Peto MacCallum Ltd.
CONSULTING ENGINEERS

FOUNDATION INVESTIGATION AND DESIGN REPORT FOR PORTAGE LAKE NORTHBOUND BRIDGE W.P. 349-00-01, SITE 44-404N G.W.P. 293-97-00 HIGHWAY 69, DISTRICT 52 NOBEL, ONTARIO

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FOR
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FOUNDATION INVESTIGATION REPORT
For
Portage Lake Northbound Bridge
W.P. 349-00-01, SITE 44-404N
G.W.P. 293-97-00
Highway 69, District 52
Nobel, Ontario

1. INTRODUCTION

This report summarizes the results of the foundation investigation carried out for construction of the proposed Highway 69 northbound bridge over Portage Lake in Parry Sound (Nobel), Ontario. The investigation was carried out for McCormick Rankin Corporation (MRC) on behalf of the Ministry of Transportation of Ontario (MTO).

The proposed Highway 69 northbound bridge will span Portage Lake between approximately Stations 18+532 to 18+711.

The report pertains to the proposed bridge structure and approach embankments within 20 m of the abutments, between approximate Stations 18+512 and 18+731.

2. SITE DESCRIPTION

The site is located about 6.0 km north of Parry Sound in the Town of Nobel and about 250 m east of the existing Highway 69 alignment. The proposed bridge will span the Portage Lake valley and carry Highway 69 traffic on a northbound direction. The bridge will have a north south alignment.

South of Portage Lake, the ground is covered with sparse trees and grasses. A rock outcrop partially covered with fill is evident at the proposed south abutment location and the ground surface dips from the south abutment to the lake with a relief of about 16 m. North of the lake, the ground surface is a low-lying grassed area with cottages and the ground rises northerly with a gentle relief of about 2 m to the proposed north abutment location. A rock outcrop is evident about 20 m beyond the proposed north abutment of the bridge.

Photographs of the south and north margins of Portage Lake along the northbound bridge alignment are shown on Plates 1 to 5, attached in Appendix A. The Plates depict relevant topographic conditions at the south abutment and pier locations, in particular the rock outcrop at the south abutment location and the flatland on the north margin.

3. BEDROCK GEOLOGY

The bridge site is located within the Central Gneiss Belt of the Grenville Province. The Grenville is a structural subdivision of the Canadian Precambrian Shield and forms the southern margin of the Shield between Georgian Bay and Labrador.

The site lies within a litho tectonic subdivision of the Central Gneiss Belt known as the Algonquin Terrain and in particular, within a sub-unit identified as the Britt Domain, in a relatively narrow band between the Parry Sound Domain to the south, and the Bolger Pluton to the north.

The Britt Domain comprises strongly deformed pink and grey gneisses and migmatites intruded by younger plutons that are also further deformed and migmatized.

Based on Ontario Department of Mines Geological Report 52, Geology and Mineral Deposits of the Parry Sound-Huntsville Areas, 1967, the subject site is located within an area of Precambrian plutonic rocks classified as granitic gneisses and more specifically described as strongly granitized banded hornblende migmatite. Metasedimentary rocks, including amphibolite, hornblende gneiss and schist are just east of the site. Long, linear structural features are parallel to the boundary between these two geologic zones. (This lineation is from NE to SW at the site.)

The local rivers and lakes that are controlled by, and tend to follow depressions in the bedrock surface reflect the extent and effect of these structural features on the landscape/physiography of the area. A good example of this effect is illustrated by Nine Mile Lake situated about 3 to 4 km northeast of the site. This lake is located about 1 km west of the contact between the plutonic rocks to the west and the metasedimentary rocks to the east and appears to follow a depression in the bedrock surface that is parallel to the contact. The lake is about 14 km long, but is often only 100 m wide.

The depressions may reflect accelerated erosion of relatively weak rock layers associated with variations in mineralogy. The variations are caused by differing degrees of metamorphism occurring in close proximity to the boundaries between adjacent litho tectonic units. Based on the regional structural geology, the depression of Portage Lake is considered to be linear in nature and is possibly an extension of the feature exhibited at Nine Mile Lake.

4. INVESTIGATION PROCEDURES

The field work was primarily carried out during the period December 5, 2001 to January 6, 2002. The results of boreholes and dynamic cone penetration tests previously drilled at the site on August 24, 25 and 26, 2001 were also incorporated in this report. A total of twenty five test holes were drilled for this investigation.

Eighteen of the boreholes were drilled at the locations of the proposed two abutments and three piers. The boreholes were advanced to refusal on bedrock/inferred bedrock at depths of 0.00 to 37.50 m. Coring to 3.05 to 6.70 m below the soil/bedrock interface in a total of six boreholes proved the bedrock. Two of the cored holes were located at opposite corners of the south abutment and four were drilled at the centre of each of the other bridge foundation elements. Unsampled boreholes were advanced to refusal on the probable soil/bedrock interface at the proposed south pier and north abutment to verify the local slope of the probable bedrock surface. Rock core could not be obtained from borehole ST1N-11 at the south pier due to sloping rock surface although several attempt were made.

Boreholes were drilled in both approach embankments some 20 m beyond the bridge abutments. The south approach borehole ST1N-1 terminated at 1.95 m on probable bedrock. The north approach borehole ST1N-17 was originally located over an existing cottage and was relocated 6 m westerly, where it terminated at 0.00 m depth on exposed bedrock. Borehole ST1N-17A previously drilled on August 25, 2001 to probable bedrock at 0.90 m depth between the north abutment and 20 m north was incorporated in the report for completeness.

Boreholes 102-4M, 4N and 5N and dynamic cone penetration test 102-4N were also advanced for the proposed north approach abutment to better define the local subsurface conditions. These test holes were advanced to depths from 3.20 to 14.30 m. Borehole 102-4M and cone test 102-4N encountered probable bedrock at depths of 3.40 and 3.20 m, respectively.

MRC staked out the working points marking the centre of abutments and piers. Peto MacCallum Ltd. laid out the location of the boreholes based on the working points. The ground surface elevations of the boreholes were determined by Peto MacCallum Ltd. and referred to a geodetic benchmark provided by MRC.

The boreholes were advanced using continuous flight hollow stem augers and washboring through the soil cover and NQ rotary diamond drilling into the bedrock. The holes were advanced with a track-mounted CME 55 drill rig, supplied and operated by a specialist drilling contractor, working under the full-time supervision of a member of our engineering staff.

The hollow stem augers were kept full of water throughout the drilling to minimize hydraulic disturbance to the cohesionless soils being sampled. In general, no blow back was observed at the sampling levels and the standard penetration resistance "N" values are considered representative of the relative density of the soils sampled.

The groundwater conditions in the boreholes were closely monitored during the course of the field work.

The boreholes were backfilled after completion following procedures approved by MTO.

The recovered soil and rock core samples were returned to our laboratory for detailed visual examination and classification. Fifty-five natural moisture content determinations, 14 grain size distribution analyses and 3 Atterberg limit tests were carried out on selected soil samples. The particle size distribution charts are reported on the Record of Borehole sheets and summarized on Figures 1 to 4. The Atterberg limits are recorded on the Record of Borehole sheets and plotted on Figures PC1 and PC2.

5. SUMMARIZED SUBSURFACE CONDITIONS

Reference is made to the appended Record of Borehole sheets and Table I for details of the subsurface conditions including soil classifications, inferred stratigraphy, rock core descriptions, natural moisture content determinations, results of grain size analyses and groundwater observations. The results of laboratory grain size analyses and Atterberg limits are shown on the Record of Borehole sheets and attached Figures 1 to 4, PC1 and PC2. Stratigraphic profiles prepared from the borehole data are presented on Drawings ST1N-1 and ST1N-2.

The soil stratigraphy comprised discontinuous fill units with organic materials and boulders overlying generally loose to compact cohesionless sands and silts locally interbedded with typically firm cohesive silty clay soils. Large rock outcrop and surface boulders were observed at the south abutment. Probable bedrock was encountered below the soil cover at all other foundation locations. The soil/rock interface dips below the ground surface and Portage Lake from the south side and outcrops about 20 m north of the proposed north abutment location.

5.1 Fill

Localized loose fill was encountered south of Portage Lake at the surface in borehole ST1N-2. The fill was about 2.10 m thick, extended to elevation 206.25 and comprised sand, silt, roots and boulders with a topsoil cover about 200 mm thick.

Typically loose to compact mixed silty sand, topsoil, organic materials and clay was encountered north of Portage Lake, in boreholes ST1S-14, 15 and 16. The fill extended to between 0.90 and 1.80 m depths, elevations 190.85 and 193.80 in the boreholes. The 250 mm upper zone of the fill in borehole ST1N-14 comprised topsoil.

Water content determinations in the fill ranged from 10 to 21% south of the lake and between 18 and 25% north of the lake.

5.2 Peat and Topsoil

Dark brown peat 430 to 600 mm thick was encountered in boreholes ST1N-8, 11 and 13 drilled for the south pier at the south edge of Portage Lake. Topsoil 200 to 550 mm thick was encountered at ground surface south of the lake, in boreholes ST1N-1 to 3 and ST1N-7 and north of the lake in boreholes ST1N-14, 102-4N and 102-5N.

5.3 Silty Sand/Silt Some Sand

Discontinuous layers of cohesionless silty sand and sand with varying amounts of silt and trace clay were encountered at the surface and below the fill, peat and topsoil layers at depths up to 1.80 m. Localized gravel and cobbles were also encountered in the deposits. South of the lake the materials extended to 1.95 m, elevation 201.10 in borehole ST1N-1 (where it occurred below isolated silty clay) and to 1.35 m, elevation 191.45 in borehole ST1N-8. North of the lake, the material was encountered at depths from the surface to 1.80 m and extended to depths ranging between 0.90 and 6.10 m, elevations 187.55 to 195.55 in all sampled boreholes. The layer extended to bedrock in borehole ST1N-17A, drilled in the proposed north approach embankment area. The materials were in typically very loose to loose condition with "N" values ranging from 2 to 9. An isolated compact layer with "N" value of 18 was also encountered in borehole ST1N-16.

The envelope of four grain size distribution charts of the material is plotted on attached Figure 1. Natural moisture content determinations in these materials ranged from 21 to 40%.

5.4 Silty Clay

South of Portage Lake, localized layers of cohesive stiff to very stiff silty clay were encountered in boreholes ST1N-1, 3, 11 and 13, at depths from 200 to 600 mm below the topsoil or peat cover. The silty clay extended to depths from 0.45 to 1.35 m, elevations 191.40 and 191.55 near the lake and to elevations 201.45 and 201.85 in the proposed south abutment/south approach embankment areas.

Layers of cohesive very soft to stiff silty clay were also encountered north of the lake in boreholes ST1N-14 at 2.90 m and 6.10 m depths (2 layers) and ST1N-15 at 7.60 m depth. The silty clay occurred in two 1.60 and 2.90 m thick zones in borehole ST1N-14 that was drilled at the proposed centre pier location and one 2.45 m thick layer in borehole ST1N-15 drilled at the location of the proposed north pier. The deeper of silty clay layers extended to depths of 9.00 and 9.15 m, elevations 183.65 and 184.50 in boreholes ST1N-14 and 15, respectively. Undrained shear strength of the silty clay from field vane and pocket penetrometer tests ranged from about 35 to over 100 kPa.

Grain size distribution charts of the silty clay are provided as Figures 2 and 3 attached. The results of the Atterberg limits were plotted on Figures PC1 and PC2. The following range of Atterberg limits results and water content determinations were obtained on the clay samples:

ATTERBERG LIMITS			MOISTURE CONTENT (%)
LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
28 to 47	16 to 22	12 to 25	21 to 64

5.5 Sandy Silt

Localized cohesionless sandy silt trace clay layers were encountered in boreholes ST1N-14 at 4.50 m depth and ST1N-15 at 6.10 and 9.15 m depths (2 layers) interbedded with the silty clay deposits. In both boreholes, an upper layer of sandy silt extended to about 6.10 m and 7.60 m, elevation 186.55 and 186.05, respectively. The sandy silt was also found below the silty clay layer in borehole ST1N-15 between 9.15 and 13.70 m depths, elevations 184.50 to 179.95. The silt was in a very loose to loose condition with "N" values ranging from 4 to 7.

A grain size distribution chart of the sandy silt was included in Figure 1. Representative samples of the silt were examined by the project engineer and were deemed to be non-plastic, consequently Atterberg limits tests were not conducted. One natural water content determination of 18% was obtained in the material.

5.6 Fine Sand

Cohesionless fine sand trace to with silt trace clay and gravel was encountered at 1.35 m depth in boreholes ST1N-8, 11 and 13 drilled south of the lake and at 1.50 to 13.70 m depths in boreholes ST1N-14, 15 and 16, 102-4M, 4N and 5N north of the lake. The fine sand deposit contained layers of cobbles and boulders in borehole ST1N-15 (proposed north pier location) below about 24.75 m depth, elevation 168.90. The material extended to depths ranging from 3.40 to 37.50 m, elevations 192.10 to 156.15. The fine sand typically mantled bedrock in the boreholes, except in boreholes 102-4N and 5N that were terminated in the fine sand deposit.

South of the lake, the fine sand is typically very loose to loose with "N" values ranging from 1 to 9. North of the lake, the fine sand was typically compact to very dense with very loose and loose zones based on variable "N" values ranging from 3 to over 50.

The envelope of the grain size distribution charts of seven samples of the fine sand is presented on Figure 4, attached. Natural moisture content determinations of the fine sand ranged from 18 to 25%. The typical moisture content was about 20%.

5.7 Bedrock

Rock in the boreholes comprised typically sound granitic gneiss of medium to high strength. At the north pier location (borehole ST1N-15) the upper 2.75 m of the rock was described as highly to completely weathered friable schist of very low to low strength, and the underlying rock type was moderately weathered granite of low strength.

The bedrock surface at the site is exposed at elevations 203.4 to 206.25 at the proposed south abutment (boreholes ST1N-4, 5 and 6), dips below grade northerly, reaching a maximum depth of 37.50 m, elevation 156.15 at the north pier (borehole ST1N-15) and rises to the north from this point, outcropping at elevation 197.15 about 20 m beyond the north abutment (borehole ST1N-17).

The level of the inferred bedrock surface was variable and dipped generally at steep angles (estimated to be up to 50°) at the south edge of the lake and at the north end of the bridge span.

Rock core lengths 3.05 to 6.70 m were recovered from 6 boreholes. Where cores proved bedrock, the soil/bedrock interface depths and elevations at the bridge foundations were as follows:

LOCATION	DEPTH TO ROCK (m)	BEDROCK ELEVATION	BOREHOLES
South Abutment	0.35 to 2.10	201.65 to 206.25	ST1N-2, 7
South Pier	5.35	187.45	ST1N-8
Centre Pier	30.80	161.85	ST1N-14
North Pier	37.50	156.15	ST1N-15
North Abutment	7.60	187.10	ST1N-16

At the proposed south abutment location (boreholes ST1N-2 to 7) the bedrock surface was encountered at depths ranging from 0.00 to 2.10 m, elevations 201.45 to 206.25. At the proposed south pier location (boreholes ST1N-8 to 13 and 11A) the inferred depth to bedrock ranged from 2.30 to 6.40 m, elevations 186.35 to 190.65. The inferred bedrock topography at the south pier location was variable, with surface angles varying from near level at the west edge, 50° at the center and 25° at the east edge of the footprint investigated.

At the proposed north abutment location the bedrock was encountered by at depths ranging from 2.90 and 7.60 m, elevations 187.10 to 191.95 and appears to slope up on a northerly direction at estimated angles of 35° to 40° between the boreholes. The depths/elevation to bedrock at the south pier and north abutment locations were summarized on the following Table:

LOCATION	DEPTH TO BEDROCK (m)		BEDROCK ELEVATION
South Pier	ST1N-8	5.35 *	187.45
	ST1N-9	5.70	187.50
	ST1N-10	2.30	190.65
	ST1N-11	5.35	187.55
	ST1N-11A	4.55	188.35
	ST1N-12	5.75	187.05
	ST1N-13	6.40	186.35
North Abutment	ST1N-16	7.60 *	187.10
	ST1N-16A	2.90	191.95
	ST1N-16B	4.40	190.50

* Confirmed by rock core. Depth at other locations was inferred by refusal to augering.

