FOUNDATION DESIGN REPORT

PROPOSED THREE POLE-MOUNTED VARIABLE MESSAGE SIGNS, HIGHWAY 401 AND 417, ONTARIO

Site#6 Location(Lat: 45.057272˚, Long: -74.875969˚)

Site#14 Location(Lat: 45.201111˚, Long: -74.363847˚)

Site#15 Location(Lat: 45.548364˚, Long: -74.425097˚)

MINISTRY OF TRANSPORTATION ONTARIO

G.W.P 4022-20-00

GEOCRES NO. 31G-285

WSP PROJECT NO.: 20M-00589-00

MARCH 11, 2021

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5 DISCUSSION AND RECOMMENDATIONS

5.1 GENERAL

This section of the report, on foundation design (FDR), provides recommendations for the foundation aspects for the proposed three, Pole-Mounted Variable Message Signs (VMS) at three distinct locations along Highway 401 and 417. This was undertaken as part of the WSP Retainer Assignment 2019-E-0042. The foundation investigation reports (FIR) for the three VMS signs (for Priority Sign 6: Hwy 401 – EB at Avonmore Road; for Priority Sign 14: Hwy 401 – WB Quebec Border OnRoute; for Priority Sign 15: Hwy 417 – WB Quebec Border Travel Info Tourist Centre), were documented by another foundation service provider. This was commissioned by MTO, under a separate assignment, 4019-E-0002 Assignment #5, in two separate FIR reports; namely, FIR report for Priority Signs 14 and 15 dated October 7, 2020 (referred to as FIR 1 in this report); FIR report for Priority Sign 6 dated November 30, 2020 (referred to as FIR 2 in this report). For ease of reading, the two FIR reports are attached to this FDR report as Appendix A where the site locations of the three VMS structures are shown. The recommendations are based on our understanding of the project and on our interpretation of the factual data compiled from both field and laboratory investigations documented in the FIR reports.

The discussions and recommendations presented in this report are intended to assist the designers with sufficient information that would enable them to proceed with the design of the proposed VMS Structure foundations.

Construction comments made herein are based on geotechnical considerations only and should not be relied upon without further independent assessment and qualification in the selection of means and methods for construction.

In what follows, Canadian Highway Bridge Design Code (CHBDC, 2019: CSA S6-19) will be referred to as CHBDC (2019), the Commentary on CSA S6-19, Canadian Highway Bridge Design Code will be referred to as CHBDC (2019) Commentary and the MTO Sign Support Manual (February 2019) will be referred to as MTO SSM (2019).

5.2 GROUND CHARACTERISATION

5.2.1 FROST DEPTH AND FROST SUSCEPTIBILITY

The minimum earth cover required for a structure subjected to frost action at the project sites is 1.8 m in accordance with Ontario Provincial Standard Drawing, OPSD 3090.101 (Foundation, Frost Penetration Depths for Southern Ontario).

5.2.2 OVERVIEW OF SUB-SURFACE CONDITIONS

Site #6

BH6 refers to the borehole advanced at this VMS location (See FIR 2) (Ground El. 82.7 m). It was advanced to a depth of 9 m below existing grade. Overburden thickness intercepted was 6.3 m and the remaining explored underlying depth of 2.7 m was cored limestone bedrock. Overlying a veneer of topsoil, a fill thickness of about 2.0 m comprising silty sand and amorphous organic fill was underlain by native deposits. Underlying the fill was about 0.9 m thick silty clay underlain by a compact to very dense gravelly, clayey sand (glacial till) overlying bedrock.

The bedrock is described as limestone and based on the RQD (77% to 91%) and UCS (36.7 MPa) can be described as good quality (CFEM, Table 3.10) and medium strong (CFEM, Table 3.5).

Egress of Groundwater was observed at the time of the investigation at a depth of 1.8 m below existing grades, probably from the amorphous organic fill. No groundwater monitoring well was installed.

Based on the borehole information and our review of the general subsurface conditions in the area, the subject site for the proposed VMS pole foundation can be classified as Site Class 'D' for seismic site response according to Table 4.1 of the CHBDC (2019).

The geotechnical model of the subsurface conditions is given in Table 5-1.

Site #15

BH15 refers to the borehole advanced at this VMS location (See FIR 1) (Ground El. 52.7 m). It was advanced to a depth of 10.0 m below existing grade. The borehole was terminated within the overburden. Below a veneer of topsoil, about 1.7 m thick fill comprising silty sand was contacted, underlain by a native glacial deposit of sandy silt. The borehole was terminated in this glacial deposit.

The fill material is probably a re-worked till based on the grain size distribution. This fill based on a single SPT test carried out within this layer, has a SPT 'N' value of 43, thus probably reflective of cobbles. The underlying cohesionless glacial till was compact to very dense. Due to auger refusal, the native till had to be cored from a depth of 4.5 to 6.5 m below ground surface, through possible boulders.

No egress of Groundwater was observed at the time of the investigation. No groundwater monitoring well was installed.

Based on the borehole information and our review of the general subsurface conditions in the area, the subject site for the proposed VMS pole foundation can be classified as Site Class 'C' for seismic site response according to Table 4.1 of the CHBDC (2019).

The geotechnical model of the subsurface conditions is given in Table 5-2.

Site #14

BH14 refers to the borehole advanced at this VMS location (See FIR 1) (Ground El. 48.8 m). It was advanced to a depth of 10.0 m below existing grade. The borehole was terminated within the overburden. In general, below a veneer of topsoil of 0.1 m thickness, a 7.9 m thick deposit of silty clay was contacted, underlain by a native glacial deposit of silty sand. The borehole was terminated in this glacial deposit.

The silty clay deposit was of high plasticity based on the Atterberg results. It was stiff to very soft, up to to 3.5 m depth. The consistency of this deposit thereafter became very soft to soft with depth based on field shear vane testing. Following a 0.3 m thick deposit of silt, the basal layer intercepted at 8.3 m depth was a silty sand of glacial origin. Following auger refusal at 8.5 m depth, coring was undertaken till the termination of the borehole at 10.0 m depth.

Egress of Groundwater was observed at the time of the investigation at a depth of 1.2 m below existing grades, probably from the amorphous organic fill. No groundwater monitoring well was installed.

Based on the borehole information and our review of the general subsurface conditions in the area, the subject site for the proposed VMS pole foundation can be classified as Site Class 'E' for seismic site response according to Table 4.1 of the CHBDC (2019).

The geotechnical model of the subsurface conditions is given in Table 5-3.

5.3 FOUNDATION RECOMMENDATIONS

5.3.1 GENERAL

VMS structure foundations are typically founded on short caisson foundations (MTO SSM (2019)) unless this is not possible due to shallow bedrock. SLS conditions typically dictate VMS structure foundation design (CHBDC (2019) for lateral loading. Vertical loading effects are not considered significant for these structure foundations. The geotechnical lateral resistance is

greatly affected by the soil properties close to the ground level (about 10 pile diameters, Ref: Piling Engineering, Fleming, et. al.).

It is to be noted that the major lateral load direction (i.e. due to wind action) is along the road for VMS structures as the signage boards will be oriented perpendicular to the road centreline. This major lateral loading direction is favourable to resist lateral load due to non-interference with slope effects.

5.3.2 CONSEQUENCE AND SITE UNDERSTANDING CLASSIFICATION

The proposed VMS structure foundations are classified as having a "Low Consequence Level" associated with exceeding limit states design, as per Section 6.5.1 of CHBDC (2019).

Based on the level of foundation investigations completed at the proposed VMS structure locations, in comparison to the degree of site understanding outlined in Section 6.5 of CHBDC (2019), a "Typical Degree of Site and Prediction Model Understanding" is considered appropriate for the proposed VMS structure foundations.

Value for the corresponding consequence factor, Ψ = 1 is then appropriate. Given that typical VMS foundations are deep foundations, i.e. caissons, geotechnical resistance factors, ϕ_{gu} = 0.4 for axial compression and ϕ_{gu} = 0.5 for lateral resistance and ϕ_{gs} = 0.8 for settlement and lateral deflection, from Tables 6.1 and 6.2 of the CHBDC (2019) have been used for the appropriate aspects of the foundation design.

5.3.3 GEOTECHNICAL PARAMETERS – LATERAL/AXIAL STRENGTH/STIFFNESS

Site #6

Based on the overburden soil conditions, short caissons are recommended. Geotechnical recommendations (pertaining to lateral/axial - capacity and deformations) are addressed in Table 5-1 and are made with respect to the proposed VMS structure foundation, taking into account the intercepted site ground conditions, i.e. Layered Cohesive/Cohesionless Strata.

Table 5-1: Geotechnical Parameters – Lateral/Axial - Caisson Resistance/Deformation Parameters – Site #6

Layer/Elevation (m) BH6 Ground Elevation – 82.7	Unit Weight (kN/m^3)	Lateral Resistance		Lateral Deformation		Axial - Compression/Deformation	
		Passive Earth Pressure Coefficient (K_p)	Undrained Shear Strength (kPa)	Constant of Horizontal Subgrade Reaction (MN/m^3)	Spring Constant (MN/m)	Shaft Friction/ End Bearing (Factored ULS) (kPa)	Deformation Modulus (MPa)
Layer 1: Fill (compact silty sand/amorphous organic silt) (El. 82.5 To El. 80.5)	18	NA	NA	NA	NA	NA	NA
Layer 2: Stiff Silty Clay (El. 80.5 to El. 79.6)	19	NA	75	12	15	4/ NA	20

Layer/Elevation (m) BH6 Ground Elevation – 82.7	Unit Weight (kN/m^3)	Lateral Resistance		Lateral Deformation		Axial - Compression/Deformation	
		Passive Earth Pressure Coefficient (K_p)	Undrained Shear Strength (kPa)	Constant of Horizontal Subgrade Reaction (MN/m^3)	Spring Constant (MN/m)	Shaft Friction/ End Bearing (Factored ULS) (kPa)	Deformation Modulus (MPa)
Layer 3: Compact Gravelly Clayey Sand Till_1 (El. 79.6 to El. 78.2)	20	3.3	NA	25	30	9/ NA	40
Layer 4: Dense to very dense Gravelly Clayey Sand Till_2 (El. 78.2 to El. 76.4)	21	3.9	NA	42	50	18/ NA	70
Layer 5: Limestone Bedrock – good quality/medium strength BH terminated at El. 73.7	25	NA	1000	420	500	300/ 5000	1000

*Notes: In the absence of groundwater level monitoring and in view of the sandy nature of the surficial deposits, the design water level should be assumed at existing ground elevation.

Site #15

Based on the overburden soil conditions, short caissons are recommended. Geotechnical recommendations (pertaining to lateral/axial - capacity and deformations) are addressed in Table 5-2 and are made with respect to the proposed VMS structure foundation, taking into account the intercepted site ground conditions, i.e. Layered Cohesionless Strata.

Table 5-2: Geotechnical Parameters – Lateral/Axial - Caisson Resistance/Deformation Parameters – Site #15

Layer/Elevation (m) BH15 Ground Elevation – 52.7	Unit Weight (kN/m^3)	Lateral Resistance		Lateral Deformation		Axial - Compression/Deformation	
		Passive Earth Pressure Coefficient (K_p)	Undrained Shear Strength (kPa)	Constant of Horizontal Subgrade Reaction (MN/m^3)	Spring Constant (MN/m)	Shaft Friction/ End Bearing (Factored ULS) (kPa)	Deformation Modulus MPa
Layer 1: Fill (Loose to dense, silty sand) (El. 52.6 To El. 50.9)	19	NA	NA	NA	NA	NA	NA
Layer 2: Compact to dense, Sandy Silt_1(Till) (El. 50.9 to El. 49.0)	20	3.3	NA	42	50	10/ NA	45
Layer 3: Very dense to dense Sandy Silt_2 (Till) (El. 49.0 to El. 42.7)	21	3.5	NA	50	60	16/ 2000	80

*Notes: In the absence of groundwater level monitoring and in view of the sandy nature of the surficial deposits, the design water level should be assumed at existing ground elevation.

Site #14

Drawing 1 attached shows that this VMS structure is to be located on the road embankment side slope. The lateral resistance of the VMS structure will be largely exploited within the stiff to very soft silty clay deposit. The axial load can be resisted on top of the dense glacial till. Hence, the design will be controlled by lateral resistance and more specifically by lateral deflection. Therefore, in order to augment lateral resistance of the surficial layers, it was considered prudent to replace the upper 1.0 m with engineered OPSS 1010 Granular 'A' material.

A four-layer geotechnical model was used with the p-y modelling approach. The top 1.0 m should be sub-excavated and backfilled engineered Granular 'A' layer to 98% of the SPMDD. This sub-excavation, in plan, should be constructed in a rectangular slot 4.5 m long, i.e. parallel to the road and 2.1 m wide. This slot will be centred around a 1.5 m diameter caisson. The compaction should be undertaken with hand-operated equipment. Table 5-3 shows the geotechnical model adopted.

Table 5-3: Geotechnical Parameters – Lateral Loading Analysis- p-y model – Site #14

Layer/Thickness (m) BH14	Unit Weight (kN/m^3)	p-y model parameters			
		Strain Factor	Undrained Shear Strength (kPa)	Friction Angle (deg)	k_{py} (kN/m^3)
Layer 1: Fill (Engineered OPSS 1010 Granular 'A') 1.0 m thick	20	NA	NA	32	24400
Layer 2: Silty Clay_1 0.8 m	17	0.02	5	NA	NA
Layer 3: Silty Clay_2 1.0 m	18	0.02	36	NA	NA
Layer 4: 5.5 m	17	0.02	10	NA	NA

The lateral pile analysis was undertaken with the RSPile software (Rocscience). The caisson will be end bearing and nominally embedded into the glacial till at El. 40.2 based on BH14. A factored ULS for end-bearing resistance of 3.0 MPa at or below El. 40.2 m, i.e. 300 mm into the glacial till, is recommended. The predicted lateral movement of 17 mm under free-head boundary condition at the top of the caisson is predicted for a horizontal factored load of 64 kN and a factored moment of 534 kN-m. The predicted lateral displacement is considered reasonable for a pole-mounted structure given that it was based on a non-linear conservative geotechnical model. A permanent liner is recommended in view of the very soft clay deposit as the VMS structure will be founded on a single caisson. Therefore, any compromise of the integrity of the caisson likely to be introduced while retrieving the liner in very soft mud must be avoided.

5.4 CONSTRUCTION CONSIDERATIONS

5.4.1 GENERAL

Construction should be compliant with OPSS.PROV 903 - Construction Specifications for Deep Foundations and OPSS.PROV 915 – Construction Specifications for VMS Structures. Caisson construction should be monitored by qualified geotechnical personnel as per OPSS 903 to verify the soil conditions and to confirm that the exposed soil conditions are compatible with the design assumptions in this report.

