THURBER ENGINEERING LTD.

FINAL PRELIMINARY
FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 17 EASTBOUND - JUNCTION CREEK BRIDGE
1.3 KM EAST OF MUNICIPAL ROAD 55
SUDBURY
SITE NO.: 46-281, GWP 5100-16-00

Report to:

McIntosh Perry Consulting Engineers

Latitude: 46.423529
Longitude: -81.105655

September 2019
Thurber File No.: 21428

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PART 1. FACTUAL INFORMATION

1 INTRODUCTION

This report presents the results of a preliminary foundation design assessment based on a desktop review of existing information for the Highway 17 bridge crossing over Junction Creek, which is located about 1.3 km east of Municipal Road 55 in Sudbury, Ontario. The purpose of this assessment was to carry out a desktop review of existing subsurface information within the vicinity of the site, summarize the subsurface conditions, and provide preliminary foundation engineering recommendations. A site investigation will be required at the detailed design stage.

Thurber Engineering Ltd. (Thurber) was retained by McIntosh Perry Consulting Engineers (MPCE) to provide foundations engineering services for this project. This work is being carried out under assignment number 5017-E-0020.

The Ministry of Transportation (MTO) has initiated a study to determine an appropriate rehabilitation/replacement strategy of the existing bridge. The design alternatives for this assignment were outlined by McIntosh Perry Consulting Engineers (MPCE) in the Short List Evaluation Report, dated June 2018. That report identified a preferred alternative which includes twinning Highway 17 and the construction of a new bridge for two, future, westbound lanes on a new alignment 37.5 m north of existing Highway 17. The existing bridge will be replaced on the current alignment and will carry two, future, eastbound lanes over Junction Creek. Preliminary design recommendations for the future westbound lanes are provided in a separate document.

2 SITE DESCRIPTION

Currently Highway 17 is a two lane rural arterial highway. The existing bridge over Junction Creek was constructed in 1973 and is a 54.9 m long, three-span concrete structure which crosses over both Junction Creek and a recreational pathway on the east bank of the creek. The highway is oriented east-west and the creek flows from north to south. The terrain in the area is rugged with the highway cross-section consisting of rock cuts interspersed with rock and earth fill embankments. The deck elevation of the existing bridge is approximately 255 m and the creek level is at approximate elevation 243 m. It is understood that the existing abutments are founded on steel piles driven to refusal and that the piers are on spread footings. The approach fills were to be placed with slopes of 1.75H:1V in the longitudinal direction.

3 SITE INVESTIGATIONS AND FIELD TESTING

In preparation of this memorandum, Thurber has reviewed previous Foundation Investigation and Design Reports (FIDR) Geocres 41I 069 (February 1972) and Geocres 41I 223 (July 2008) prepared by the Foundations Office and Peto MacCallum Ltd. (PML) respectively. The 1972 report provides foundation design recommendations for the exsting Highway 17 bridge crossing over Junction Creek. The 2008 report was a Preliminary FIDR for a proposed bridge for a pair of new westbound Highway 17 lanes located approximately 40 m north of the existing Highway 17 alignment. It must be recognized that the service providers that produced the historical FIDR documents are solely responsible for the accuracy and quality of the factual information and design recommendations presented in their respective reports.

4 DESCRIPTION OF SUBSURFACE CONDITIONS

The borehole records, borehole location plans and stratigraphic plots from the 2008 and 1972 FIDRs are provided in Appendix A and Appendix B, respectively. The 2008 report is based on an investigation consisting of two boreholes (L1-1 and L1-2), one on either side of the creek. As this information was acquired on an alignment 40 m north of the proposed new eastbound structure it has been presented in Appendix A for information purposes only. The 1972 FIDR provides records for ten boreholes (1 through 7 and 9 through 11) drilled for the design of the existing structure.

Detailed descriptions of the previous field investigation methodologies and results are presented in the individual reports listed in Section 3. Details of the soil stratigraphy encountered during the previous investigations are presented on the Record of Borehole sheets and the Borehole Locations and Soil Strata drawings provided in Appendices A and B. The laboratory test results from the previous investigations are also appended.

The following subsections provide a summary of the subsurface conditions observed in the 1972 boreholes. It is noted that a significant amount of fill has been placed at the site since 1972 and that additional information on the fill materials will need to be acquired during a subsequent detail investigation stage.

In general terms, subsurface conditions at the site consist of a deposit of sandy silt to silt on the west side of the creek and a boulder stratum mixed with gravel and silty sand on the east side of the creek. Bedrock was observed at ground surface for the boreholes located near the west bank of the creek. A summary of the pertinent subsurface information from the previous investigations is presented in the following sections.

4.1 Surficial Materials

A 0.3 m thick layer of sandy topsoil was observed at ground surface in Borehole 3.

4.2 Sandy Silt to Silt to Sand

A surficial deposit of sandy silt, sand and silt, trace gravel is present in Boreholes 1 and 11 on the west side of the creek. These boreholes were terminated in this deposit at 11.3 and 15.2 m depth in Boreholes 1 and 11 respectively at elevations 247.6 and 245.7 m. A thin layer of silty sand was also noted in Borehole 2 at ground surface; it was 0.3 m thick with an underside elevation of 246.6 m. SPT N values in this material ranged from 11 to 100 for

100 mm but were generally greater than 50, indicating a typically dense material. The moisture content on tested samples ranged from 11% to 22%. Gradation testing on five samples yielded the following results:

Soil Particle	Percentage (%)
Gravel	0 to 3
Sand	2 to 93
Silt and Clay	4 to 98

Atterberg Limits tests on two samples indicated the liquid and plastic limits ranged from 26 to 28 and 20 to 25, respectively.

4.3 Boulders Mixed with Gravel and Silty Sand

A stratum of boulders in a gravel and silty sand matrix was observed at ground surface in all of the boreholes on the east side of the creek, Boreholes 6, 7, 9 and 10. The boulders were noted to be as large as 450 mm. Borehole 10 was terminated in this layer at a depth of 1.6 m (elevation 244.8 m). The boulder layer was fully penetrated in Boreholes 6, 7 and 9, and was observed to extend to depths ranging from 3.1 to 10.1 m (elevations 235.5 to 240.3 m). The stratum was observed to be very dense and coring was required to advance the boreholes. Sample recovery was poor thus only one sample was available for testing. A moisture content of 23% was recorded. The tested sample was composed of 0% gravel, 45% sand, 52% silt and 3% clay sized particles, however, cobbles and boulders are excluded from consideration and the gradation is considered to not be representative of the whole deposit.

4.4 Bedrock

The bedrock is described as diorite in a sound state in the 1972 FIDR. It is noted that the bedrock from the adjacent investigation from the 2008 FIDR is described as argillite. No strength testing of the bedrock was carried out in either of the investigations. Confirmation of bedrock type and strength should be an objective in the detailed investigation phase. In general terms, the bedrock surface slopes or decreases in elevation in an easterly direction. The bedrock elevations are summarized as follows.

Table 1 Summary of Bedrock Elevations from West to East

Borehole	Bedrock Elevation, m
11	deeper than 245.7 (bedrock not encountered)
1	deeper than 247.6 (bedrock not encountered)
2	246.6
3	247.1
4	243.7
5	245.4
6	240.3
7	239.5
9	235.5
10	deeper than 244.8 (bedrock not encountered)

4.5 Groundwater

Groundwater levels in the historical documents were reported at elevations generally varying from 247.0 to 242.9 m. The water level in Junction Creek is shown at elevation 243.0, 242.9 and 242.7 m in Geocres 41I-069, Geocres 41I-223 and a MPCE preliminary drawing, respectively.

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PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS

5 GENERAL

This section of the report presents an interpretation of the factual information outlined in Part 1. Based on the existing information, preliminary foundation recommendations are provided for use in the preliminary design of the replacement structure at the site. It is understood that the details of the proposed works are yet to be decided. Additional investigation and analysis will be required in the subsequent detail design phase of the project.

This preliminary foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The construction or design-build contractor must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

5.1 Existing Structure

It is understood that the existing Highway 17 bridge was constructed in 1973 and consists of a three-span structure with a total length of 54.9 m. The two piers are supported on spread footings with the west pier bearing on bedrock and the east pier bearing on a 0.9 m thick tremie concrete pad founded on a stratum of boulders. The west and east abutments were to be supported on steel piles driven to refusal on bedrock and boulders, respectively. The historical FIDR (Geocres 41I-069) indicated an allowable bearing capacity of 1915 and 335 kPa for design of the west and east pier footings, respectively, and an allowable pile load (12HP74 Steel H-pile) of 946 kN at the east abutment. It is understood that during construction, the piles at the east abutment were driven to bedrock. The historical FIDR had provided a bearing capacity of 1915 kPa for design of the west abutment assuming it would be founded as a spread footing on bedrock. It is understood that the west abutment was founded on piles driven to bedrock and it is assumed they were designed with a capacity greater than or equal to the east abutment piles.

5.2 Proposed Structures

The preferred alternative includes construction of a new bridge on an alignment approximately 37.5 m north of the existing structure. This new structure which will ultimately be used for two new westbound lanes will be utilized as a temporary two-lane, two-way detour during replacement of the existing Junction Creek Bridge. The preliminary drawings provided by MPCE indicate that the new Highway 17 eastbound structure will replace the existing structure on the same alignment and will be a single-span structure with a preliminary length of 40 m and 6 m long wingwalls retaining the approach fills. General Arrangement, profile and cross section drawings were not available at the time of preparation of this report.

5.3 Applicable Codes and Design Considerations

The geotechnical assessment has been prepared based on the available data regarding the proposed bridge option, the existing subsurface information presented in the historical Geocres reports and in accordance with the Canadian Highway Bridge Design Code (CHBDC), version CSA S6-14.

In accordance with the CHBDC it is understood that the replacement structure and temporary detour bridge are classified as *Major-Route Bridge* with a *Typical Consequence* resulting in a consequence factor (ψ) of 1.0. As per Section 6.5.3.2 of the CHBDC, the degree of site and prediction model understanding is considered to be *Low Understanding* based on the existing foundation data.

The frost penetration depth at this site is 2.1 m as per OPSD 3090.100. Accordingly, a minimum of 2.1 m of earth cover, or equivalent thermal cover, must be provided above the base of all pile caps and shallow foundations (where not founded on bedrock) to serve as frost protection.