A detailed description of the recovered rock cores is provided on attached Table I. Rock core recovery ranged typically from 87 to 100% in the granitic gneiss and the RQD ranged from 44 to 100%, indicating poor to excellent quality. At the north pier (borehole ST1N-15) core recovery of the schist bedrock was 38 to 87% and RQD was 0% indicating very poor rock quality. Rock core recovery was 40% for the granite encountered below the schist in borehole ST1N-15 and the RQD was 0%, indicating very poor quality.

Photographs of typical granitic gneiss obtained from boreholes ST1N-2 and ST1N-14 are shown on Plates 6 and 7, respectively. Cores of the schist and granite taken from borehole ST1N-15 are depicted on Plate 8.

5.8 Groundwater

Most of the boreholes were charged with drill water and water levels were not established in these holes. Water levels observed during drilling in boreholes ST1N-13 and 15 and boreholes 102-4N and 5N were between 1.00 and 1.35 m depths, elevations 191.4 and 192.7. The remaining boreholes that were drilled at the south abutment and north approach embankment were on rock outcrops and probable bedrock under shallow soil cover or remained dry during and at completion of drilling.

Based on the observations and natural moisture content of the soil samples that indicated wet conditions within all boreholes drilled to depths below the water level of the lake, it is inferred that the groundwater level at the site is typically controlled by the lake water level. The lake water level was at about elevation 192.6 during the investigation. Groundwater levels at the site are subject to seasonal fluctuations and rainfall patterns.

6. CLOSURE

The field work was carried out under the supervision of Mr. F. Portela, C.E.T. Marathon Drilling Inc. supplied the drilling equipment. This report was written by Mr. C.M.P. Nascimento, P. Eng., Senior Project Engineer and reviewed by Mr. D.W. Kerr, M.Eng., P.Eng., Chief Foundation Engineer. Mr. B.R. Gray, M.Eng, P.Eng., President of Peto MacCallum Ltd., conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

Carlos M.P. Nascimento, P.Eng.
Senior Project Engineer

Dennis W. Kerr, M.Eng., P.Eng.
Chief Foundation Engineer

Brian R. Gray, M.Eng., P.Eng.
President

CN/cn-mi

TABLE I

ROCK CORE DESCRIPTION
PORTAGE LAKE NORTHBOUND BRIDGE
WP 349-00-1, SITE 44-404N
G.W.P. 293-97-00
DISTRICT 52, TOWNSHIP OF McDOUGALL
HIGHWAY 69
NOBEL, ONTARIO

CORE RECOVERY					CORE DESCRIPTION	
HOLE NO.	CORE NO.	DEPTH (m)	RECOVERY %	RQD %	DEPTH (m)	DESCRIPTION
ST1N-2	3 4 5	2.10 – 3.05 3.05 – 4.57 4.57 – 5.20	92 100 100	58 90 100	2.10 – 5.20	GRANITIC GNEISS: grey fine crystalline; medium to high strength; unweathered; with occasional layers of pegmatite, coarse crystalline; with thin bards of green/red mineralization; separating on mica concentrations; close to wide spaced; with dipping parting, rough planar; oxidized with iron oxide filling; fair to excellent quality.
ST1N-7	2 3	0.35 – 1.89 1.89 – 3.40	87 100	77 92	0.35 – 3.40	GRANITIC GNEISS: grey fine to medium crystalline; medium to high strength; unweathered; with near vertical parting; rough planar; tight; good to excellent quality.
ST1N-8	7 8 9	5.35 – 6.10 6.10 – 7.62 7.62 – 8.40	93 95 97	70 70 47	5.35 – 8.40	GRANITIC GNEISS: grey fine crystalline; medium to high strength; unweathered; with dipping to near vertical partings; very close to close spaced; tight to oxidized with red/green mineralization on parting surfaces; fair to poor quality.
ST1N-14	19 20 21	30.80 – 31.85 31.85 – 33.38 33.38 – 33.85	100 100 89	71 58 44	30.80 – 33.85	GRANITIC GNEISS: pink and grey fine to medium crystalline; medium to high strength; unweathered; with dipping to near vertical parting; rough planar; oxidized with layers of pegmatite; poor to fair quality.

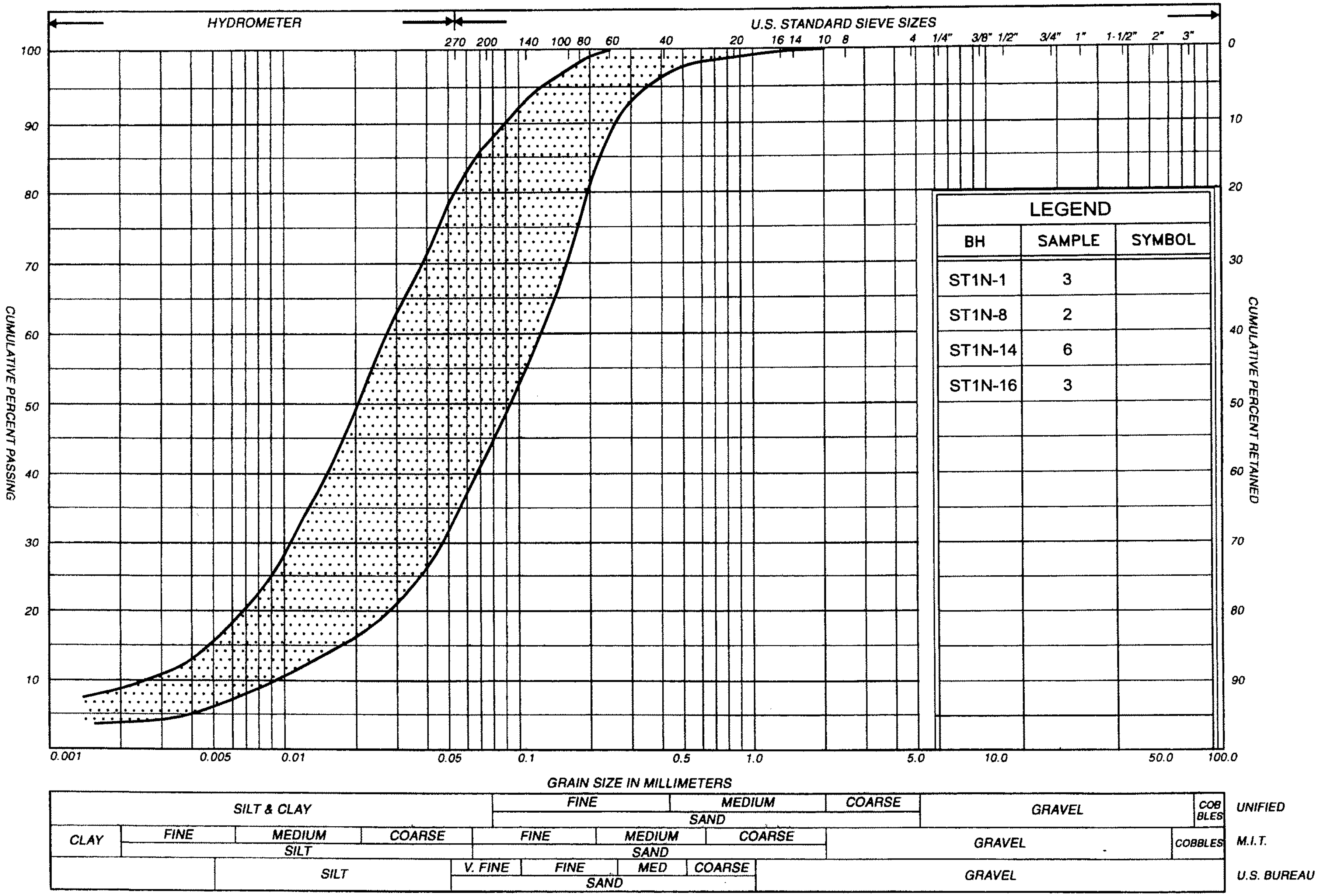
Originated: FP
Compiled: JW
Checked: CN

TABLE I

ROCK CORE DESCRIPTION
PORTAGE LAKE NORTHBOUND BRIDGE
WP 349-00-1, SITE 44-404N
G.W.P. 293-97-00
DISTRICT 52, TOWNSHIP OF McDOUGALL
HIGHWAY 69
NOBEL, ONTARIO

CORE RECOVERY					CORE DESCRIPTION	
HOLE NO.	CORE NO.	DEPTH (m)	RECOVERY %	RQD %	DEPTH (m)	DESCRIPTION
ST1N-15	20	37.50 – 38.10	38	0	37.50 – 40.25	SCHIST: brown, fine to medium crystalline; very low to low strength; friable; highly weathered; very poor quality.
	21	38.10 – 39.62	47	0		
	22	39.62 – 41.15	87	0		
	23	41.15 – 42.67	40	0	40.25 – 44.20	GRANITE: pink fine grained with numerous veinlets; low strength; moderately weathered; very poor quality
	24	42.67 – 44.20	40	0		
ST1N-16	9	7.60 – 9.00	94	89	7.60 – 10.65	GRANITIC GNEISS: pink and grey fine to coarse crystalline; medium to high strength; unweathered; with flat partings, wide spaced; smooth planar; oxidized; and dipping to near vertical partings; rough planar; oxidized; with layers of pegmatite; good to fair quality.
	10	9.00 – 10.65	100	62		

Originated: FP
Compiled: JW
Checked: CN



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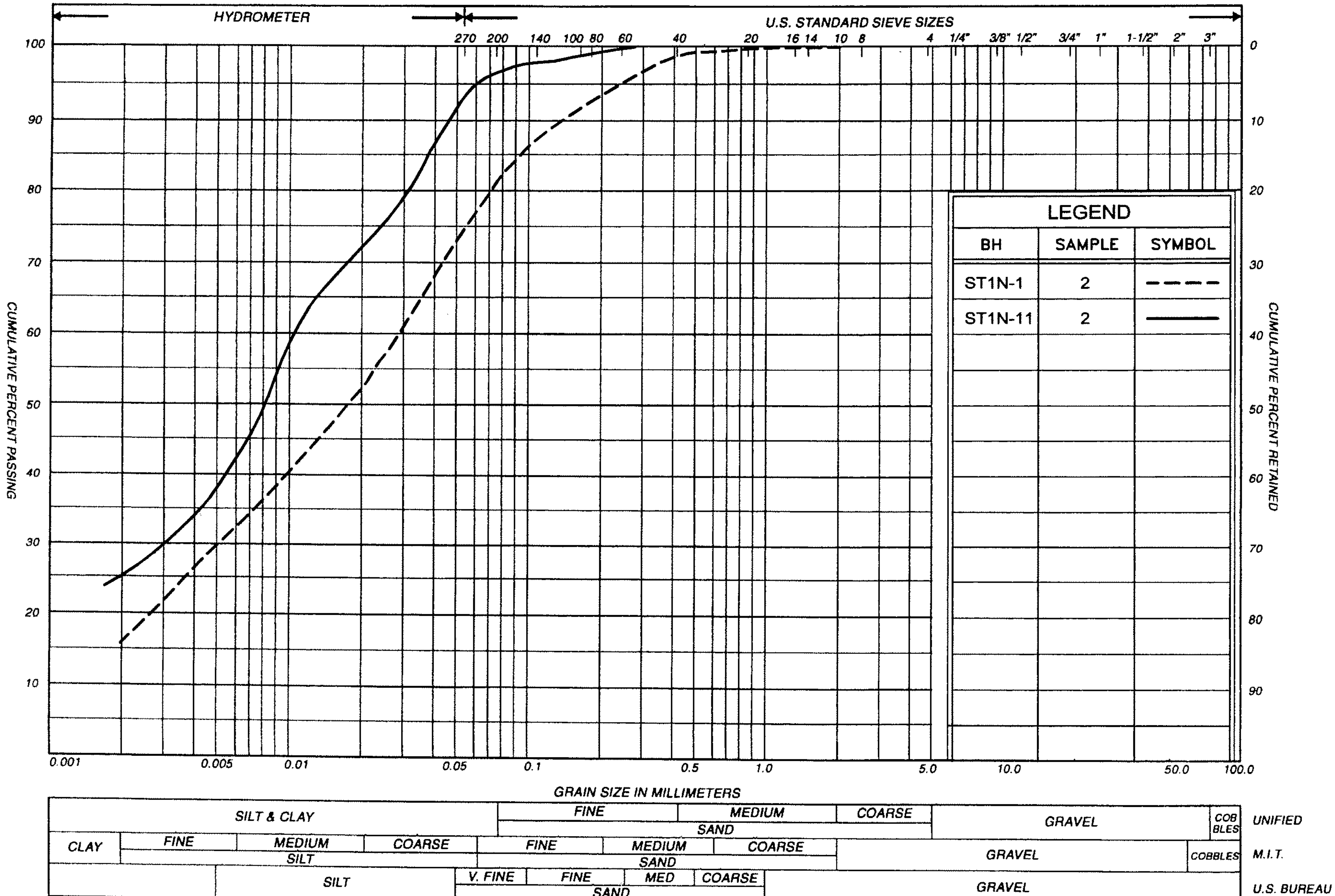
GRAIN SIZE DISTRIBUTION

SILT some sand to SILTY SAND trace clay

FIG No	1
HWY 69	Portage Lake Northbound Bridge
G.W.P No.	293-97-00



GRAIN SIZE DISTRIBUTION

SILTY CLAY, trace to some sand (CL)

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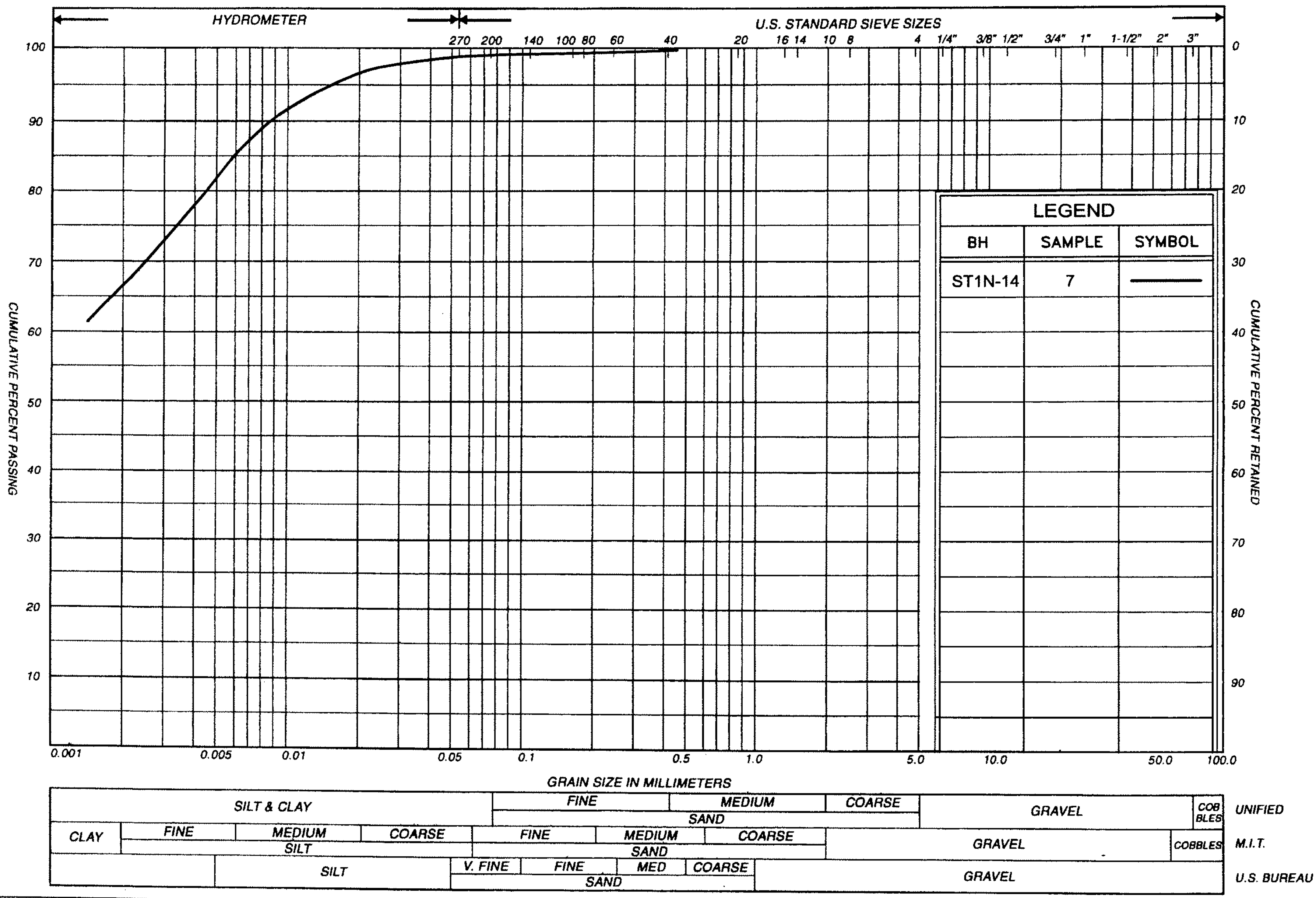
FIG No 2

