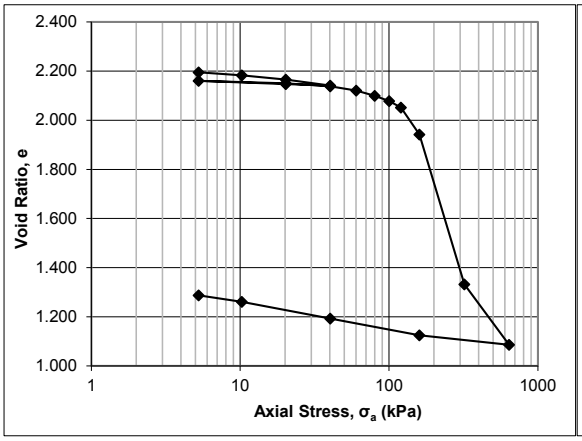
Filename: V:\01216\active\1216223XX\1216223309\03_data\laboratory\internal\Ottawa Tes
Date: 3-Dec-18
Checked by: D. Boateng Date: 3-Dec-18
Approved by: R. Hache Date: 3-Dec-18

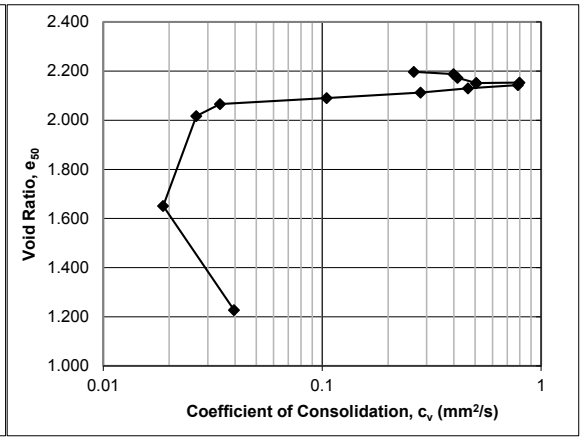
Specimen Details

Project Name	PCA Artifact Storage
Project Location	Gatineau, Quebec
Borehole	BH 18-03
Sample No.	ST 2
Depth	35-37 ft.
Sample Date	November 9, 2018
Test Number	Two
Technician Name	Daniel Boateng

Calculations

		Calculated using Interpretation Procedure 2				Interpretation Procedure 1		Interpretation Procedure 2	
Load Increment	Axial Stress $\sigma_{a,\ average}$ kPa	Corrected Deformation ΔH_{50} mm	Specimen Height H_{50} mm	Axial Strain $\varepsilon_{a,50}$ %	Void Ratio e_{50}	Time t_{50} sec	Coeff. Consol. c_v mm^2/s	Time t_{90} sec	Coeff. Consol. c_v mm^2/s
Seating	3								
1	5	0.0282	19.9718	0.14	2.197			322	2.62E-01
2	8	0.0840	19.9160	0.42	2.188			211	3.99E-01
3	15	0.1838	19.8162	0.92	2.172			200	4.15E-01
4	30	0.3137	19.6863	1.57	2.151			162	5.06E-01
5	30	0.3554	19.6446	1.78	2.145				
6	13	0.2786	19.7214	1.39	2.157				
7	13	0.3013	19.6987	1.51	2.153			103	7.96E-01
8	30	0.3681	19.6319	1.84	2.143			104	7.85E-01
9	50	0.4477	19.5523	2.24	2.130			175	4.64E-01
10	70	0.5581	19.4419	2.79	2.112			285	2.81E-01
11	90	0.6926	19.3074	3.46	2.091			754	1.05E-01
12	110	0.8483	19.1517	4.24	2.066			2274	3.42E-02
13	140	1.1495	18.8505	5.75	2.017			2832	2.66E-02
14	240	3.4359	16.5641	17.18	1.651			3097	1.88E-02
15	480	6.0859	13.9141	30.43	1.227			1038	3.96E-02
16	400	6.8079	13.1921	34.04	1.112				
17	100	6.4783	13.5217	32.39	1.164				
18	25	6.2855	13.7145	31.43	1.195				
19	8	5.8479	14.1521	29.24	1.265				





Stantec	Project No.: 121622309.200	Photo Log
	Project Name: PCA Artifact Storage	

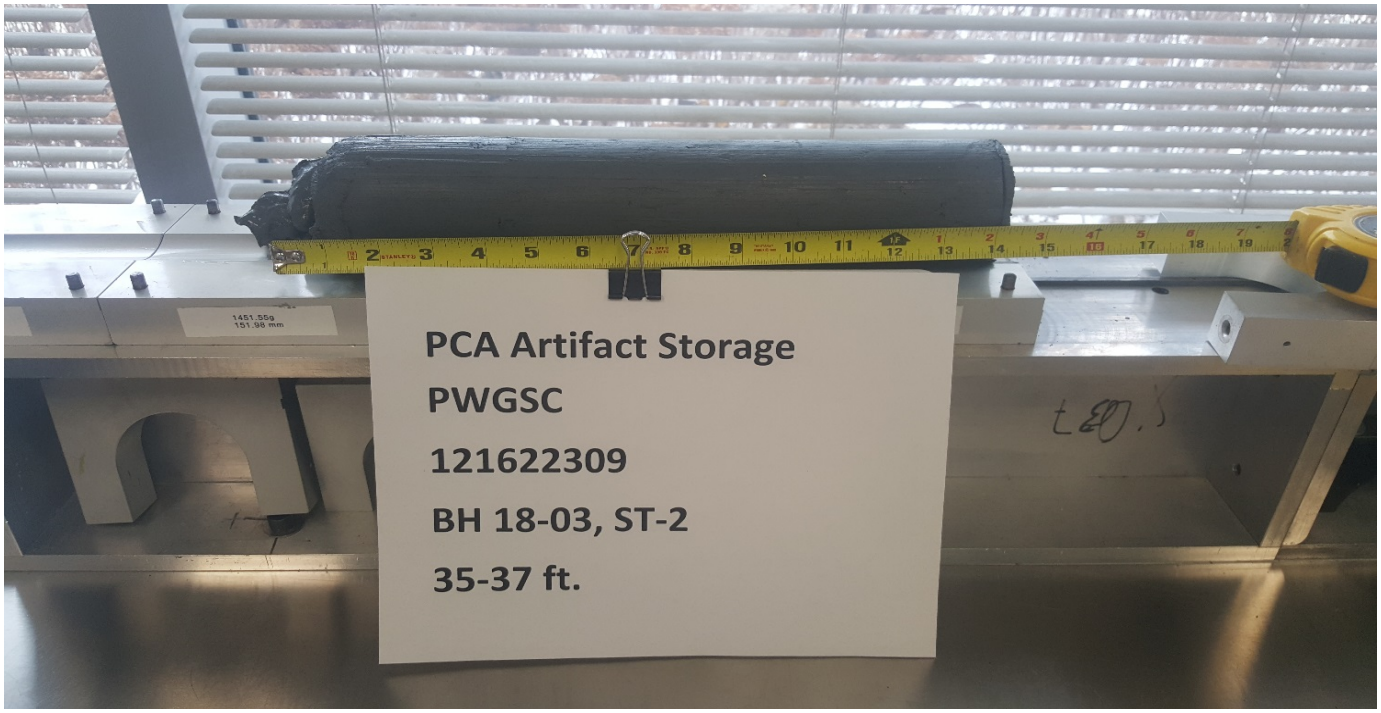


Photo No.: 1	Borehole: BH 18-03, ST 2	Depth: 35 – 37 ft.