6 SEISMIC CONSIDERATIONS

Based on the fifth-generation seismic model developed by the Geological Survey of Canada (GSC), the *reference* Site Class C peak ground acceleration (PGA) with a 2% probability of exceedance in 50 years (2475-year event) at this site is 0.062g. This value is to be scaled by the F(PGA) based on the *site-specific* Site Class, as discussed below. The GSC seismic hazard calculation data sheet is included in the attachments of this memorandum.

The *site-specific* Site Class was assessed based on the harmonic mean of the shear wave velocity within the upper 30 m with correlations to the standard penetration test (SPT) N-values. The consistency of the overburden soils is noted to vary between the drilled locations. The seismic site classification along the existing Highway 17 alignment (future EBL structure) is a *Site Class C*. It should be noted that the boreholes drilled for the future WBL structure is a *Site Class D*. Therefore, for preliminary design the EBL structure should also be designed based on a *Site Class D*.

As per the Section 4.4.4 of the CHBDC, a seismic performance category shall be assigned based on the fundamental period of the structure, the importance category and the spectral accelerations scaled to the site class discussed above. Regardless of the fundamental period, the structure is classified as Category 1.

The susceptibility of the cohesionless soils to liquefaction was assessed following the simplified procedure outlined in Idriss and Boulanger (2008, 2014). Based on the relatively low PGA_{ref} of 0.062g and the consistency of the cohesionless foundation soils present in the boreholes drilled along the existing alignment, the site is not considered susceptible to cyclic mobility or liquefaction during a seismic event with a return period of 2475-years.

The seismic recommendations should be re-evaluated upon completion of the detailed design investigation.

7 FOUNDATION DESIGN RECOMMENDATIONS

7.1 New Foundation Types and Capacities

Based on the information received to date, the replacement Highway 17 bridge will be a single-span structure and foundation recommendations are only required for the support of abutments.

Based on the stratigraphy provided in the historical Geocres reports and anticipated structural loads, the following foundation alternatives are considered feasible from a geotechnical perspective:

Table 2 Feasible Foundation Types and Capacities

Foundation Type	Factored Geotechnical Resistance at ULS	Factored Geotechnical Resistance at SLS
Shallow Foundation (2 m wide)		
bearing directly on bedrock	1,500 kPa	will not govern
bearing on a tremie pad or engineered fill pad (Granular ‘A’) founded on compact to dense native cohesionless soil or perched in competent fill	400 kPa	195 kPa
Deep Foundation (driven HP 310x110)		
bearing on bedrock	1,750 kN	will not govern
bearing on refusal on boulders above bedrock**	765 kN	675 kN
*Deep foundation (drilled caisson)**		
0.6 m diameter, socketed a minimum of 2 m into sound bedrock	2,800 kN	will not govern
0.9 m diameter, socketed a minimum of 2 m into sound bedrock	4,375 kN	will not govern

Note: (*) may encounter difficulty drilling through boulders, thus reducing feasibility, (**) may not provide sufficient embedment length

The resistances provided in Table 2 for shallow foundations include a geotechnical resistance factor of 0.45 and 0.7 for ULS and SLS, respectively based on a *Low Understanding*. The shallow foundation bearing resistance values are for vertical, concentric loading only. In the case of eccentric or inclined loading, the bearing resistance must be reduced in accordance with CHBDC Clauses 6.10.3 and 6.10.4. SLS resistance is based on up to 25 mm settlement. The values presented assume that all soft, loose or otherwise deleterious materials are removed from the foundation footprint. Resistance to lateral forces/sliding resistance for a cast-in-place shallow foundation founded on an engineered pad should be evaluated in accordance with the CHBDC assuming an ultimate coefficient of friction of 0.5 and a geotechnical resistance factor of 0.7.

The resistances provided in Table 2 for deep foundations include a geotechnical resistance factor of 0.35 and 0.7 for ULS and SLS, respectively based on a *Low Understanding*. SLS resistance is based on 10 mm settlement. Pile tips should be protected from damage during driving. Downdrag forces on deep foundations are considered to be negligible at this site.

Since bedrock could be shallow west of Junction Creek, driven H-piles would typically not be cost effective or practical from a foundation point of view. Piles socketed into bedrock could be used to provide axial geotechnical resistance and to accommodate the design of an integral abutment provided the piles are long enough (~6 m).

In the case of an integral abutment, excavation of bedrock may be required within the west abutment footprint and special consideration must be given to the details of the pile installation in order to provide the required flexibility in the upper 3 m length. The preliminary recommendations provided herein must be reviewed during the detail design based on the final alignment, structure arrangement and the results of the detailed site investigation and field testing to the be completed at that time.

7.2 Backfill and Lateral Earth Pressure

The lateral earth pressures parameters provided in Table 3 and Table 4 below are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for buildup of hydrostatic pressures should be considered in design.

7.2.1 Static Lateral Earth Pressure Coefficients

Lateral earth pressures acting on retaining structures should be computed in accordance with the CHBDC but generally are given by the following expression:

$$\sigma_h = K * (\gamma * d + q)$$

where:

σ_h = lateral earth pressure at depth d (kPa)
K = static earth pressure coefficient (see table below)
γ = unit weight of retained soil (adjusted for groundwater level)
d = depth below top of fill where pressure is computed (m)
q = stress from any surcharge (kPa)

A lateral earth pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with Clause 6.12.3 of the CHBDC. Typical earth pressure coefficients for backfill against vertical walls are shown below.

Table 3 Static Earth Pressure Coefficients

Condition	Earth Pressure Coefficient (K)					
	OPSS Granular A or OPSS Granular B Type II ϕ = 35°, γ = 22.8 kN/m^3		OPSS Granular B Type I ϕ = 32°, γ = 21.2 kN/m^3		OPSS SSM and Existing Sand Fill ϕ = 30°, γ = 21.0 kN/m^3	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active, K_A (Yielding Wall)	0.27	0.39	0.31	0.47	0.33	0.54
At Rest, K_O (Non-Yielding Wall)	0.43	-	0.47	-	0.50	-
Passive, K_P (Movement towards Soil Mass)	3.7	-	3.3	-	3.0	-

A geotechnical resistance factor of 0.5 (ϕ_{gu}) should be applied in static design to the passive earth pressures of new backfill in accordance with Table 6.2 of the CHBDC.

The use of a material with a high friction angle and low active earth pressure coefficient (Granular A or Granular B Type II) is preferred as it results in lower earth pressures acting on the abutment and walls.

For rigid structures, it is recommended that at-rest horizontal lateral earth pressures be used for design. Active pressures should be used for the design of unrestrained walls. The active and passive coefficients in the table correspond to full mobilization of active and passive earth pressure and require certain relative movements between the wall and retained soil to produce these conditions (see Figure C6.16, CHBDC). Where ground surfaces are sloped behind the walls, the corresponding coefficients should be used.

7.2.2 Combined Static and Seismic Lateral Earth Pressure Parameters

In accordance with Clause 4.6.5 of the CHBDC, a structure should be designed using dynamic earth pressure coefficients that incorporate the effects of earthquake loading. The following recommendations are as per Section C4.6.5 of the Commentary of the CHBDC which states that seismically induced lateral soil pressures may be calculated using Mononobe-Okabe Method with:

k_h = ½ * F(PGA) * PGA_{ref}, for structures that allow 25 to 50 mm of movement, and
k_h = F(PGA) * PGA_{ref}, for non-yielding walls

The coefficients of horizontal earth pressure for seismic loading presented in the Table 4 below may be used for preliminary assessment. The earth pressure coefficients in Table 4 are provided for a **Seismic Site Class D**, a PGA_{ref} with a 2% probability of exceedance in 50 years (2475-year event) of 0.062g (Geological Survey of Canada - Fifth Generation) and a F(PGA) of 1.290 as per Table 4.8 of the CHBDC.

Table 4 Combined Static and Seismic Earth Pressure Coefficients, Site Class D

Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^o$, $\gamma = 22.8$ kN/m^3		OPSS Granular B Type I $\phi = 32^o$, $\gamma = 21.2$ kN/m^3	
	Horizontal Surface Behind Wall	Slope Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Slope Surface Behind Wall (2H:1V)
Active, K_{AE} Yielding Wall	0.29	0.45	0.33	0.54
Active, K_{AE} Non-Yielding Wall	0.32	0.51	0.35	0.62

The total pressure due to combined static and seismic loads acting at a specific depth below the top of the wall may be determined using the following equation that includes consideration of material properties and the soils profile.

$$\sigma_h = K * \gamma * d + (K_{AE} - K_A) * \gamma * (H - d)$$

where:

σ_h = lateral earth pressure at depth d (kPa)
d = depth below top of fill where pressure is computed (m)
K = static earth pressure coefficient
(K_A for yielding walls, K_o for non-yielding walls)
γ = unit weight of retained soil (adjusted for groundwater level)
K_{AE} = combined static and seismic earth pressure coefficient
H = total height of the wall (m)

7.3 Approach Embankments

Based on the drawings provided by MPCE, no grade raise is indicated to be required along the existing alignment of Highway 17. The replacement structure will require approximately 6 m of new fill as a result of a shortened total span length.

The existing ground surfaces should be benched in accordance with OPSD 208.010. The embankment could be constructed with either rock fill or granular fill. If the embankment is constructed with rock fill, the embankment construction and rock fill size should be in accordance with OPSS.PROV 206. If rock fill is not used, the embankment fill should consist of Granular B Type I or Select Subgrade Material (SSM) in compliance with OPSS.PROV 1010. Granular fill must not be used to backfill below ponded water. Mid-height berms comprising 2 m wide benches should be incorporated along the length of embankments with heights at or exceeding 8 m in embankments with granular fill and 10 m in embankments with rock fill. Embankment side slopes for 2H:1V and 1.25H:1V are suitable for granular and rock fill, respectively.

The settlement in the underlying cohesionless soils is expected to be rapid, limited in area and less than 25 mm.

Scour protection must be provided for the approach fills as well as structure foundations.

7.4 Temporary Protection Systems

Temporary protection systems are not anticipated as it is understood that traffic will be directed to the new bridge to the north during construction of the new Highway 17 Eastbound structure. If needed, the installation of temporary protection systems will be difficult due to the presence of shallow bedrock west of Junction Creek and frequent boulders in the native soils encountered east of Junction Creek. Drilled-in soldier piles and lagging is considered a feasible option.