HWY 69 Portage Lake Northbound Bridge

G.W.P No. 293-97-00



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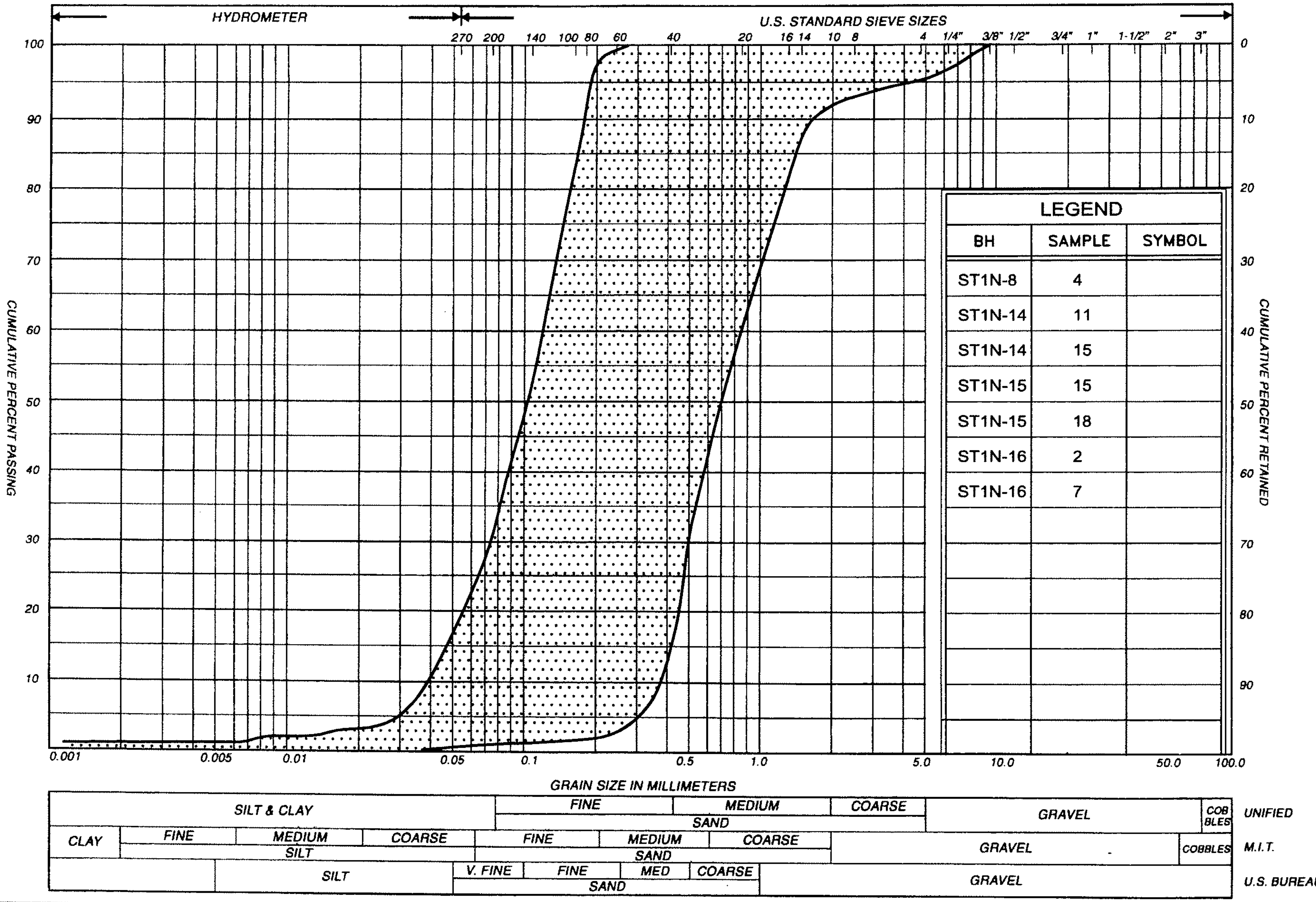
GRAIN SIZE DISTRIBUTION

SILTY CLAY trace sand (CI)

FIG No	3
HWY 69	Portage Lake Northbound Bridge
G.W.P No.	293-97-00



LEGEND

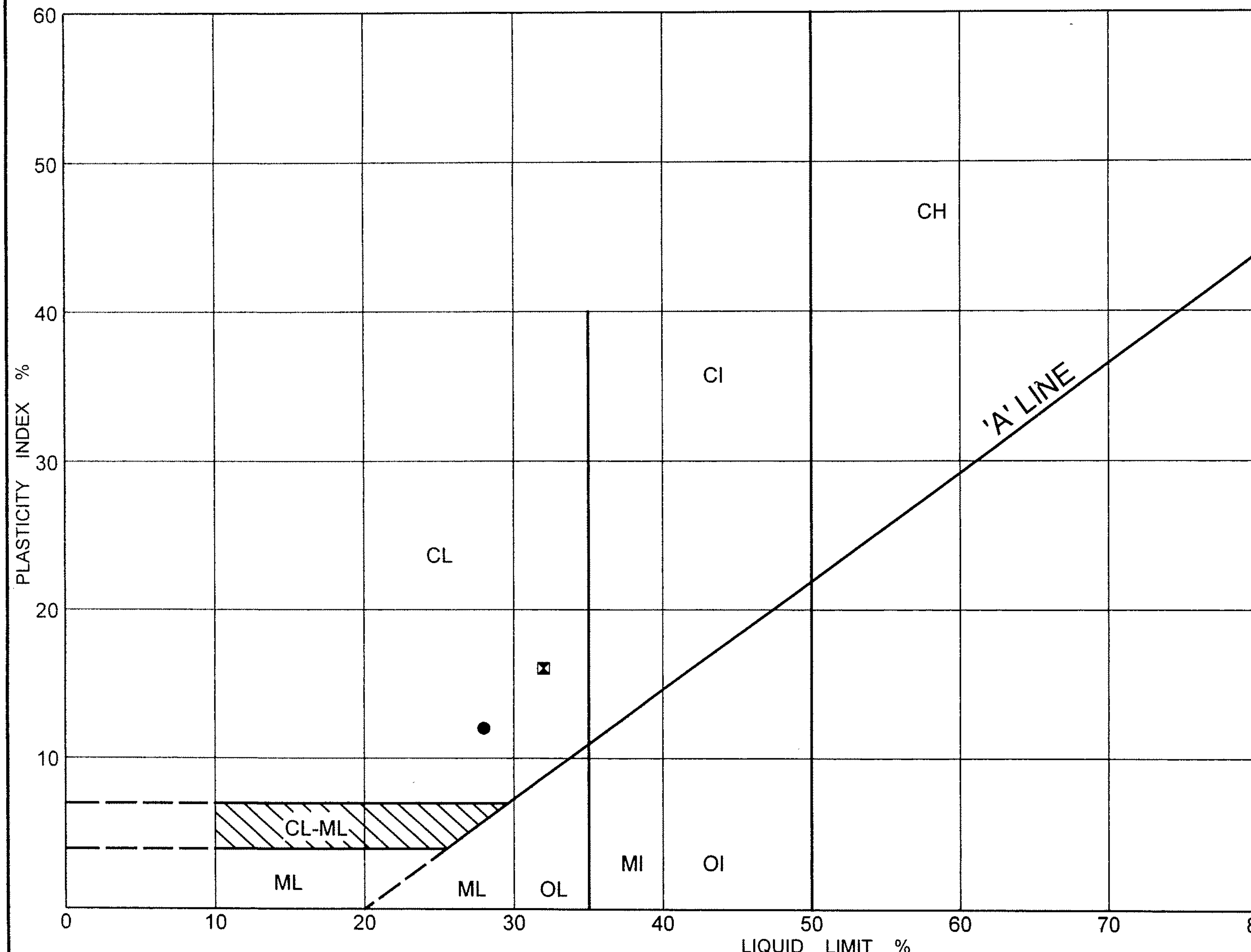
BH	SAMPLE	SYMBOL
ST1N-8	4	
ST1N-14	11	
ST1N-14	15	
ST1N-15	15	
ST1N-15	18	
ST1N-16	2	
ST1N-16	7	

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

SAND trace to with silt trace gravel trace clay

FIG No	4
HWY 69	Portage Lake Northbound Bridge
G.W.P No.	293-97-00



LEGEND		
BH	SAMPLE	SYMBOL
ST1N-1	2	●
ST1N-11	2	⊠

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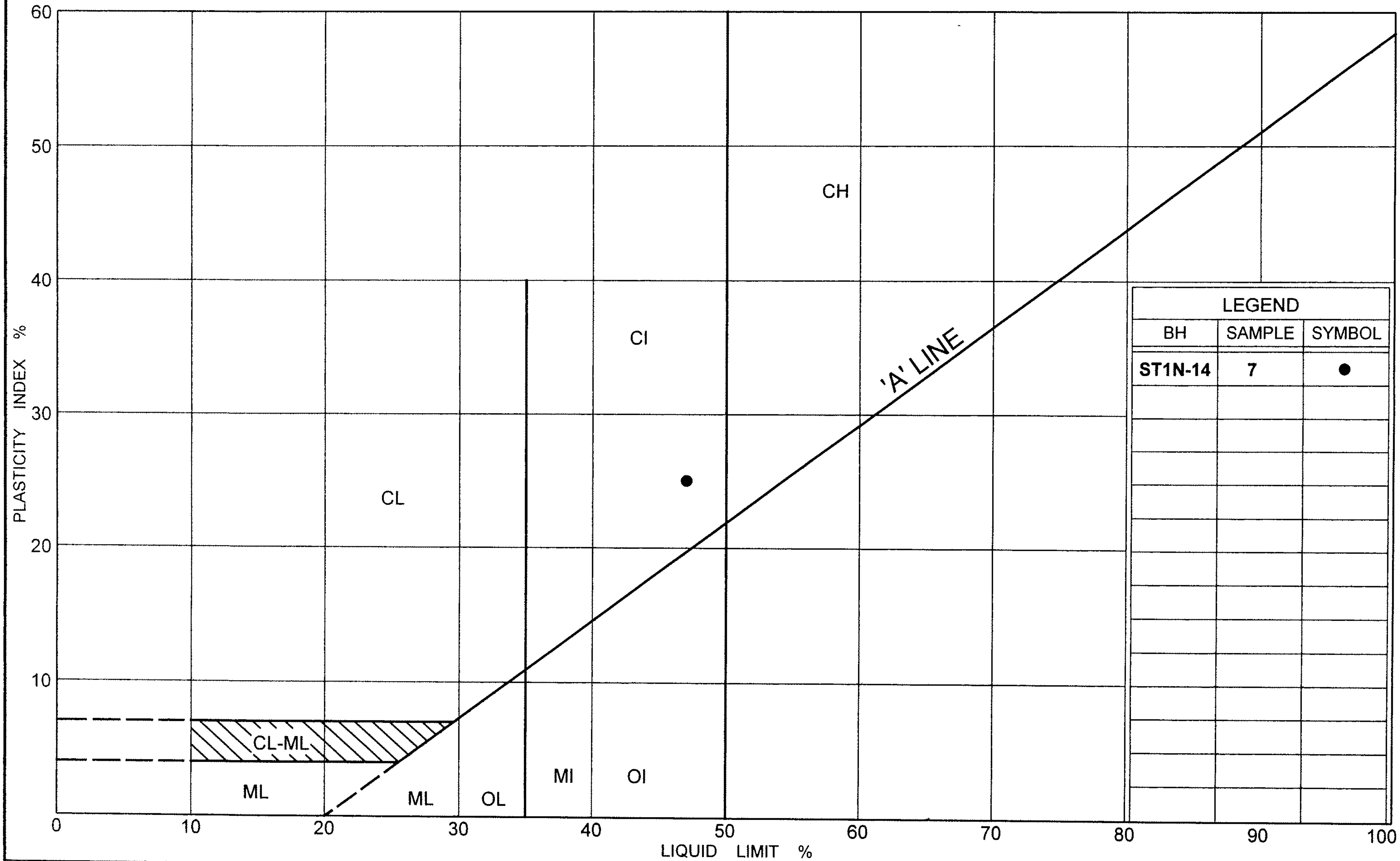
PLASTICITY CHART

SILTY CLAY trace to some sand (CL)

FIG No.	PC-1
HWY69	Portage Lake Northbound Bridge
G.W.P. No. 293-97-00	



Ministry of Transportation Ontario

PLASTICITY CHART

SILTY CLAY trace sand (CI)

FIG No.	PC-2
HWY69	Portage Lake Northbound Bridge
G.W.P. No. 293-97-00	

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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 (RQD), 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

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 $= \frac{w_L - w}{I_p}$
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

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RECORD OF BOREHOLE No ST1N-1

METRIC

G.W.P. 293-97-00 | LOCATION Co-ords. 5 029 193.2 N; 260 852.9 E. | ORIGINATED BY FP

DIST 52 HWY 69 | BOREHOLE TYPE Continuous Flight Hollow Stem Augers | COMPILED BY CN

DATUM Geodetic | DATE December 13, 2001 | CHECKED BY C.A.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
203.05	Ground Level				*	203				
0.00	Topsoil									
0.20	Silty clay, some sand, Very Stiff, Moist, Mottled Brown/Grey	1	SS	2						
201.85		2	SS	17		202	0	18	65	17
1.20	Silty sand trace clay, Dense, Brown, Moist	3	SS	41/23cm**			0	52	40	8
201.10 / 1.95	End of borehole. Refusal on probable bedrock									

* Groundwater level not established

** Refusal to Spoon

Chart headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X 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

ON_MOT VER3 ST1.GPJ ON_MOT.GDT 01/25/2002 1:11:55 PM

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

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

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RECORD OF BOREHOLE No ST1N-2

METRIC

G.W.P. 293-97-00 LOCATION Co-ords. 5 029 207.3 N; 260 841.4 E. ORIGINATED BY FP

DIST 52 HWY 69 BOREHOLE TYPE Continuous Flight Hollow Stem Augers and NQ Coring COMPILED BY CN

DATUM Geodetic DATE December 11, 2001 CHECKED BY

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)
208.35	Ground Level					
0.00						
0.20	Topsoil	1	SS	2	208	
	Mixed sand, silt, roots Loose Brown (Fill) Moist Boulders	2	SS	3	207	
206.25 / 2.10	Granitic Gneiss Sound Bedrock	3	RC NQ	REC 92%	206	RQD=58%
		4	RC NQ	REC 100%	205	RQD=90%
		5	RC NQ	REC 100%	204	RQD=100%
203.15 / 5.20	End of borehole * 2001 12 11 Borehole charged with drillwater. Groundwater level not established					

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS *; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X 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; GR SA SI CL

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

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

Ministry of Transportation Ontario

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RECORD OF BOREHOLE No ST1N-3

METRIC

G.W.P. 293-97-00 | LOCATION Co-ords. 5 029 211.2 N; 260 850.6 E. | ORIGINATED BY FP

DIST 52 HWY 69 | BOREHOLE TYPE Continuous Flight Hollow Stem Augers | COMPILED BY CN

DATUM Geodetic | DATE December 13, 2001 | CHECKED BY CA

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa 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
201.90	Ground Level										
0.00 0.20	Topsoil		1	SS	5/28cm**						
201.45 0.45	Silty clay, some sand Stiff Brown Moist										
	End of borehole Refusal on probable bedrock										

* Borehole dry on completion

** Refusal to Spoon

ON_MOT LINES OVER BDRY ST1.GPJ ON_MOT.GDT 01/24/2002 2:12:19 PM

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

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

Ministry of Transportation
Ontario

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RECORD OF BOREHOLE No ST1N-4