The contractor is responsible for construction of the VMS foundations to ensure least disturbance to the material at the sides and/or bases of the caisson foundations.

5.4.2 SITE PREPARATION AND RESTORATION

All surficial topsoil, organics loosened/softened and deleterious materials should be stripped from the proposed VMS structure foundation locations and should backfill the area in accordance with OPSS 902 (Excavating and Backfilling

Structures). Further the contractor is responsible for proper disposal of excavated materials as per OPSS 180 and site restoration as per OPSS 492.

5.4.3 TEMPORARY OPEN-CUT EXCAVATIONS

All open-cut excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA). O. Reg. 213/91. The open-cut side slope recommendations given below are for short-term open excavations only and should be visually monitored especially when people are working inside.

Excavations in the overburden soils should be possible using heavy equipment such as a hydraulic excavator and obstructions such as cobbles and boulders within the fill and native deposits should be anticipated.

Additional geotechnical engineering input will be required if any proposed temporary excavation were to abut an existing embankment or embankment side slope.

Where space permits, and appropriate groundwater control measures are in place, as deemed required, temporary open cut excavations may be undertaken subject to the following guidelines:

Site #6

In accordance with OHSA and based on the geotechnical understanding and interpretation of the site conditions, the sub-soils intercepted can be classified as follows:

- Fill Material - not steeper than 2H:1V
- Silty Clay: not steeper than 1.5H:1V

Deeper excavations are not expected to be required.

Site #15

In accordance with OHSA and based on the geotechnical understanding and interpretation of the site conditions, the sub-soils intercepted can be classified as follows:

- Fill Material - not steeper than 1H:1V
- Sandy Silt Till: not steeper than 1H:1V

Site #14

- Open-cut excavations up to the upper 2.0 m of Silty Clay- not steeper than OHSA Type 4
- Open-cut excavations below 2.5 m depth into Silty Clay: Independent geotechnical advice should be sought

5.4.4 GROUNDWATER CONTROL

Seepage and/or soil sloughing into the caisson holes may occur from existing fill and cohesionless soils.

The control of groundwater during construction should be undertaken as per OPSS.PROV 517 (Construction Specification for Dewatering). In the event of any minor dewatering, no settlement impacts are envisaged.

Site #6

Significant inflows into the caisson bore are not expected but cannot be ruled out (in view of the glacial deposit). In view of the weak upper strata as discussed in Section 5.2.2, use of temporary liners should be anticipated. Therefore, temporary liners must be available on site, or be made available on very short notice, to support the caisson sidewalls and provide seepage cut-off where required. Preparedness for bailing/pumping out any groundwater inflow should be anticipated.

Site #15

Significant inflows into the caisson bore are not expected but cannot be ruled out (in view of the glacial deposit). Preparedness for bailing/pumping out any groundwater inflow should be anticipated.

Site #14

Significant inflows into the caisson bore are not expected but cannot be ruled out. Preparedness for bailing/pumping out any groundwater inflow should be anticipated.

5.4.5 EXCAVATABILITY CONSIDERATIONS

Based on the intercepted ground conditions at the three VMS sites, variable subsurface conditions cannot be ruled out. In view of the observations during the field investigations that impact excavatability reported in the borehole logs, the contractor must be equipped with caisson shaft excavation equipment to remove/penetrate obstructions posed by cobbles and boulders.

Site #6

In addition to the possible requirement for the use of a temporary liner discussed in Section 5.4.3, presence of cobbles and boulders in the glacial till and debris inclusions in the fill materials cannot be ruled out. In fact, presence of cobbles has been noted in BH6. Temporary liners must be available on site, or be made available on very short notice, to support the caisson sidewalls and provide seepage cut-off where required;

Site #15

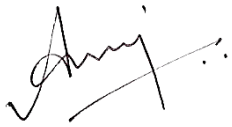
Requirement for the use of a temporary liner is not anticipated for the construction of the VMS foundation. Presence of cobbles and boulders have been noted in BH15 and coring through an intermediate depth of the glacial till was undertaken and these observations should be taken note of.

Site #14

Requirement for the use of a permanent liner is recommended for the construction of VMS foundation as discussed in Section 5.3.3. Presence of cobbles and boulders have been noted in BH14 and a significant depth of the glacial till was cored, and these observations should be taken note of.

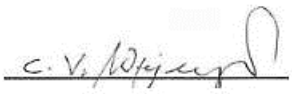
It is recommended that contract documents should contain an NSSP alerting the contract bidders of the specific ground conditions relating to caisson construction for the VMS foundations at each site. A suggested wording for the NSSP is attached in Appendix C.

SIGNATURES



Anuj Choudhari, M.Sc., P.E.
Geotechnical EI

Nick La Posta, P.Eng.
Senior Geotechnical Engineer

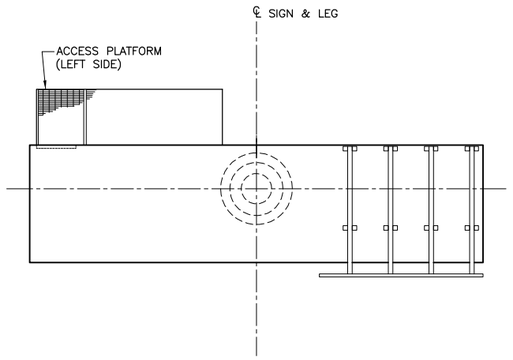


Vasantha Wijeyakulasuriya, M.Eng., P.Eng.
Senior Technical Director (Geotechnical)
MTO Designated Contact (Foundations)

REFERENCES

- Canadian Highway Bridge Design Code (CHBDC) and Commentary on CAN/CSA S6-19. 2019. CSA Special Publication, S6.1 19. Canadian Standard Association.
- Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, 4th Edition. The Canadian Geotechnical Society c/o BiTech Publisher Ltd, British Columbia.
- MTO Sign Support Manual, 2019.

DRAWINGS



PLAN

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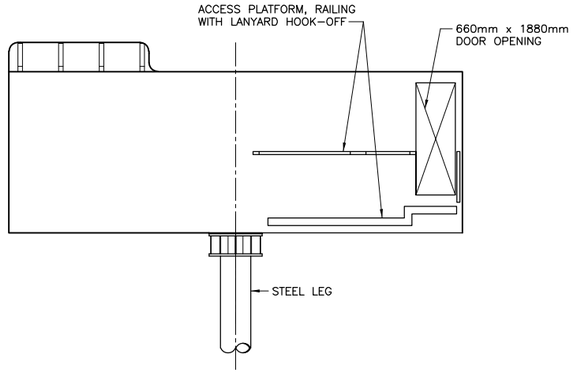

BACK ELEVATION

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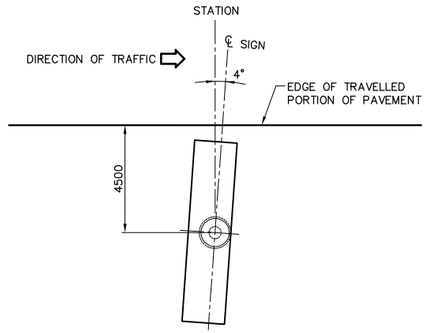
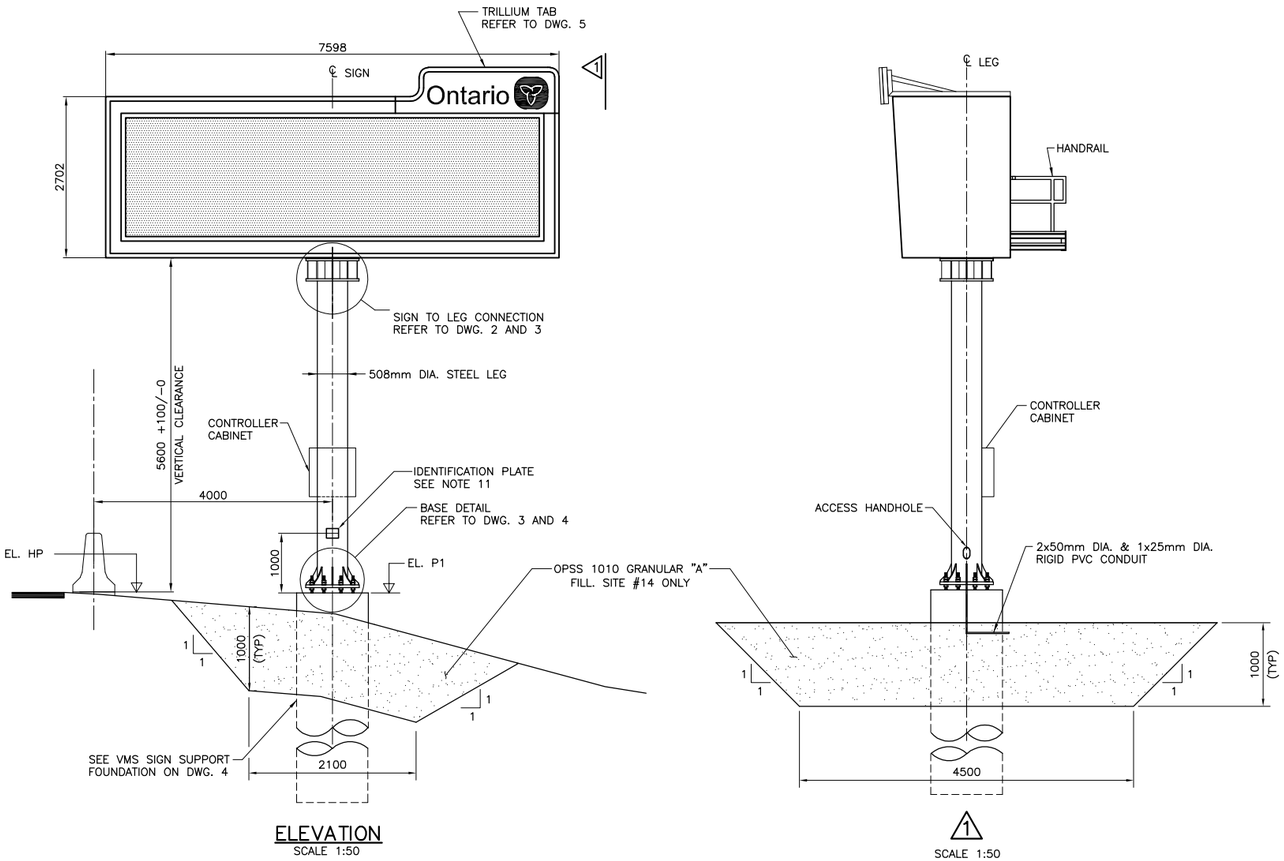


LAYOUT PLAN



ELEVATION

SCALE 1:50

1

SCALE 1:50

TABLE 1 – GENERAL

PVMS SITE No.	6	14	15
STRUCTURE SITE No.			
STATION	13+113	22+871	25+716
EL. HP	83.35	50.35	53.73
EL. P1	85.77	49.39	52.10

DISTRICT
CONT. No.
WP No. 4022-20-00

HIGHWAY 401 & 417
POLE MOUNTED VMS

GENERAL ARRANGEMENT

wsp

SHEET
23
METRIC

GENERAL NOTES

1. ALL ALUMINUM EXTRUDED TUBE SECTIONS SHALL BE ALLOY 6061-T6 UNLESS NOTED.
2. ALUMINUM COMPONENTS MADE OF ALLOY 6061-T6.
3. ALL STRUCTURAL STEEL SHALL CONFORM TO STANDARD CAN/CSA-G40.21-M92 GRADE 300W.
4. ALL BOLTS, NUTS AND WASHERS SHALL CONFORM TO ASTM A325M AND BE GALVANIZED IN ACCORDANCE WITH STANDARD CAN/CSA-G164-M92 UNLESS SPECIFIED OTHERWISE.
5. STRUCTURE SHALL NOT BE ERECTED UNTIL FOUNDATION HAS REACHED 80% OF SPECIFIED STRENGTH.
6. ALL STRUCTURAL STEEL WELDING SHALL BE DONE IN ACCORDANCE WITH THE LATEST EDITION OF CSA STANDARD W59-M.
7. ALL ALUMINUM WELDING AND ANCHOR LAYOUT SHALL BE DONE IN ACCORDANCE WITH THE LATEST EDITION OF CSA STANDARD W59.2-M.
8. WELDING DETAILS ARE GIVEN FOR REFERENCE AND ESTIMATING PURPOSES ONLY. FINAL WELD CONNECTIONS SHALL BE DETAILED ON SUBMITTED SHOP DRAWINGS STAMPED BY A PROFESSIONAL ENGINEER.
9. ANCHORAGE LAYOUT AND ELEVATIONS TO BE VERIFIED IN THE FIELD BEFORE SIGN SUPPORT STRUCTURE FABRICATION.
10. ALL STRUCTURAL STEEL SHALL BE GALVANIZED AFTER FABRICATION IN ACCORDANCE WITH STANDARD CAN/CSA-G164-M92. LEG AND ATTACHMENTS SHALL BE SUBSEQUENTLY COATED WITH AN APPROVED PAINT SYSTEM.
11. THIS SIGN SUPPORT SHALL HAVE AN IDENTIFICATION MARKING SHOWING THE STRUCTURE I.D. NUMBER, THE MANUFACTURER'S NAME OR TRADEMARK, AND THE DATE OF MANUFACTURE. THIS MARKING SHALL BE ON A CORROSION PROTECTED PLATE SECURELY ATTACHED TO THE LEG OF THE STUCTURE BY MEANS OF STAINLESS STEEL BAND CLAMPS. THE CONTRACTOR SHALL USE PERMANENT LINER AT SITE # 14 FROM ELEVATION 45.3m DOWN TOELEVATION 40.5m
12. SIGN LEG SHALL NOT BE PLACED ON TOP OF CAISSON UNTIL GRANULAR "A" FILL AT SITE #14 IS PLACED AS SHOWN ON THE DRAWING.
13. NO SHOP SPLICES IN ANY MEMBER.
14. LEGEND:
    HSS DENOTES HOLLOW STRUCTURAL STEEL
    □ DENOTES ALUMINUM SQUARE TUBE

ALUMINUM TUBE SECTIONS	
SIGN COMPONENT	
METRIC SIZE	IMPERIAL SIZE
□ 101.6x101.6x4.78	□ 4"x4"x0.188"
□ 114.3x114.3x9.525	□ 4.5"x4.5"x0.375"
□ 127x127x5.08	□ 5"x5"x0.20"
NOTE: DIMENSIONS OF ALUMINUM TUBE SECTIONS TO BE IMPERIAL AS PER TABLE.	