7.5 Groundwater Control

Excavations on the east side of Junction Creek which extend below the water level in the creek will be difficult to dewater and should be avoided. The underside of the footing/pile cap of the abutments and wingwalls should be positioned above the creek level if possible. Enclosure of excavations and/or use of wet work techniques will need to be considered if deeper excavations are necessary. Acquisition of additional groundwater information and completion of hydraulic conductivity testing should be carried out during detailed design.

8 LIMITATIONS

The recommendations provided in this report are considered preliminary only. For detailed design, it will be necessary to carry out additional site investigation and laboratory testing to support the preparation of foundation design recommendations. Detailed foundation investigation will be required at the locations of the foundation elements prior to detailed design to confirm subsurface conditions.

9 SCOPE OF ADDITIONAL FOUNDATION INVESTIGATIONS

An additional foundation investigation will be required to advance to a detail design. A suggested field investigation scope includes:

- Two boreholes at each new foundation element. The boreholes should extend a minimum of 3 m into bedrock. For shallow footings on bedrock, the number of explorations should increase to five boreholes with one borehole at each corner of the footing and one at the center.
- One borehole at each approach embankment.
- Boreholes should be advanced for cuts/high fills required to construct the embankments.
- A monitoring well should be installed on the east side of Junction Creek to allow measurement of the groundwater level and in-situ hydraulic conductivity testing, should excavations be anticipated.
- Bedrock cores should be acquired in the investigation and be carefully logged. Unconfined compressive strength testing should be carried out on the bedrock cores at each foundation element.
- Soil chemical laboratory testing should be carried out. One sample from each foundation element should be tested for pH, water soluble sulphate, sulphide, chloride, resistivity and electrical conductivity.

This scope of work should be reviewed once the alignment, profile and bridge option have been selected.

10 CLOSURE

Engineering analysis and preparation of this preliminary report were carried out by Mr. Stephen Peters, P.Eng. and Dr. Fred Griffiths, P.Eng. The report was reviewed Dr. P.K. Chatterji, P.Eng. the Designated Principal Contact for MTO Foundation Projects.

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Appendix A.

Portions of Preliminary Foundation Investigation and Design Report, Geocres 41I-223, July 2008

METRIC

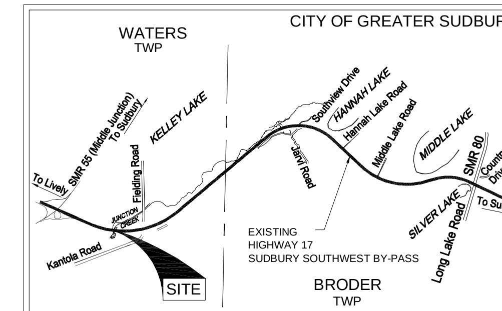
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES

CONT No
GWP No 5825-05-00

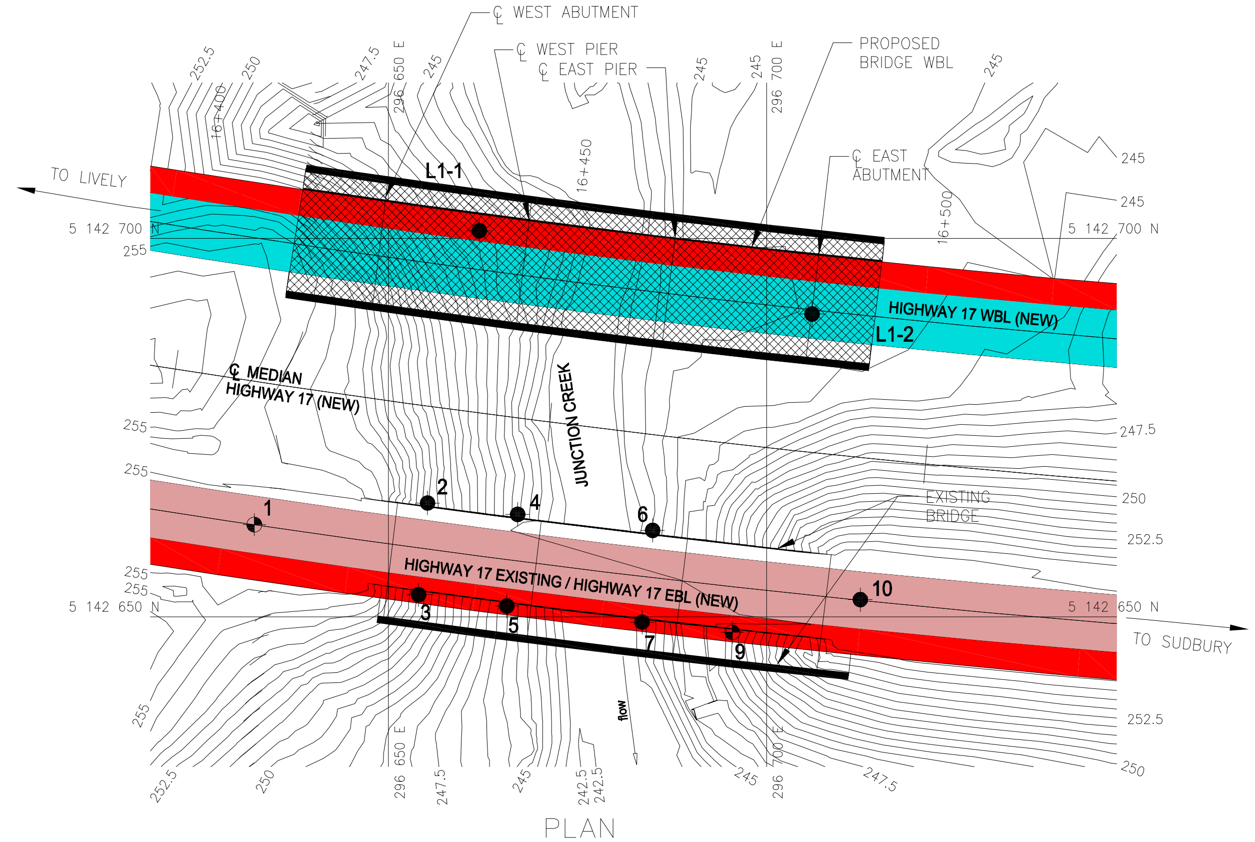
JUNCTION CREEK BRIDGE WESTBOUND
BOREHOLE LOCATIONS & SOIL STRATA

SHEET

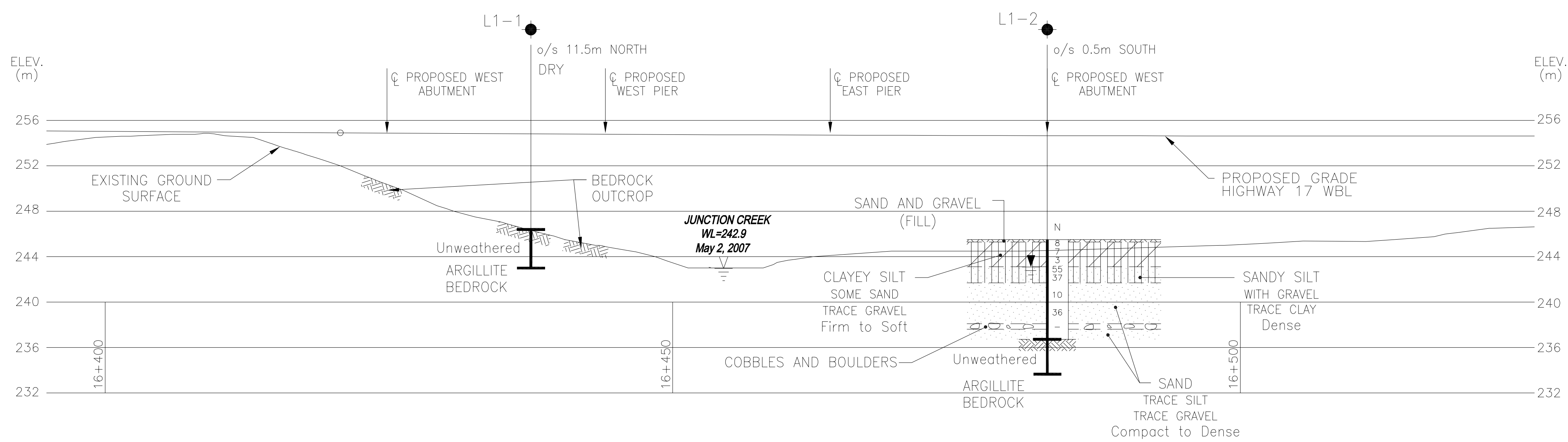
Peto MacCallum Ltd.
CONSULTING ENGINEERS



KEY PLAN
SCALE



PLAN
SCALE



℄ PROFILE
JUNCTION CREEK BRIDGE WESTBOUND
SCALE

LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone
- N Blows/0.3m (Std. Pen Test, 475 J / blow)
- CONE Blows/0.3m (60 Cone, 475 J / blow)
- W L at time of investigation May 2007 (Boreholes 1 to 7, 9 & 10 Jan/Feb 1972)
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	CO-ORDINATES NORTHINGS	EASTINGS
L1-1	246.4	5 142 701	296 662
L1-2	245.5	5 142 690	296 706

REFER DRAWING 72-11011A FOR BOREHOLES 1 TO 7, 9 AND 10 DETAILS

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

NOTES:

1. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
2. LOCATIONS OF BOREHOLES 1 TO 7, 9 AND 10 ARE ESTIMATED FROM DRAWING 72-11011A
3. PRELIMINARY LOCATION OF PROPOSED ABUTMENTS AND PIERS WERE ESTIMATED FOR DISCUSSION PURPOSES IN THIS REPORT ONLY.