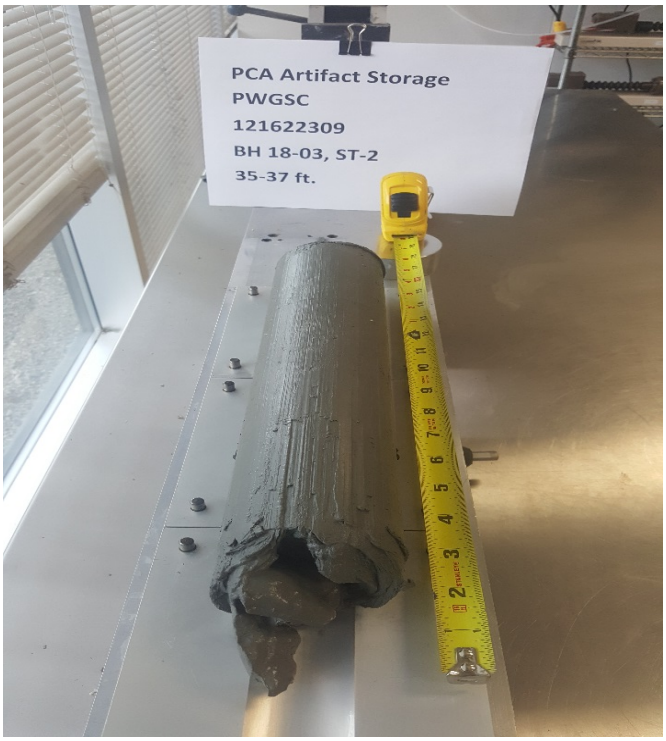


Photo No.: 2	Borehole: BH 18-03, ST 2	Depth: 35 – 37 ft.

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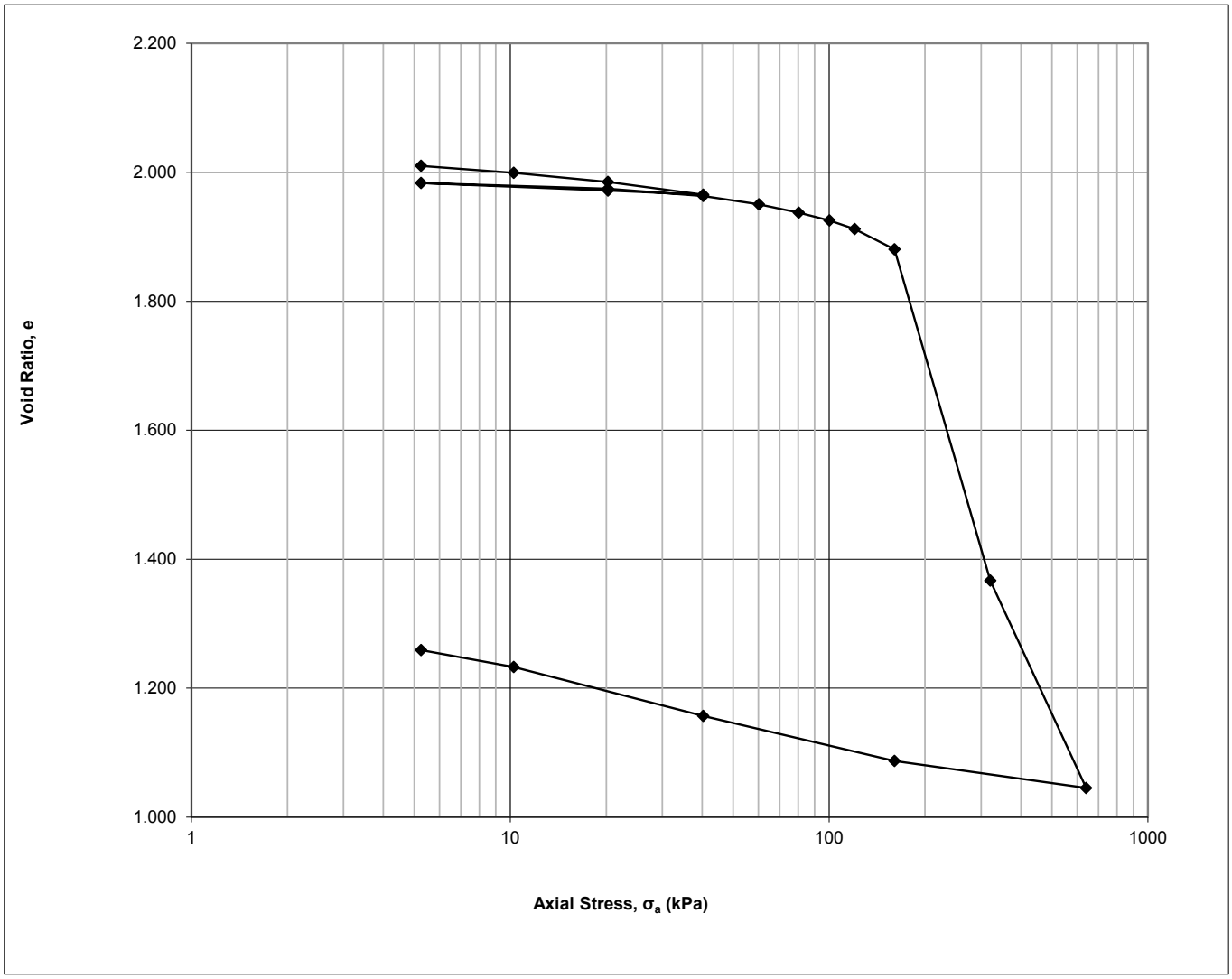
One-Dimensional Consolidation Properties of Soils Using Incremental Loading

ASTM D2435/D2435M - 11

Project	**PCA Artifact Storage**
Project No.	**121622309.200**
Borehole No.	**BH 18-03**
Sample No.	**ST 3**
Sample Depth	**50-52 ft.**



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Stantec Consulting Ltd.