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS			
DATE	BY	DESCRIPTION	

DESIGN	MB	CHK	CJ	CODE CHBDC 2019	LOAD CL-625-ONT
DRAWN	ZP	CHK	WR	SITE	

DATE FEB/21
DWG 1

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

CAD FILE LOCATION AND NAME: S:\2020\2004-00589-03\300\S2OM-00589-03-0010H.dwg
MODIFIED: 2/9/2021 1:39:42 PM BY: PANZ
DATE PLOTTED: 2/9/2021 1:40:02 PM BY: PAN, WILSON

APPENDIX

A

FOUNDATIONS INVESTIGATION REPORTS BY OTHERS

November 30, 2020 AG File No. 19570-5

Eastern Region Geotechnical Section
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(p) 613-544-2220
(e) Hong.Ye@ontario.ca

Attn: **Hong Ye**, **P.Eng., Project Soils Engineer**

Ref: **Final Foundations Investigation and Recommendation Report for Sixteen (16) Priority Sign Support Base Locations Alongside Highway 401 and 417 (Priority Sign 6), 4019-E-0002 Assignment #5**

Dear Mr. Ye,

Further to the request of the Ministry of Transportation Ontario (MTO), Eastern Region to evaluate the soil conditions at a total of one (1) priority PVMS sign locations along Highway 401. We are pleased to present below the results of our investigation and recommendations.

1.0 GENERAL DATA

The geotechnical component for this project involved obtaining subsoil and bedrock information to enable the structural design of footings for pole-mounted variable message sign supports to be completed by others. This report contains all field investigation results, at the proposed footing locations (as provided by MTO) and soil classification information for all sign locations.

The signs are identified and located as follows:

Sign #6 Hwy 401 –EB at Avonmore Road

All signs are located at or near the base of the road embankment within the MTO right-of-way. A copy of the sign location map provided to our office by MTO is attached to this report as **Enclosure No. 1** along with the individual sign location soil profile figures.

2.0 FIELD INVESTIGATION

A soils investigation was conducted on November 10, 2020 under the constant supervision of a member of the Ainley Group's geotechnical team in accordance with our Terms of Reference. Prior to commencing the field program, Ainley Group contacted the local utility companies and appropriate site authorities to obtain clearances for all underground services and site access in the immediate area of the proposed field program.

One borehole was advanced by means of a track mounted CME 55 (based on site access restrictions) to a depth of 10.0 m below existing site grades or refusal, whichever was less. Representative samples were collected using split spoon sampling methods (Standard Penetration Testing). In situ shear vane testing was completed as necessary in clay deposits. Where split spoon refusal was encountered less than 10.0 m below existing site grades, coring procedures were completed to prove the inferred bedrock contact.

Upon completion, each borehole was backfilled using native material and the core locations were sealed with bentonite hole plug.

The location and ground surface elevation at each respective footing location was surveyed and data shape files were produced with ArcPad V.10.2 and provided electronically to MTO to update their GIS.

3.0 SUBSURFACE CONDITIONS AND LABORATORY ANALYSIS

Full details of the subsurface conditions encountered at the borehole locations are presented on the individual borehole logs attached to this report as **Enclosure No. 2**. It is emphasized however, that the soil types, their sequence, thickness and physical properties may vary between borehole locations and samples both vertically and horizontally at each individual sign location.

Representative samples of materials encountered at each borehole location were secured during the investigation and select samples were forwarded to SNC-Lavalin Group Inc. in Kingston for laboratory analysis. A copy of the individual test results are attached to this report as **Enclosure No. 3.**

In general, the subsoil and groundwater conditions encountered at the individual proposed sign locations and results of the laboratory testing consisted of the following:

Sign No. 6 – Hwy 401 – EB at Avonmore Road

One (1) borehole was advanced at this sign location, referenced as BH6. The borehole was advanced to a depth of 9.0 m below existing site grades and terminated within limestone bedrock.

The subsoil conditions encountered at the borehole location consisted of surficial topsoil overlying loose silty sand some clay extending to a depth of 0.2 m below existing grade. Loose becoming compact silty sand some gravel, cobbles and amorphous organic fill was encountered at a depth of 0.2 m and extended to a depth of 2.2 m below grade. Stiff silty clay trace sand and gravel was encountered at a depth of 2.2 m below grade and extended to a depth of 3.1 m below grade. Compact becoming dense glacial till was encountered at a depth of 3.1 m and extended to a depth of 6.3 m where refusal to auger occurred. Coring techniques were employed at a depth of 6.3 m and was terminated at a depth of 9.0 m below existing grades proving the presence of bedrock. The bedrock was found to be good quality limestone bedrock with some horizontal fractures becoming excellent quality with few horizontal fractures with depth. The RQD was found to be 77% and 91% and a compressive strength of 36.7 MPa.

Groundwater infiltration was encountered at the time of the site investigation at a depth of 1.80 m below existing site grades. The borehole for this sign location was advanced on November 10, 2020.

Two (2) soil samples were submitted for laboratory analysis (JC042, 2.25 – 2.85 m and JC043, 3.0 – 6.3 m). Results of the laboratory analysis are summarized below:

JC042 - Silty Clay trace Sand and Gravel
% Passing 4.75 mm = 98.0
75 µm = 90.0
5 µm = 73.0 LSFH
2 µm = 60.0
Moisture Content = 30.7%
Plasticity Index = 25.6
Classification = CL

JC043 - Clayey Sand with Gravel some Silt and Cobbles
% Passing 4.75 mm = 79.0
75 µm = 43.0
5 µm = 31.0 LSFH
2 µm = 25.0
Moisture Content = 13.6%

4.0 RECOMMENDATIONS

Table Nos. 1 to 16 attached to this report as **Enclosure No. 4,** summarizes the soil engineering parameters for the various soil types noted within the proposed sign locations to assist the structural designer.

5.0 GENERAL COMMENTS

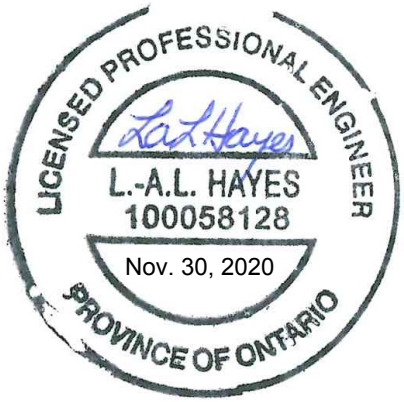
All soil information and laboratory analysis information has been attached to this report. A soils consultant should be retained should the field construction results differ than what has been assumed in this report.

6.0 CONCLUSIONS

We trust the attached information meets your needs at this time and should you have any questions or concerns, please do not hesitate to contact our office.

Yours very truly,
AINLEY GRAHAM & ASSOCIATES LIMITED

Lois-Ann L. Hayes P.Eng.
Senior Engineer



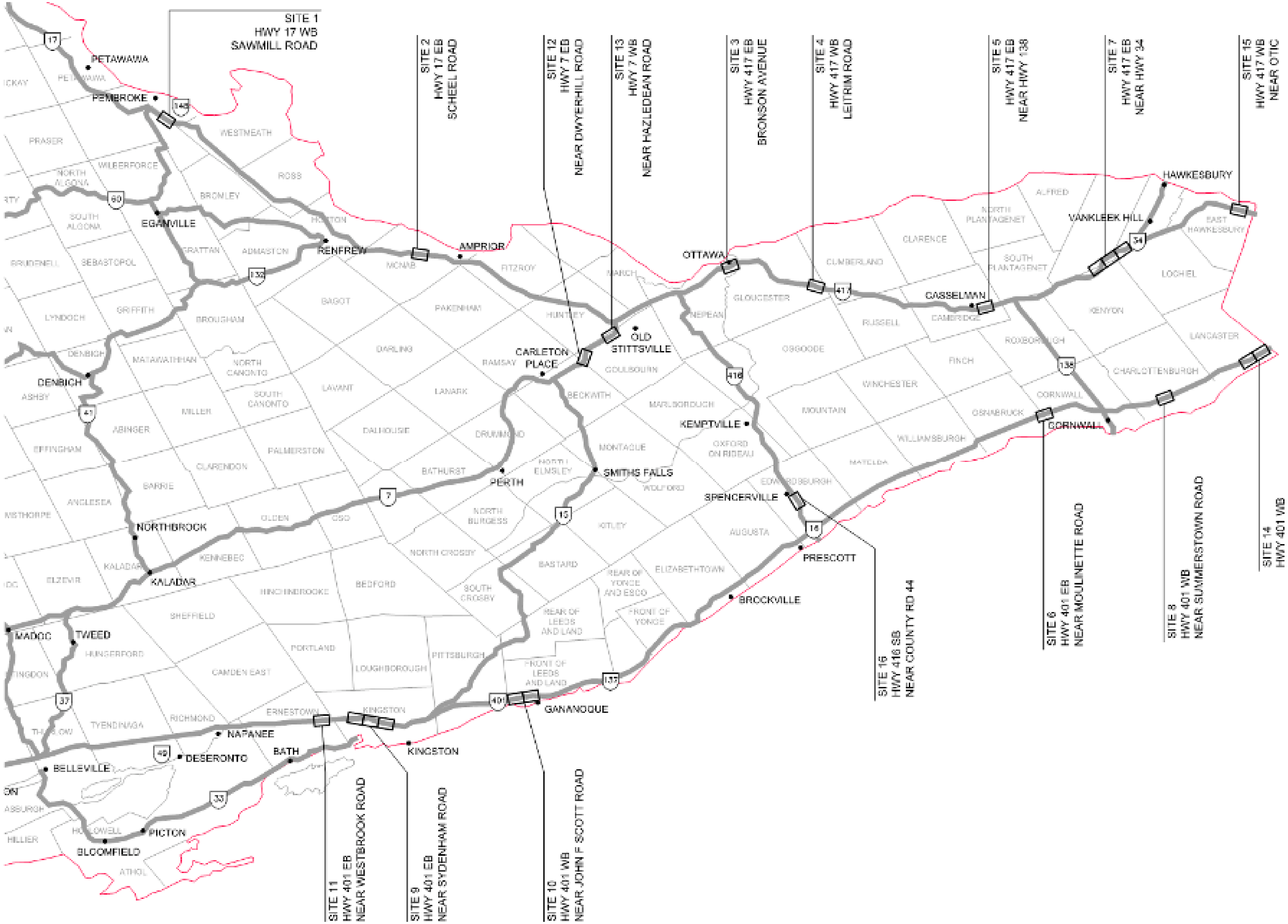
GEOTECHNICAL SURVEY DATA	
DATE OFSURVEY	**TYPE OF SURVEY**
July - November 2020	Ainley Group (steel column breakaway sign posts investigation, manual sampling)

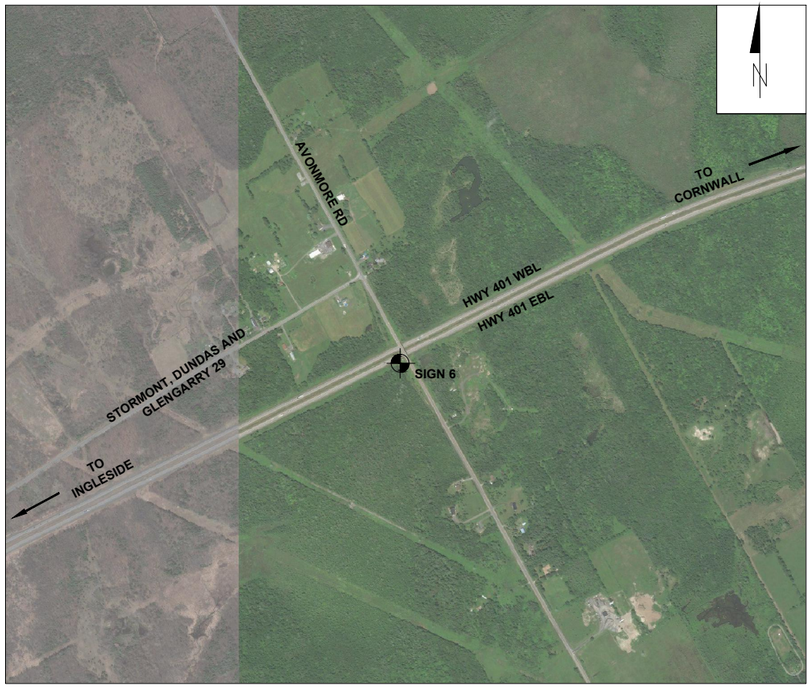
NOTES:

1. Conditions and pavement depths apply only to the date of the survey.
2. The boundaries between the strata have been established only at the core/borehole locations.
   Between cores/boreholes the boundaries are assumed and may be subject to error.
3. Soils are described according to MTO Soils Classification System.
4. Pavement core locations were established using random numbers unless otherwise specified.
5. Dimensions are meters and/or millimeters unless otherwise shown. Stations are in kilometers and meters.
6. Abbreviations for boring and test data conform to OPSD. 100.06

ENCLOSURE No. 1

SIGN LOCATION MAP AND INDIVIDUAL SIGN SOIL PROFILE FIGURES


SITE 1
HWY 17 WB
SAWMILL ROAD
SITE 2
HWY 17 EB
SCHEEL ROAD
SITE 12
HWY 7 EB
NEAR DWYERHILL ROAD
SITE 13
HWY 7 WB
NEAR HAZLEDEAN ROAD
SITE 3
HWY 417 EB
BRONSON AVENUE
SITE 4
HWY 417 WB
LEITRIM ROAD
SITE 5
HWY 417 EB
NEAR HWY 138
SITE 7
HWY 417 EB
NEAR HWY 34
SITE 15
HWY 417 WB
NEAR OTIC
SITE 14
HWY 401 WB
NEAR QUEBEC BORDER
SITE 8
HWY 401 WB
NEAR SUMMERSTOWN ROAD
SITE 6
HWY 401 EB
NEAR MOULINETTE ROAD
SITE 16
HWY 416 SB
NEAR COUNTY RD 44
SITE 10
HWY 401 WB
NEAR JOHN F SCOTT ROAD
SITE 9
HWY 401 EB
NEAR SYDENHAM ROAD
SITE 11
HWY 401 EB
NEAR WESTBROOK ROAD
PETAWAWA
PEMBROKE
EGANVILLE
RENFREW
ARNPRIOR
OTTAWA
CARLETON PLACE
OLD STITTSVILLE
SMITHS FALLS
PERTH
KEMPTVILLE
SPENCERVILLE
PRESCOTT
BROCKVILLE
GANANOQUE
KINGSTON
BATH
NAPANEE
DESERONTO
BELLEVILLE
PICTON
BLOOMFIELD
TWEED
MADOC
KALADAR
NORTHBROOK
DENBIGH
CASSELMAN
VANKLEEK HILL
HAWKESBURY
CORNWALL