REGISTERED PROFESSIONAL ENGINEER C M P Nascimento 07/08/08 PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER B. R. GRAY July 8, 08 PROVINCE OF ONTARIO

REVISIONS

DATE	BY	DESCRIPTION

REF No. Stantec Drawings; 599_Alternate 1.dwg; 599_base.dwg; 599_Contours.dwg; Received January 16, 2008

Geocres No. 41I-223

HWY No 17			DIST 54
SUBM'D NSB	CHECKED CN	DATE JULY 08, 2008	SITE 46-281/2
DRAWN NA	CHECKED CN	APPROVED BRG	DWG L1-1

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS $\overline{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL
e	1, %	VOID RATIO

n	1, %	POROSITY
w	1, %	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX $= w_L - w_P$
I_L	1	LIQUIDITY INDEX $= \frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX $= \frac{w_L - w}{I_P}$
DTPL		DRIER THAN PLASTIC LIMIT
APL		ABOUT PLASTIC LIMIT
WTPL		WETTER THAN PLASTIC LIMIT

e_{max}	1, %	VOID RATIO IN LOOSEST STATE
e_{min}	1, %	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_u	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

RECORD OF BOREHOLE No L1-1

METRIC

G.W.P.	5825-05-00	LOCATION	Co-ords: 5 142 701 N; 296 662 E	ORIGINATED BY	F.P.
DIST	54 HWY 17	BOREHOLE TYPE	Rotary Diamond Drilling	COMPILED BY	N.S.B
DATUM	Geodetic	DATE	May 03, 2007	CHECKED BY	NB/CN

SOIL PROFILE: ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
246.4	Ground Surface					*					
0.0	Bedrock Argillite Dark grey High strength Unweathered Fair to excellent quality		1	RC NQ	REC 100%		246				RQD 75%
			2	RC NQ	REC 100%		245 244				RQD 65%
243.0			3	RC NQ	REC 100%		243				RQD 100%
3.4	End of borehole										
	* Borehole charged with drilling water										

+7, ×5 : Numbers refer to Sensitivity

20, 15, 5, 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No L1-2

METRIC

G.W.P.	5825-05-00	LOCATION	Co-ords: 5 142 690 N; 296 706 E	ORIGINATED BY	F.P.
DIST	54 HWY 17	BOREHOLE TYPE	C.F.H.S.A. + Rotary Diamond Drilling	COMPILED BY	N.S.B
DATUM	Geodetic	DATE	May 02, 2007	CHECKED BY	NB/CN

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
245.5	Ground Surface					
0.0	Sand and gravel					
0.2	clayey silt and topsoil inclusions Brown (FILL)	1	SS	8	o	
	Clayey silt, some sand layers of silt Firm Brown Moist trace gravel, cobbles Soft Grey	2	SS	7	⊢o⊣	0 14 62 24
		3	SS	3	o	
243.1 / 2.4	Sandy silt with gravel, trace clay cobbles Dense Grey Wet	4	SS	55		
		5	SS	37	o	25 32 41 2
241.7 / 3.8	Sand trace silt, trace gravel cobbles and boulders Compact to dense Grey Wet	6	SS	10	o	
		7	SS	36		
238.1 / 7.4	Boulder 0.5m thick	7A	RC NQ	-		
237.6 / 7.9						
236.7 / 8.8	Bedrock Argillite Grey High strength Unweathered Fair quality	8	RC NQ	REC 100%		RQD 73%
		9	RC NQ	REC 92%		RQD 51%
233.6 / 11.9	End of borehole					

Water level ∇* observed at approx. El. 243.1 (GROUND WATER CONDITIONS column).

Elevation scale: 245, 244, 243, 242, 241, 240, 239, 238, 237, 236, 235, 234

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m³

* 2007 05 02

∇ Water level observed during drilling

C.F.H.S.A. denotes Continuous Flight Hollow Stem Augers

+7, ×5 : Numbers refer to Sensitivity

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

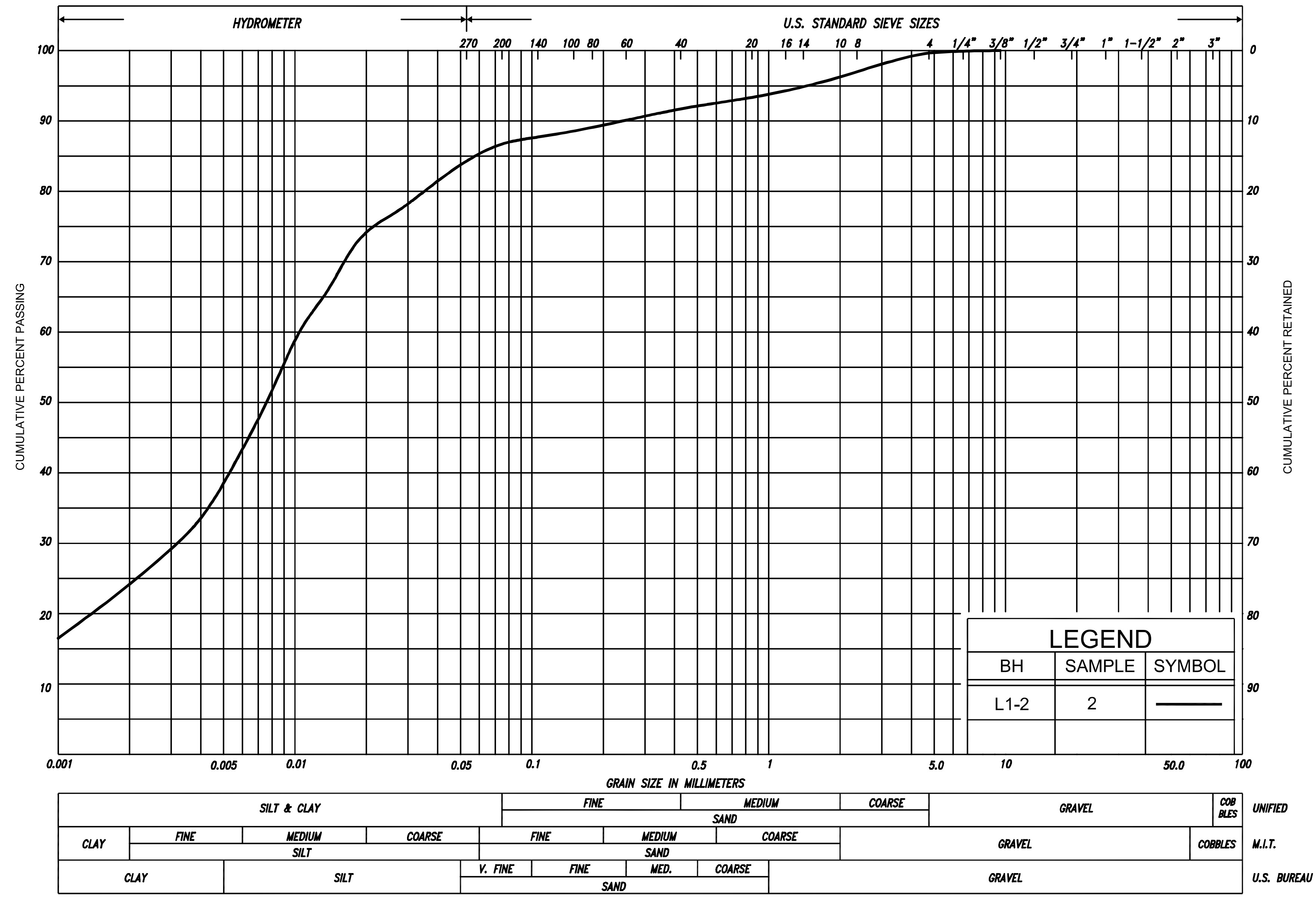
TABLE A

ROCK CORE DESCRIPTIONS

CORE RECOVERY					CORE DESCRIPTION	
BOREHOLE NO.	**CORE NO.**	**DEPTH (m)**	**RECOVERY (%)**	**RQD (%)**	**DEPTH (m)**	**DESCRIPTION**
L1-1	1	0.0 – 1.4	100	75	0.0 – 3.4	ARGILLITE: Dark grey, fine crystalline, with dark brown to rust oxidation on partings, high strength, unweathered, very close to moderate spaced flat dipping partings, some vertical partings, smooth to rough planar, tight to oxidized, fair to excellent quality.
	2	1.4 – 3.0	100	65		
	3	3.0 – 3.4	100	100		
L1-2	8	8.8 – 10.1	100	73	8.8 – 11.9	ARGILLITE: Grey, fine crystalline, with thin white veins, variably pink, green to black coating on partings, high strength, unweathered, close to moderate spaced flat dipping partings, rough planar, tight to oxidized, fair quality.
	9	10.1 – 11.9	92	51		