One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

Filename: V:\0121\active\121622XX\121622309\03_data\l
Checked by: D. Boateng Date: 3-Dec-18
Approved by: R. Hache Date: 3-Dec-18

Specimen Details

Project Name	PCA Artifact Storage
Project Location	Gatineau, Quebec
Borehole	BH 18-03
Sample No.	ST 3
Depth	50-52 ft.
Sample Date	November 12, 2018
Test Number	Three
Technician Name	Daniel Boateng

Soil Description & Classification

Silty Clay, Soft, Grey, Friable, Wet - CI		
Specific Gravity of Solids		2.780
Liquid Limit	%	49
Plastic Limit	%	26
Plasticity Index	%	23
Average water content of trimmings	%	71
Additional Notes (information source, occurence and size of large isolated particles etc.)		
Specific Gravity of Solids Assumed		

Initial Specimen Conditions

Height	mm	20.00
Diameter	mm	50.00
Area	mm^2	1963
Volume	mm^3	39270
Mass	g	61.79
Dry Mass	g	36.10
Density	Mg/m^3	1.573
Dry Density	Mg/m^3	0.919
Water Content	%	71.16
Degree of Saturation	%	97.7
Height of Solids	mm	6.61
Initial Void Ratio		2.024

Final Specimen Conditions

Water Content	%	50.70
Final Void Ratio		1.259
Estimated Preconsolidation Stress	kPa	155

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One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

Filename: V:\01216\active\1216223XX\12162230903_data\laboratory\internal\Ottawa Testi
Date: 3-Dec-18
Checked by: D. Boateng Date: 3-Dec-18
Approved by: R. Hache Date: 3-Dec-18

Specimen Details

Project Name	PCA Artifact Storage
Project Location	Gatineau, Quebec
Borehole	BH 18-03
Sample No.	ST 3
Depth	50-52 ft.
Sample Date	November 12, 2018
Test Number	Three
Technician Name	Daniel Boateng

Test Procedure

Date Started		November 24, 2018
Date Finished		November 25, 2018
Machine Number		Frame E
Cell Number		E
Ring Number		E
Trimming Procedure		Trimming Turntable/Cutting Shoe
Moisture Condition		Natural Moisture/Inundated
Axial Stress at Inundation	kPa	5
Water Used		Distilled
Test Method		B
Interpretation Procedure for c_v		2

All Departures from Outlined ASTM D2435/D2435M-11 Procedure

Calculations

Load Increment	Increment Duration min	Axial Stress σ_a kPa	Corrected Deformation ΔH mm	Specimen Height H mm	Axial Strain ε_a %	Void Ratio e
Seating	0.0	5	0.0000	20.0000	0.00	2.024
1	21.5	5	0.0937	19.9063	0.47	2.010
2	21.5	10	0.1649	19.8351	0.82	1.999
3	24.8	20	0.2591	19.7409	1.30	1.985
4	26.5	40	0.3889	19.6111	1.94	1.965
5	18.3	20	0.3471	19.6529	1.74	1.972
6	23.3	5	0.2677	19.7323	1.34	1.984
7	18.3	20	0.3285	19.6715	1.64	1.974
8	21.5	40	0.4034	19.5966	2.02	1.963
9	26.5	60	0.4875	19.5125	2.44	1.950
10	33.0	80	0.5719	19.4281	2.86	1.938
11	36.5	100	0.6522	19.3478	3.26	1.925
12	48.3	120	0.7416	19.2584	3.71	1.912
13	78.3	160	0.9488	19.0512	4.74	1.881
14	344.0	320	4.3476	15.6524	21.74	1.367
15	165.5	640	6.4730	13.5270	32.37	1.045
16	36.8	160	6.1957	13.8043	30.98	1.087
17	81.8	40	5.7352	14.2648	28.68	1.157
18	177.3	10	5.2328	14.7672	26.16	1.233
19	126.3	5	5.0608	14.9392	25.30	1.259

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Stantec Consulting Ltd.

One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

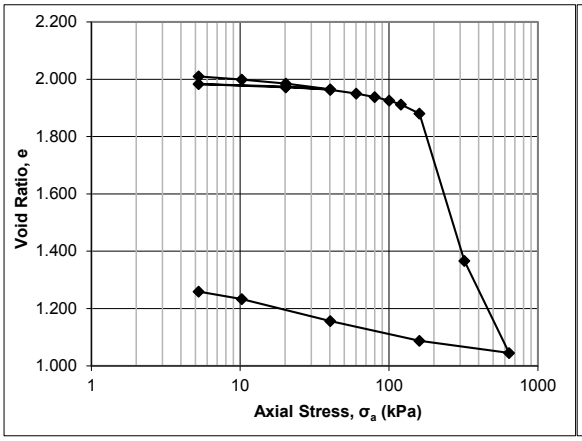
Filename: V:\01216\active\1216223XX\1216223O9\03_data\laboratory\internal\Ottawa Tes
Date: 3-Dec-18
Checked by: D. Boateng Date: 3-Dec-18
Approved by: R. Hache Date:

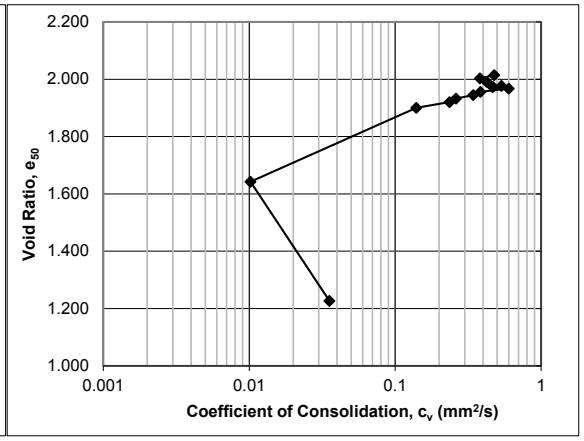
Specimen Details

Project Name	PCA Artifact Storage
Project Location	Gatineau, Quebec
Borehole	BH 18-03
Sample No.	ST 3
Depth	50-52 ft.
Sample Date	November 12, 2018
Test Number	Three
Technician Name	Daniel Boateng