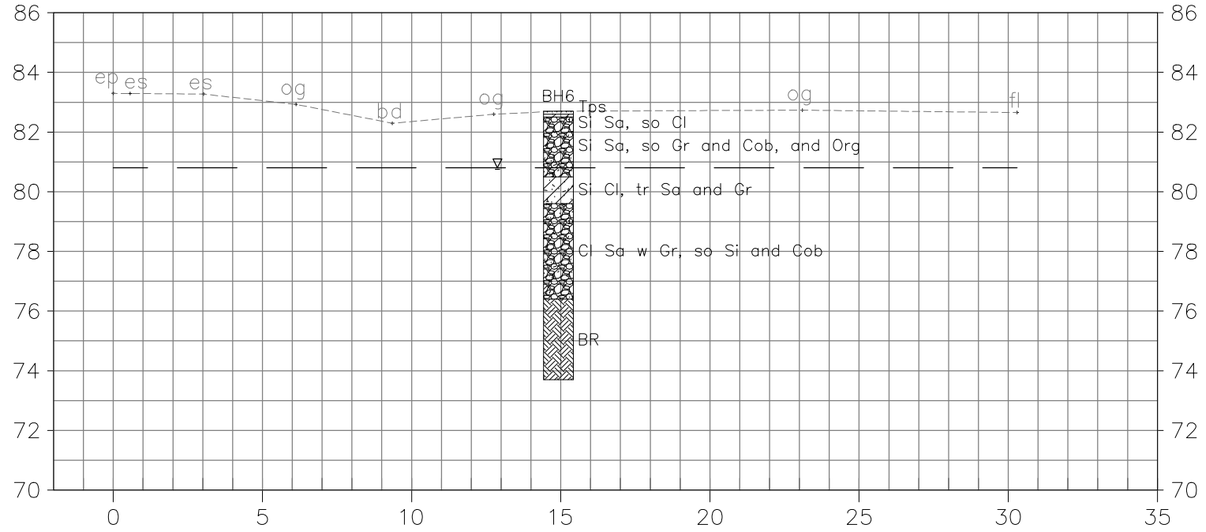


KEY MAP
N.T.S.

ID	TOP OF GRADE ELEVATION (masl)	BEDROCK ELEVATION (masl)	GROUNDWATER ELEVATION (masl)
SIGN 6	82.701	76.401	80.801

BOREHOLE DATA

SIGN NO.6



SIGN PROFILE
1:200

LEGEND
= BOREHOLE LOCATION
NE = FEATURE NOT ENCOUNTERED

Ainley GROUP CONSULTING ENGINEERS PLANNERS

FIGURE NO.6
SITE AND BOREHOLE LOCATION PLAN

ENCLOSURE No. 2

BOREHOLE LOGS

RECORD OF BOREHOLE No 6

1 OF 2 **METRIC**

W.P. 19570-5 LOCATION Sign 6 ORIGINATED BY JRC

DIST - HWY 401 BOREHOLE TYPE Track Mounted CME 55 COMPILED BY JRC

DATUM GEODETIC DATE 2020.11.10 - 2020.11.10 LATITUDE 45.05727222 LONGITUDE -74.87596944 CHECKED BY LAH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
82.7	Topsoil										
82.6 / 0.1	Silty sand some clay and rootlets, brown.										
82.5 / 0.2	Silty sand some clay, fill, loose, brown.										
	Silty sand some gravel and cobbles and amorphous organics, fill, loose to compact, brown. Wet at 2.1 m.		40	SS	16		82				
			41	SS	10	▽	81				
80.5 / 2.2	Silty clay, trace sand and gravel, stiff, grey.		42	SS	11		80				2 8 30 60
79.6 / 3.1	Clayey sand with gravel some silt and cobbles, till, compact becoming dense, grey, wet.		43	SS	15		79				
			43	SS	29						
			43	SS	35		78				21 36 18 25
							77				

Continued Next Page

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

RECORD OF BOREHOLE No 6

2 OF 2 **METRIC**

W.P. 19570-5 LOCATION Sign 6 ORIGINATED BY JRC

DIST - HWY 401 BOREHOLE TYPE Track Mounted CME 55 COMPILED BY JRC

DATUM GEODETIC DATE 2020.11.10 - 2020.11.10 LATITUDE 45.05727222 LONGITUDE -74.87596944 CHECKED BY LAH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
76.4	Clayey sand with gravel some silt and cobbles, till, compact becoming dense, grey, wet. *(continued)*		43	SS	57						
6.3	Good quality limestone bedrock with some horizontal fracture becoming excellent quality with few horizontal fractures. RC1 (6.3 m - 7.5 m) Rec = 92% RQD = 77% Compressive Strength = 36.7 MPa RC2 (7.5 m - 9.0 m) Rec = 99% RQD = 91%		RC1	CORE			76 75 74				
73.7			RC2	CORE							
9.0	End of Borehole at 9.0 m below exisitng site grades.										

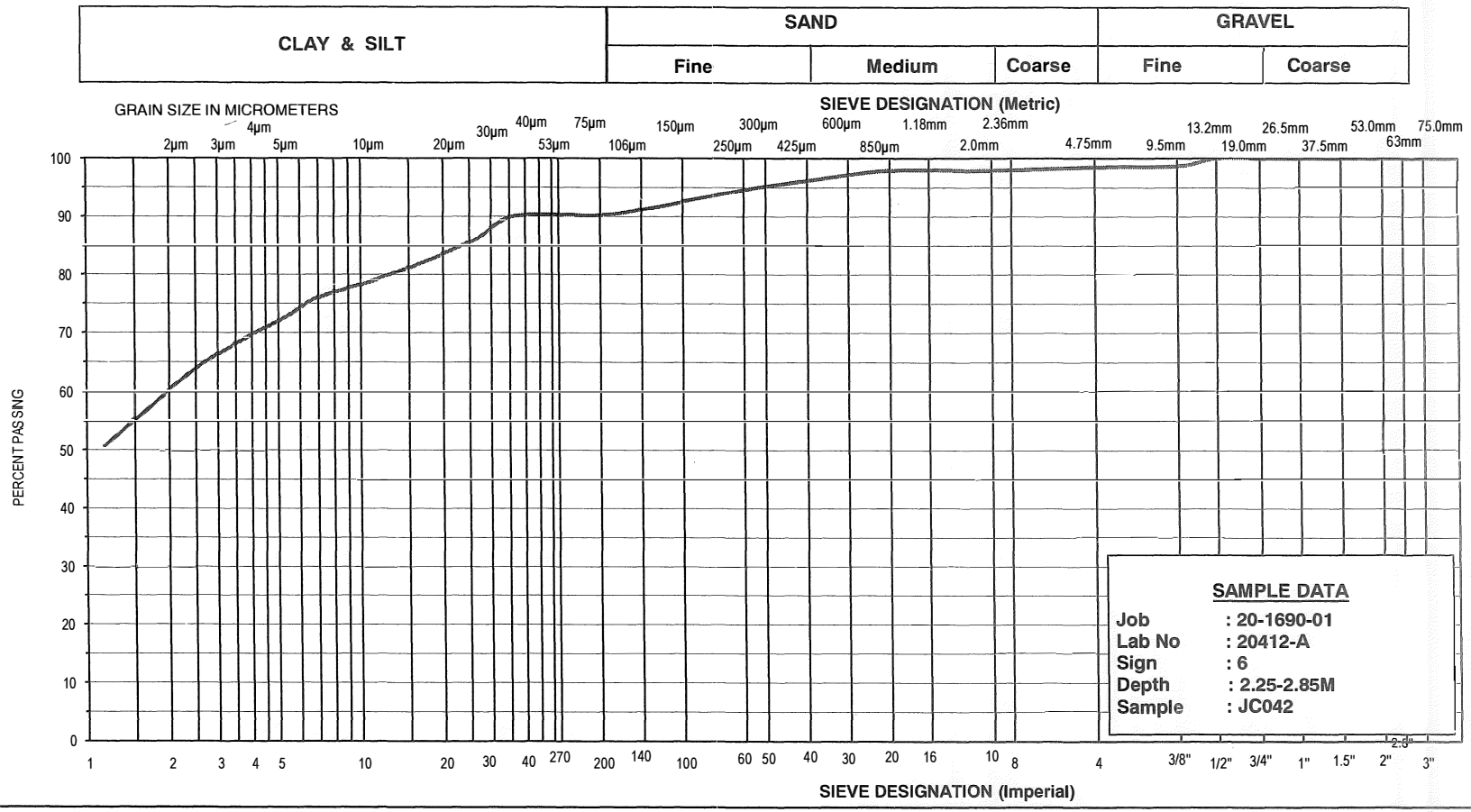
$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

ENCLOSURE No. 3

LABORATORY RESULTS

SNC-LAVALIN

UNIFIED SOIL CLASSIFICATION SYSTEM



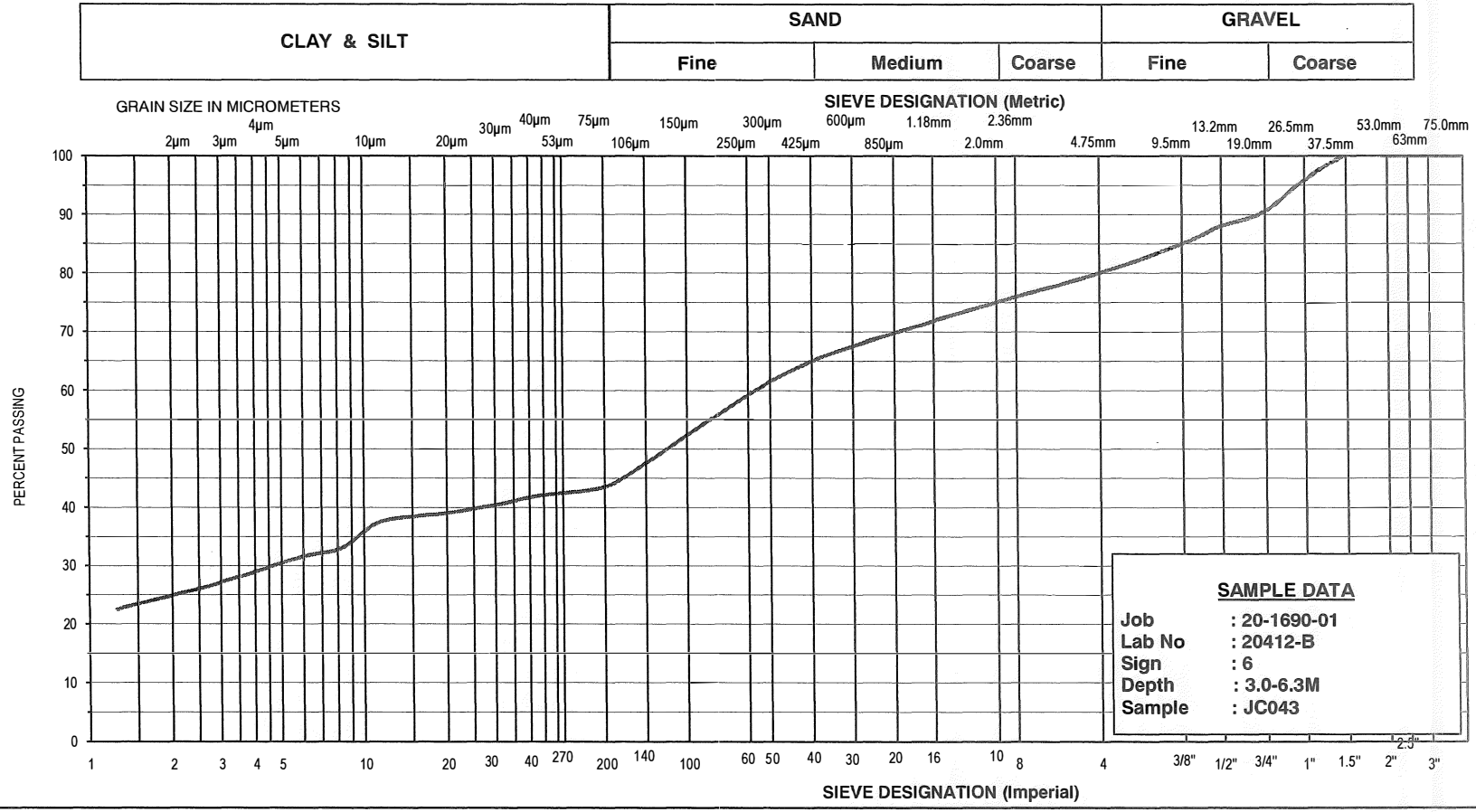
% +3"	% Gravel		% Sand			% Fines	
	Course	Fine	Course	Medium	Fine	Silt	Clay
	0	2	1	2	6	30	60

SNC-LAVALIN 1164 Clyde Court Kingston, Ontario K7P 2E4	**GRAIN SIZE DISTRIBUTION**	**Client: Ainley**
		Project: 20-1690-01
	SILTY CLAY	**19570-5 PVMS Signs**
	Trace Sand,Trace Gravel	**Date:November 10,2020** — **Moisture Content is 30.7%**

SNC·LAVALIN

SNC-LAVALI N

UNIFIED SOIL CLASSIFICATION SYSTEM



% +3"	% Gravel		% Sand			% Fines	
	Course	Fine	Course	Medium	Fine	Silt	Clay
	10	11	5	10	21	18	25

SNC-LAVALIN 1164 Clyde Court Kingston, Ontario K7P 2E4	**GRAIN SIZE DISTRIBUTION**	**Client: Ainley**
		Project: 20-1690-01
	CLAYEY SAND	**19570-5 PVMS Signs**
	With Gravel Some Silt	**Date:November 10,2020** — **Moisture Content is 13.6%**