RQD: Rock Quality Designation

Originated: FP
Compiled: JFW
Checked: NSB/CN

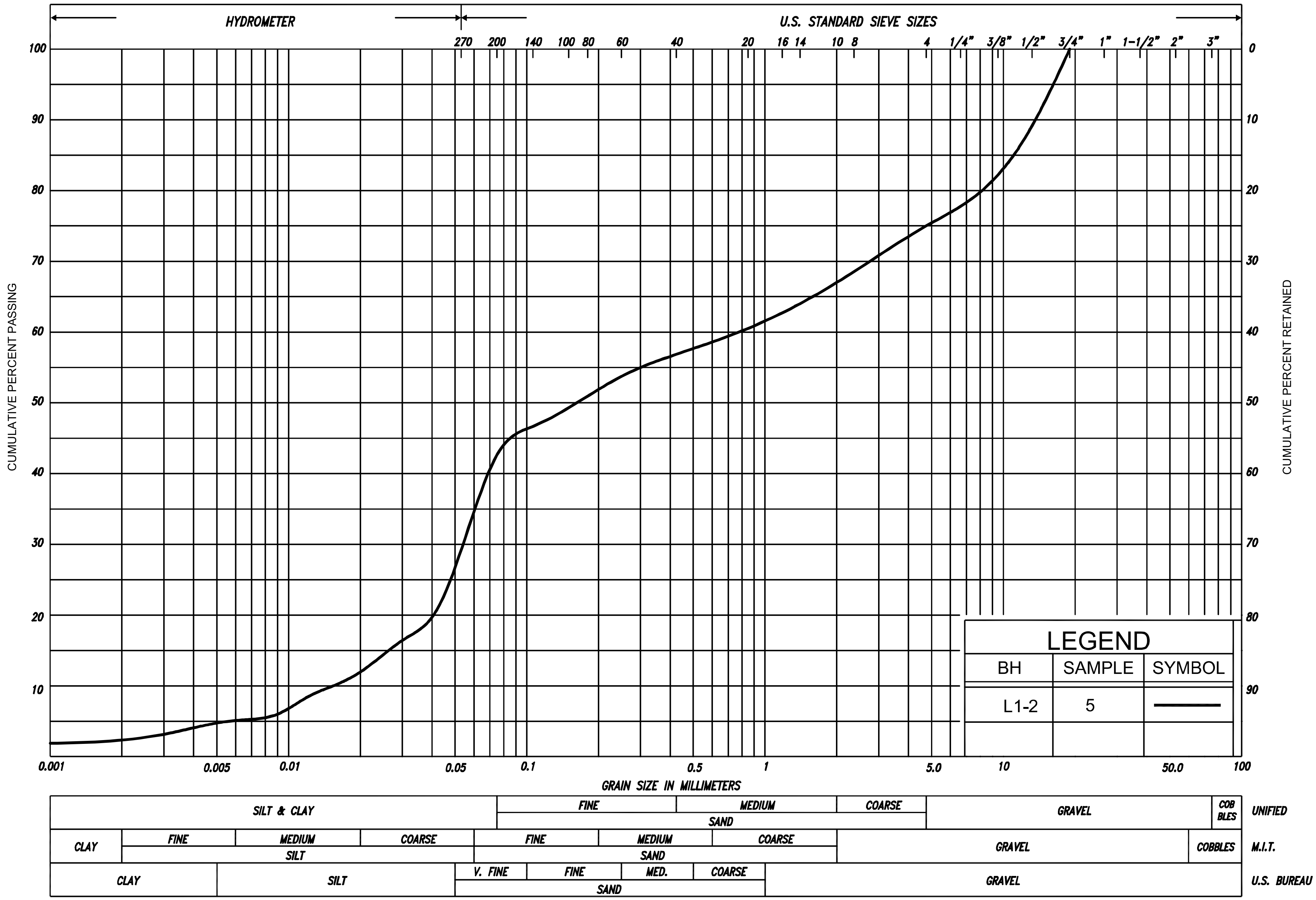


Ministry of Transportation Ontario

GRAIN SIZE DISTRIBUTION

CLAYEY SILT, some sand

FIG No.	GS-L1-1
HWY	17
G.W.P. No.	5825-05-00

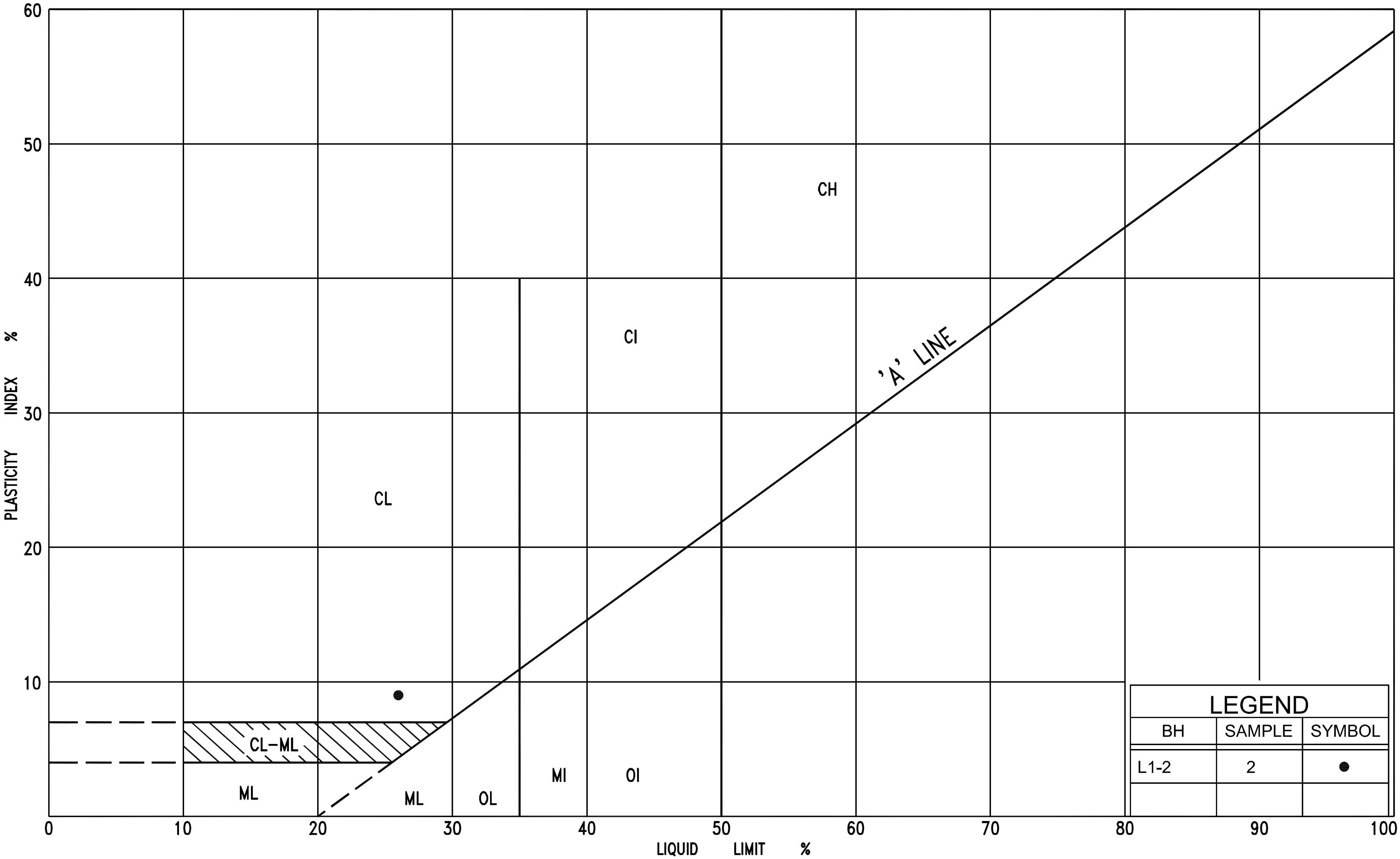


Ministry of Transportation Ontario

GRAIN SIZE DISTRIBUTION

SANDY SILT, with gravel, trace clay

FIG No.	GS-L1-2
HWY	17
G.W.P. No.	5825-05-00



LEGEND		
BH	SAMPLE	SYMBOL
L1-2	2	●

Ministry of Transportation Ontario

PLASTICITY CHART

CLAYEY SILT, some sand

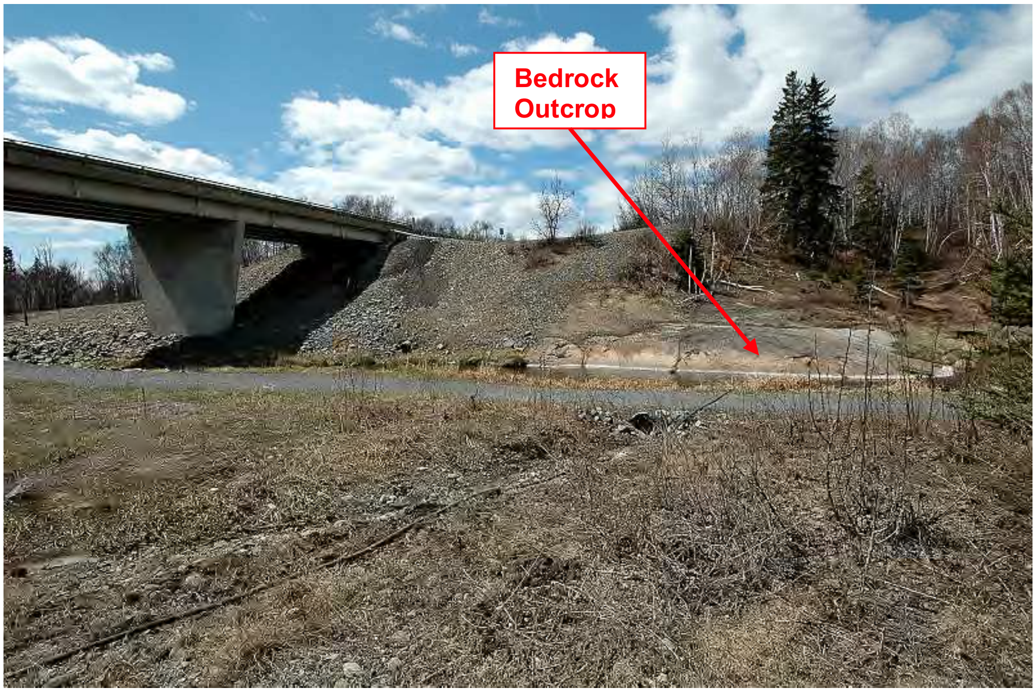
FIG No.	PC-L1-1
HWY	17
G.W.P. No.	5825-05-00

Photograph 1: Argillite rock core from borehole L1-1, RC-1. RQD value of 75%.

Photograph 2: Argillite rock core from borehole L1-1, RC-2 and RC-3. RQD values of 65 and 100% for RC-2 and RC-3, respectively.

Photograph 3: Argillite rock core from borehole L1-2, RC-8 and RC-9. RQD values of 73 and 51% for RC-8 and RC-9, respectively.