METRIC

G.W.P. 293-97-00 | LOCATION Co-ords. 5 029 211.6 N; 260 845.0 E. | ORIGINATED BY FP

DIST 52 HWY 69 | BOREHOLE TYPE Continuous Flight Hollow Stem Augers | COMPILED BY CN

DATUM Geodetic | DATE December 13, 2001 | CHECKED BY [signature]

SOIL PROFILE			SAMPLES			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
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	*					
203.40	Ground Level										
0.00	End of borehole Refusal on bedrock * Groundwater level not established										

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

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

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No ST1N-5

METRIC

G.W.P. 293-97-00 LOCATION Co-ords. 5 029 212.0 N; 260 839.5 E. ORIGINATED BY FP

DIST 52 HWY 69 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY CN

DATUM Geodetic DATE December 13, 2001 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	*					
206.25 / 0.00	Ground Level										
	End of borehole Refusal on bedrock										
	* Groundwater level not established										

ON_MOT LINES OVER BDRY ST1.GPJ ON_MOT.GDT 01/24/2002 2:12:26 PM

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

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

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RECORD OF BOREHOLE No ST1N-6

METRIC

G.W.P. 293-97-00 LOCATION Co-ords. 5 029 213.9 N; 260 844.1 E. ORIGINATED BY FP

DIST 52 HWY 69 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY CN

DATUM Geodetic DATE December 13, 2001 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE; 20 40 60 80 100	PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	*					
203.40	Ground Level										
0.00	End of borehole Refusal on bedrock * Groundwater level not established										

ON_MOT LINES OVER BDRY ST1.GPJ ON_MOT.GDT 01/24/2002 2:12:30 PM

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

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

RECORD OF BOREHOLE No ST1N-7

METRIC

G.W.P. 293-97-00 LOCATION Co-ords. 5 029 215.8 N; 260 848.7 E. ORIGINATED BY FP

DIST 52 HWY 69 BOREHOLE TYPE Continuous Flight Hollow Stem Augers and NQ Coring COMPILED BY CN

DATUM Geodetic DATE December 13, 2001 CHECKED BY

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	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, X 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
202.00	Ground Level					*					
0.00 201.65	Topsoil		1	SS	2/16cm**				o		
0.35	Granitic Gneiss Sound Bedrock		2	RC NQ	REC 87%		201				REC=77%
			3	RC NQ	REC 100%		200 199				REC=92%
198.60 3.40	End of borehole										

* 2001 12 11
Borehole charged with drillwater. Groundwater level not established

** Refusal to Spoon

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

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

Ministry of Transportation Ontario

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RECORD OF BOREHOLE No ST1N-8

METRIC

G.W.P. 293-97-00 | LOCATION Co-ords. 5 029 248.1 N; 260 831.3 E. | ORIGINATED BY FP

DIST 52 HWY 69 | BOREHOLE TYPE Continuous Flight Hollow Stem Augers and NQ Coring | COMPILED BY CN

DATUM Geodetic | DATE December 05 and 06, 2001 | CHECKED BY Cn

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%) w	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
192.80	Ground Level						
0.00	Peat dark brown fine fibrous	1	SS	1			
192.35 / 0.45	Silt some sand trace clay Compact Brown Wet	2	SS	17	192		0 13 79 8
191.45 / 1.35	Fine sand with silt trace clay Loose to Very Loose Grey Wet	3	SS	6	191		
		4	SS	4	190		0 72 26 2
		5	SS	2	189		
		6	SS	4	188		
187.45 / 5.35	Granitic Gneiss Sound Bedrock	7	RC NQ	REC 93%	187		RQD=70%
		8	RC NQ	REC 95%	186		RQD=70%
		9	RC NQ	REC 97%	185		RQD=47%
184.40 / 8.40	End of borehole						

End of borehole

* 2001 12 06
Borehole charged with drillwater. Groundwater level not established

Legend: 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

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

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

Ministry of Transportation
Ontario

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RECORD OF BOREHOLE No ST1N-9

METRIC

G.W.P. 293-97-00 LOCATION Co-ords. 5 029 244.0 N; 260 827.5 E. ORIGINATED BY FP

DIST 52 HWY 69 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY CN

DATUM Geodetic DATE December 09, 2001 CHECKED BY [signature]

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.20	Ground Level										
0.00	Unsampled						193				
							192				
							191				
							190				
							189				
							188				
187.50 5.70	End of borehole Refusal on probable bedrock * Groundwater level not established										

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

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

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No ST1N-14

METRIC

G.W.P. 293-97-00 LOCATION Co-ords. 5 029 309.9 N; 260 811.2 E. ORIGINATED BY FP

DIST 52 HWY 69 BOREHOLE TYPE Continuous Flight Hollow Stem Augers and NQ Coring COMPILED BY CN

DATUM Geodetic DATE December 15 and 16, 2001 CHECKED BY CM

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
192.65	Ground Level					
					177	
		13	SS	19		
	with silt trace gravel Loose				176	
		14	SS	6	175	
					174	
					173	
		15	SS	6	172	0 74 25 1
					171	
					170	
		16	SS	6	169	
					168	
					167	
	Compact					
		17	SS	14	166	
					165	
					164	
	Very dense				163	
	Cont'd					

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

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

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

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No ST1N-10

METRIC

G.W.P. 293-97-00 LOCATION Co-ords. 5 029 245.7 N; 260 832.2 E. ORIGINATED BY FP

DIST 52 HWY 69 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY CN

DATUM Geodetic DATE December 09, 2001 CHECKED BY [illegible]

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X 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
192.95	Ground Level					*					
0.00	Unsampled						192				
							191				
190.65 / 2.30	End of borehole Refusal on probable bedrock * Groundwater level not established										

ON_MOT VER3 ST1.GPJ ON_MOT.GDT 01/24/2002 2:05:58 PM

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

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

RECORD OF BOREHOLE No ST1N-11

METRIC

G.W.P. 293-97-00 LOCATION Co-ords. 5 029 247.5 N; 260 836.9 E. ORIGINATED BY FP

DIST 52 HWY 69 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY CN

DATUM Geodetic DATE December 08, 2001 CHECKED BY [signature]

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
192.90	Ground Level				*		
0.00 / 192.30	Peat, dark brown, coarse, fibrous	1	SS	1			
0.60 / 191.55	Silty clay trace sand Stiff Mottled Moist Grey/Brown	2	SS	10		192	0 4 70 26
1.35	Fine sand some silt trace clay Loose to Very loose Grey Wet	3	SS	9		191	
		4	SS	5		190	
		5	SS	2		189	
187.55		6	SS	6		188	
5.35	End of borehole Refusal on probable bedrock Rock coring not successful due to sloping bedrock surface Additional borehole advanced 0.90m south of present location * Groundwater level not established Probable bedrock sloping down northerly.						

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

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

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No ST1N-11A

METRIC

G.W.P. 293-97-00 | LOCATION Co-ords. 5 029 246.7 N; 260 837.2 E. | ORIGINATED BY FP

DIST 52 HWY 69 | BOREHOLE TYPE Continuous Flight Hollow Stem Augers | COMPILED BY CN

DATUM Geodetic | DATE December 08, 2001 | CHECKED BY Ch

ELEV DEPTH	SOIL PROFILE 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, X 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
192.90	Ground Level					*					
0.00	Unsampled						192				
							191				
							190				
							189				
188.35 4.55	End of borehole Refusal on probable bedrock * Groundwater level not established Auger probe drilled 0.90m South of Borehole ST1N-11										

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

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

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Ontario

Foundation Design

RECORD OF BOREHOLE No ST1N-12

METRIC

G.W.P. 293-97-00 | LOCATION Co-ords. 5 029 248.7 N; 260 825.8 E. | ORIGINATED BY FP

DIST 52 HWY 69 | BOREHOLE TYPE Continuous Flight Hollow Stem Augers | COMPILED BY CN

DATUM Geodetic | DATE December 09, 2001 | CHECKED BY [signature]

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X 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
192.80	Ground Level					*					
0.00	Unsampled						192				
							191				
							190				
							189				
							188				
187.05 5.75	End of borehole Refusal on probable bedrock * Groundwater level not established										

ON_MOT VER3 ST1.GPJ ON_MOT.GDT 01/24/2002 2:06:12 PM

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

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

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Foundation Design

RECORD OF BOREHOLE No ST1N-13

METRIC

G.W.P. 293-97-00	LOCATION Co-ords. 5 029 249.8 N; 260 835.9 E.	ORIGINATED BY FP
DIST 52 HWY 69	BOREHOLE TYPE Continuous Flight Hollow Stem Augers	COMPILED BY CN
DATUM Geodetic	DATE December 08, 2001	CHECKED BY [signature]

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS
192.75	Ground Level				
0.00	Peat, dark brown, coarse and fine fibrous	1	SS	1	
192.32 / 0.43	Silty clay trace sand Stiff Mottled Grey/Brown Moist	2	SS	13	∇*
191.40 / 1.35	Sand trace silt trace clay Loose to Very loose Grey Wet	3	SS	9	
		4	SS	1	
		5	SS	2	
		6	SS	4	
186.35 / 6.40		7	SS	3/15cm**	

Elevation scale: 192, 191, 190, 189, 188, 187

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X 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

End of borehole

Refusal on probable bedrock

* 2001 12 08

∇ Water level during drilling

** Refusal to Spoon

+7, X5: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No ST1N-14

METRIC

G.W.P. 293-97-00 | LOCATION Co-ords. 5 029 309.9 N; 260 811.2 E. | ORIGINATED BY FP

DIST 52 HWY 69 | BOREHOLE TYPE Continuous Flight Hollow Stem Augers and NQ Coring | COMPILED BY CN

DATUM Geodetic | DATE December 15 and 16, 2001 | CHECKED BY

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
192.65	Ground Level				
0.00 / 0.25	Topsoil				
	Mixed sand, silt, topsoil Very Loose Brown Wet (Fill)	1	SS	3	
		2	SS	4	
190.85 / 1.80	Silty sand Very Loose Brown Wet	3	SS	2	
		4	SS	2	
189.75 / 2.90	Silty clay trace sand Very Soft Grey Wet	5	SS	0	
188.15 / 4.50	Sandy silt trace clay Loose Grey Wet	6	SS	7	0 33 62 5
186.55 / 6.10	Silty clay trace sand Firm to Stiff Grey Wet	7	SS	1	0 1 32 67
		8	SS	2	
183.65 / 9.00	Fine sand some silt trace clay Compact Grey Wet	9	SS	12	
		10	SS	11	Borehole continued from 12.0m on December 16, 2001.
		11	SS	16	0 82 16 2
	Cont'd	12	SS	17	

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (192 to 178); 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.

Field vane sensitivity label: 3

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

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

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No ST1N-14

METRIC

G.W.P. 293-97-00 LOCATION Co-ords. 5 029 309.9 N; 260 811.2 E. ORIGINATED BY FP

DIST 52 HWY 69 BOREHOLE TYPE Continuous Flight Hollow Stem Augers and NQ Coring COMPILED BY CN

DATUM Geodetic DATE December 15 and 16, 2001 CHECKED BY Cn

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
192.65	Ground Level					*					
			18	SS	50/15cm				o		
161.85 30.80							162				
	Granitic Gneiss Sound Bedrock		19	RC NQ	REC 100%		161				RQD=71%
			20	RC NQ	REC 100%		160				RQD=58%
158.80 33.85			21	RC NQ	REC 100%		159				RQD=44%
	End of borehole										

* Groundwater level not established

■ Penetrometer Test

Legend: SHEAR STRENGTH kPa — O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE; scale 20 40 60 80 100. PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60.

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

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

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No ST1N-15

METRIC

G.W.P. 293-97-00 LOCATION Co-ords. 5 029 347.4 N; 260 800.7 E. ORIGINATED BY FP

DIST 52 HWY 69 BOREHOLE TYPE C.F.H.S.A., Cone Test and NQ Coring COMPILED BY FP/DH

DATUM Geodetic DATE August 26, December 05 and 06, 2001 CHECKED BY

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT, WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.65	Ground Surface									
0.00	Silty sand with organic inclusions, wood chips Loose Brown Damp (FILL)	1	SS	1	∇*	193				
192.15 1.50	Fine to medium sand trace silt Loose Grey Wet	2	SS	3***		192				
						191				
190.60 3.05	Silty sand Interbedded sandy silt seams Loose Grey Wet	3	SS	5		190				
	Trace gravel	4	SS	5		189				
						188				
187.55 6.10	Sandy silt trace clay Loose Grey Wet	5	SS	1***		187				
186.05 7.60	Silty clay trace sand Stiff Reddish Grey Wet	6	SS	2		186				
						185	×+			
184.50 9.15	Sandy silt trace clay Interbedded silty sand and clayey silt seams Loose Grey Wet	7	SS	4		184				
						183				
		8	SS	7		182				
		9	SS	4		181				
						180				
179.95 13.70	Fine sand trace silt Compact Grey Wet	10	SS	13		179				
	Cont'd									

Dynamic cone plot scale: 20 40 60 80 100. Shear strength legend: O UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE; scale 20 40 60 80 100. Water content scale: 20 40 60; W_P, W, W_L.

ON_MOT TWO DATES NB_102A.GPJ ON_MOT.GDT 03/21/2002 8:52:44 AM

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

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

RECORD OF BOREHOLE No ST1N-15

METRIC

G.W.P. 293-97-00 LOCATION Co-ords. 5 029 347.4 N; 260 800.7 E. ORIGINATED BY FP

DIST 52 HWY 69 BOREHOLE TYPE C.F.H.S.A., Cone Test and NQ Coring COMPILED BY FP/DH

DATUM Geodetic DATE August 26, December 05 and 06, 2001 CHECKED BY CM

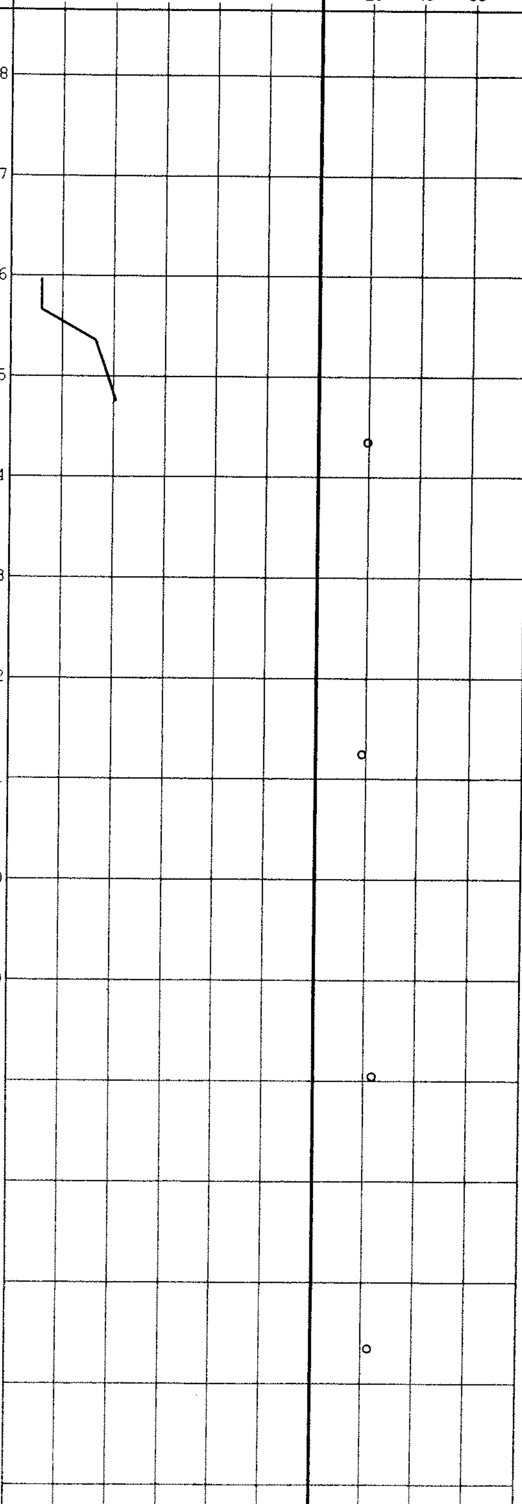
SOIL PROFILE: ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.65	Ground Surface							
			11	SS	22		178	
							177	
			12	SS	24		176	
							175	
	some silt trace gravel Dense Brown Wet		13	SS	33		174	Borehole extended on December 5, 2001
							173	
							172	
	Compact		14	SS	25		171	
							170	
							169	
	Cobbles and boulders							
	Loose Grey		15	SS	4		168	6 80 14 0
							167	
							166	
	Dense		16	SS	31		165	
							164	
	Cont'd							