Calculations

		Calculated using Interpretation Procedure 2				Interpretation Procedure 1		Interpretation Procedure 2	
Load Increment	Axial Stress $\sigma_{a,\ average}$ kPa	Corrected Deformation ΔH_{50} mm	Specimen Height H_{50} mm	Axial Strain $\varepsilon_{a,50}$ %	Void Ratio e_{50}	Time t_{50} sec	Coeff. Consol. c_v mm^2/s	Time t_{90} sec	Coeff. Consol. c_v mm^2/s
Seating	3								
1	5	0.0637	19.9363	0.32	2.014			176	4.78E-01
2	8	0.1371	19.8629	0.69	2.003			219	3.82E-01
3	15	0.2196	19.7804	1.10	1.991			195	4.24E-01
4	30	0.3331	19.6669	1.67	1.974			176	4.66E-01
5	30	0.3558	19.6442	1.78	1.970				
6	13	0.2895	19.7105	1.45	1.980				
7	13	0.3103	19.6897	1.55	1.977			154	5.35E-01
8	30	0.3736	19.6264	1.87	1.968			136	6.02E-01
9	50	0.4474	19.5526	2.24	1.956			210	3.86E-01
10	70	0.5234	19.4766	2.62	1.945			234	3.43E-01
11	90	0.6051	19.3949	3.03	1.933			305	2.62E-01
12	110	0.6827	19.3173	3.41	1.921			336	2.36E-01
13	140	0.8184	19.1816	4.09	1.900			558	1.40E-01
14	240	2.5253	17.4747	12.63	1.642			6343	1.02E-02
15	480	5.2739	14.7261	26.37	1.227			1294	3.55E-02
16	400	6.2878	13.7122	31.44	1.073				
17	100	5.9258	14.0742	29.63	1.128				
18	25	5.7211	14.2789	28.61	1.159				
19	8	5.2071	14.7929	26.04	1.237			851	5.45E-02





Stantec	Project No.: 121622309.200	Photo Log
	Project Name: PCA Artifact Storage	

Photo No.: 1	Borehole: BH 018-03, ST 3	Depth: 50 – 52 ft.

Photo No.: 2	Borehole: BH 018-03, ST 3	Depth: 50 – 52 ft.

Stantec

2781 Lancaster Rd.
Ottawa ON, K1B 1A7

Project:	PCA Artifact Storage
Project No.:	121622309
Date Sampled:	November 2018.
Sampled From:	BH 18-03, ST 1
Date Tested:	November 26, 2018
Tested By:	Daniel Boateng
Max. Particle Size:	2 mm

Specific Gravity
LS-705

Test Data

Sample No.	BH 18-03, ST 1	BH 18-03, ST 1	BH 18-03, ST 1
Pycnometer Reference No.	16	30	59
Mass of Pycnometer (m_f)	47.64	46.45	45.62
Mass of Dry Specimen + Pycnometer (m_s)	70.20	68.79	67.92
Mass of Dry Soil ($m_s - m_f = m_o$)	22.56	22.34	22.30
Mass of Pycnometer + Water (m_a)	147.37	146.23	146.18
Mass of Pynometer + Specimen + Water (m_b)	161.81	160.57	160.42
Mass of Water Displaced = [($m_a + m_o$) - m_b]	8.12	8.00	8.06
Temperature of the Content (T_x)	22.00	22.00	22.00
Specific Gravity $G = \frac{m_o}{[m_o + (m_a - m_b)]}$	2.779	2.793	2.767
Mean Specific Gravity at Temperature T_x, $G_{avg} = (G_1 + G_2 + G_3)/3$			2.780
Specific Gravity at 20° C, $G_s = K (G_{avg})$ 2.715 x 0.9996			

Removal of entrapped air by:
a) Vacuum ☐
b) Boiling ☑

Comments:

Reviewed By: _____ Date: _____

APPENDIX E

NBCC Seismic Hazard Sheet
Shear Wave Velocity Results

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

January 11, 2019

Site: 45.5126 N, 75.6502 W User File Reference: 555 rue des Entreprises, Gatineau, QC

Requested by: ,

National Building Code ground motions: 2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.05)	Sa(0.1)	**Sa(0.2)**	Sa(0.3)	**Sa(0.5)**	**Sa(1.0)**	**Sa(2.0)**	**Sa(5.0)**	**Sa(10.0)**	**PGA (g)**	**PGV (m/s)**
0.451	0.527	**0.442**	0.335	**0.238**	**0.118**	**0.056**	**0.015**	**0.0054**	**0.283**	**0.198**

Notes. Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC 2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are specified in **bold** font. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. ***These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.***

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.05)	0.046	0.152	0.252
Sa(0.1)	0.063	0.191	0.305
Sa(0.2)	0.056	0.164	0.258
Sa(0.3)	0.044	0.126	0.197
Sa(0.5)	0.032	0.089	0.140
Sa(1.0)	0.015	0.045	0.070
Sa(2.0)	0.0061	0.021	0.033
Sa(5.0)	0.0012	0.0047	0.0081
Sa(10.0)	0.0006	0.0019	0.0032
PGA	0.033	0.104	0.166
PGV	0.022	0.069	0.112

References

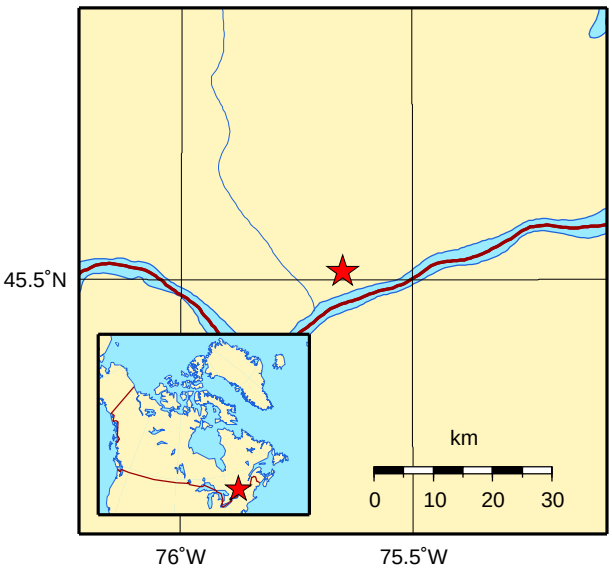
National Building Code of Canada 2015 NRCC no. 56190;
Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

User's Guide - NBC 2015, Structural Commentaries NRCC no. xxxxxx (in preparation)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information

Aussi disponible en français



Jacques Whitford
Stantec Limited

SHEAR WAVE VELOCITY CALCULATION

Project No. 1049643
CPT09-2

Depth	Elevation	Time (s)	Distance (m)	V_s
3.99	98.21	0.0210	4.20	108.1
4.70	97.50	0.0240	4.88	227.6
5.62	96.58	0.0345	5.77	85.2
6.59	95.61	0.0440	6.72	100.1
7.57	94.63	0.0515	7.68	127.9
8.55	93.65	0.0605	8.65	106.9
9.53	92.67	0.0655	9.61	193.9
10.49	91.71	0.0726	10.57	134.7
11.47	90.73	0.0829	11.54	94.1
12.44	89.76	0.0870	12.51	236.3
13.42	88.78	0.0933	13.48	154.7
14.40	87.80	0.1003	14.45	138.6
15.38	86.82	0.1093	15.43	108.4
16.36	85.84	0.1145	16.41	187.8
17.33	84.87	0.1173	17.38	347.4
18.31	83.89	0.1256	18.36	118.0
19.29	82.91	0.1320	19.34	152.4
20.28	81.92	0.1360	20.32	246.1
21.26	80.94	0.1388	21.30	350.8
24.20	78.00			120.0
28.20	74.00			350.0
30.20	72.00			350.0
32.20	70.00			350.0
33.40	68.80			350.0