SNC-LAVALIN

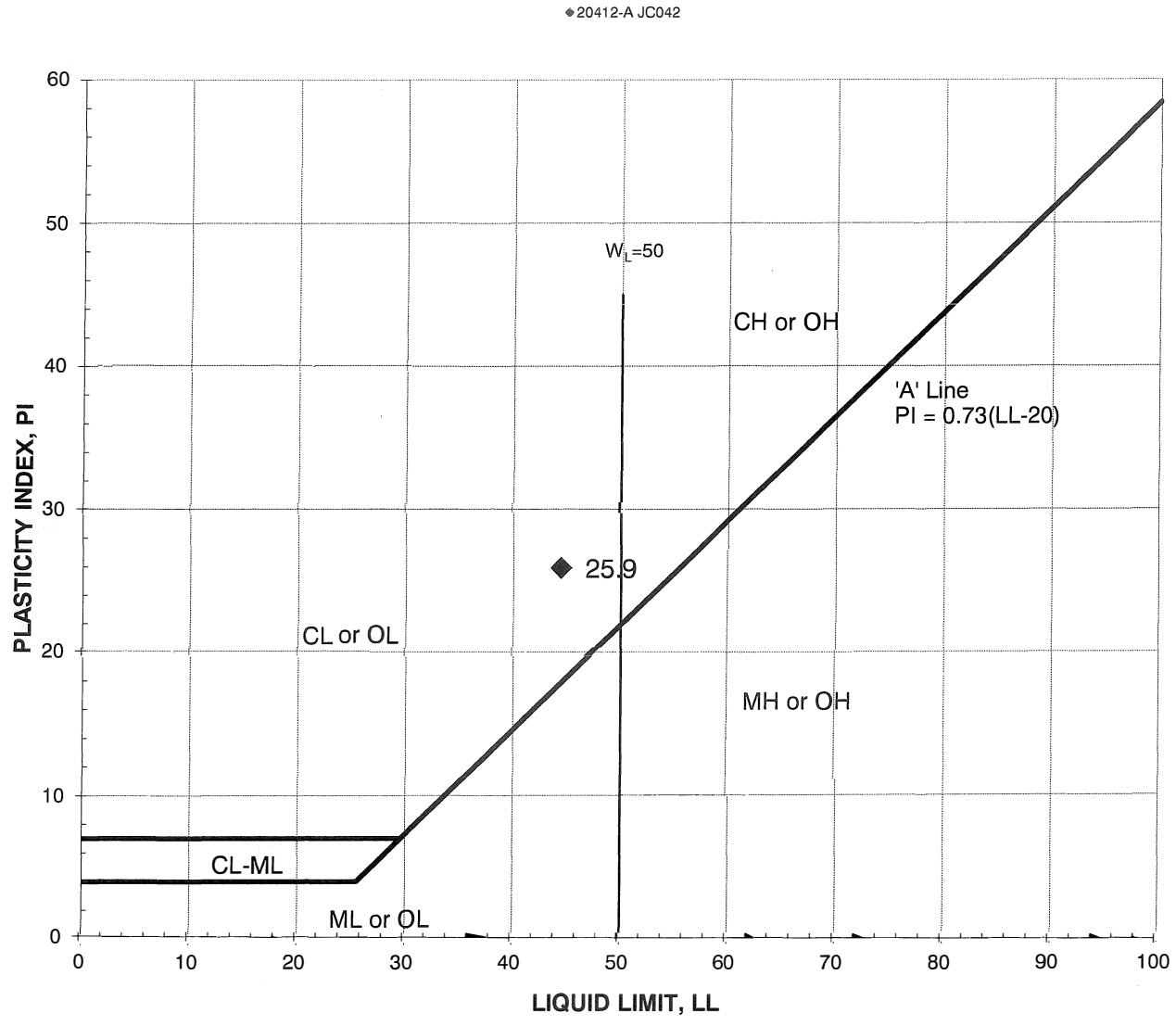
SNC·LAVALIN

PLASTICITY CHART

Job # :	20-1690-06	**Lab #** :	20412-A
Project Client:	Ainley	**Technician** :	COS
Project :	19570-5 PVMS Signs	**Manager**	JU
Location :	Boreholes	**Date** :	10/11/20

TEST RESULTS

Specimen #	Sample #	Depth	LL%	PL%	PI	Fines	W%	Classification	Remarks
20412-A	JC042	2.25-2.85	44.4	18.5	25.9			CL	Moisture 30.7%



Compressive Strength

19570-5 PVMS Signs

Sign #	Depth (m)	**Diameter (mm)**	Length (mm)	Load (LBS)	**Radius (mm)**	Area	MPA	Lab #
6	6.3-7.5	47.0	94.0	14300.0	23.5	1734.9	36.7	20412-C

ENCLOSURE No. 4

SOIL ENGINEERING PARAMETERS

Table No. 6
Soil and Bedrock Parameters – Sign 6

Location	Soil Type	Depth (m)	Unit Weight of Soil (kN/m^3)	Angle of Internal Friction (**ϕ**)	Rankine Passive Earth Pressure Coefficient (kp)	UNDRAINED SHEAR STRENGTH (c_u) (kPa)	Bedrock Compressive Strength (MPa)	Bond Stress between sound rock and anchor grout (kPa)	End Bearing Capacity (SLS) (KPa)
BH6	Silty sand some organics Fill, loose	0.2-2.2	16.0	30	3.0	-	-	-	-
BH6	Silty Clay, stiff	2.2-3.1	19.0	-	1.0	-	-	-	150
BH6	Glacial Till, compact to dense	3.1-6.3	22.0	40	4.6	-	-	-	200
BH6	Limestone Bedrock	6.3-9.0	-	-	-	-	36.7	500	500

A frost depth of 1.8 m may be used at this sign location. Unit weight of soil not adjusted for groundwater levels (subtract 9.81 kN/m3 below water level).

October 7, 2020 AG File No. 19570-5

Eastern Region Geotechnical Section
Postal Bag 4000, 1355 John Counter Blvd.
Kingston Ont. Canada
K7L 5A3
(p) 613-544-2220
(e) Hong.Ye@ontario.ca

Attn: **Hong Ye**, **P.Eng., Project Soils Engineer**

Ref: **Final Foundations Investigation and Recommendation Report for Sixteen (16) Priority Sign Support Base Locations Alongside Highway 401 and 417 (Priority Signs 14 & 15), 4019-E-0002 Assignment #5**

Dear Mr. Ye,

Further to the request of the Ministry of Transportation Ontario (MTO), Eastern Region to evaluate the soil conditions at a total of two (2) priority PVMS sign locations along Highway 401 and 417. We are pleased to present below the results of our investigation and recommendations.

1.0 GENERAL DATA

The geotechnical component for this project involved obtaining subsoil and bedrock information to enable the structural design of footings for pole-mounted variable message sign supports to be completed by others. This report contains all field investigation results, at the proposed footing locations (as provided by MTO) and soil classification information for all sign locations.

The signs are identified and located as follows:

Sign #14 Hwy 401 – WB Quebec border OnRoute

Sign #15 Hwy 417 – WB Quebec border Travel Info Tourist Centre

Both signs are located at or near the base of the road embankment within the MTO right-of-way (ROW). A copy of the sign location map provided to our office by MTO is attached to this report as **Enclosure No. 1** along with the individual sign location soil profile figures.

2.0 FIELD INVESTIGATION

A soils investigation was conducted starting July 31st through to August 27th, 2020 under the constant supervision of a member of the Ainley Group geotechnical team in accordance with our Terms of Reference. Prior to commencing the field program, Ainley Group contacted the

local utility companies and appropriate site authorities to obtain clearances for all underground services and site access in the immediate area of the proposed field program.

Two boreholes (BH14 and BH15) were advanced by means of track mounted CME 55 to 10.0 m below existing site grades or refusal, whichever was less. Representative samples were collected using split spoon sampling methods (Standard Penetration Testing). In situ shear vane testing was completed as necessary in clay deposits. Where split spoon refusal was encountered less than 10.0 m below existing site grades, coring procedures were completed to prove the inferred bedrock contact. In both advanced boreholes, coring was completed and proved that refusal occurred on a very dense glacial till deposit and not on bedrock.

Representative soil samples were collected from the borings using split spoon sampling methods. Upon completion, each borehole was backfilled using native material and the core locations were sealed with bentonite hole plug.

The location and ground surface elevation at each respective footing location was surveyed and data shape files were produced with ArcPad V.10.2 and provided electronically to MTO to update their GIS.

3.0 SUBSURFACE CONDITIONS AND LABORATORY ANALYSIS

Full details of the subsurface conditions encountered at the borehole locations are presented on the individual borehole logs attached to this report as **Enclosure No. 2**. It is emphasized however, that the soil types, their sequence, thickness and physical properties may vary between borehole locations and samples both vertically and horizontally at each individual sign location.

Representative samples of materials encountered at each borehole location were secured during the investigation and select samples were forwarded to SNC-Lavalin Group Inc. in Kingston for laboratory analysis. A copy of the individual test results are attached to this report as **Enclosure No. 3.**

In general, the subsoil and groundwater conditions encountered at the individual proposed sign locations and results of the laboratory testing consisted of the following:

Sign No. 14 – Hwy 401 – WB Quebec border OnRoute

One (1) borehole was advanced at this sign location, referenced as BH14. The borehole was advanced to a depth of 10.0 m below existing site grades and terminated within a very dense glacial till deposit.

The subsoil conditions encountered at the borehole location consisted of surficial topsoil overlying soft silty clay some sand extending to a depth of 0.5 m below existing grade. A very stiff, becoming very soft deposit of clay with silt was encountered at a depth of 0.5 m and extended to a depth of 3.5 m below grade. Very soft clay with silt was encountered from a depth of 3.5 m below grade and extended to a depth of 8.0 m below grade. Shear vane testing was

completed at regular intervals within this layer with undrained shear values ranging between 8 kPa and 12 kPa.

Beneath the very soft clay deposit, a thin layer of loose, silt some clay was encountered extending to a depth of 8.3 m below grade. Very dense glacial till was encountered at a depth of 8.3 m and refusal to auger on boulders occurred at a depth of 8.5 m below existing grade. Coring techniques were employed at a depth of 8.5 m and terminated at a depth of 10.0 m below existing grade proving the presence of glacial till and not a bedrock contact.

Groundwater infiltration was encountered at the time of the site investigation at a depth of 1.20 m below existing site grades. The borehole for this sign location was advanced on August 27, 2020.

Two (2) soil samples were submitted for laboratory analysis (JC029, 0.75 – 2.1 m and JC031, 4.5 - 6.6 m). Results of the laboratory analysis are summarized below:

JC029 - Clay with Silt
% Passing 4.75 mm = 100.0
75 µm = 99.0
5 µm = 89.0 LSFH
2 µm = 72.0
Moisture Content = 49.8%
Plasticity Index = 34.0
Classification = CH

JC031 - Clay some Silt
% Passing 4.75 mm = 100.0
75 µm = 100.0
5 µm = 92.0 LSFH
2 µm = 88.0
Moisture Content = 74.5%
Plasticity Index = 38.0
Classification = CH

Sign No. 15 – Hwy 417 – WB Quebec border Travel Info Tourist Centre

One (1) borehole was advanced at this sign location, referenced as BH15. The borehole was advanced to a depth of 10.0 m below existing site grades and terminated within the compact glacial till.

The subsoil conditions encountered at the borehole location consisted of surficial topsoil overlying loose becoming dense fill consisting of silty sand extending to a depth of 1.8 m below existing grade.

Compact, becoming very dense sandy silt till was encountered at a depth of 1.8 m and extended to a depth of 10.0 m below existing grade. Due to refusal to auger at a depth of 4.5 m below existing grade, coring techniques were employed to 6.5 m below grade below existing grade proving the presence of glacial till and not a bedrock contact.

Groundwater infiltration was not encountered at the time of the site investigation. The borehole for this sign location was advanced on July 31, 2020.

Two (2) soil sample were submitted for laboratory analysis (JC008, 0.75 – 1.35 m and JC011, 3.0 - 3.6 m). Results of the laboratory analysis are summarized below:

JC008 - Silty Sand some Gravel
% Passing 4.75 mm = 86.5
75 µm = 39.2
Moisture Content = 9.2%

JC011 - Sandy Silt some clay, trace gravel
% Passing 4.75 mm = 93.0
75 µm = 62.0
5 µm = 26.0 LSFH
2 µm = 17.0
Moisture Content = 11.8%

4.0 RECOMMENDATIONS

Table Nos. 1 to 2 attached to this report as **Enclosure No. 4,** summarizes the soil engineering parameters for the various soil types noted within the proposed sign locations to assist the structural designer.

5.0 GENERAL COMMENTS

All soil information and laboratory analysis information has been attached to this report. A soils consultant should be retained should the field construction results differ than what has been assumed in this report.

6.0 CONCLUSIONS

We trust the attached information meets your needs at this time and should you have any questions or concerns, please do not hesitate to contact our office.

Yours very truly,
AINLEY GRAHAM & ASSOCIATES LIMITED

Lois-Ann L. Hayes

Lois-Ann L. Hayes P.Eng.
Senior Engineer

GEOTECHNICAL SURVEY DATA	
DATE OFSURVEY	**TYPE OF SURVEY**
July & August 2020	Ainley Group (steel column breakaway sign posts investigation, manual sampling)