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



$+^7$, $\times^5$: Numbers refer to Sensitivity 20 15 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No ST1N-15

METRIC

G.W.P. 293-97-00	LOCATION Co-ords. 5 029 347.4 N; 260 800.7 E.	ORIGINATED BY FP
DIST 52 HWY 69	BOREHOLE TYPE C.F.H.S.A., Cone Test and NQ Coring	COMPILED BY FP/DH
DATUM Geodetic	DATE August 26, December 05 and 06, 2001	CHECKED BY [signature]

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.65	Ground Surface						
	Cobbles and boulders				163		
	Coarse Very Dense	17	SS	50/10cm	162		
	Cobbles and boulders trace silt				161 160		
		18	SS	51	159	20	0 98 2 0
	Cobbles and boulders				158 157		
156.15 37.50	Schist Bedrock Fractured	19	SS	20/0cm**	156		
		20	RC NQ	REC 38%			RQD = 0%
		21	RC NQ	REC 47%	155 154		RQD = 0%
153.40 40.25	Granite Bedrock Fractured	22	RC NQ	REC 87%	153		RQD = 0%
		23	RC NQ	REC 40%	152 151		RQD = 0%
		24	RC NQ	REC 40%	150		RQD = 0%
149.45 44.20	End of borehole Cont'd						

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

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

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

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No ST1N-15

METRIC

G.W.P. 293-97-00 LOCATION Co-ords. 5 029 347.4 N; 260 800.7 E. ORIGINATED BY FP

DIST 52 HWY 69 BOREHOLE TYPE C.F.H.S.A., Cone Test and NQ Coring COMPILED BY FP/DH

DATUM Geodetic DATE August 26, December 05 and 06, 2001 CHECKED BY CH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE; 20 40 60 80 100	PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
193.65	Ground Surface										
	Drill water added from 4.55m to equalize groundwater pressure										
	* 2001 08 26										
	∇ Water level observed during drilling										
	*** Low 'N' value due to hydraulic disturbance.										
	** Refusal to spoon										

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

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

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Ontario

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RECORD OF BOREHOLE No ST1N-16

METRIC

G.W.P. 293-97-00
LOCATION Co-ords. 5 029 382.6 N; 260 792.1 E.
ORIGINATED BY FP

DIST 52 HWY 69
BOREHOLE TYPE Continuous Flight Hollow Stem Augers and NQ Coring
COMPILED BY CN

DATUM Geodetic
DATE January 05, 2002
CHECKED BY

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.70	Ground Level					
0.00	Mixed sandy silt, topsoil Very loose Wet Black/Brown (Fill)	1	SS	3		
193.80 / 0.90	Sand trace silt, trace clay Very Loose Brown Wet	2	SS	3		0 96 3 1
193.15 / 1.55	Silty sand, trace clay Very Loose Brown Wet to Compact	3	SS	2		0 58 38 4
		4	SS	18		
191.60 / 3.10	Fine sand trace silt Loose Brown Wet	5	SS	8		
		6	SS	7		
	Very Loose Grey	7	SS	3		0 92 8 0
		8	SS	50/10cm		
187.10 / 7.60	Granitic Gneiss Sound Bedrock	9	RC NQ	REC 94%		RQD=89%
		10	RC NQ	REC 100%		RQD=62%
184.05 / 10.65	End of borehole					

* 2002 01 05
Borehole charged with drillwater.
Groundwater level not established

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (194, 193, 192, 191, 190, 189, 188, 187, 186, 185); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE, 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

$+^7, \times^5$: Numbers refer to Sensitivity
20 / 15 – 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

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RECORD OF BOREHOLE No ST1N-16A

METRIC

G.W.P.	293-97-00	LOCATION	Co-ords. 5 029 387.5 N; 260 796.0 E.	ORIGINATED BY	FP
DIST 52	HWY 69	BOREHOLE TYPE	Continuous Flight Hollow Stem Augers	COMPILED BY	CN
DATUM	Geodetic	DATE	January 06, 2002	CHECKED BY	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.85	Ground Level										
0.00	Unsampled						194				
							193				
191.95 2.90	End of borehole Refusal on probable bedrock * Groundwater level not established						192				

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

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

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No ST1N-16B

METRIC

G.W.P. 293-97-00 LOCATION Co-ords. 5 029 385.1 N; 260 786.3 E. ORIGINATED BY FP

DIST 52 HWY 69 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY CN

DATUM Geodetic DATE January 06, 2002 CHECKED BY

SOIL PROFILE		SAMPLES									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: 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
194.90	Ground Level										
0.00	Unsampled						194				
							193				
							192				
							191				
190.50 4.40	End of borehole Refusal on probable bedrock * Groundwater level not established										

ON_MOT VER3 ST1.GPJ ON_MOT.GDT 01/24/2002 2:06:32 PM

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

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

Ministry of Transportation
Ontario

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RECORD OF BOREHOLE No ST1N-17

METRIC

G.W.P. 293-97-00 LOCATION Co-ords. 5 029 399.6 N; 260 782.6 E. ORIGINATED BY FP

DIST 52 HWY 69 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY CN

DATUM Geodetic DATE January 05, 2002 CHECKED BY

SOIL PROFILE		SAMPLES									
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X 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
197.15 / 0.00	Ground Level					*					
	End of borehole Refusal on bedrock * Groundwater level not established										

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

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

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No ST1N-17A

METRIC

G.W.P. 293-97-00 | LOCATION Co-ords. 5 029 394.6 N; 260 789.3 E. | ORIGINATED BY FP

DIST 52 HWY 69 | BOREHOLE TYPE Continuous Flight Hollow Stem Augers | COMPILED BY FP/DH

DATUM Geodetic | DATE August 25, 2001 | CHECKED BY [signature]

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X 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
196.45	Ground Surface					*					
0.00	Silty sand, rootlets Loose Brown Damp		1	SS	2		196				
195.55 0.90	End of borehole Refusal on probable bedrock										
	* Borehole dry on completion										

ON_MOT VER3 NB_102A.GPJ ON_MOT.GDT 01/24/2002 2:32:54 PM

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

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

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No 102-4M

METRIC

G.W.P. 293-97-00 LOCATION Co-ords. 5 029 378.4 N; 260 776.1 E. ORIGINATED BY FP

DIST 52 HWY 69 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY FP/DH

DATUM Geodetic DATE August 25, 2001 CHECKED BY [signature]

ELEV / DEPTH	SOIL PROFILE: 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
195.50	Ground Surface					*					
0.00	Silty sand, rootlets Loose Brown Damp		1	SS	4		195				
							194				
			2	SS	8						
							193				
192.45 3.05	Fine to medium sand Compact Brown Wet		3	SS	29						
192.10 3.40	End of borehole Refusal on probable bedrock										

* Borehole dry on completion

ON_MOT VER3 NB_102A.GPJ ON_MOT.GDT 12/04/2002 7:56:33 AM

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

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

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No 102-4N

METRIC

G.W.P. 293-97-00
LOCATION Co-ords. 5 029 370.2 N; 260 794.6 E.
ORIGINATED BY FP

DIST 52 HWY 69
BOREHOLE TYPE Continuous Flight Hollow Stem Augers
COMPILED BY FP/DH

DATUM Geodetic
DATE August 25, 2001
CHECKED BY Cy

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS
193.35	Ground Surface				
0.00	Topsoil	1	SS	1	
192.80 / 0.55	Silty sand trace clay Interbedded sand seams Loose Grey Wet				∇* (approx. 192.2)
		2	SS	9	
190.30 / 3.05	Fine to medium sand Loose Grey Wet	3	SS	3***	
		4	SS	0/45cm***	
		5	SS	7	
	Trace silt Compact	6	SS	10	
		7	SS	16	
		8	SS	19	
182.10 / 11.25	End of borehole				

Elevation scale: 193, 192, 191, 190, 189, 188, 187, 186, 185, 184, 183

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

End of borehole

Drill water added from 4.55m to equalize groundwater pressure

* 2001 08 25

∇ Water level observed during drilling

*** Low 'N' value due to hydraulic disturbance

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

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

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No 102-5N

METRIC

G.W.P. 293-97-00 LOCATION Co-ords. 5 029 390.6 N; 260 823.5 E. ORIGINATED BY FP

DIST 52 HWY 69 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY FP/DH

DATUM Geodetic DATE August 24 and 25, 2001 CHECKED BY

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%)
193.70	Ground Surface					
0.00	Topsoil					
0.20	Silty sand, Loose, Brown, Damp	1	SS	2	∇*	
192.20 / 1.50	Fine to medium sand trace silt, Compact, Brown, Wet	2	SS	14		
	Loose	3	SS	3***		
		4	SS	6		
		5	SS	4		
		6	SS	4		
	Trace gravel, Compact	7	SS	20		*2001 08 24
		8	SS	16		∇ Water level observed during drilling. At 4.55m, 0.60m sand heave
		9	SS	5***		Drill water added from 4.55m to equalize groundwater pressure. Borehole continued from 5.20 m on August 25, 2001. *** Low 'N' value due to hydraulic disturbance.
	Compact	10	SS	27		
179.40 / 14.30	End of borehole					

Elevation scale: 193, 192, 191, 190, 189, 188, 187, 186, 185, 184, 183, 182, 181, 180

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

GR SA SI CL

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

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

Ministry of Transportation
Ontario

Foundation Design

RECORD OF PENETRATION TEST No 102-4N

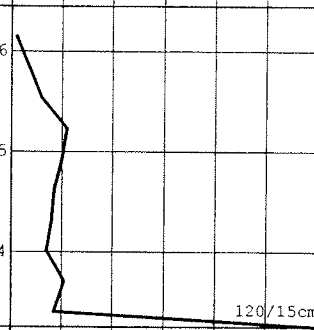
 METRIC

G.W.P. 293-97-00 LOCATION Co-ords. 5 029 410.6 N; 260 812.6 E ORIGINATED BY FP

DIST 52 HWY 69 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY FP/DH

DATUM Geodetic DATE August 25, 2001 CHECKED BY

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER (SAMPLES)	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
196.45 / 0.00	Ground Surface						196 / 195 / 194	120/15cm			
193.25 / 3.20	End of dynamic cone penetration test Refusal on probable bedrock										



MOT DCPT NB_102PT.GPJ ON_MOT.GDT 12/04/2002 7:47:34 AM

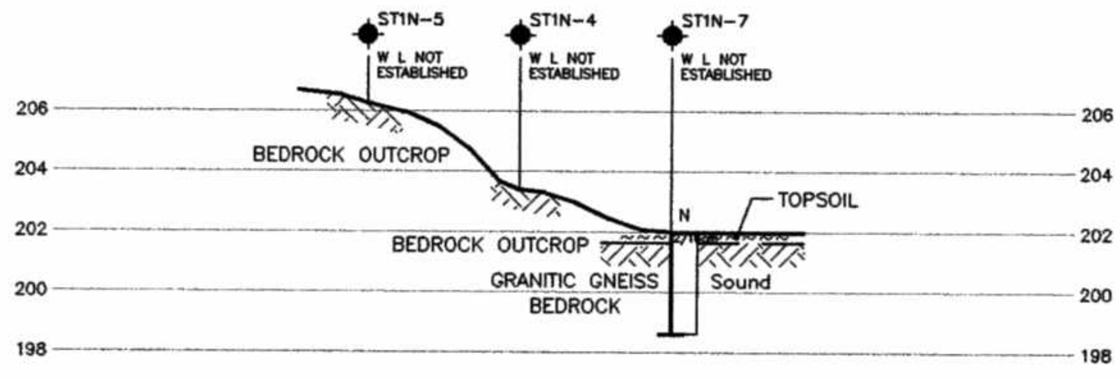
$+^7$, $\times^5$: Numbers refer to Sensitivity

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

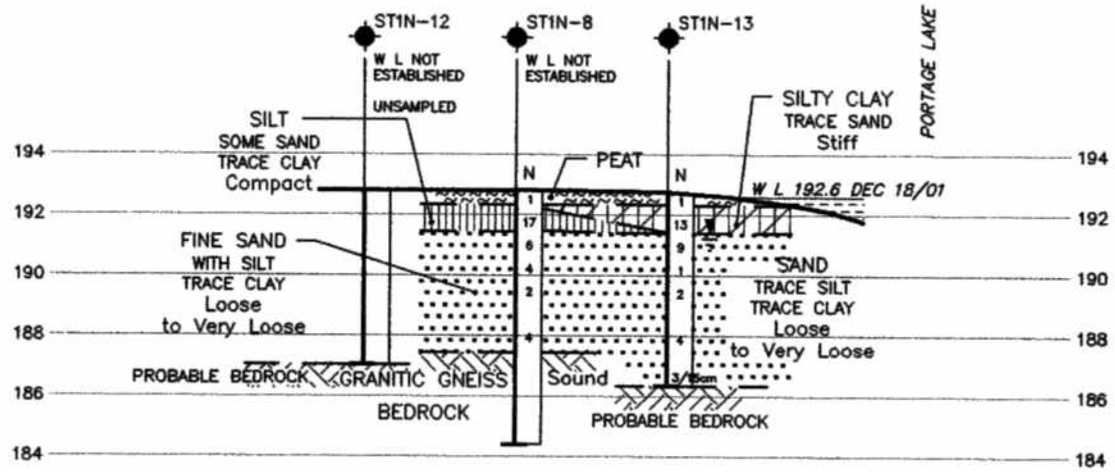
(Legend Continued)

BH No	ELEVATION	CO-ORDINATES NORTH	EAST
ST1N-16A	194.85	5 029 387.5	260 796.0
ST1N-16B	194.90	5 029 385.1	260 786.3
ST1N-17	197.15	5 029 399.6	260 782.6
ST1N-17A	196.45	5 029 394.6	260 789.3
102-4M	195.50	5 029 378.4	260 776.1
102-4N	193.35	5 029 370.2	260 794.6
102-5N	193.70	5 029 390.6	260 823.5

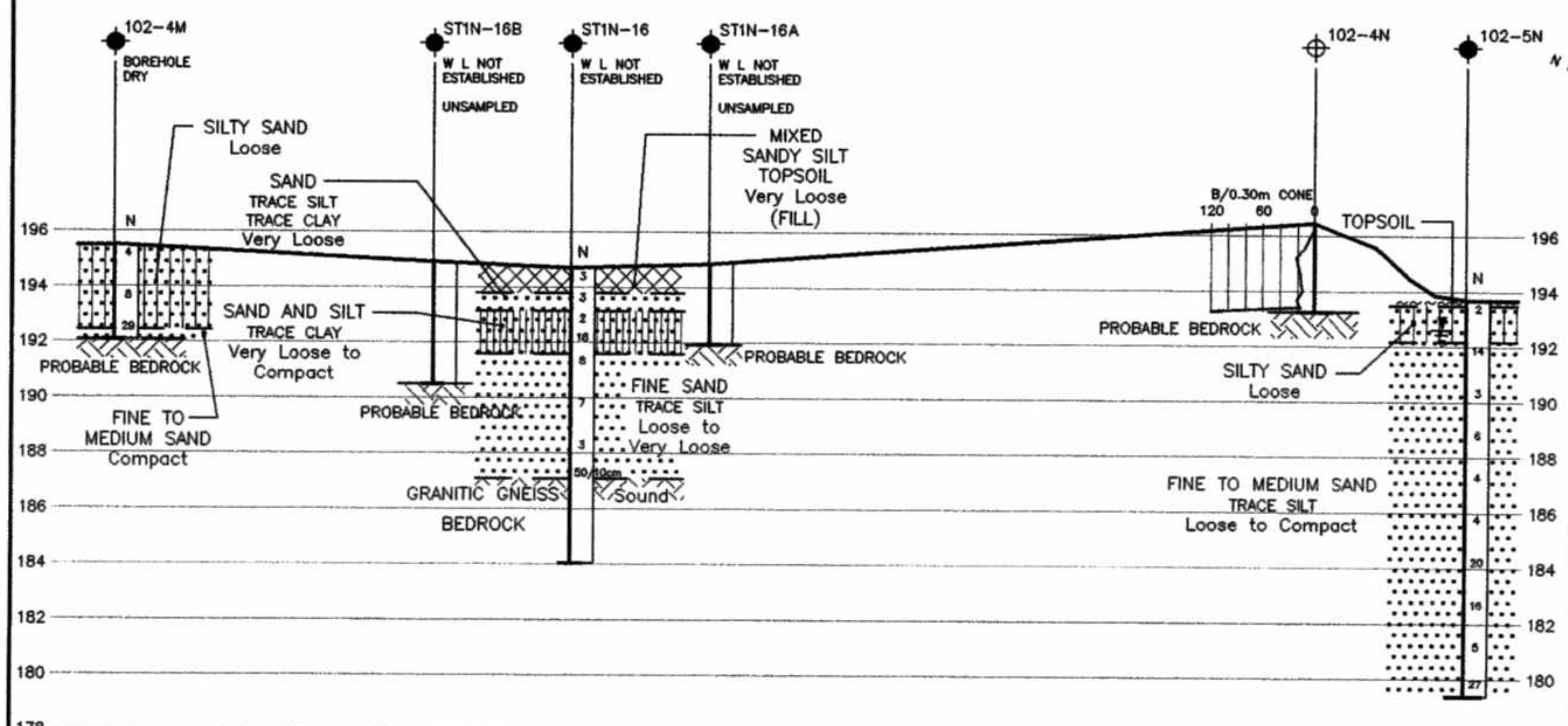
PT No	ELEVATION	CO-ORDINATES NORTH	EAST
102-4N	196.45	5 029 410.6	260 812.6