Photograph 1: Looking southwest from east of the structure site. Drill rig at borehole L1-2 (proposed east abutment location). (May 2, 2007)

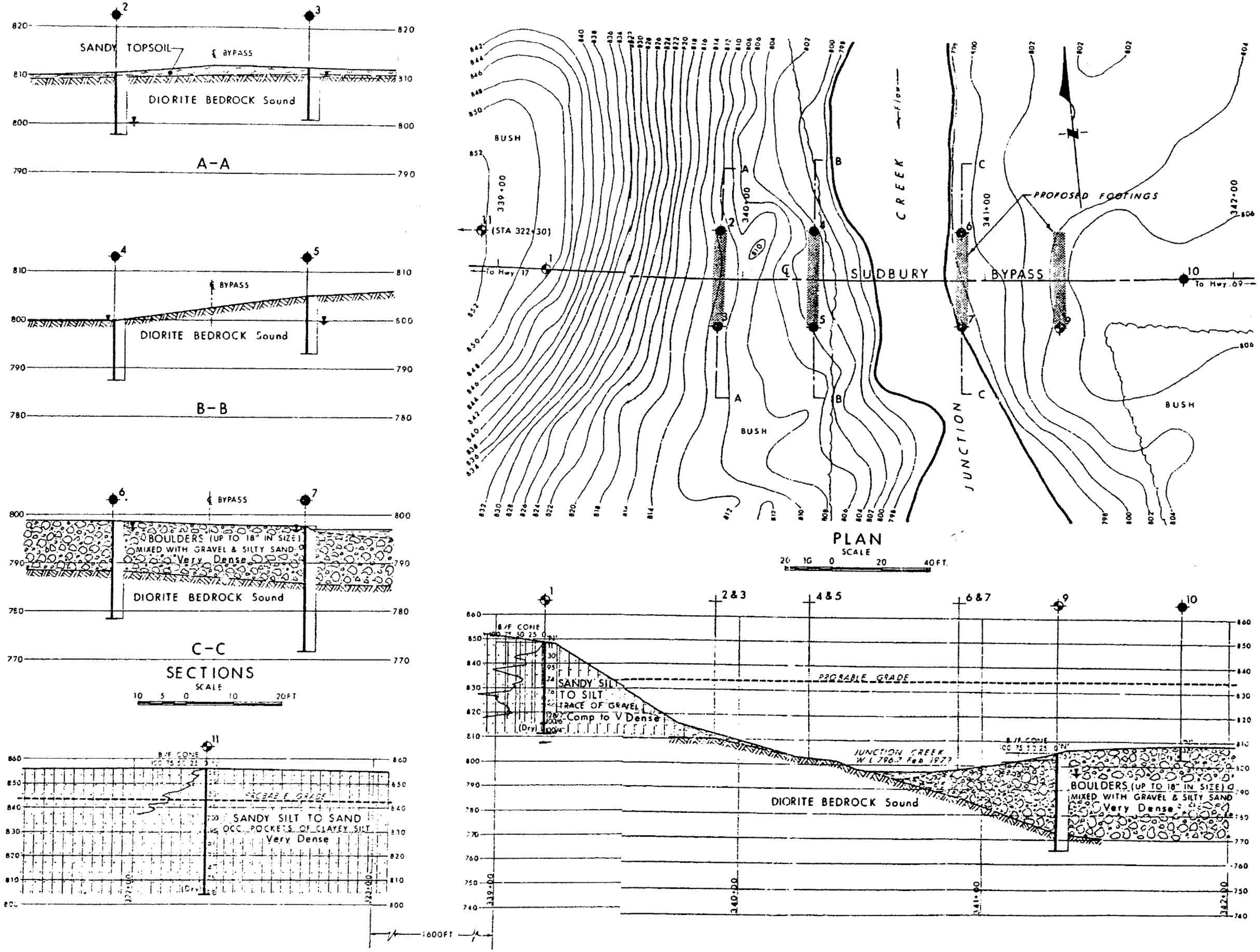


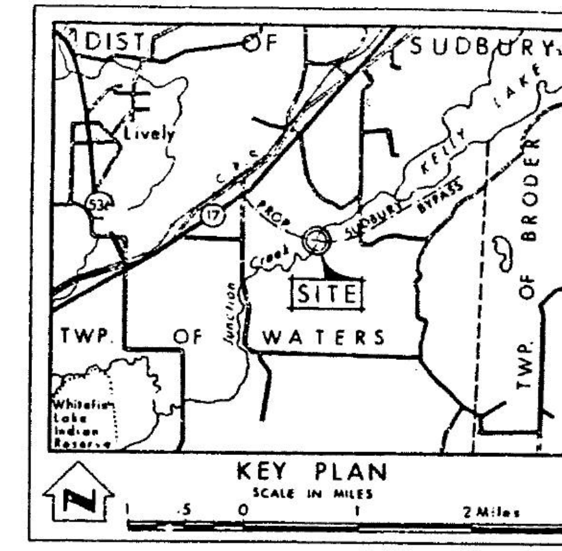
Photograph 2: Looking west from proposed east abutment location. Note bedrock outcrop at west pier location. (May 2, 2007)

Photograph 3: Looking south from west pier of structure site. Drill rig is at borehole L1-1. Note bedrock outcrop sloping (about 19°) towards the Junction Creek, from west to east. (May 3, 2007)

Appendix B.

Portions of the Foundation Investigation and Design Report, Geocres 41I-069, February, 1972





LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation. Jan. & Feb. 1972

NO.	ELEVATION	STATION	OFFSET
1	849.3	339+20	℄
2	810.7	339+90	20' LT.
3	811.6	339+90	20' RT.
4	799.6	340+30	20' LT.
5	805.1	340+30	20' RT.
6	798.7	340+90	20' LT.
7	797.8	340+90	20' RT.
9	805.5	341+30	20' RT.
10	808.4	341+80	℄
11	856.0	322+30	15' LT.

— NOTE —

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

REVISIONS DATE	BY	DESCRIPTION

DEPARTMENT OF TRANSPORTATION & COMMUNICATIONS
DESIGN SERVICES BRANCH – FOUNDATION OFFICE

JUNCTION CREEK

HIGHWAY NO Prop. SUDBURY BYPASS DIST. NO. 17
Dist. of SUDBURY

ABBREVIATIONS USED IN THIS REPORT

PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N' : - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE : - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS : -

CONSISTENCY	'N' BLOWS / FT.	c LB. / SQ. FT.
VERY SOFT	0 - 2	0 - 250
SOFT	2 - 4	250 - 500
FIRM	4 - 8	500 - 1000
STIFF	8 - 15	1000 - 2000
VERY STIFF	15 - 30	2000 - 4000
HARD	> 30	> 4000

DENSENESS	'N' BLOWS / FT.
VERY LOOSE	0 - 4
LOOSE	4 - 10
COMPACT	10 - 30
DENSE	30 - 50
VERY DENSE	> 50

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.B.	SCRAPER BUCKET SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE
S.T.	SLOTTED TUBE SAMPLE		

P.H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

SOIL TESTS

Qu	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
Qcu	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Qd	DRAINED TRIAXIAL	S	SENSITIVITY

ABBREVIATIONS USED IN THIS REPORT

SOIL PROPERTIES

γ UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s UNIT WEIGHT OF SOLID PARTICLES
γ_w UNIT WEIGHT OF WATER
γ_d UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ' UNIT WEIGHT OF SUBMERGED SOIL

G SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$

e VOID RATIO
n POROSITY
w WATER CONTENT
S_r DEGREE OF SATURATION
w_L LIQUID LIMIT
w_P PLASTIC LIMIT
I_P PLASTICITY INDEX
s SHRINKAGE LIMIT

I_L LIQUIDITY INDEX $= \frac{w - w_P}{I_P}$

I_C CONSISTENCY INDEX $= \frac{w_L - w}{I_P}$

e_{max} VOID RATIO IN LOOSEST STATE
e_{min} VOID RATIO IN DENSEST STATE

I_D DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$

RELATIVE DENSITY D_r IS ALSO USED

h HYDRAULIC HEAD OR POTENTIAL
q RATE OF DISCHARGE
v VELOCITY OF FLOW
i HYDRAULIC GRADIENT
k COEFFICIENT OF PERMEABILITY
j SEEPAGE FORCE PER UNIT VOLUME

m_v COEFFICIENT OF VOLUME CHANGE $= \frac{-\Delta e}{(1+e)\,\Delta\sigma}$

c_v COEFFICIENT OF CONSOLIDATION

C_c COMPRESSION INDEX $= \frac{\Delta e}{\Delta \log_{10} \sigma}$

T_v TIME FACTOR $= \frac{c_v t}{d^2}$ (d, DRAINAGE PATH)

U DEGREE OF CONSOLIDATION
τ_f SHEAR STRENGTH

c' EFFECTIVE COHESION INTERCEPT
ϕ' EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
} IN TERMS OF EFFECTIVE STRESS $\tau_f = c' + \sigma' \tan \phi'$

c_u APPARENT COHESION
ϕ_u APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
} IN TERMS OF TOTAL STRESS $\tau_f = c_u + \sigma \tan \phi$

μ COEFFICIENT OF FRICTION
S_t SENSITIVITY

GENERAL

π $= 3 \cdot 1416$
e BASE OF NATURAL LOGARITHMS $2 \cdot 7183$
$\log_e a$ OR $\ln a$ NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$ LOGARITHM OF a TO BASE 10
t TIME
g ACCELERATION DUE TO GRAVITY
V VOLUME
W WEIGHT
M MOMENT
F FACTOR OF SAFETY

STRESS AND STRAIN

u PORE PRESSURE
σ NORMAL STRESS
σ' NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ SHEAR STRESS
ε LINEAR STRAIN
γ SHEAR STRAIN
ν POISSON'S RATIO (μ IS ALSO USED)
E MODULUS OF LINEAR DEFORMATION (YOUNGS MODULUS)
G MODULUS OF SHEAR DEFORMATION
K MODULUS OF COMPRESSIBILITY
η COEFFICIENT OF VISCOSITY

EARTH PRESSURE

d DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ ANGLE OF WALL FRICTION
K DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_o COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

B BREADTH OF FOUNDATION
L LENGTH OF FOUNDATION
D DEPTH OF FOUNDATION BENEATH GROUND
N DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY. DEPTH AND COHESION ETC IN THE FORMULA FOR BEARING CAPACITY
k_s MODULUS OF SUBGRADE REACTION

SLOPES

H VERTICAL HEIGHT OF SLOPE
D DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β ANGLE OF SLOPE TO HORIZONTAL

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

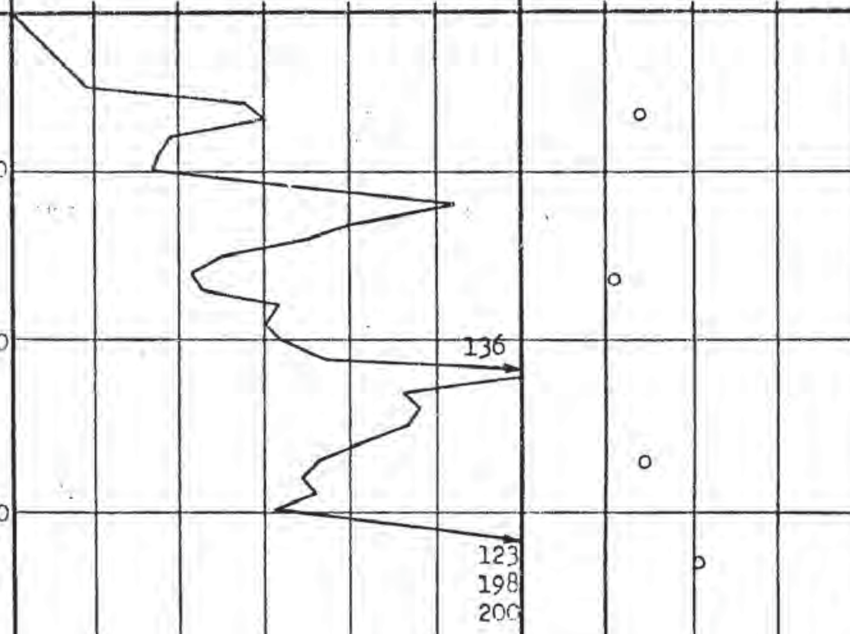
DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 1