Estimated Values

Weighted Average Vs = 170.3 m/s

Estimated Vs_{30} = 220.5 m/s

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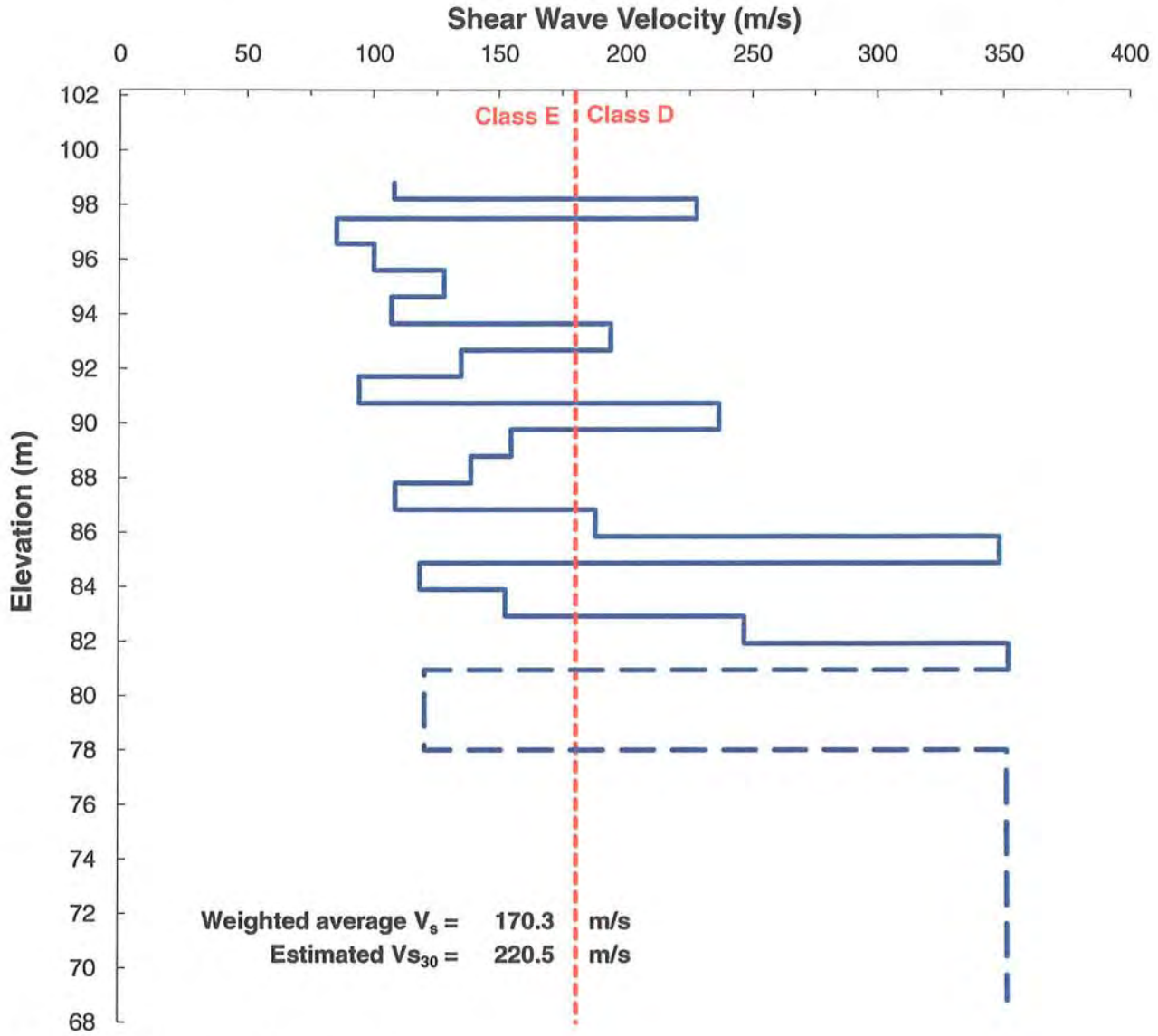
Jacques Whitford
Stantec Limited

SHEAR WAVE VELOCITY
Incremental Between Measured Depths



Shear Wave Velocity, V_s

- The "shear wave velocity" of a soil represents the speed at which any shear wave will travel within this soil (or medium).

- The shear wave velocity at specific depths is measured by inducing a shear wave at surface and measuring the arrival time of the wave at depth.

- The incremental V_s values were calculated as

$$V_s = \frac{L_2 - L_1}{t_2 - t_1}$$

where L_2 and L_1 are the shear wave travel length at two depths and t_2 and t_1 are the arrival times of the waves on the trace plots for the two corresponding depths.

Jacques Whitford
Stantec Limited

SHEAR WAVE VELOCITY CALCULATION

Project No. 1049643

CPT09-3

Depth	Elevation	Time (s)	Distance (m)	V_s
4.10	98.04	0.0114	4.30	133.8
5.06	97.08	0.0189	5.22	122.8
6.04	96.10	0.0255	6.18	145.3
7.04	95.10	0.0321	7.16	148.2
7.98	94.16	0.0369	8.08	193.4
9.01	93.13	0.0470	9.10	100.9
10.00	92.14	0.0540	10.08	140.5
11.95	90.19	0.0675	12.02	143.1
13.93	88.21	0.0803	13.99	81.7
16.80	85.34	0.0920	16.85	244.9
18.59	83.55	0.1446	18.63	33.9
20.14	82.00			350.0
24.14	78.00			350.0
26.14	76.00			350.0
28.14	74.00			350.0
30.14	72.00			350.0
32.14	70.00			350.0
34.14	68.00			350.0