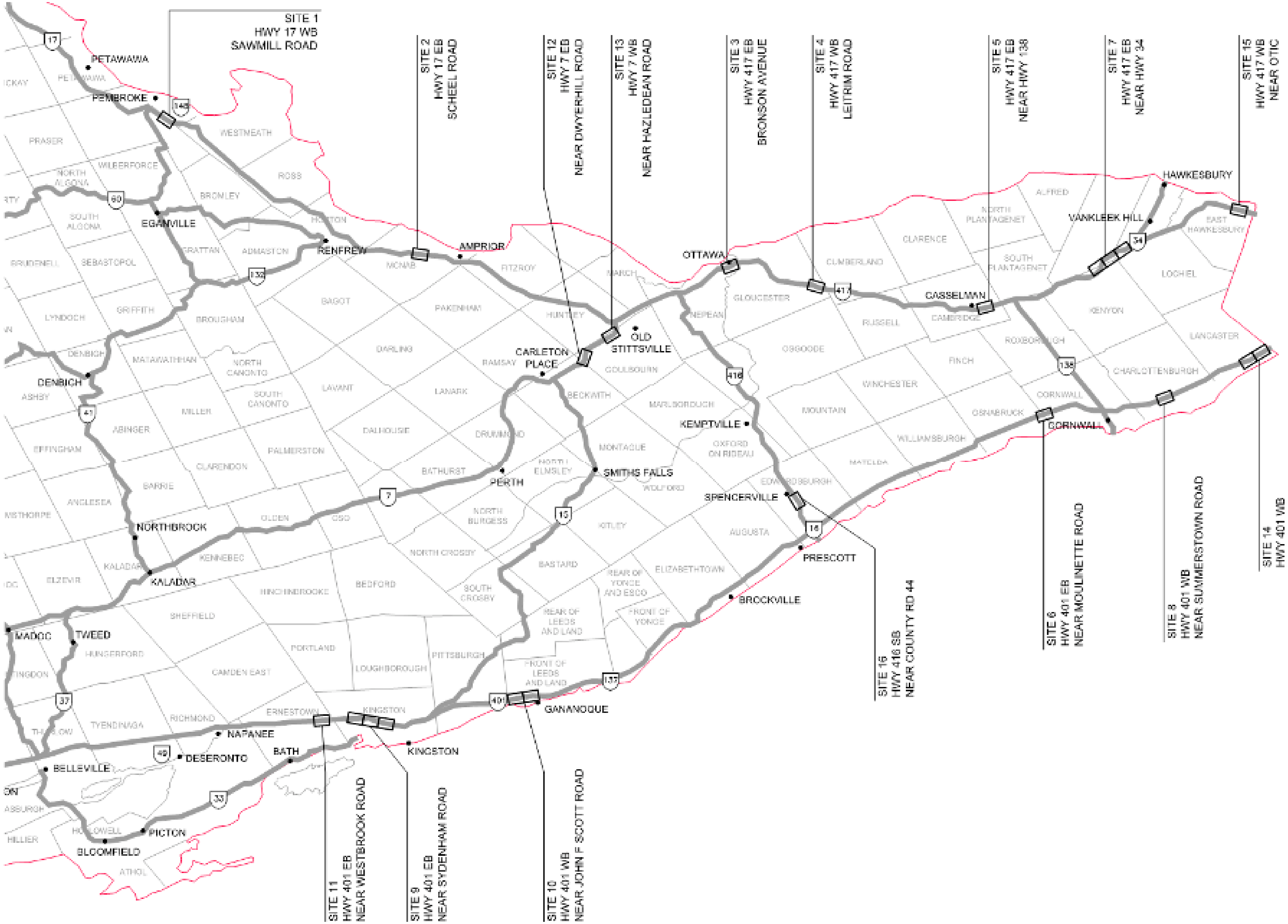
NOTES:

1. Conditions and pavement depths apply only to the date of the survey.
2. The boundaries between the strata have been established only at the core/borehole locations.
   Between cores/boreholes the boundaries are assumed and may be subject to error.
3. Soils are described according to MTO Soils Classification System.
4. Pavement core locations were established using random numbers unless otherwise specified.
5. Dimensions are meters and/or millimeters unless otherwise shown. Stations are in kilometers and meters.
6. Abbreviations for boring and test data conform to OPSD. 100.06

Agreement No. 4019-E-0002	Assignment No: 5	Foundation Investigation for PVMS Sign Supports

ENCLOSURE No. 1

SIGN LOCATION MAP AND INDIVIDUAL SIGN SOIL PROFILE FIGURES

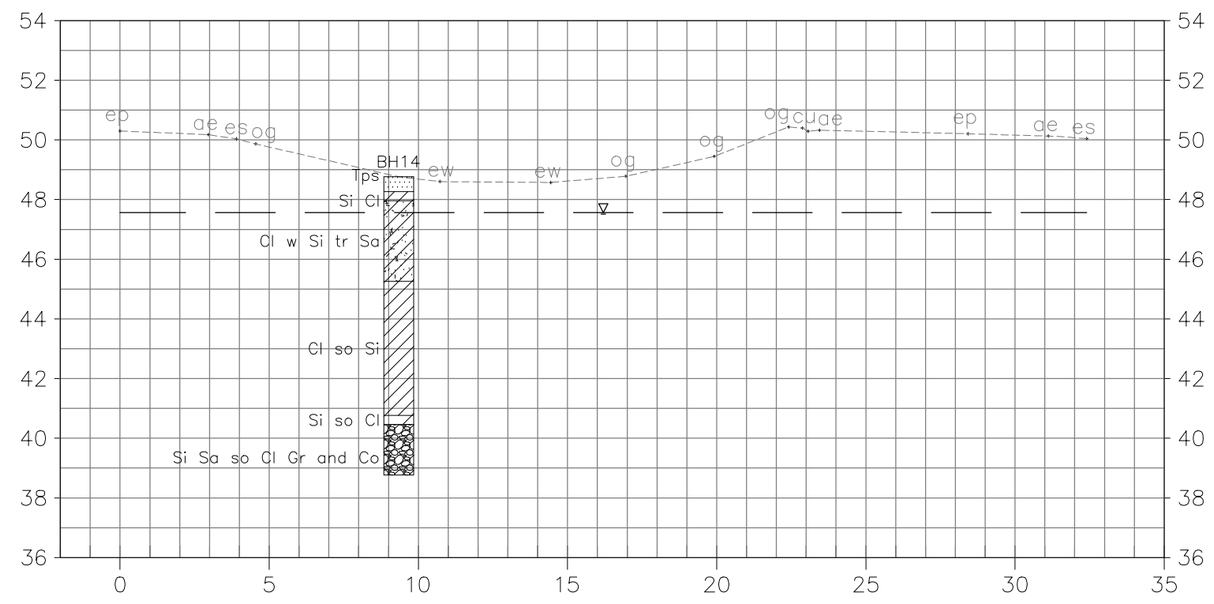

SITE 1
HWY 17 WB
SAWMILL ROAD
SITE 2
HWY 17 EB
SCHEEL ROAD
SITE 12
HWY 7 EB
NEAR DWYERHILL ROAD
SITE 13
HWY 7 WB
NEAR HAZLEDEAN ROAD
SITE 3
HWY 417 EB
BRONSON AVENUE
SITE 4
HWY 417 WB
LEITRIM ROAD
SITE 5
HWY 417 EB
NEAR HWY 138
SITE 7
HWY 417 EB
NEAR HWY 34
SITE 15
HWY 417 WB
NEAR OTIC
SITE 14
HWY 401 WB
NEAR QUEBEC BORDER
SITE 8
HWY 401 WB
NEAR SUMMERSTOWN ROAD
SITE 6
HWY 401 EB
NEAR MOULINETTE ROAD
SITE 16
HWY 416 SB
NEAR COUNTY RD 44
SITE 10
HWY 401 WB
NEAR JOHN F SCOTT ROAD
SITE 9
HWY 401 EB
NEAR SYDENHAM ROAD
SITE 11
HWY 401 EB
NEAR WESTBROOK ROAD
PETAWAWA
PEMBROKE
EGANVILLE
RENFREW
ARNPRIOR
OTTAWA
HAWKESBURY
VANKLEEK HILL
CASSELMAN
OLD
STITTSVILLE
CARLETON
PLACE
KEMPTVILLE
PERTH
SMITHS FALLS
SPENCERVILLE
PRESCOTT
BROCKVILLE
CORNWALL
DENBIGH
NORTHBROOK
KALADAR
MADOC
TWEED
NAPANEE
DESERONTO
BELLEVILLE
BATH
KINGSTON
GANANOQUE
PICTON
BLOOMFIELD
17
148
60
132
7
15
416
417
34
138
16
41
37
49
33
401
137

KEY MAP
N.T.S.

ID	TOP OF GRADE ELEVATION (masl)	BEDROCK ELEVATION (masl)	GROUNDWATER ELEVATION (masl)
SIGN 14	48.763	NE	47.563

BOREHOLE DATA

SIGN NO.14



SIGN PROFILE
1:200

LEGEND
= BOREHOLE LOCATION
NE = FEATURE NOT ENCOUNTERED

Ainley GROUP CONSULTING ENGINEERS PLANNERS

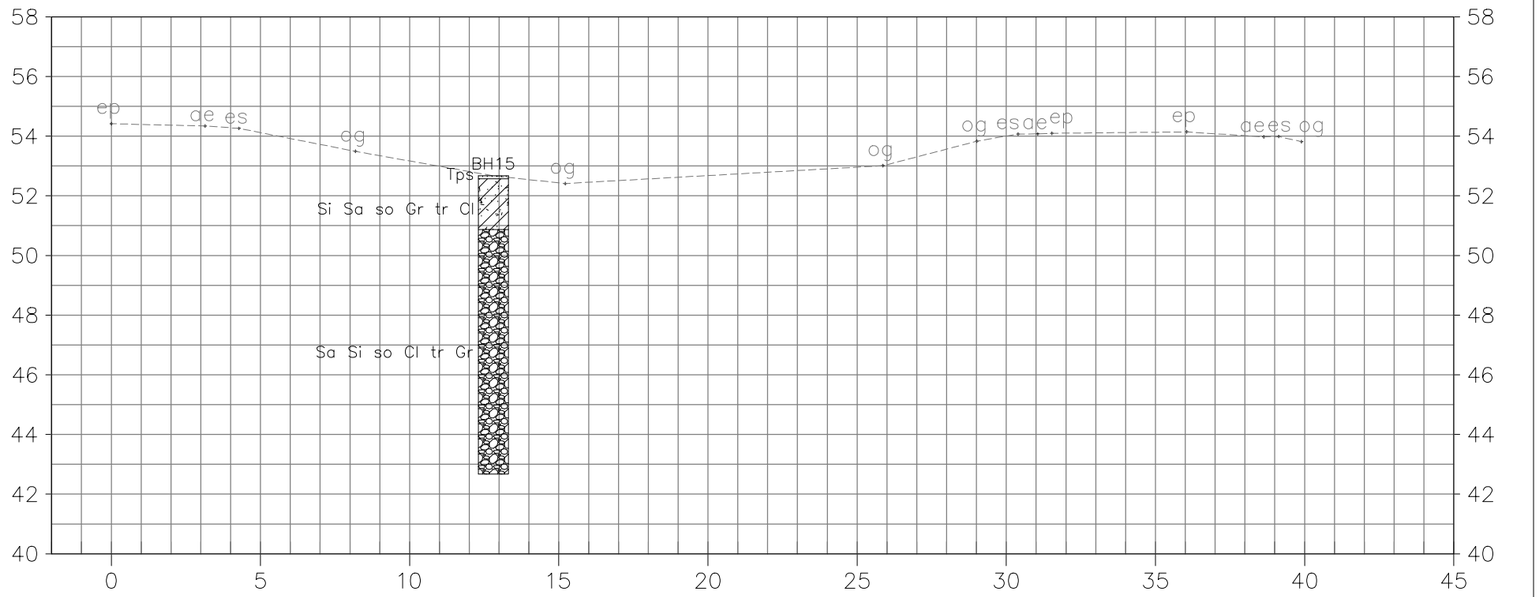
FIGURE NO. 14
SITE AND BOREHOLE LOCATION PLAN

KEY MAP
N.T.S.

ID	TOP OF GRADE ELEVATION (masl)	BEDROCK ELEVATION (masl)	GROUNDWATER ELEVATION (masl)
SIGN 15	52.670	NE	NE

BOREHOLE DATA

SIGN NO.15



SIGN PROFILE
1:200

LEGEND
= BOREHOLE LOCATION
NE = FEATURE NOT ENCOUNTERED

Ainley GROUP CONSULTING ENGINEERS PLANNERS

FIGURE NO. 15
SITE AND BOREHOLE LOCATION PLAN

ENCLOSURE No. 2

BOREHOLE LOGS

RECORD OF BOREHOLE No 14

1 OF 2 **METRIC**

W.P. 19570-5 LOCATION Sign 14 ORIGINATED BY JRC

DIST - HWY 401 BOREHOLE TYPE Track Mounted CME 55 COMPILED BY JRC

DATUM GEODETIC DATE 2020.08.27 - 2020.08.27 LATITUDE 45.20111111 LONGITUDE -74.36384722 CHECKED BY LAH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
48.8	Topsoil										
48.7 / 0.1	Silty clay, some sand and rootlets, topsoil, brown.										
	Silty clay, some sand, soft, grey.										
48.3 / 0.5	Clay with silt, trace of sand, very stiff becoming very soft, brown.		29	SS	9	▽	48				0 1 27 72
			29	SS	7		47				
			30	SS	4		46				
45.3			30	SS	1						
3.5	Clay some silt, very soft, wet, grey. V1 (3.9 m - 4.2 m) Cu = 8.04 kPA V2 (4.2 m - 4.5 m) Cu = 8.04 kPA V3 (5.4 m - 5.7 m) Cu = 11.28 kPA V4 (3.9 m - 4.2 m) Cu = 12.09 kPA		V1	VANE			45	+			
			V2	VANE				+			
			31	SS	0		44				
			V3	VANE				+			0 0 12 88
							43				

Continued Next Page

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

RECORD OF BOREHOLE No 14

2 OF 2 **METRIC**

W.P. 19570-5 LOCATION Sign 14 ORIGINATED BY JRC

DIST - HWY 401 BOREHOLE TYPE Track Mounted CME 55 COMPILED BY JRC

DATUM GEODETIC DATE 2020.08.27 - 2020.08.27 LATITUDE 45.20111111 LONGITUDE -74.36384722 CHECKED BY LAH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Clay some silt, very soft, wet, grey. V1 (3.9 m - 4.2 m) Cu = 8.04 kPA		31	SS	0						
	V2 (4.2 m - 4.5 m) Cu = 8.04 kPA V3 (5.4 m - 5.7 m) Cu = 11.28 kPA V4 (3.9 m - 4.2 m) Cu = 12.09 kPA *(continued)*		V4	VANE			42	+			
40.8			32	SS	2		41				
8.0 40.5	Silt some clay, loose, wet, grey.										
8.3	Silty sand, some clay and gravel and cobbles, till, loose becoming very dense, grey. Auger refusal at 8.5 m on boulder. Cored till from 8.5 m to 10.0 m.		-	CORE			40				
38.8							39				
10.0	End of Borehole at 10.0 m below existing site grades.										

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

RECORD OF BOREHOLE No 15

1 OF 2 **METRIC**

W.P. 19570-5 LOCATION Sign 15 ORIGINATED BY JRC

DIST - HWY 417 BOREHOLE TYPE Track Mounted CME 55 COMPILED BY JRC

DATUM GEODETIC DATE 2020.07.31 - 2020.07.27 LATITUDE 45.54836389 LONGITUDE -74.42509722 CHECKED BY LAH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
52.7	Topsoil										
52.6 / 0.1	Silty sand, some gravel and rootlets, topsoil, brown.										
	Silty sand, some gravel, trace of clay, fill, loose becoming dense, brown.		8	SS	43		52		○		14 47 (39)
50.9 / 1.8	Sandy silt, some clay, trace of gravel, cobbles and boulders, till, compact becoming very dense, brown.		9	SS	35		51				
	Auger refusal at 4.5 m on boulders. Cored till from 4.5 m - 6.5 m.		10	SS	18		50				
			11	SS	29		49		○		0 31 45 17
			12	SS	50+						
			-	SS	50+		48				
				CORE			47				

Continued Next Page

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

RECORD OF BOREHOLE No 15

2 OF 2 **METRIC**

W.P. 19570-5 LOCATION Sign 15 ORIGINATED BY JRC

DIST - HWY 417 BOREHOLE TYPE Track Mounted CME 55 COMPILED BY JRC

DATUM GEODETIC DATE 2020.07.31 - 2020.07.27 LATITUDE 45.54836389 LONGITUDE -74.42509722 CHECKED BY LAH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Sandy silt, some clay, trace of gravel, cobbles and boulders, till, compact becoming very dense, brown. Auger refusal at 4.5 m on boulders. Cored till from 4.5 m - 6.5 m. *(continued)*			CORE			46				
			15	SS	34		45				
							44				
							43				
42.7 10.0	End of Borehole at 10.0 m below exisitng site grades.										