A–A



B–B



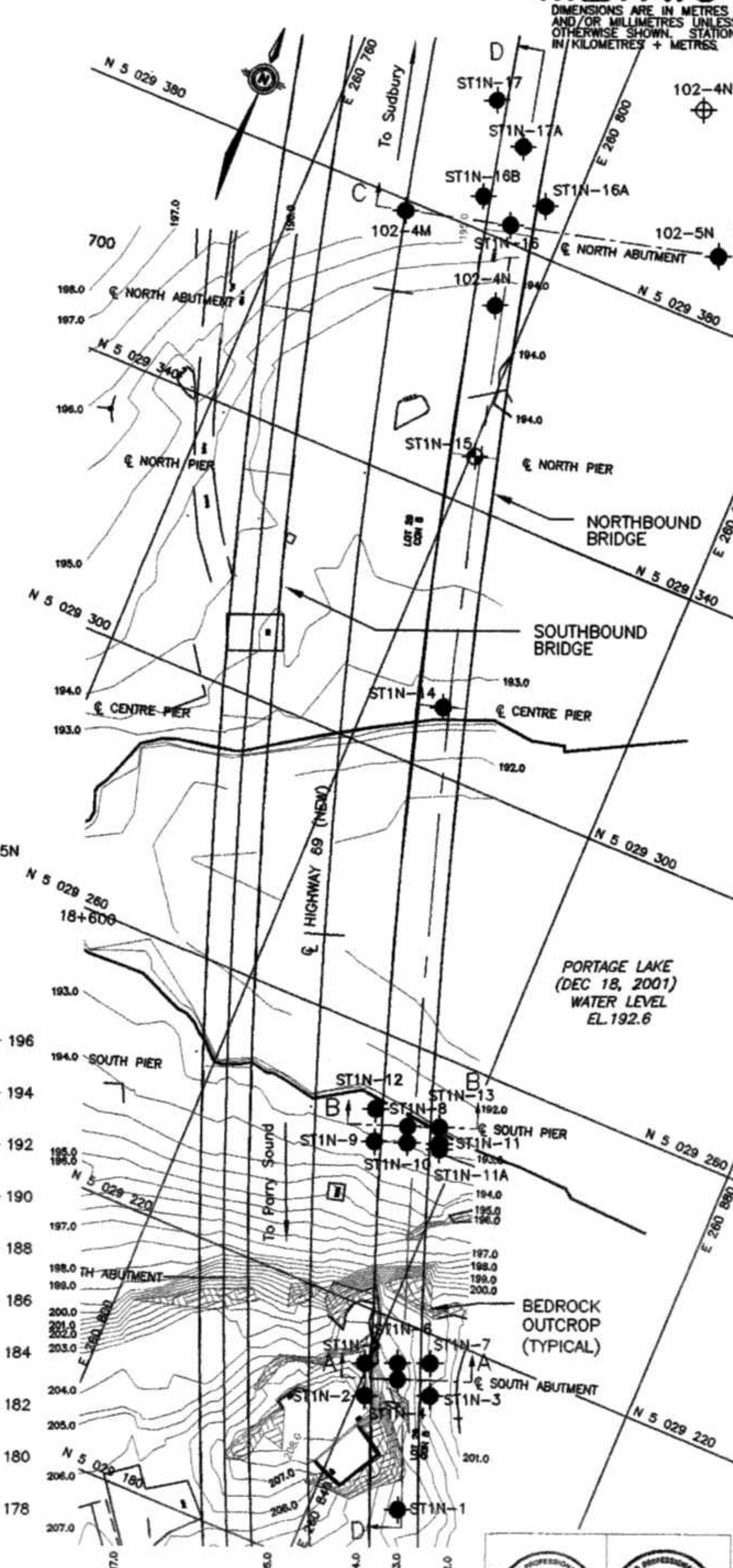
C–C

NOTES:

1. SECTIONS ARE PROVIDED SOLELY FOR ILLUSTRATIVE PURPOSES. REFER TO RECORD OF BOREHOLE AND RECORD OF PENETRATION TEST FOR DETAILED DESCRIPTION OF SUBSURFACE CONDITIONS, IN-SITU TEST DATA AND LABORATORY TEST RESULTS.
2. REFER TO DRAWING ST1N-2 FOR SECTION D-D.

SECTIONS
SCALE
2.5 0 2.5 5m

REF No E-01-020 Base; H4545xa1.dwg; H4545xn1.dwg; H4545xB2.dwg; March, 2001
E04520069002.dwg; September, 2001
McCormick Rankin Corporation preliminary site plan dated January 11, 2002
PROFILE.dwg; July, 2002



PLAN
SCALE
10 5 0 10 20m

METRIC

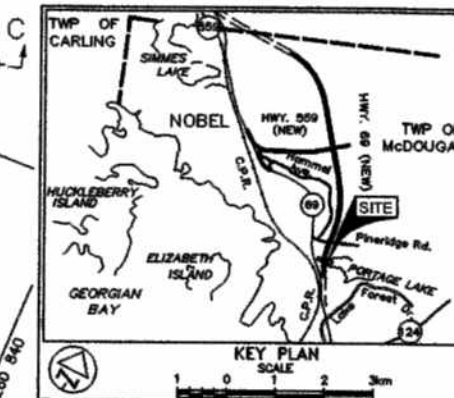
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No: 2006-5156
GWP No 293-97-00

HIGHWAY 69 FOUR-LANING
(2.6 km North of Hwy 124, Northerly 4.8 km)
PORTAGE LAKE NORTHBOUND BRIDGE
BOREHOLE LOCATIONS & SOIL STRATA

SHEET 152

Peto MacCallum Ltd.
CONSULTING ENGINEERS



KEY PLAN
SCALE
1 0 1 2 3km

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 Dec. 2001 and Jan. 2002
- Head
- ARTESIAN WATER Encountered

BH No	ELEVATION	CO-ORDINATES NORTH	EAST
ST1N-1	203.05	5 029 193.2	260 852.9
ST1N-2	208.35	5 029 207.3	260 841.4
ST1N-3	201.90	5 029 211.2	260 850.6
ST1N-4	203.40	5 029 211.6	260 845.0
ST1N-5	206.25	5 029 212.0	260 839.5
ST1N-6	203.40	5 029 213.9	260 844.1
ST1N-7	202.00	5 029 215.8	260 848.7
ST1N-8	192.80	5 029 248.1	260 831.3
ST1N-9	193.20	5 029 244.0	260 827.5
ST1N-10	192.95	5 029 245.7	260 832.2
ST1N-11	192.90	5 029 247.5	260 836.9
ST1N-11A	192.90	5 029 246.7	260 837.2
ST1N-12	192.80	5 029 246.7	260 825.8
ST1N-13	192.75	5 029 249.8	260 835.9
ST1N-14	192.65	5 029 309.9	260 811.2
ST1N-15	193.65	5 029 347.4	260 800.7
ST1N-16	194.70	5 029 382.6	260 792.1

(Legend Continues)

– NOTE –

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

C M P Rennick
B. R. GRAY

REVISIONS

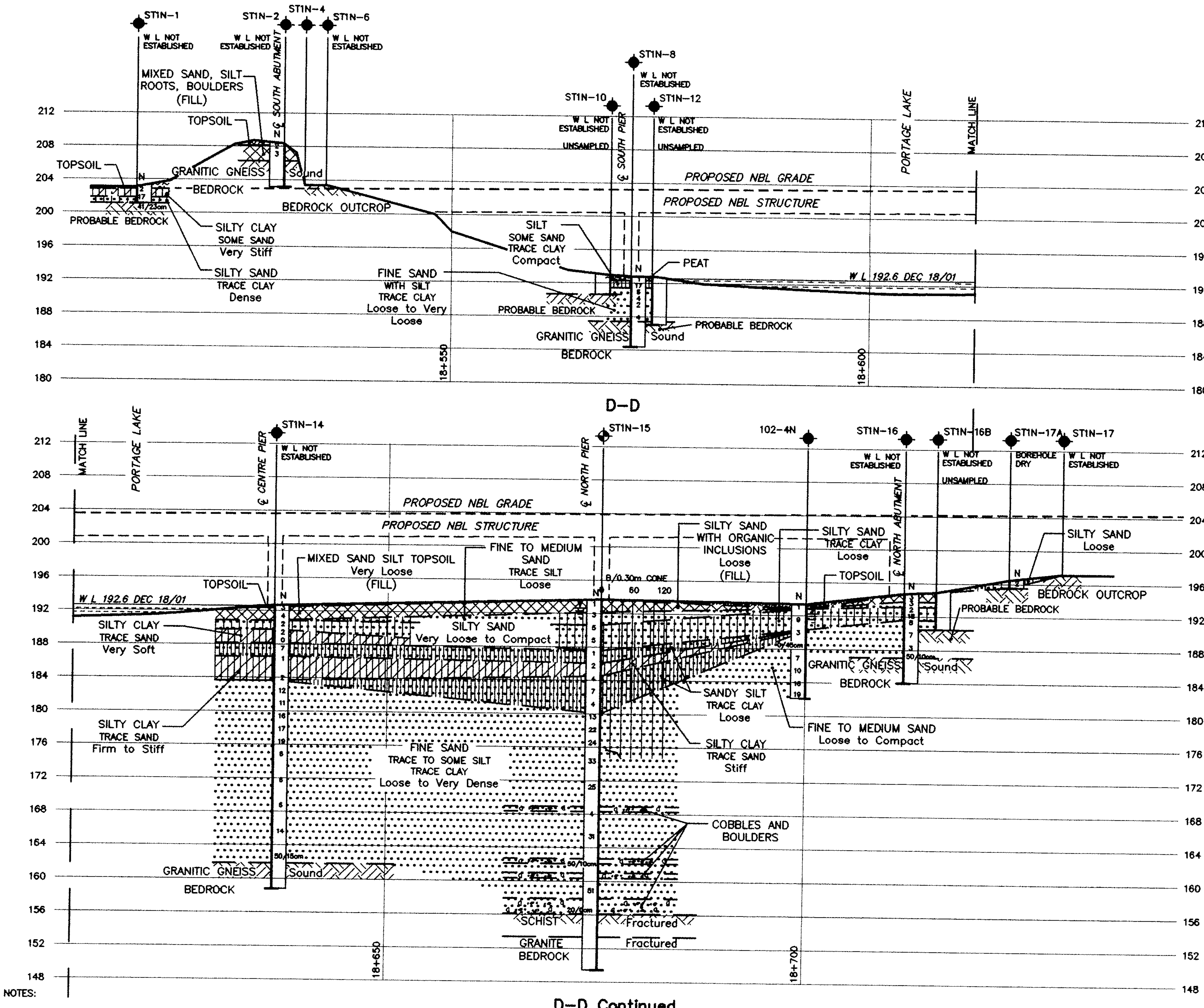
DATE	BY	DESCRIPTION
19/04/06	CN	Contract No. Added

Geocres No. 41H-42

HWY No 69			DIST 52
SUBM'D CN	CHECKED CN	DATE NOV 30, 2002	SITE 44-404N
DRAWN MM	CHECKED CN	APPROVED BRG	DWG ST1N-1

METRIC

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



NOTES:

1. SECTIONS ARE PROVIDED SOLELY FOR ILLUSTRATIVE PURPOSES. REFER TO RECORD OF BOREHOLE AND RECORD OF PENETRATION TEST FOR DETAILED DESCRIPTION OF SUBSURFACE CONDITIONS, IN-SITU TEST DATA AND LABORATORY TEST RESULTS.
2. REFER TO DRAWING ST1N-1 FOR PLAN AND SECTIONS A-A, B-B AND C-C.

SECTION
SCALE
5 0 5 10m

REF No E-01-020 Base; H4545xa1.dwg; H4545xn1.dwg; H4545xB2.dwg; March, 2001
E04520069002.dwg; September, 2001
McCormick Rankin Corporation preliminary site plan dated January 11, 2002
PROFILE.dwg; July, 2002

CONT No 2006-5156 GWP No 293-97-00	
HIGHWAY 69 FOUR-LANING (2.6 km North of Hwy 124, Northerly 4.8 km) PORTAGE LAKE NORTHBOUND BRIDGE BOREHOLE LOCATIONS & SOIL STRATA	SHEET 153

Peto MacCallum Ltd.
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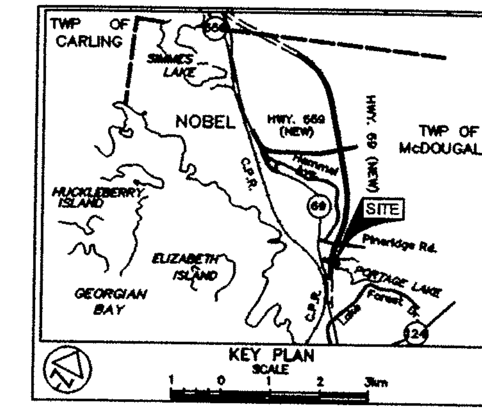

LEGEND

- 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 Dec. 2001 and Jan. 2002
- Head
- ARTESIAN WATER Encountered

BH No	ELEVATION	CO-ORDINATES NORTH	EAST
Refer to drawing ST1N-1 for coordinates			

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

REVISIONS		
19/04/06	CN	Contract No. Added
DATE	BY	DESCRIPTION

Geocres No. 41H-42

HWY No 69			DIST 52
SUBM'D CN	CHECKED CN	DATE NOV 30, 2002	SITE 44-404N
DRAWN MM	CHECKED CN	APPROVED BRG	DWG ST1N-2

B. R. GRAY

APPENDIX A

PLATES 1 TO 8

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PML Ref: 01TF012AN

PORTAGE LAKE NORTHBOUND STRUCTURE
W.P. 349-00-01, SITE 44-404N
G.W.P. 293-97-00

Plate No. 1:

South abutment

Looking south (right photograph) and southeast (bottom photograph) at location of borehole ST1N-2. Painted staked in foreground in location of borehole ST1N-4. Note difference of elevation of about 5 m between borehole locations. Note visible bedrock outcrop and rock fill.

PORTAGE LAKE NORTHBOUND STRUCTURE
W.P. 349-00-01, SITE 44-404N
G.W.P. 293-97-00

Plate No. 2: South Pier. Looking north across Portage Lake. Note proximity of pier to edge of lake. Stake marks location of centre of pier, where borehole ST1N-8 was drilled.