Estimated Values

Weighted Average Vs = 140.3 m/s

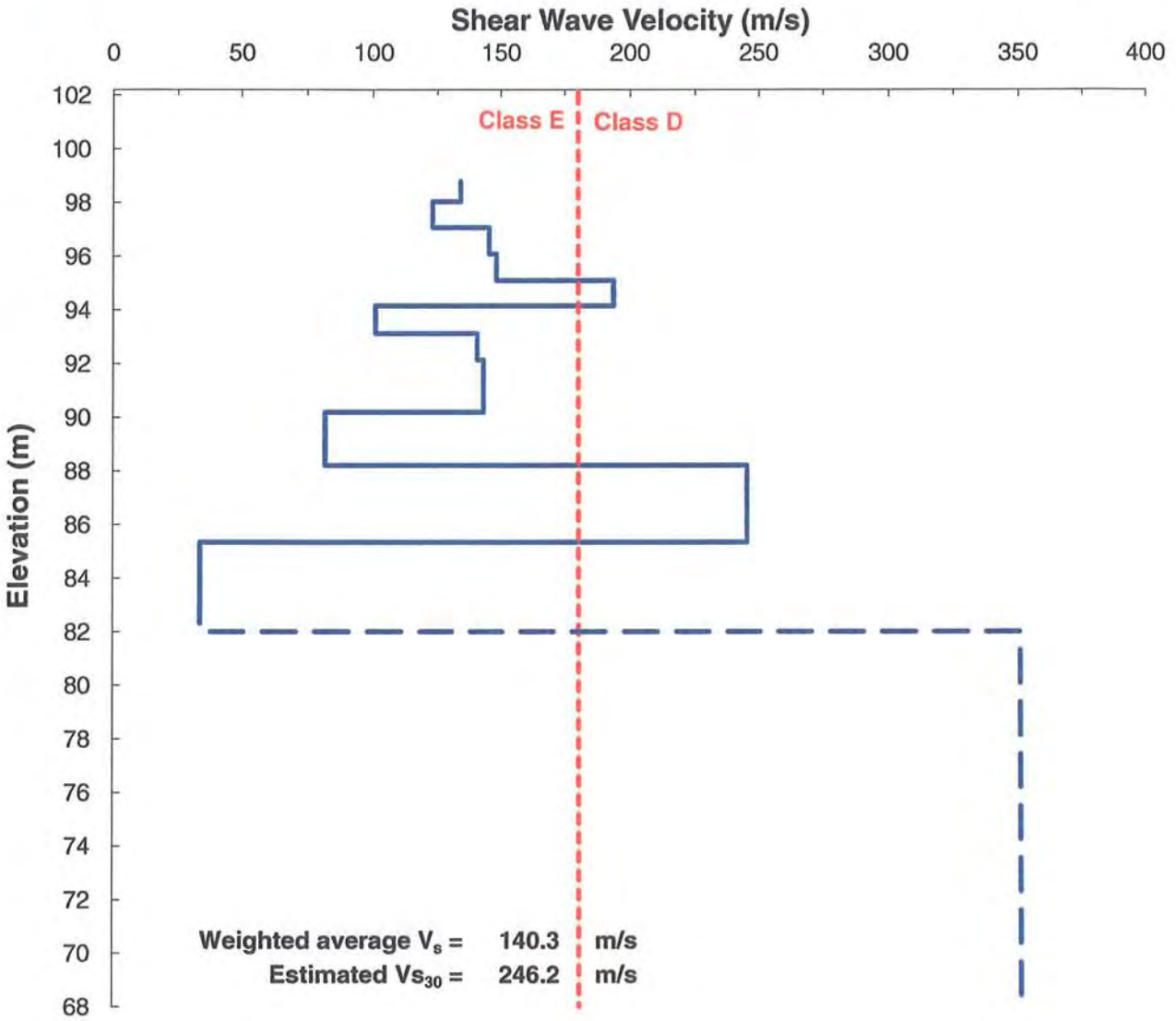
Estimated Vs_{30} = 246.2 m/s

Stantec

Jacques Whitford

SHEAR WAVE VELOCITY

Incremental Between Measured Depths



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where L_2 and L_1 are the shear wave travel length at two depths and t_2 and t_1 are the arrival times of the waves on the trace plots for the two corresponding depths.

Jacques Whitford
Stantec Limited

SHEAR WAVE VELOCITY CALCULATION

Project No. 1049643
CPT09-4

Depth	Elevation	Time (s)	Distance (m)	V_s
2.20	99.81	0.0298	2.55	85.6
3.19	98.82	0.0410	3.44	79.2
4.18	97.83	0.0495	4.37	109.5
5.16	96.85	0.0587	5.32	103.2
6.15	95.86	0.0666	6.28	122.7
7.13	94.88	0.0764	7.25	98.1
8.12	93.89	0.0844	8.22	121.9
9.11	92.90	0.0894	9.20	194.9
10.09	91.92	0.0980	10.18	113.9
11.08	90.93	0.1012	11.16	305.4
12.07	89.94	0.1092	12.14	123.0
13.06	88.95	0.1127	13.12	281.0
14.05	87.96	0.1198	14.11	139.0
15.04	86.97	0.1278	15.10	123.3
16.03	85.98	0.1326	16.08	205.3
17.02	84.99	0.1384	17.07	169.9
18.01	84.00	0.1439	18.05	179.5
19.99	82.02	0.1676	20.03	83.3
20.98	81.03	0.1730	21.01	182.7
21.96	80.05	0.1866	22.00	72.5
22.95	79.06	0.1918	22.98	189.1
23.94	78.07	0.1963	23.97	220.1
28.01	74.00			120.0
30.01	72.00			120.0
32.01	70.00			120.0
33.21	68.80			120.0