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

ENCLOSURE No. 3

LABORATORY RESULTS

E-MAILED SEP 29 2020

SNC·LAVALIN

Lab # 20263 Client: Ainley

Project Name:19570-5 PVMS Signs Date: August 27,2020

SAMPLE INFORMATION	SAMPLE	MASS OF SAMPLE WET & TARE (g)	MASS OF SAMPLE DRY & TARE (g)	MASS OF WATER (g)	MASS OF DRY SOIL (g)	MASS OF TARE (g)	MOISTURE CONTENT (%)
JC029	A	556.9	418.1	138.8	278.6	139.5	49.8
JC031	B	506.6	346	160.6	215.5	130.5	74.5
JC008	C	601.7	561.7	40	435.8	125.9	9.2
JC011	D	513.9	473.1	40.8	345.9	127.2	11.8

SNC-LAVALIN

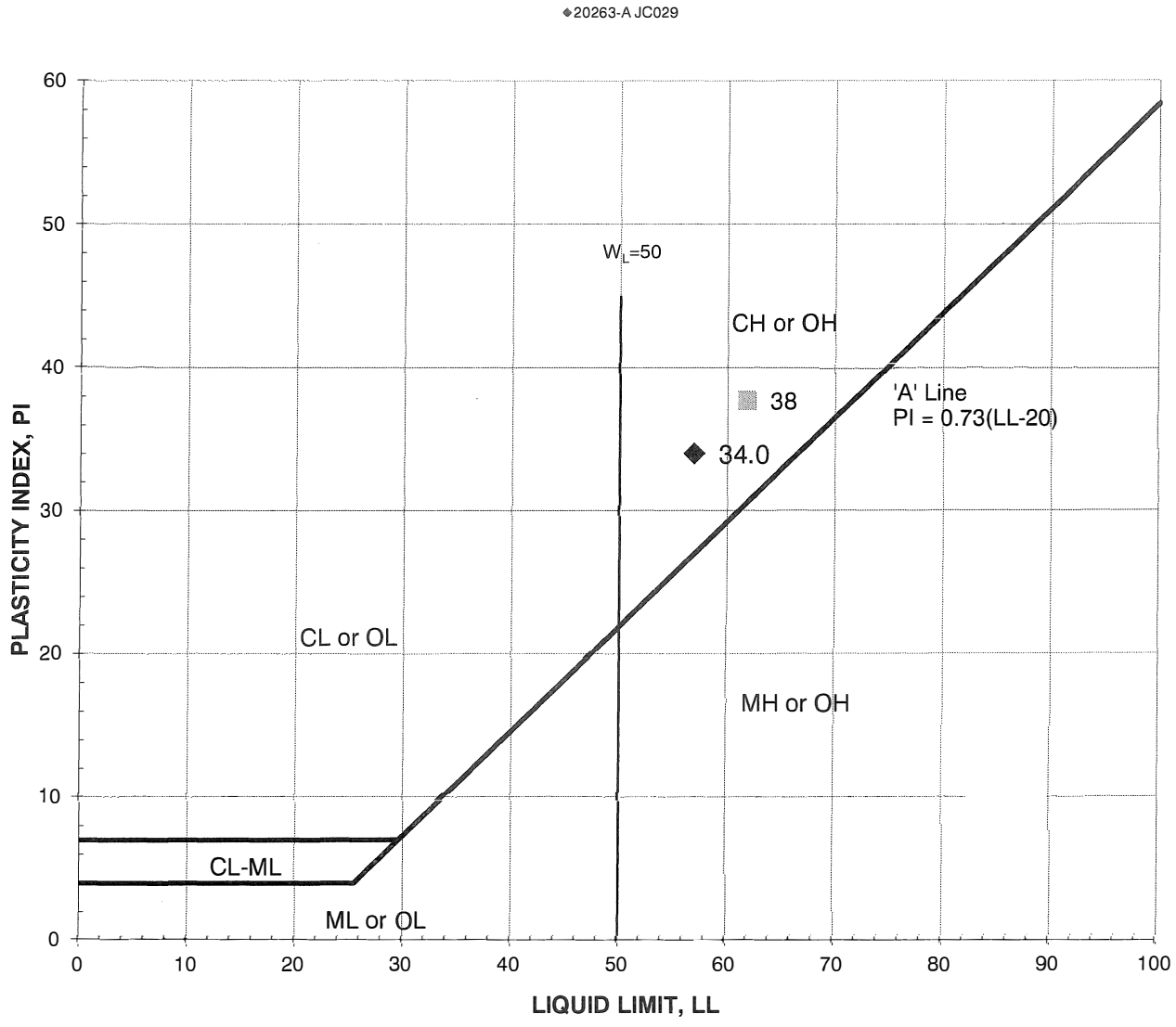
SNC·LAVALIN

PLASTICITY CHART

Job # :	20-1690-01	**Lab #** :	20263
Project Client:	Ainley	**Technician** :	COS
Project :	19570-5 PVMS Signs	**Manager**	JU
Location :	Borehole	**Date** :	08/27/20

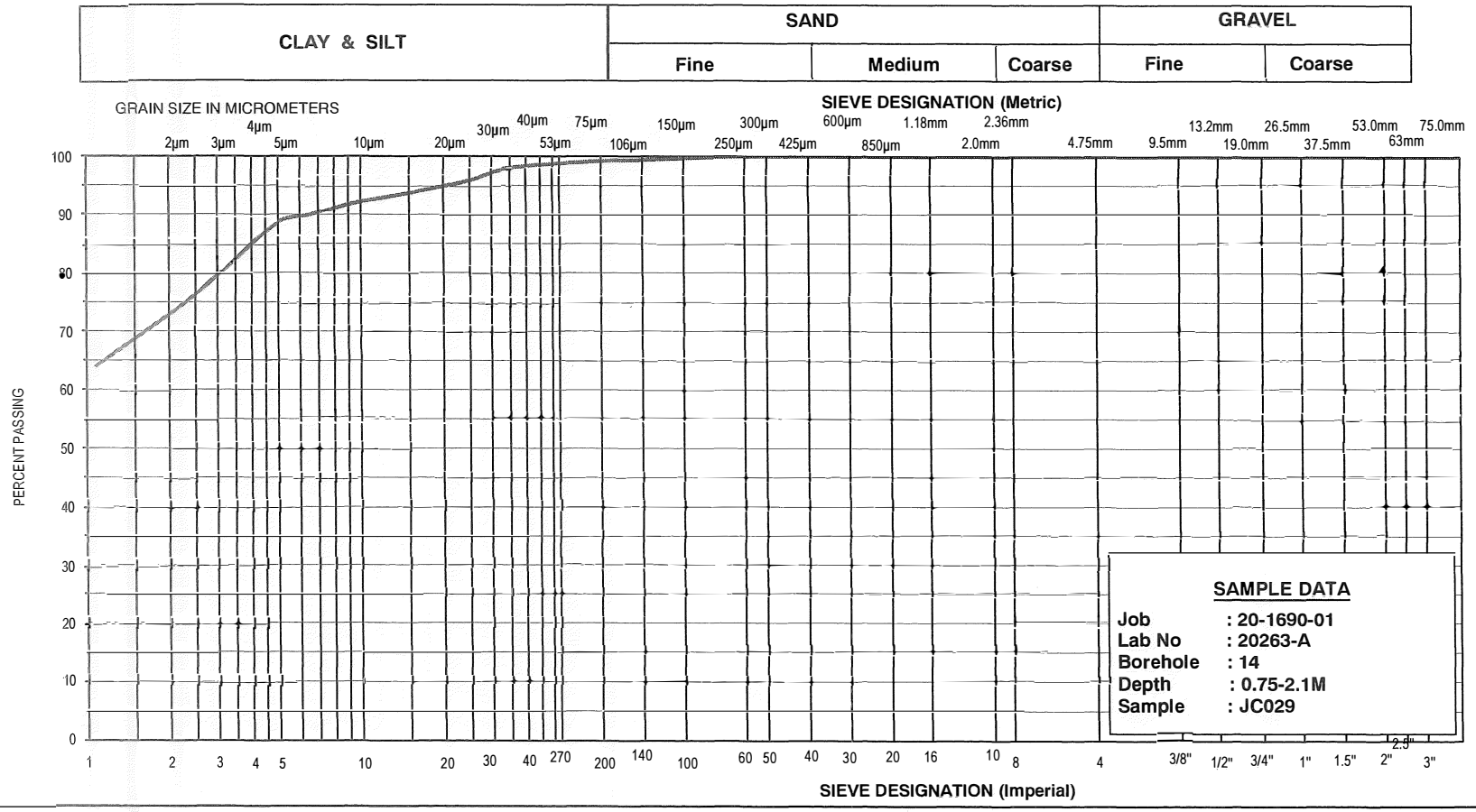
TEST RESULTS

Specimen #	Sample #	Depth	LL%	PL%	PI	Fines	W%	Classification	Remarks
20263-A	JC029	0.75-2.1M	56.9	22.9	34.0			CH	Moisture 49.8%
20263-B	JC031	4.5-6.6M	62	24	38			CH	Moisture 74.5%



SNC-LAVALIN

UNIFIED SOIL CLASSIFICATION SYSTEM



% +3"	% Gravel		% Sand			% Fines	
	Course	Fine	Course	Medium	Fine	Silt	Clay
	0	0	0	0	1	27	72

SNC-LAVALIN
1164 Clyde Court
Kingston, Ontario K7P 2E4

GRAIN SIZE DISTRIBUTION

CLAY

With Silt Trace Sand

Client: Ainley

Project: 20-1690-01

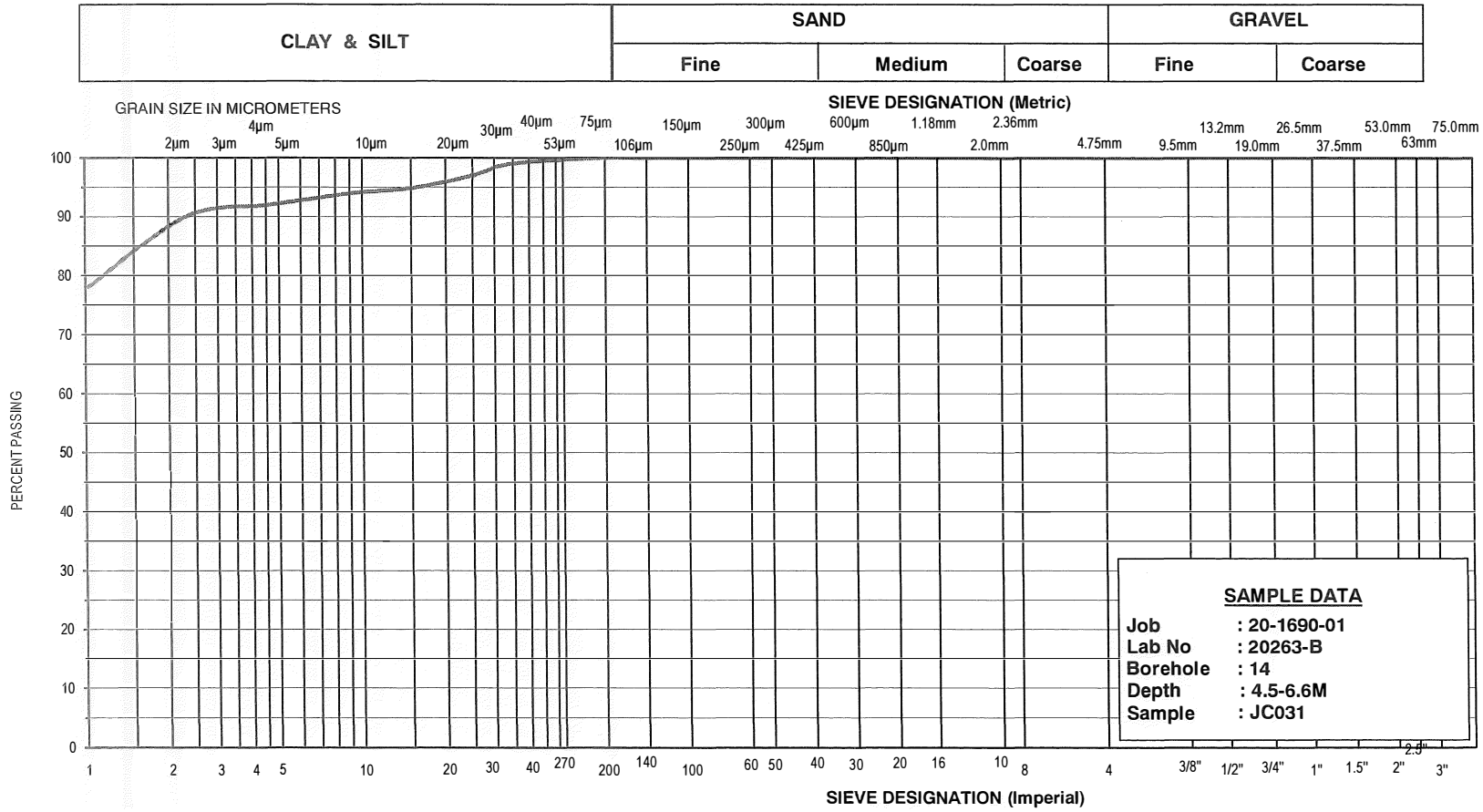
19570-5 PVMS Signs

Date:August 27,2020

Moisture Content is 49.8%

SNC-LAVALIN

UNIFIED SOIL CLASSIFICATION SYSTEM



% +3"	% Gravel		% Sand			% Fines	
	Course	Fine	Course	Medium	Fine	Silt	Clay
	0	0	0	0	0	12	88

SNC-LAVALIN
1164 Clyde Court
Kingston, Ontario K7P 2E4

GRAIN SIZE DISTRIBUTION	Client: Ainley	
	Project: 20-1690-01	
CLAY	19570-5 PVMS Signs	
Some Silt	Date:August 27,2020	Moisture Content is 74.5%