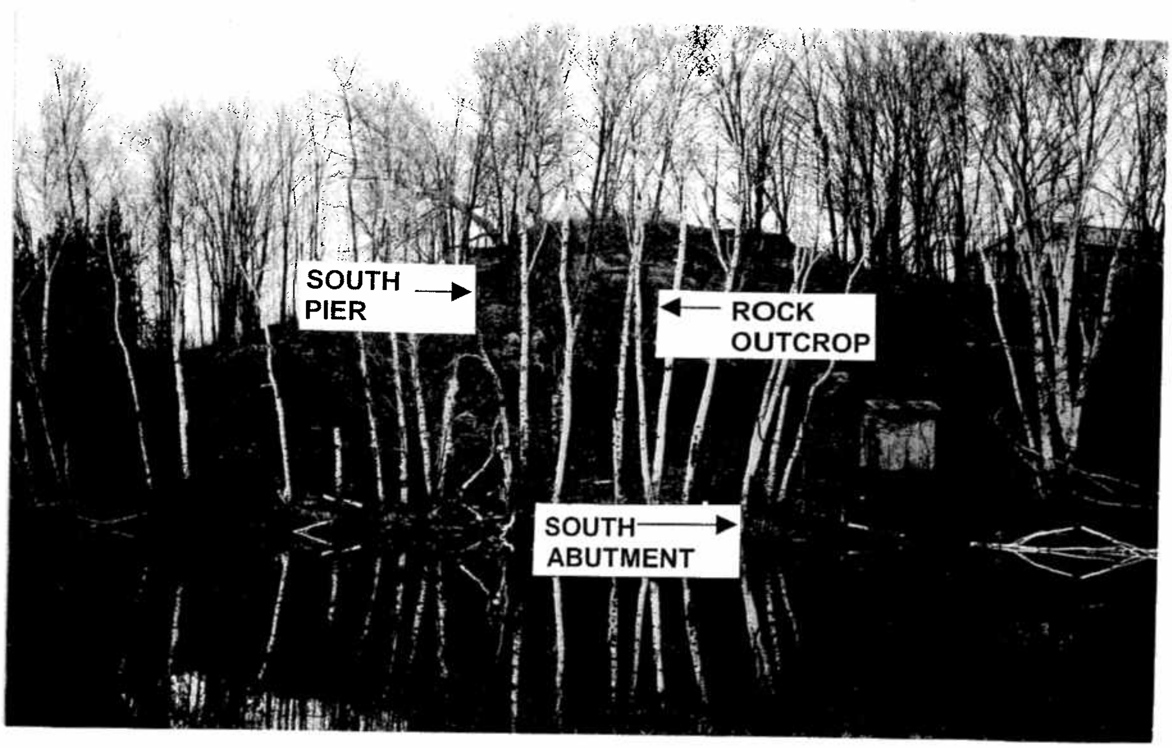

Plate No. 3: Looking southerly at south pier (stake at margin of lake) and south abutment (stake on east side of rock outcrop). Elevation difference is 10.6 m.

PORTAGE LAKE NORTHBOUND STRUCTURE
W.P. 349-00-01, SITE 44-404N
G.W.P. 293-97-00

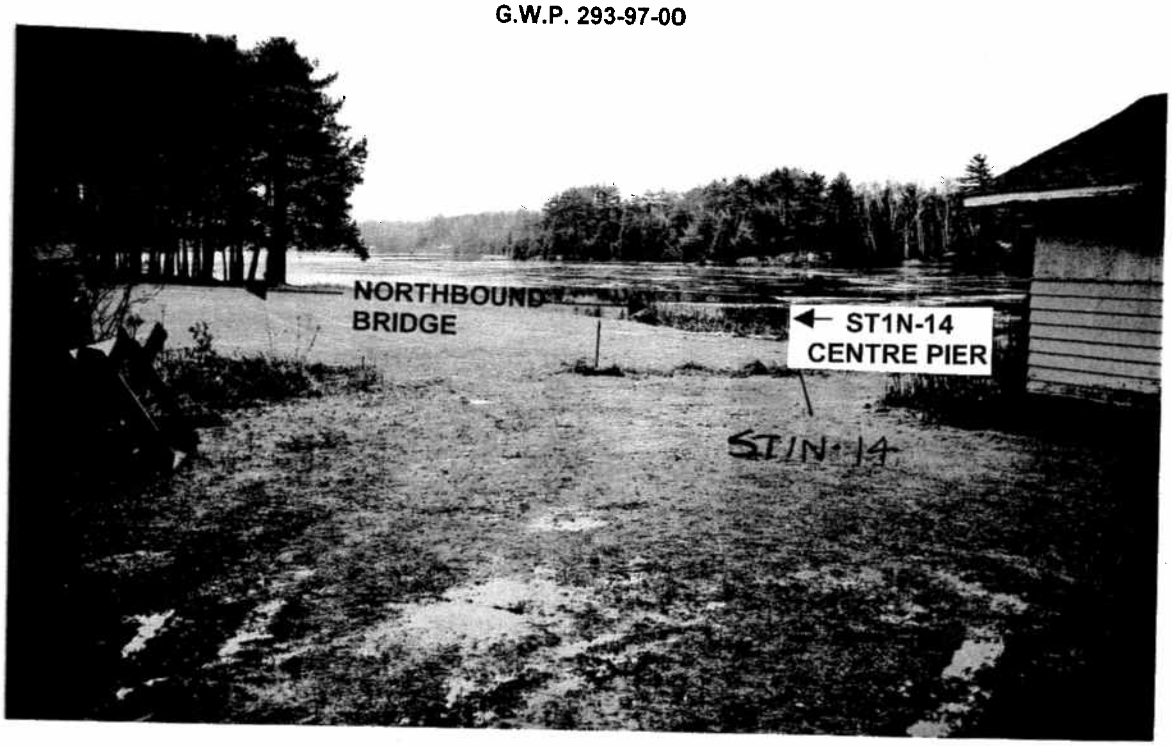

Plate No. 4: Looking southerly at centre pier location. Note location is in low lying area near north margin of Portage Lake. Stake marks centre of pier and borehole ST1N-14.

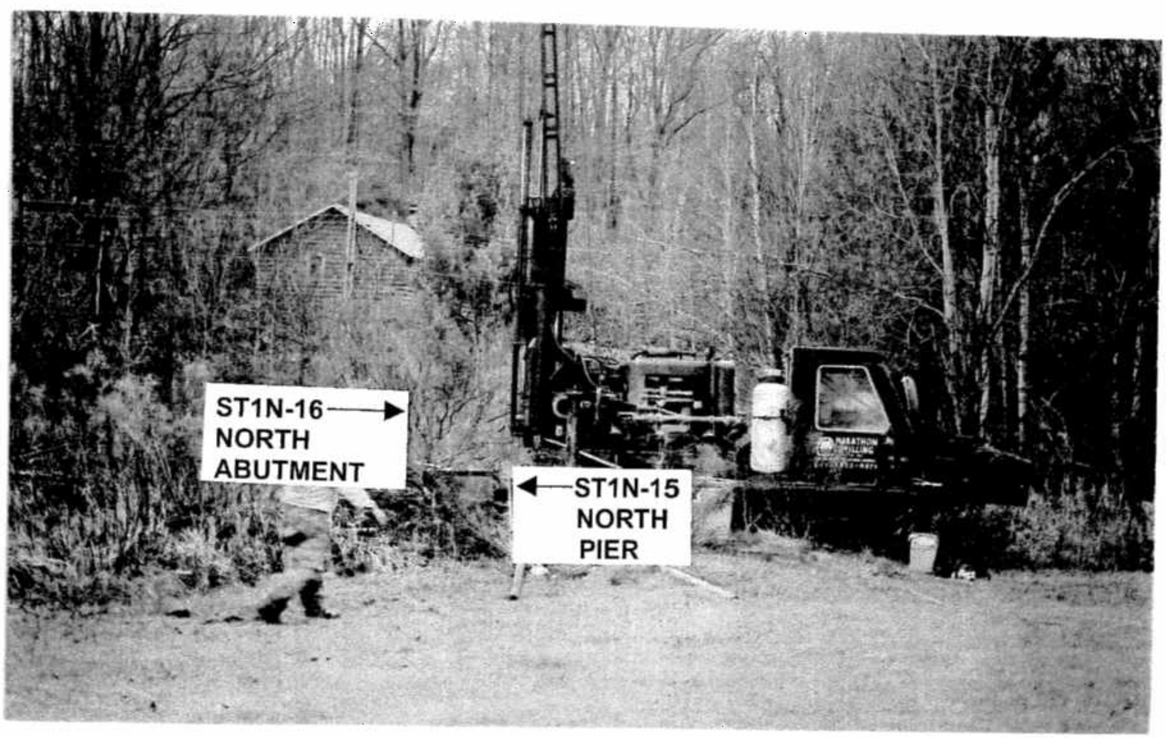

Plate No. 5: Looking northerly at location of <u>North Pier</u>. Borehole ST1N-15 being drilled at centre of pier. Hydro pole in front of cottage in background is due west of North Abutment.

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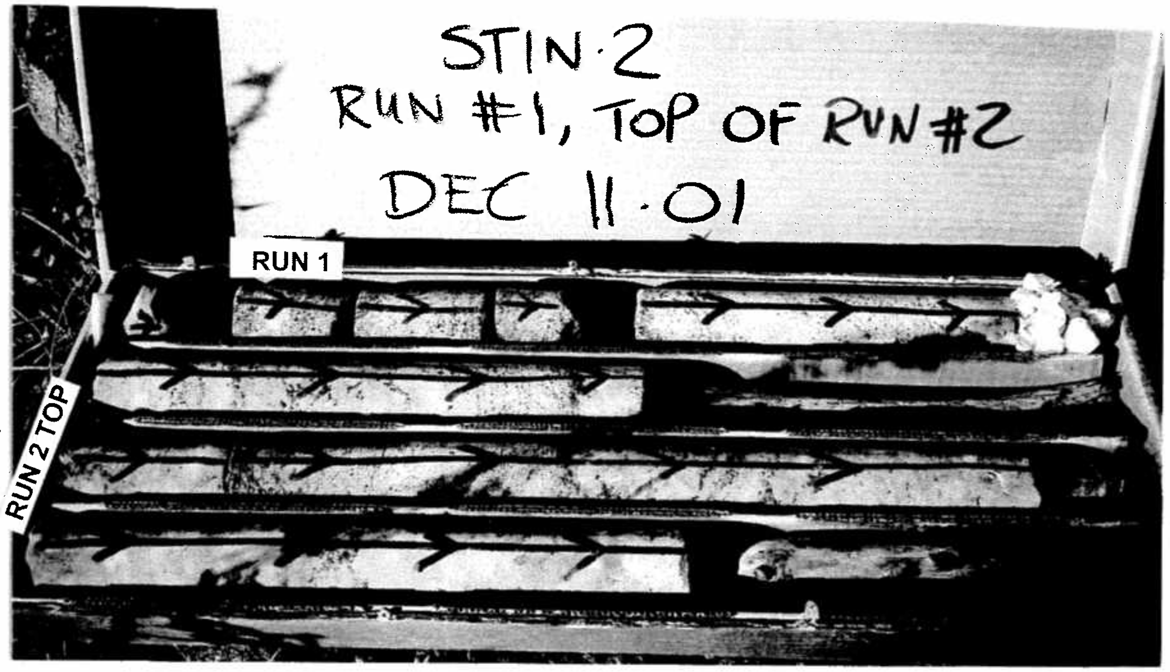
PML Ref: 01TF012AN

PORTAGE LAKE NORTHBOUND STRUCTURE
W.P. 349-00-01, SITE 44-404N
G.W.P. 293-97-00



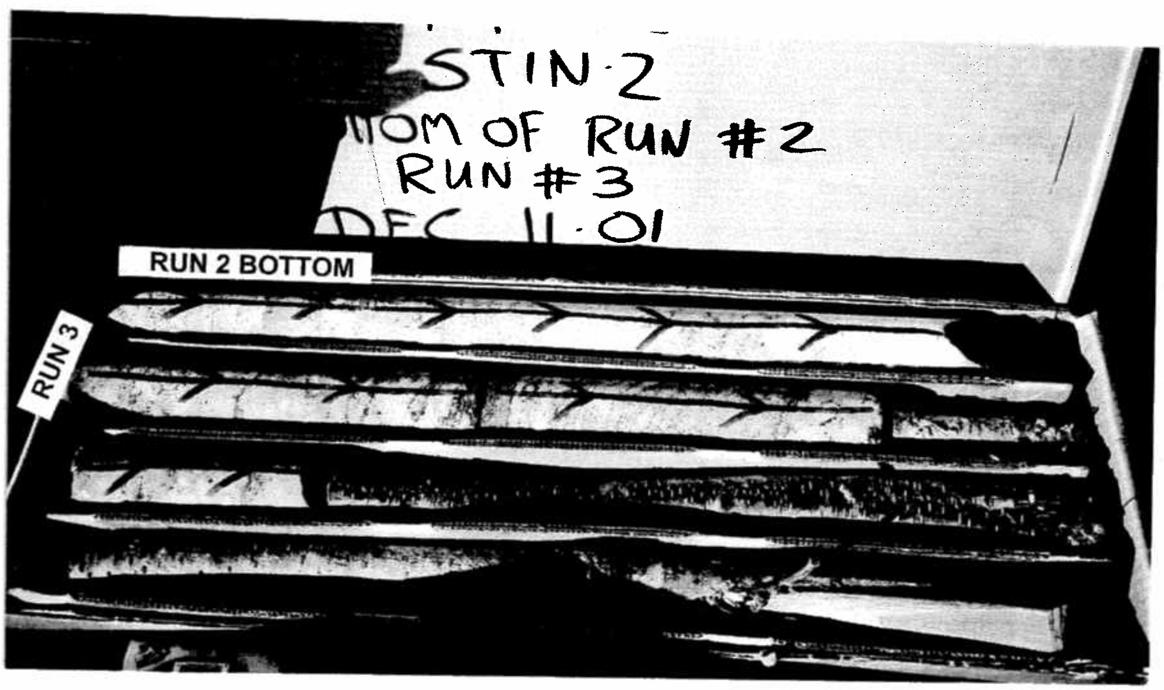


Plate No. 6: Core from granitic gneiss taken from borehole ST1N-2 drilled at southwestern corner of south abutment.

Run No.	Core No.	Recovery (%)	RQD (%)
1	3	92	58
2	4	100	90
3	5	100	100

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CONSULTING ENGINEERS

PML Ref: 01TF012AN

PORTAGE LAKE NORTHBOUND STRUCTURE
W.P. 349-00-01, SITE 44-404N
G.W.P. 293-97-00

Plate No. 7: Core from granitic gneiss taken from borehole ST1N-14 drilled at centre pier location.

Run No.	Core No.	Recovery (%)	RQD (%)
1	19	100	71
2	20	100	58
3	21	100	44

PORTAGE LAKE NORTHBOUND STRUCTURE
W.P. 349-00-01, SITE 44-404N
G.W.P. 293-97-00

Plate No. 8: Core from Schist and granite bedrock taken from borehole ST1N-15 drilled at the location of the north pier.

Run No.	Core No.	Rock Type	Recovery (%)	RQD (%)
1	20	Schist	38	0
2	21	Schist	47	0
3	22	Schist/Granite	87	0
4	23	Granite	40	0
5	24	Granite	40	0

Peto MacCallum Ltd.
C O N S U L T I N G   E N G I N E E R S

FOUNDATION DESIGN REPORT
FOR
PORTAGE LAKE NORTHBOUND BRIDGE
W.P. 349-00-01, SITE 44-404N
G.W.P. 293-97-00
HIGHWAY 69, DISTRICT 52
NOBEL, ONTARIO

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Job No.: 01TF012AN
Geocres No. 41H-42

November 2002

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BARRIE, BRAMPTON, HAMILTON, KITCHENER, TORONTO

TABLE OF CONTENTS

LIST OF ENCLOSURES:

FOUNDATION DESIGN REPORT
For
Portage Lake Northbound Bridge
W.P. 349-00-01, Site 44-404N
G.W.P. 293-97-00
Highway 69, District 52
Nobel, Ontario

1. INTRODUCTION

This report provides geotechnical comments and recommendations regarding design and construction of foundations, abutments and approach embankments for the proposed Highway 69 northbound bridge at Portage Lake in Parry Sound (Nobel), Ontario. The investigation was conducted for McCormick Rankin Corporation (MRC) on behalf of the Ministry of Transportation of Ontario (MTO).

Construction of a two-lane four-span bridge with a total length of about 178 m is planned (Drawing No. 1 dated March 2002 titled 'Hwy 69 – Portage Lake Crossing – NBL, prepared by MRC. The road grade on the bridge shown on the drawing ranges from about 203.0 (south abutment) to 203.9 (north abutment).

Existing grade along the alignment of most of the bridge typically ranges from elevation 192.7 to 193.7. At the south abutment, it ranges from elevation 201.9 to 208.3 and is about elevation 194.7 at the north abutment. The water level in the lake measured on December 18, 2001 was at elevation 192.6.