Estimated Values

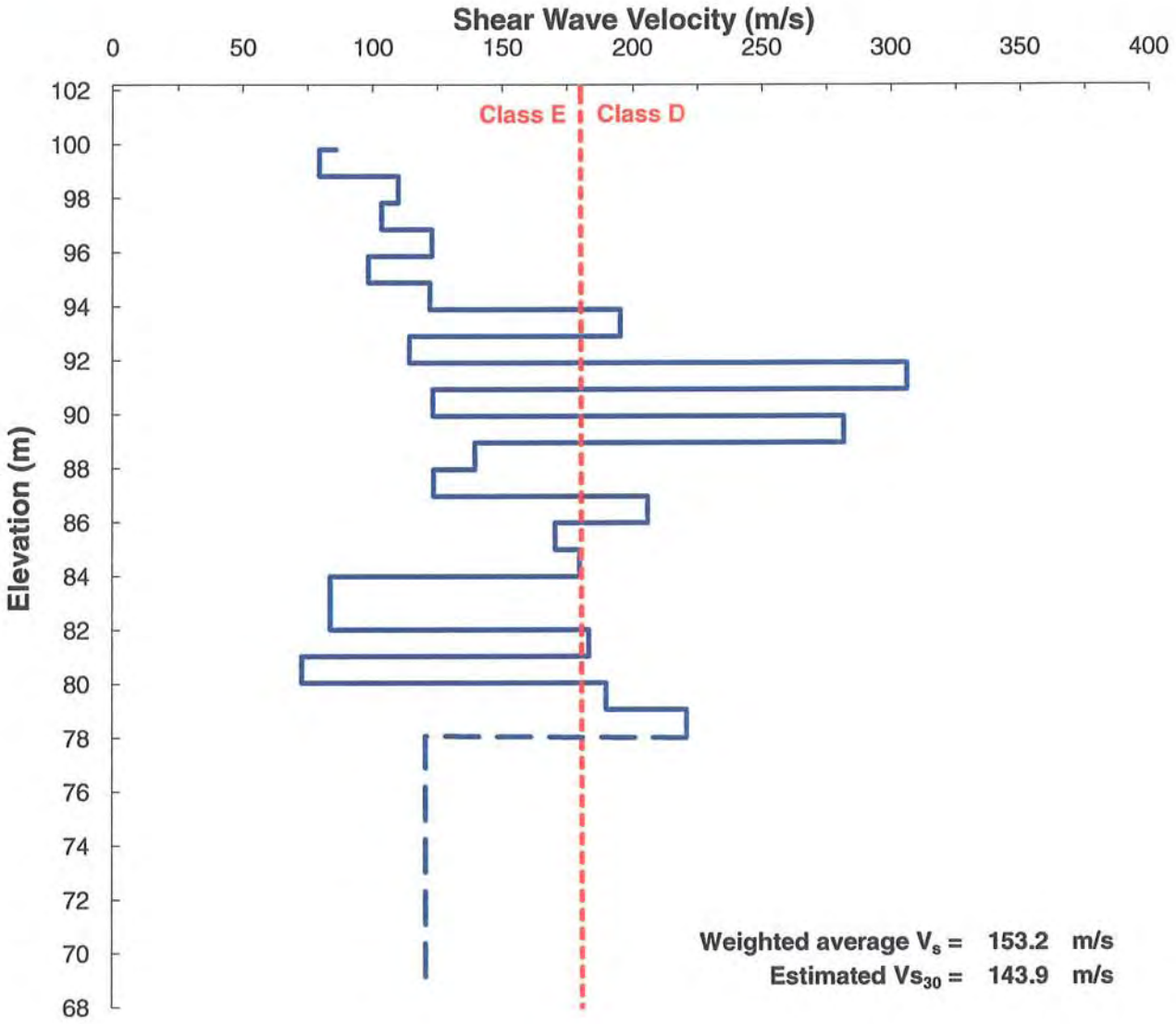
Weighted Average Vs = 153.2 m/s

Estimated Vs_{30} = 142.9 m/s

Jacques Whitford
Stantec Limited

SHEAR WAVE VELOCITY

Incremental Between Measured Depths



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$$V_s = \frac{L_2 - L_1}{t_2 - t_1}$$

where L_2 and L_1 are the shear wave travel length at two depths and t_2 and t_1 are the arrival times of the waves on the trace plots for the two corresponding depths.

Project No. 1049643
CPT09-4

Jacques Whitford
Stantec Limited

SHEAR WAVE VELOCITY CALCULATION

Project No. 1049643
CPT09-5

Depth	Elevation	Time (s)	Distance (m)	V_s
3.18	98.86	0.0097	3.43	353.7
4.15	97.89	0.0146	4.34	184.4
5.10	96.94	0.0235	5.26	104.0
6.05	95.99	0.0331	6.19	95.9
7.01	95.03	0.0429	7.13	96.4
7.97	94.07	0.0503	8.07	127.1
8.92	93.12	0.0591	9.01	107.3
9.87	92.17	0.0672	9.95	115.3
10.82	91.22	0.0768	10.89	98.8
11.77	90.27	0.0839	11.84	132.5
12.72	89.32	0.0918	12.78	119.7
14.60	87.44	0.1090	14.66	108.8
15.56	86.48	0.1128	15.61	250.7
16.51	85.53	0.1179	16.56	186.9
17.47	84.57	0.1259	17.51	118.9
19.32	82.72	0.1379	19.36	154.0
20.27	81.77	0.1454	20.31	127.1
21.20	80.84	0.1497	21.24	214.9
22.13	79.91	0.1538	22.16	225.6
23.08	78.96	0.1679	23.12	67.6
28.04	74.00			350.0
30.04	72.00			350.0
32.04	70.00			350.0
33.24	68.80			350.0

Estimated Values

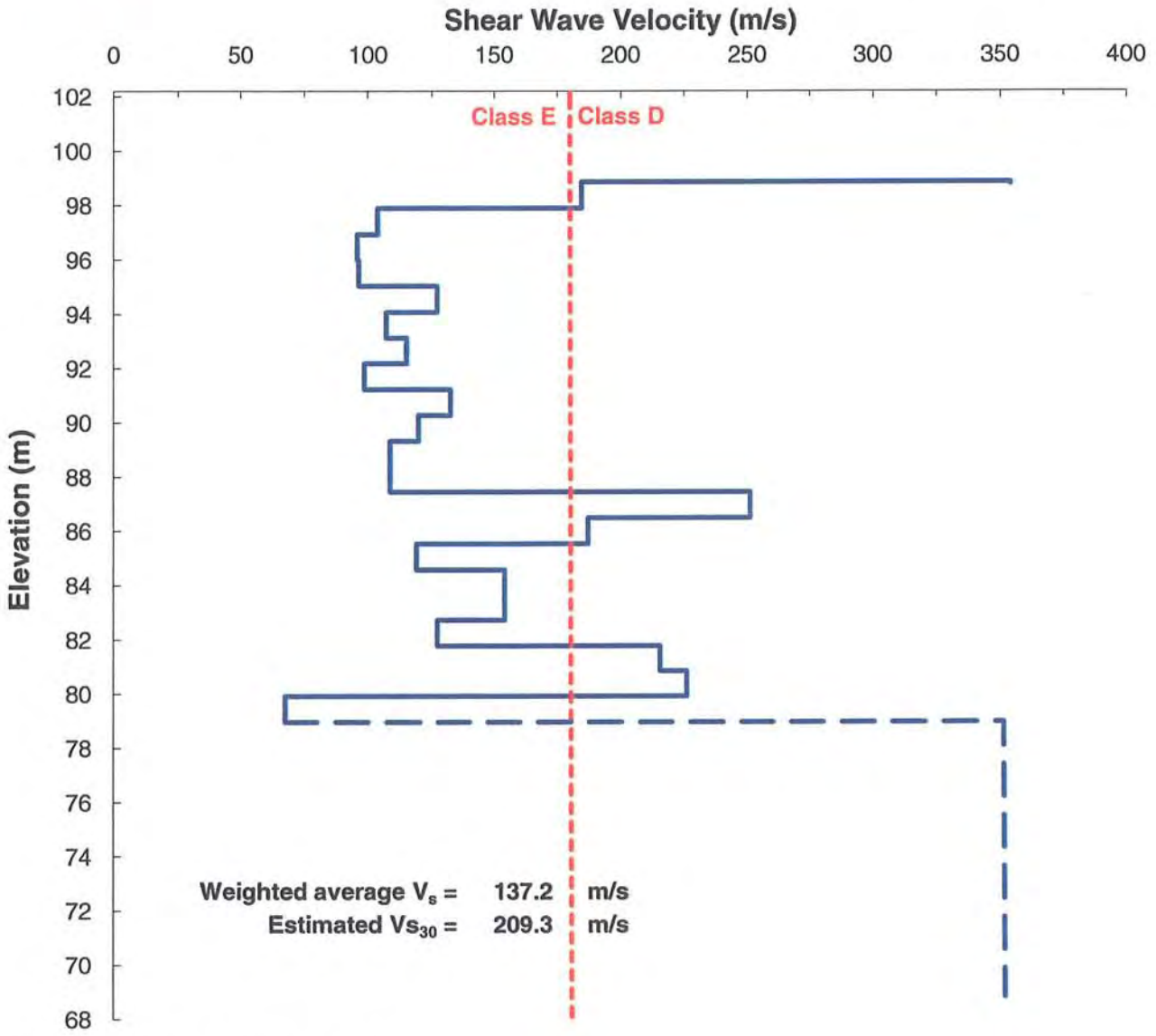
Weighted Average Vs = 137.2 m/s

Estimated Vs_{30} = 209.3 m/s

Jacques Whitford
Stantec Limited

SHEAR WAVE VELOCITY

Incremental Between Measured Depths



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- The incremental V_s values were calculated as $$V_s = \frac{L_2 - L_1}{t_2 - t_1}$$