FOUNDATION SECTION

JOB	72-11011	LOCATION	Sta. 339 + 20 Ø	ORIGINATED BY	TV
W.P.	911-71	BORING DATE	Jan. 26 - 28, 1972	COMPILED BY	GP
DATUM	Geodetic	BOREHOLE TYPE	BX Casing Washboring Cone Test	CHECKED BY	

ELEV. DEPTH	SOIL PROFILE DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 20 40 60 80 100; SHEAR STRENGTH P.S.F. O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB. VANE	LIQUID LIMIT — w_L PLASTIC LIMIT — w_P WATER CONTENT — w; WATER CONTENT % 10 20 30	BULK DENSITY γ P.C.F.	REMARKS GR. SA. SI. CL.
849.3	Ground Level									
0.0			1	SS	11					BH Dry Jan.28/72
	Sandy silt to silt, trace of gravel.		2	SS	30					0 15 82 3
						840				
	Compact to Very Dense		3	SS	95					
			4	SS	74					
	Brown to Grey					830	136			
			5	SS	76					
			6	SS	55					
						820				
			7	SS	128/7"		123			3 52 40 5
			8	SS	100/6"		198			
812.3							200			
			9	SS	100/4"					
37.0	End of Borehole					810				



FORM OD-MT - 126 (REV. 1969)

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS- ONTARIO

MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 2

FOUNDATION SECTION

JOB 72-11011 LOCATION Sta. 339 + 90 o/s 20' Lt. ORIGINATED BY TV

W.P. 911-71 BORING DATE Jan. 27, 1972 COMPILED BY GP

DATUM Geodetic BOREHOLE TYPE BX Rock Core CHECKED BY

SOIL PROFILE			SAMPLES				DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. (o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB. VANE)	LIQUID LIMIT w_L, PLASTIC LIMIT w_P, WATER CONTENT w; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR,SA,SI,CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE				
810.2	Ground Level									
	Silty sand					810				
0.9	Bedrock Diorite		1	RC	100%					
			2	RC	100%					
			3	RC	100%					
	Sound		4	RC	100%					
			5	RC	100%					800.2
797.7 12.5	Grey		6	RC	100%	800				Jan.27/72
						790				

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

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 3

FOUNDATION SECTION

JOB 72-11011 LOCATION Sta. 339 + 90 o/s 20' Rt. ORIGINATED BY TV

W.P. 911-71 BORING DATE Jan. 20 - 24, 1972 COMPILED BY GP

DATUM Geodetic BOREHOLE TYPE BX Rock Core CHECKED BY

ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB. VANE)	LIQUID LIMIT w_L, PLASTIC LIMIT w_P, WATER CONTENT w; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
811.6	Ground Level									
	Sandy Topsoil		1	CS	-					
1.0	Bedrock diorite		2	BX	100%	810				810.3 Jan.27/72
			3	BX	100%					
	Sound		4	RC	100%					
			5	RC	100%					
800.9	Grey		6	BX	100%					
10.7	End of Borehole					800				
						790				

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

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 4

FOUNDATION SECTION

JOB 72-11011 LOCATION Sta. 340 + 30 o/s 20' Lt. ORIGINATED BY TV
W.P. 911-71 BORING DATE Jan. 21, 1972 COMPILED BY GP
DATUM Geodetic BOREHOLE TYPE AXT & BX Rock Core CHECKED BY [signature]

ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB. VANE)	LIQUID LIMIT — w_L, PLASTIC LIMIT — w_P, WATER CONTENT — w; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
799.6	Ground Level									
0.0	Bedrock diorite		1	AXT	65%					WL frozen at surface Jan.22/72
			2	RC	100%					
			3	BX	100%					
			4	RC	100%					
	Sound		5	RC	100%					
			6	RC	100%	790				
787.3	Grey		7	BX	100%					
12.3	End of Borehole									
						780				

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

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 5

FOUNDATION SECTION

JOB 72-11011 LOCATION Sta. 340 + 30 o/s 20' Rt. ORIGINATED BY TV

W.P. 911-71 BORING DATE Jan. 24, 1972 COMPILED BY GP

DATUM Geodetic BOREHOLE TYPE BX Rock Core CHECKED BY [signature]

ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB. VANE)	LIQUID LIMIT w_L, PLASTIC LIMIT w_P, WATER CONTENT w — WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
805.1	Ground Level									
0.0	Bedrock diorite		1	RC	100%					
			2	RC	100%					
	Sound		3	RC	100%	800				▼ 799.8
			4	BX	100%					
	Grey		5	BX	100%					
793.1										
12.0	End of Borehole					790				

FORM OD–MT - 126 (REV. 1969) OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 6

FOUNDATION SECTION

JOB 72-11011 LOCATION Sta. 340 + 90 o/x 20' Lt. ORIGINATED BY TV
W.P. 911-71 BORING DATE Jan. 19 & 22, 1972 COMPILED BY GP
DATUM Geodetic BOREHOLE TYPE BX Casing, BXL & AXT Rock Core CHECKED BY

ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT; SHEAR STRENGTH P.S.F. (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB. VANE)	LIQUID LIMIT w_L, PLASTIC LIMIT w_P, WATER CONTENT w; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR, SA, SI, CL
798.7	Ground Level									
0.0	Boulders (up to 12") mixed with gravel and silty sand. Very Dense Grey		1	CS	-					797.2 Jan.22/72
			2	BX	25%					
788.5			3	BXL	15%	790				
10.2	Bedrock diorite Sound Grey		4	BXL	100%					
			5	AXT	100%					
778.5			6	AXT	100%	780				
20.2	End of Borehole									
						770				

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

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 7

FOUNDATION SECTION

JOB 72-11011 LOCATION Sta. 340 + 90 20' Rt. ORIGINATED BY TV
W.P. 911-71 BORING DATE Feb. 8 & 9, 1972 COMPILED BY GP
DATUM Geodetic BOREHOLE TYPE Washboring-BX Casing CHECKED BY

SOIL PROFILE ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT; SHEAR STRENGTH P.S.F. ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB. VANE	LIQUID LIMIT — w_L, PLASTIC LIMIT — w_P, WATER CONTENT — w; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
797.8	Ground Level									
0.0	Boulders(up to18" in size) mixed with gravel & silty sand. Very Dense Grey		1	RC	70%					796.8 Feb. 9/72
			2	RC	29%	790				
785.8 / 12.0	Bedrock diorite Sound Grey		3	RC	58%					
			4	BX	97%	780				
			5	BX	100%					
			6	BX	100%					
771.8 / 26.0	End of Borehole					770				

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

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 9

FOUNDATION SECTION

JOB 72-11011
W.P. 911-71
DATUM Geodetic

LOCATION Sta. 341 + 30 o/s 20' Rt.
BORING DATE Jan. 27 & 28, 1972
BOREHOLE TYPE Washboring BX And AXT Rock Core ; Cone Test

ORIGINATED BY TV
COMPILED BY GP
CHECKED BY [signature]

SOIL PROFILE

ELEV. DEPTH	DESCRIPTION
805.6	Ground Level
0.0	Boulders (up to 18" in size) mixed with gravel & silty sand. Very Dense. Brown to Grey
772.6 / 33.0	Bedrock (diorite) Sound Grey
765.6 / 40.2	End of Borehole

SAMPLES

NUMBER	TYPE	BLOWS / FOOT
1	SS	75/7"
2	RC	60%
3	BX	55%
4	BX	16%
5	BX	40%
6	BX	32%
7	RC	60%
8	RC	100%
9	BX	62%
10	BX	0%
11	AXT	69%
12	AXT	0%
13	AXT	100%
14	AXT	100%
15	AXT	100%

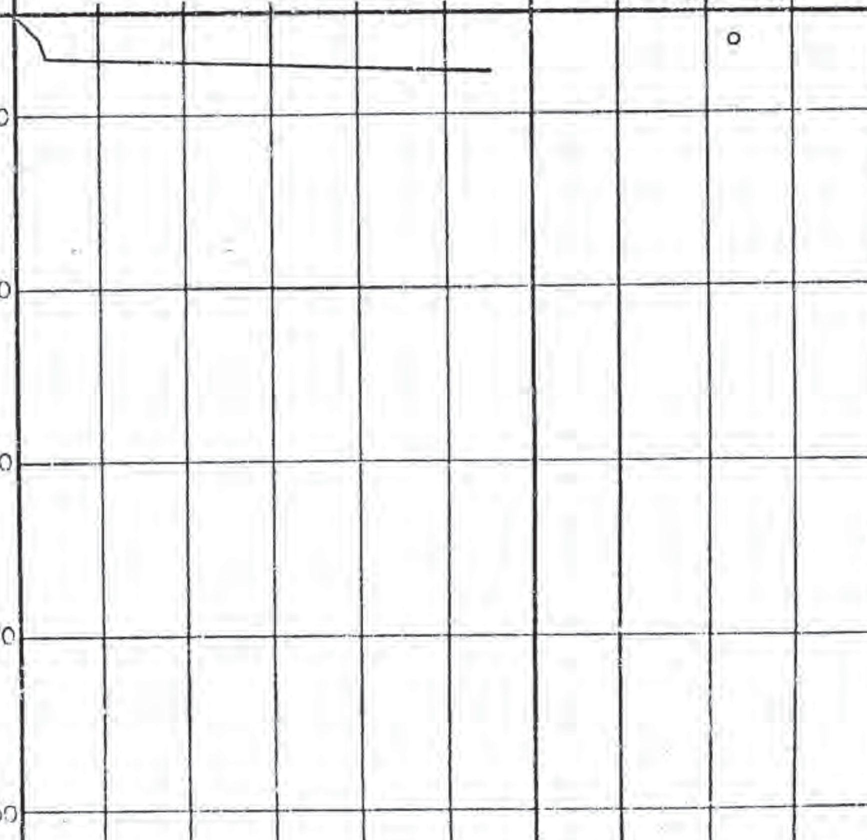
DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 20 40 60 80 100

SHEAR STRENGTH P.S.F.
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB. VANE

LIQUID LIMIT —— w_L
PLASTIC LIMIT —— w_P
WATER CONTENT —— w

WATER CONTENT % 10 30 30

ELEV. SCALE



BULK DENSITY γ P.C.F.