SNC·LAVALIN

SNC-Lavalin GEM Ontario Inc.
1164 Clyde Court
Kingston, Ontario K7P 2E4
(613) 389-1781 (613) 389-4204

Grain Size Analysis Test Report

Project No.: 20-1690-01 **Project Description:** Lab Testing **Date:** Sep 29, 2020

Project Location: **Contract No.:**

SAMPLE DATA

Material: Granular
Date Sampled: Aug 27, 2020
Time Sampled:
Sample Type: Borehole
Sample Location: 19570-5 PVMS Signs BH#15 JC008 Sign#15 Depth 0.75-1.35m
Lot: **Sublot:**
Source: Ainley
Sampled By: Client

LAB DATA

Lab No.: 20263-C **Date Tested:** Sep 22, 2020

Specification: ,

PARTICLE ANALYSIS

TEST	Sample	Specification
Percent Crushed:		
% Asphalt Coated:		
% Flat and Elongated		

WASH PASS 0.075mm

TEST	Sample	Specs
Wash Pass 0.075 mm:		

FINENESS MODULUS	1.44

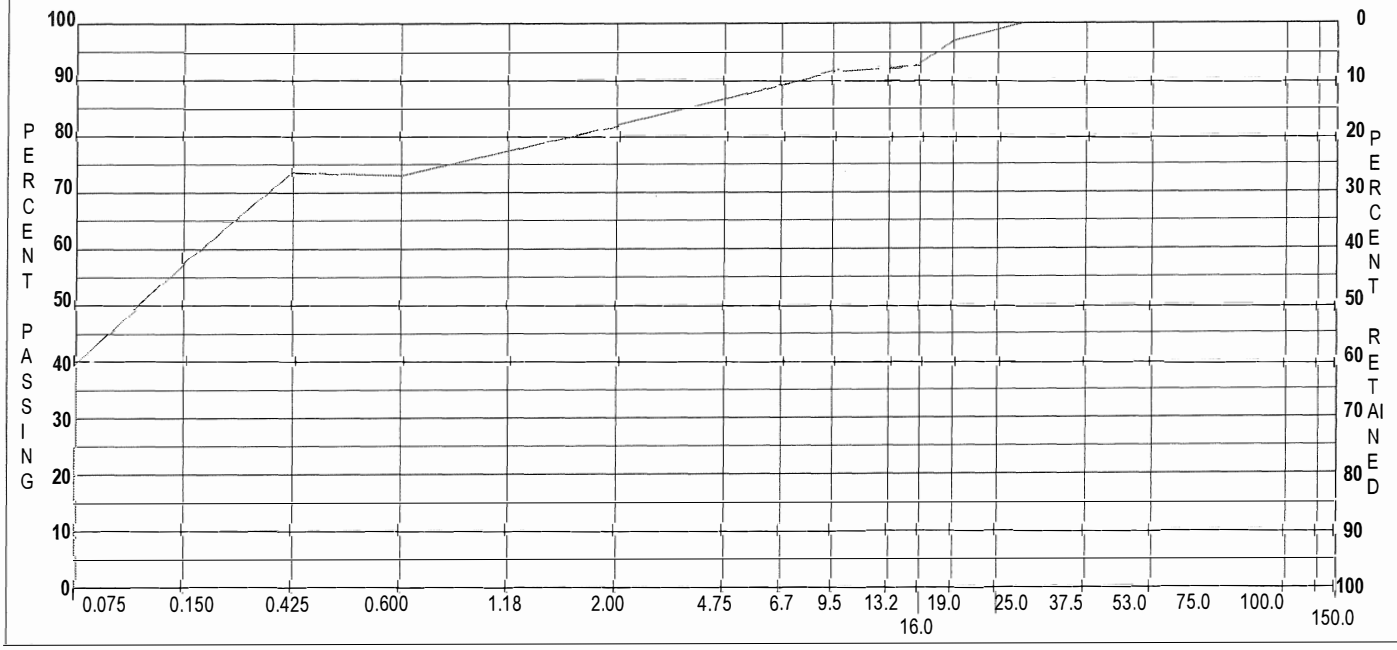
Comments: Moisture Content is 9.2%

Grain Size Analysis

Sieve Sizes (mm)	Percent Passing	
	Sample	Specification
150.0		
100.0		
75.0		
53.0		
50.0		
37.5		
26.5	100	
25.0		
19.0	96.9	
16.0	92.9	
13.2	92.4	
9.5	91.7	
6.7		
4.75	86.5	
2.36	81.8	
2.00		
1.18	77.4	
0.600	73	
0.425		
0.300	73.7	
0.150	57.3	
0.075	39.2	

* Indicates Out of Specification

Sample: ..... **Specs:** .....

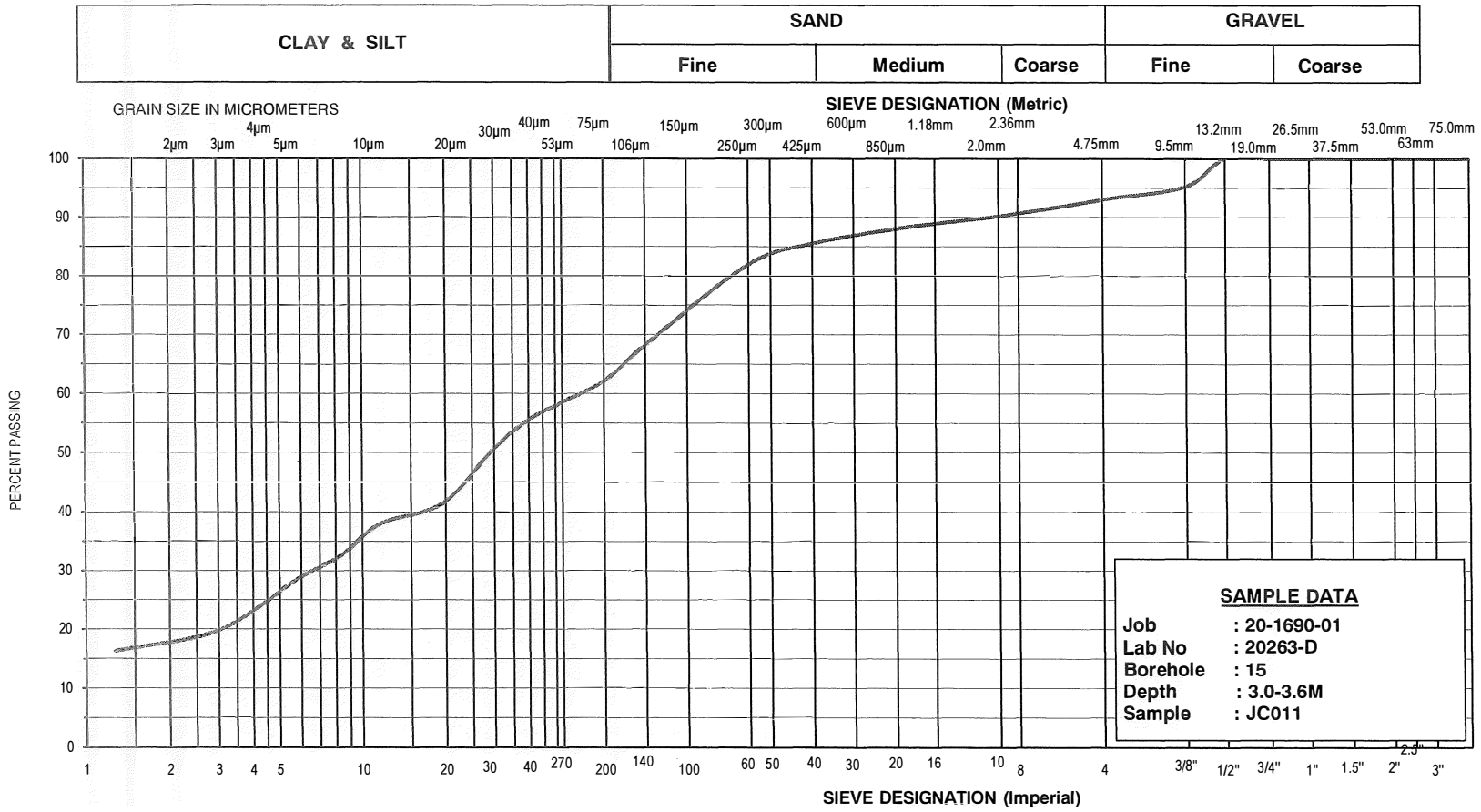


Project Manager: Mark McClelland, C.E.T

Infrastructure

SNC-LAVALIN

UNIFIED SOIL CLASSIFICATION SYSTEM



% +3"	% Gravel		% Sand			% Fines	
	Course	Fine	Course	Medium	Fine	Silt	Clay
	0	7	3	5	23	45	17

SNC-LAVALIN
1164 Clyde Court
Kingston, Ontario K7P 2E4

GRAIN SIZE DISTRIBUTION	Client: Ainley
	Project: 20-1690-01
SANDY SILT	19570-5 PVMS Signs
Some Clay,Trace Gravel	Date:August 27,2020 — Moisture Content is 11.8%

ENCLOSURE No. 4

SOIL ENGINEERING PARAMETERS

Table No. 1
Soil and Bedrock Parameters – Sign 14

Location	Soil Type	Depth (m)	Unit Weight of Soil (kN/m^3)	Angle of Internal Friction (**ϕ)**	Rankine Passive Earth Pressure Coefficient (kp)	UNDRAINED SHEAR STRENGTH (c_u) (kPa**)**	Bond Stress between sound rock and anchor grout (kPa)	END BEARING CAPACITY (SLS) (KPa)
BH14	Clay with Silt	0.5-2.0	19.0	0	1.0	75	-	175
BH14	Clay with Silt	2.0-3.5	13.3	0	1.0	8	-	15
BH14	Clay some Silt	3.5-8.0	13.3	0	1.0	10	-	30
BH14	Silty Sand	8.3-10.0	20.0	35	3.7	-	-	200

A frost depth of 1.8 m may be used at this sign location.
Unit weight of soil not adjusted for groundwater levels (subtract 9.81 kN/m3 below water level).

Table No. 2
Soil and Bedrock Parameters – Sign 15

Location	Soil Type	Depth (m)	Unit Weight of Soil (kN/m^3)	Angle of Internal Friction (**ϕ)**	Rankine Passive Earth Pressure Coefficient (kp)	UNDRAINED SHEAR STRENGTH (c_u) (kPa**)**	Bond Stress between sound rock and anchor grout (kPa)	END BEARING CAPACITY (SLS) (KPa)
BH15	Fill: Silty Sand	0.1-1.8	20.0	35	3.7	-	-	-
BH15	Sandy Silt	1.8-4.5	18.0	30	3.0	-	-	250
BH15	Sandy Silt	4.5-10.0	20.0	35	3.7	-	-	300

A frost depth of 1.8 m may be used at this sign location.
Unit weight of soil not adjusted for groundwater levels (subtract 9.81 kN/m3 below water level).

APPENDIX

B

LIST OF OPSSs, OPSDs & NSSPs

List of OPSSs, OPSDs and NSSPs Referenced in the Report

OPSS.PROV	180	GENERAL SPECIFICATION FOR MANAGEMENT OF EXCESS MATERIALS
OPSS.PROV	492	CONSTRUCTION SPECIFICATION FOR SITE RESTORATION FOLLOWING INSTALLATION OF PIPELINES, UTILITIES AND ASSOCIATED STRUCTURES
OPSS.PROV	517	CONSTRUCTION SPECIFICATION FOR DEWATERING
OPSS.PROV	902	CONSTRUCTION SPECIFICATION FOR EXCAVATING AND BACKFILLING - STRUCTURES
OPSS.PROV	903	CONSTRUCTION SPECIFICATION FOR DEEP FOUNDATIONS
OPSS.PROV	915	CONSTRUCTION SPECIFICATION FOR SIGN SUPPORT STRUCTURES
OPSS.PROV	1010	MATERIAL SPECIFICATION FOR AGGREGATES – BASE, SUBBASE, SELECT SUBGRADE, AND BACKFILL MATERIAL
OPSD	3090.101	FOUNDATION, FROST PENETRATION DEPTHS FOR SOUTHERN ONTARIO
NSSP		SPECIFIC GROUND CONDITIONS RELATING TO CAISSON CONSTRUCTION AT THE VMS SITES

WSP Canada Inc.
2 International Boulevard, Suite 201
Toronto ON M9W 1A2
Tel: 1+ 416-798-0065
www.wsp.com

APPENDIX

C

NSSPs

SPECIFIC GROUND CONDITIONS RELATING TO CAISSON CONSTRUCTION AT THE VMS SITES

Non-Standard Special Provision

Variable types of subsurface conditions should be anticipated at the three VMS sites. Presence of cobbles and boulders in the glacial till as well debris inclusions in the fill materials cannot be ruled out. The contractor must be equipped with caisson shaft excavation equipment to remove/penetrate obstructions posed by cobbles and boulders. Seepage and/or soil sloughing into the caisson holes may occur from existing fill and cohesionless soils. Preparedness for bailing/pumping out any groundwater inflow should be anticipated.

Site #6
Use of temporary liners can be anticipated. Therefore, temporary liners must be available on site, or be made available on very short notice, to support the caisson sidewalls and provide seepage cut-off where required. Presence of cobbles has been noted in Borehole BH6.

Site #14
Very soft to firm silty clay was intercepted in Borehole BH14 and will require the use of permanent liners. A significant depth of the glacial till was cored within the borehole.

Site #15
Presence of cobbles and boulders have been noted in Borehole BH15 and coring through an intermediate depth of the glacial till was undertaken.

Basis of Payment:

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

WSP Canada Inc.
2 International Boulevard, Suite 201
Toronto ON M9W 1A2
Tel: 1+ 416-798-0065
www.wsp.com

APPENDIX

D

LIMITATIONS OF REPORT

LIMITATIONS OF REPORT

This report is intended solely for the Client named. The material in it reflects our best judgment in light of the information available to WSP Canada Inc. at the time of preparation. Unless otherwise agreed in writing by WSP Canada Inc., it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity, it is written to be read in its entirety.

The conclusions and recommendations given in this report are based on information determined at the test hole locations. The information contained herein in no way reflects on the environment aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the test holes may differ from those encountered at the test hole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the test hole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of test holes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. WSP Canada Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

We accept no responsibility for any decisions made or actions taken as a result of this report unless we are specifically advised of and participate in such action, in which case our responsibility will be as agreed to at that time.