where L_2 and L_1 are the shear wave travel length at two depths and t_2 and t_1 are the arrival times of the waves on the trace plots for the two corresponding depths.

Project No. 1049643
CPT09-5

Jacques Whitford
Stantec Limited

SHEAR WAVE VELOCITY CALCULATION

Project No. 1049643
CPT09-6

Depth	Elevation	Time (s)	Distance (m)	V_s
4.03	97.57	0.0152	4.23	72.8
4.99	96.61	0.0240	5.16	104.7
5.95	95.65	0.0329	6.09	105.1
6.92	94.68	0.0425	7.04	98.5
7.87	93.73	0.0501	7.98	124.1
8.84	92.76	0.0576	8.93	126.9
9.79	91.81	0.0648	9.88	131.2
10.76	90.84	0.0721	10.84	131.6
11.72	89.88	0.0784	11.79	152.2
12.68	88.92	0.0845	12.75	156.5
14.61	86.99	0.0991	14.67	131.5
15.57	86.03	0.1050	15.63	162.2
16.53	85.07	0.1120	16.58	137.0
17.50	84.10	0.1170	17.55	192.5
19.42	82.18	0.1271	19.47	190.1
20.39	81.21	0.1327	20.43	171.9
21.60	80.00			350.0
23.60	78.00			350.0
25.60	76.00			350.0
27.60	74.00			350.0
29.60	72.00			350.0
31.60	70.00			350.0
32.80	68.80			350.0

Estimated Values

Weighted Average Vs = 138.4 m/s

Estimated Vs_{30} = 226.0 m/s

Stantec

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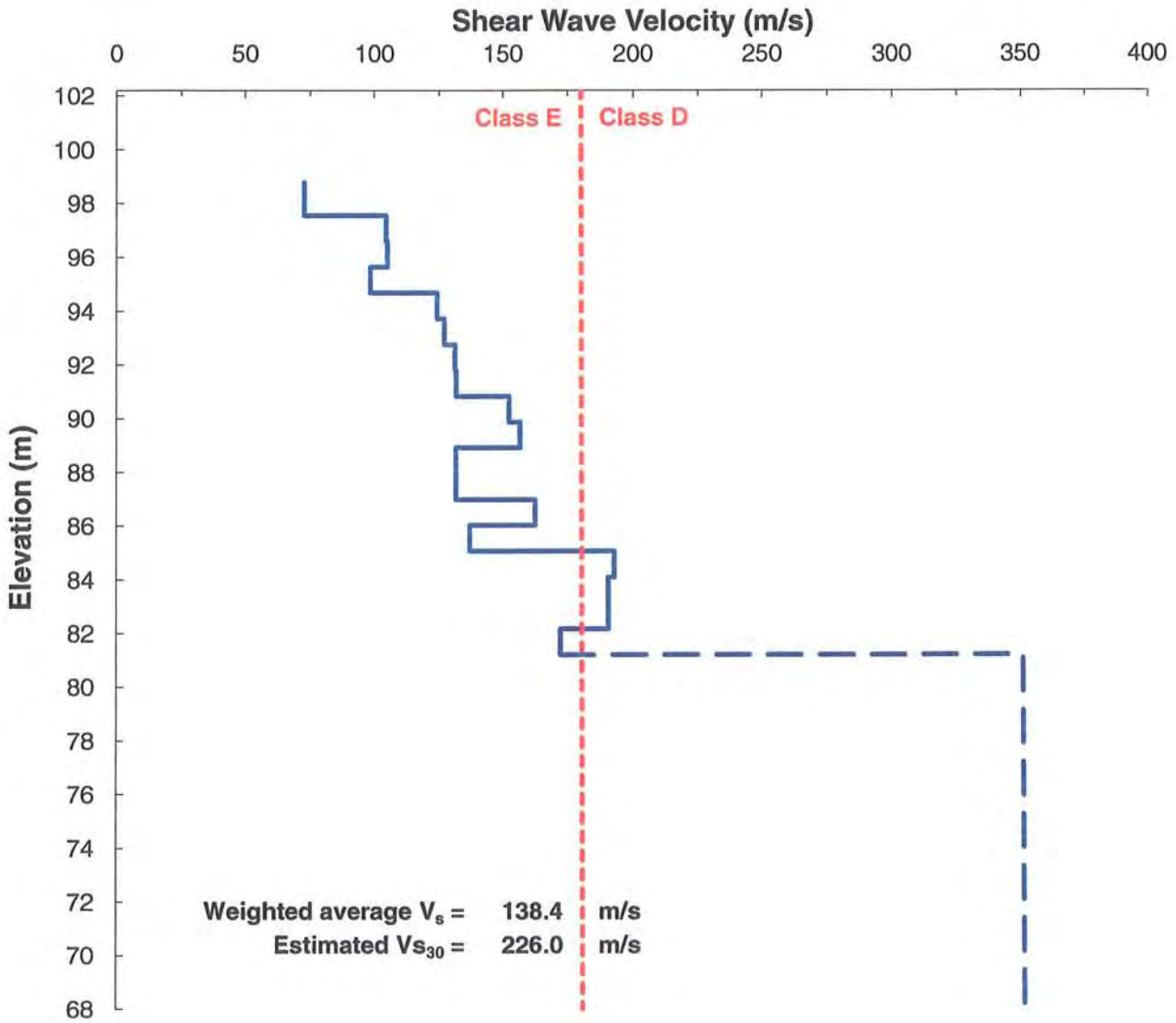
Stantec Limited

SHEAR WAVE VELOCITY

Incremental Between Measured Depths



Shear Wave Velocity, V_s

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- The incremental V_s values were calculated as

$$V_s = \frac{L_2 - L_1}{t_2 - t_1}$$

where L_2 and L_1 are the shear wave travel length at two depths and t_2 and t_1 are the arrival times of the waves on the trace plots for the two corresponding depths.

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