REMARKS GR. SA. SI. CL.

0 45 52 3

796.8 Jan.28/72

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 10

FOUNDATION SECTION

JOB 72-11011 LOCATION Sta. 341 + 80 ⌀ ORIGINATED BY TV

W.P. 911-71 BORING DATE Jan. 29, 1972 COMPILED BY GP

DATUM Geodetic BOREHOLE TYPE BX Casing, Washboring & AXT Rock Core CHECKED BY

SOIL PROFILE			SAMPLES				DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB. VANE)	LIQUID LIMIT — w_L; PLASTIC LIMIT — w_P; WATER CONTENT — w; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE				
808.4	Ground Level									
0.0	Boulders(up to 9" in size) mixed with gravel & silty sand.		1	SS	42					Hole dry
803.1			2	AXT	60%					
5.3	End of Borehole					800				

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 11

FOUNDATION SECTION

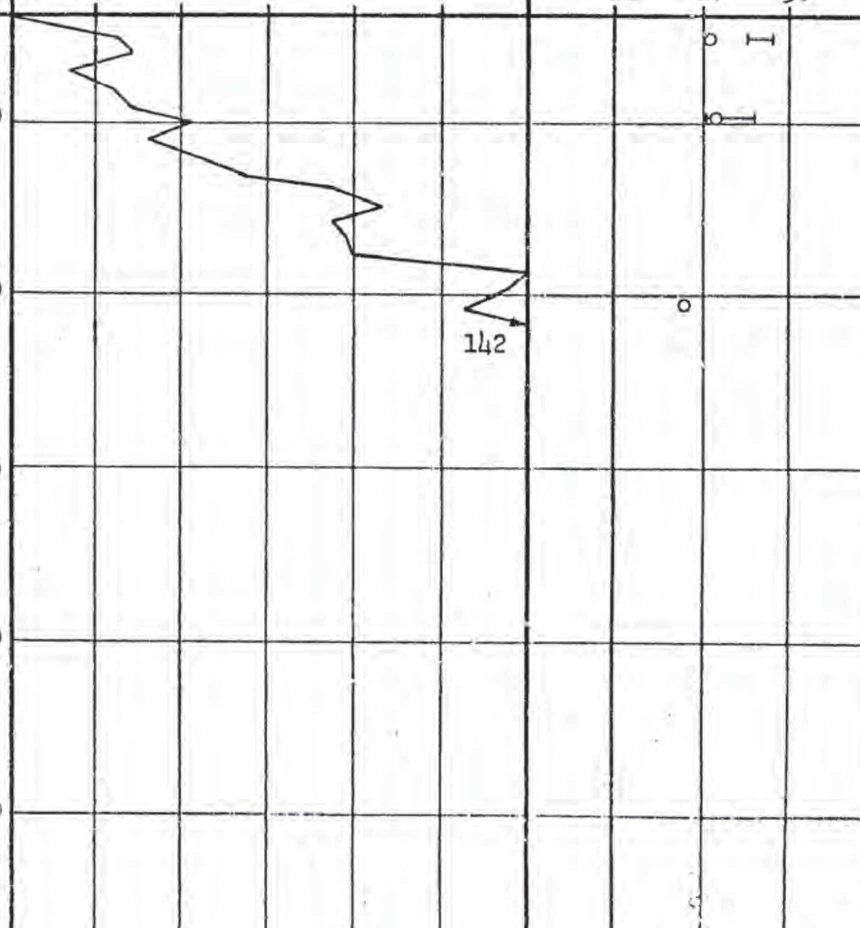
JOB 72-11011 LOCATION Sta. 322 + 30 o/s 15' Lt. ORIGINATED BY TV
W.P. 911-71 BORING DATE Jan. 31 - Feb. 2, 1972 COMPILED BY GP
DATUM Geodetic BOREHOLE TYPE BX Casing, Washboring, Cone Test CHECKED BY [illegible]

SOIL PROFILE ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	REMARKS GR. SA. SI. CL.
856.0	Ground Level						
0.0	Sandy silt to fine		1	SS	58		BH dry Feb. 2/72
	sand, with occasional		2	SS	29	850	0 2 82 16
	pockets of clayey silt		3	SS	53		
	Very Dense		4	SS	96	840	0 55 39 6
	Brown to Grey		5	SS	200		
			6	SS	195	830	
			7	SS	61		
			8	SS	71	820	
			9	SS	47		
			10	SS	75	810	
			11	SS	68		

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

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

BULK DENSITY γ P.C.F.



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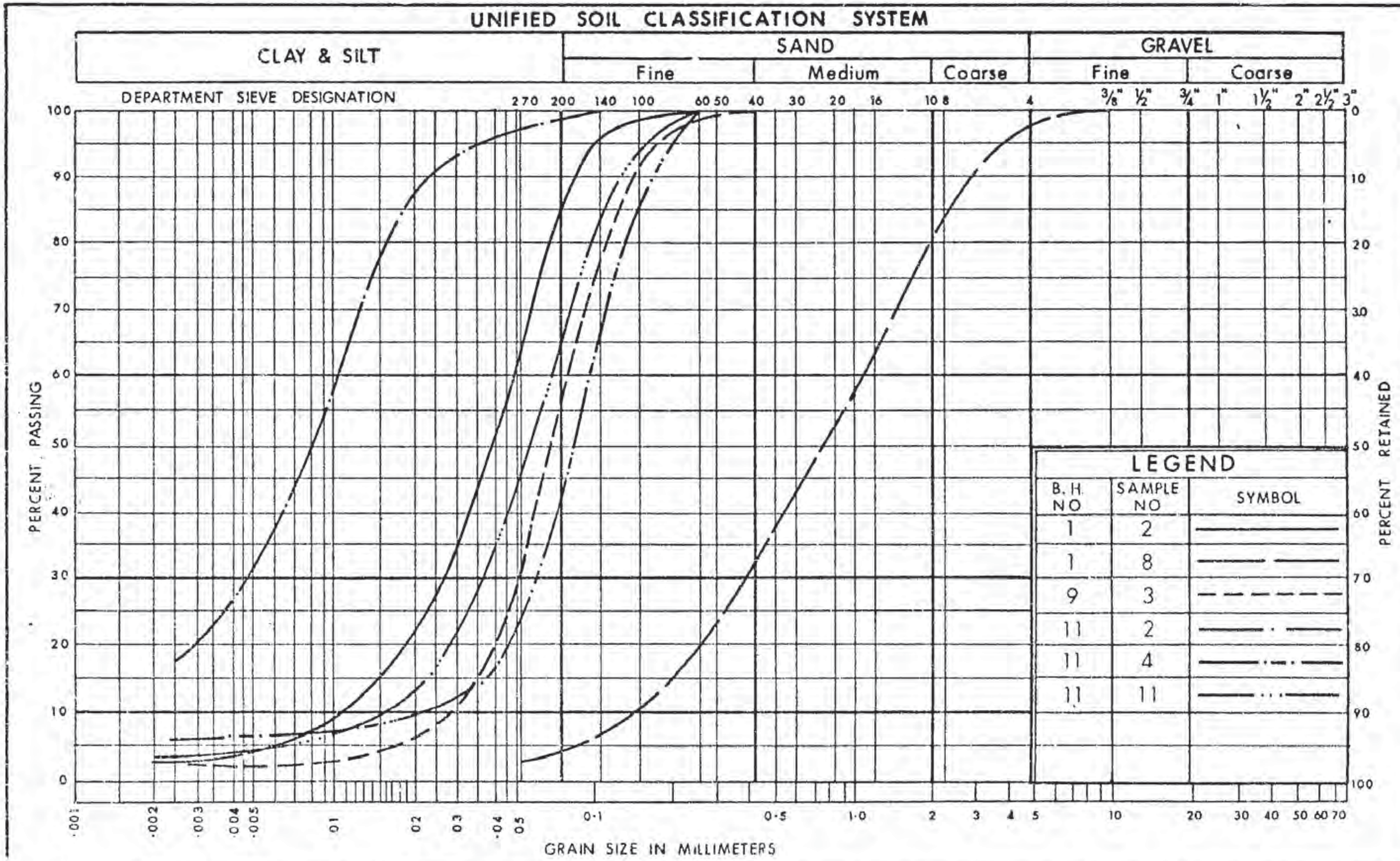

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS DESIGN SERVICES BRANCH ONTARIO	GRAIN SIZE DISTRIBUTION SANDY SILT TO SILT	W.P. No. 911-71 JOB No. 72-11011 Fig. № 1

Appendix C.

GSC Seismic Hazard Calculation Data Sheet

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

Site: 46.423557N 81.105687W **User File Reference:** Junction Creek (EBL), Sudbury ON 2019-03-11 15:51 UT

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.078	0.047	0.030	0.009
Sa (0.1)	0.108	0.067	0.044	0.015
Sa (0.2)	0.105	0.068	0.045	0.016
Sa (0.3)	0.090	0.059	0.040	0.015
Sa (0.5)	0.074	0.048	0.033	0.012
Sa (1.0)	0.045	0.029	0.019	0.006
Sa (2.0)	0.023	0.015	0.009	0.002
Sa (5.0)	0.006	0.003	0.002	0.001
Sa (10.0)	0.003	0.002	0.001	0.000
PGA (g)	0.062	0.038	0.025	0.008
PGV (m/s)	0.060	0.037	0.023	0.007

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" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. 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.**

References

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

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
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

Natural Resources Canada Ressources naturelles Canada

Canada