The subsurface stratigraphy revealed in testholes drilled along the alignment of the bridge typically comprised relatively thin discontinuous fill units with organic materials overlying a major deposit of loose to compact cohesionless sands and silts locally interbedded with firm cohesive silty clay soils that mantle bedrock. Bedrock outcrops at the south abutment and about 20 m north of the north abutment. Boulders were observed on the ground surface near the south abutment. Cobbles/boulders were also identified at depth within the sand deposit at the north pier.

The bedrock surface dips down towards Portage Lake from the north and south abutments.

The depth and elevation of the soil/bedrock interface within the approach embankments 20 m beyond the abutments, as well as at the abutment and pier locations confirmed/inferred during the foundation investigation are summarized in the following table:

Location	Depth to Bedrock (m)		Bedrock Elevation		Relevant boreholes
	Minimum	Maximum	Lowest	Highest	
South Approach	1.95	1.95	201.10	201.10	ST1N-1
South Abutment	0.00	2.10	201.45	206.25	ST1N-2 to 7
South Pier	2.30	6.40	186.35	190.65	ST1N-8 to 13 and 11A
Centre Pier	30.80	30.80	161.85	161.85	ST1N-14
North Pier	37.50	37.50	156.15	156.15	ST1N-15
North Abutment	2.90	7.60	187.15	191.80	ST1N-16, 16A, 16B
North Approach	0.00	0.00	197.15	197.15	ST1N-17

Design of the south pier and north abutment foundations will require special consideration due to variations in the surface elevation of the rock, the slope of the bedrock surface, the presence of sandy soil and the high groundwater level.

The approach embankment at the north end of the bridge will be about 9.2 m high. An approximate 7.6 m thick very loose to loose silty sand/sand deposit was identified at and in front of the abutment. Due to settlement and bearing capacity concerns, this material should be excavated to about 1.5 m depth, elevation 192 and replaced with rock fill or compacted granular fill for the construction of the embankment recommended in Section 2.2 of this report. Some 200 to 300 mm of settlement of the north approach embankment fill and the remaining native soil is likely to occur. The settlement of the embankment fill and native soils is expected to occur during construction of the embankment as recommended.

Excavation for construction of the south and centre pier foundations may require excavation below the lake water level and hence extensive groundwater control measures.

2. FOUNDATIONS

It is considered that construction of integral abutments supported on steel 'H' piles is not feasible at this site due to the length of the bridge and the shallow depth to bedrock at the south abutment.

Use of spread footings founded on bedrock to support the south abutment is recommended. The north and centre piers should be supported on driven piles extended to refusal on bedrock.

The south pier and north abutment could be supported on spread footings founded on bedrock, piles driven to bedrock or caissons founded into rock. Construction of spread footings founded on bedrock will be difficult due to the presence of sandy soils at these locations, the high water level and the wide variation in the surface elevation of the bedrock. Similarly, installation of piles will be difficult due to the sloping bedrock surface, the wide variation in depth to bedrock and difficulty 'setting' batter piles on the sloping bedrock to resist the lateral forces. Therefore, caissons embedded into rock is the preferred means of supporting the south pier and north abutment. We understand the current design location of the south pier is 1.5 m south of that shown on the MRC drawings referred to previously.

Further comments and recommendations for design of the foundations are provided in the following sections.

2.1 Spread Footings

The design founding elevation of the south abutment deduced MRC Drawing 1, referred to previously, is near elevation 198.50. The surface level of the bedrock identified in boreholes ST1N-2 to 7 ranged between elevation 201.45 on the east side to 206.25 on the west side of the abutment. It is considered therefore that the south abutment can be supported on conventional spread footings founded on bedrock.

Excavation of some 3 to 8 m of rock at the south abutment will be required to construct the foundations. Refer to Section 5 for further comments in this regard.

The bedrock surface level at the south pier ranges from elevations 186.35 to 190.65 some 2.3 to 6.4 m below existing grade. The rock surface elevation is reasonably consistent (elevations 187 to 188) in five of the seven holes drilled at the south pier. It is about 1 m lower in the northeast corner and appears to dip at an inclination of about 45° along the centre axis where an approximate 3 m high rock knob was identified at the centre of the south side of the pier location. Use of a spread footing founded on bedrock could also be considered for the south pier, however construction of the footing will be very difficult since:

- the bedrock surface elevation is some 6 m below the lake water level at the time of the investigation
- the material above the bedrock consists of a relatively pervious very loose to loose sand deposit
- groundwater control will be very difficult due to the irregular bedrock surface elevation, the high water level and the presence of sandy soils
- removal of a large bedrock knob in the south part of the footing will be required.

Footings bearing on sound bedrock at or below the design founding elevation may be designed using a factored bearing resistance of 10,000 kPa at the ultimate limit state (ULS).

The resistance at serviceability limit states normally allows for 25 mm of compression of the founding medium. Considering the bedrock to be non-yielding, the design is not expected to be governed by settlement since the loading required to produce deformation will be much larger than the factored resistance at ULS.

The south abutment footing should be founded below a line inclined upwards at 1 : 2 (H : V) from the bottom of the existing rock face or at least 1.0 m below the rock face, whichever is greater.

The horizontal force imposed on the foundations will be resisted in part by the friction force developed between the underside of the footing and the bedrock. An unfactored friction factor of 0.6 is recommended for footings on bedrock. A value of 0.7 may be used for a roughened bedrock surface (asperity height of at least 25 mm) created by mechanical means during rock excavation.

The lateral resistance of footings founded on bedrock could be increased by installing anchors into the bedrock. The increased lateral resistance will be provided by the shear strength of the steel dowels, the horizontal component of tensile forces developed in any inclined anchors, and/or increased frictional resistance between the footing and rock if the anchors are prestressed to increase the vertical pressure. Eliminating the footing and providing overturning resistance using dowels to anchor the abutment stem into rock could also be considered.

A factored rock-grout bond stress of 1.4 MPa at ULS (resistance factor of 0.4 applied, minimum 35 MPa grout) is recommended for design. The anchors should extend a minimum 30 bar diameters into sound bedrock and be spaced a distance of at least four times the diameter of the anchor. The total capacity of a group of closely spaced anchors may be less than the summed capacities of the individual anchors; the impact of anchor interaction should be assessed if the spacing is less than one-fifth of the anchor length.

Footings bearing on sound bedrock should not require protection from frost.

Prior to placement of structural concrete, geotechnical personnel qualified to verify the competency of the founding surface should examine all foundation excavations.

2.2 Piles

The piles for the proposed centre and north pier should be driven to refusal on bedrock anticipated at the depths/elevations indicated in the following table.

LOCATION	DEPTH TO ROCK (m)	BEDROCK ELEVATION*	RELEVANT BOREHOLES
Centre Pier	30.80	161.85	ST1N-14
North Pier	37.50	156.15 **	ST1N-15

Notes:

* The specification should identify the possibility for at least 1.0 m penetration of the piles below rock levels for bidding purposes.

** Very low to low strength highly weathered rock was identified in borehole ST1N-15 drilled at the north pier.

The recommended factored axial resistance at ULS for an HP 310 x 110 pile is 1,600 kN. A reduction factor of 0.80 was applied to account for a potential reduction in resistance due to the locally sloping rock, the potential for damage when driving through the cobbles and boulders identified in borehole ST1N-15 drilled at the north pier, and the poor quality rock identified in borehole ST1N-15. The HP 310 x 79 pile section should not be used since heavier sections are less likely to be damaged by the cobbles and boulders.

The resistance at SLS normally allows for 25 mm of compression of the pile and founding medium. Considering the bedrock to be non-yielding and the pile length required, the design is not expected to be governed by settlement since the loading required to produce appreciable deformation of the pile and/or bedrock is much larger than the ULS factored capacity.

The north approach embankment within the zone where piles will be driven should comprise OPSS Granular 'B' (maximum particle size 150 mm) to minimize the potential for damage during driving. Negative skin friction will not be a concern at the north abutment since the settlements induced by the approach embankment are expected to occur during its construction. Refer to Section 4 for detailed recommendations for embankment construction.

The bedrock surface at the south pier and north abutment locally slopes at an inclination of up to 45° and 42°, respectively. If piles are employed at these locations, they should be equipped with Oslo rock points (OPSD 3304). Piles for the north and centre piers should be provided with driving shoes (OPSD 3301). Titus rock points and driving shoes specified on the MTO Special Provision No. 903 S01 dated February 2001 may also be used as alternatives.

Piles driven to support the foundation loads will range in length from about 5 to over 40 m. The soil cover comprises loose to compact cohesionless sands and silts locally interbedded with firm cohesive clay. Evidence of cobbles/boulders was detected at the north pier (borehole ST1N-15). It is considered, based on our extensive experience with pile driving under similar conditions, that a hammer that transfers at least 40 kJ of energy to the pile should be employed to drive the piles. The rated energy of the hammer should therefore be 50 to 60 kJ, depending on the type of equipment employed. Since the piles will set on rock, a specific set for this project is not provided.

The piles should be installed and monitored in accordance with requirements of MTO Special Provision No. 903 S01 (February 2001). This should involve confirmation of the founding elevation, alignment, plumbness, uniformity of set and quality of splices and should be done on a full time basis by experienced geotechnical personnel.

Pile cap bases should be provided with at least 1.7 m of earth cover or MTO equivalent thermal insulation as protection against frost action. A 25 mm thick layer of polystyrene insulation is thermally equivalent to 600 mm of soil cover.

Resistance to lateral loads may be provided in part by mobilization of passive resistance along the pile. The recommended lateral resistance is:

		HP 310 x 110
Factored Lateral Resistance at ULS	=	130 kN
Lateral Resistance at SLS	=	40 kN

If greater resistance is required, batter piles should be installed.

The coefficient of horizontal subgrade reaction should be computed using the following equation to evaluate the point of contraflexure:

$$k_s = n_h \, z/b$$

where
- n_h = coefficient related to soil density, MN/m^3
- z = depth
- b = pile width (m)

Recommended values for n_h are:

Granular backfill	14,000 kN/m^3
Native sand	1,000 kN/m^3

2.3 Caissons

The south pier and north abutment should be supported on caissons installed into bedrock at the depths/elevations indicated in the following table.

LOCATION	DEPTH TO ROCK (m)	BEDROCK ELEVATION	RELEVANT BOREHOLES
South Pier	2.30 to 6.40	186.35 to 190.65	ST1N-8 to 13 and 11A
North Abutment	2.90 to 7.60	187.15 to 191.80	ST1N-16, 16A and 16B

At the south pier the depth/elevation of the bedrock surface was proven/inferred at depths of 2.30 to 6.40 m, elevation 186.35 to 190.65 respectively. It is relatively level in the west portion of the area investigated. A rock knob was identified in the south central portion of the pier (inclination up to 50° at the centre) and the bedrock surface appears to slope down to the north/northeast (inclination up to 25°) in the east half of the pier footprint.

At the north abutment, the depth/elevation of the bedrock surface was proven/inferred at depths of 2.90 to 7.60 m elevation 187.10 to 191.95. The bedrock surface within the plan area of the foundation appears to slope down from the east and west to the south central area of the foundation at an inclination of about 30 and 38° respectively and about 42° to the south, as noted earlier.

Due to the sloping bedrock surface, it will be necessary to employ special equipment to install the caissons and limit the diameter of the caissons. These measures will enable installation of the caissons with available equipment to be most cost effective.

In addition, the caissons should penetrate at least 2.5 m into bedrock. The need for a greater socket length to resist lateral loads should be assessed. Further comments in this regard are provided in subsequent paragraphs.

The bedrock surface appears to be reasonably level (slope less than 10°) in the west part of the south pier investigated. In this area, the socket length could be reduced a minimum of 1.0 m. The recommended socket length is greater than normal MTO protocol due to the small diameter caissons planned and the undulations in the surface level of the bedrock.

The caissons should be designed using a factored end bearing resistance at ULS of 8,000 kPa and a factored bond stress at ULS of 800 kPa. A reduction factor of 0.80 was applied due to the difficult construction conditions and the sloping bedrock surface.

The full values for shaft adhesion may be employed for caisson designs based on shaft adhesion only (end-bearing ignored) or where the end-bearing resistance exceeds the total shaft resistance. In cases where the total shaft resistance is greater than the end-bearing resistance and the design is based on resistance being developed by both end-bearing and shaft adhesion, the mobilized resistance of the caisson should be limited to two times the end bearing resistance, or the end bearing resistance plus 75% of the computed bond stress, whichever is greater.

Based on these values, the factored axial resistance at ULS for selected caisson diameters socketed into rock are presented below:

CAISSON DIAMETER (m)	FACTORED AXIAL RESISTANCE AT ULS (kN)					
	1 m LONG SOCKET			2.5 m LONG SOCKET		
	End Bearing	Shaft Adhesion	Total	End Bearing	Shaft Adhesion*	Total
0.60	2,260	1,505	3,765	2,260	2,825	5,085
0.76	3,625	1,910	5,535	3,625	3,580	7,205
0.91	5,200	2,285	7,485	5,200	4,285	9,485

* 75% of computed shaft adhesion

The resistance at SLS allows for 25 mm of compression of the founding medium. Considering the bedrock to be non-yielding, the design is not expected to be governed by settlement since the loading required to produce deformation will be much larger than the factored resistance at ULS.

The caissons should be installed and inspected in accordance with the requirements of MTO Special Provision No. 903 S01 (February 2001).

Resistance to lateral loads will be provided by passive pressure developed in the sand above the surface of the bedrock and the 'horizontal bearing resistance' of the rock. The passive resistance p (kPa), developed on the face of the caissons should be computed using the following equation:

$$p = K_p (\gamma h + q)$$

where K_p = lateral earth pressure coefficient
= 3.0

γ = unit weight
= 18.0 kN/m^3 above the water level
= 8.2 kN/m^3 below the water level

h = depth below final grade (m)

q = surcharge load (kPa), if present

Provided the spacing between the caissons is greater than five caisson diameters (transverse to the applied load) and the ground surface in the passive zone is level, the passive earth pressure in the sand will be developed over an area equivalent to three caisson diameters and a height of six caisson diameters. If the caisson spacing is less the five diameters, the resistance should be reduced in direct linear proportion to the spacing. In the longitudinal direction, the caissons spacing should be equal to the socket length of the caisson to enable full mobilization of the lateral restraint. If the spacing is less than the socket length, the resistance should be reduced in direct linear proportion to the socket length.

For this project the computed resistance in the sand must be reduced to account for the sloping ground surface on the north side of the bridge (refer to Figure 1).

The factored horizontal resistance of the bedrock at ULS is considered to be 5,000 kPa. The resistance at SLS will be much higher and hence the factored resistance at ULS will govern.

The bedrock core retrieved in borehole ST1N-8 drilled at the south pier had an RQD of 47 to 70% with a recovery of 93 to 97%. It also exhibits evidence of close to moderately spaced foliation planes. Consequently, for the purpose of evaluating the point of contraflexure, it is considered to be a 'frictional' material.

The point of contraflexure should be computed using the equation provided in Section 2.2 on the following basis:

Type of Material	n_h (kN/m^3)
Sand	1,000
Bedrock To a depth of 2 m* Below a depth of 2 m	 20,000 40,000

* could be reduced to 1 m in the west part of the pier where the bedrock surface is relatively level (slope up to 10°)

It is anticipated that augering will be feasible to advance the caissons through the soil cover. Groundwater seepage into the auger hole must be anticipated and may require special methods of control. Sealing the bottom of the steel liner on the bedrock surface may be difficult in view of the locally steep slope of the soil/bedrock interface. Placement of concrete by the tremie method will probably be necessary.

The caisson cap should be provided with at least 1.7 m of earth cover or equivalent thermal insulation as protection against frost action. A 25 mm thick layer of polystyrene insulation is thermally equivalent to 600 mm of soil cover.

3. ABUTMENT WALLS

The abutment walls should be designed to resist the unbalanced lateral earth pressure imposed by the backfill adjacent to the wall. The lateral earth pressure, p (kPa), may be computed using the equivalent fluid pressures presented in Section 6-7.4 of the Ontario Highway Bridge Design

Code (OHBDC, 3rd Edition, 1991) or employing the following equation, assuming a triangular pressure distribution:

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

where K = coefficient of lateral earth pressure

γ = unit weight of free-draining granular material (kN/m^3)

h = depth below final grade (m)

q = surcharge load (kPa), if present

Free-draining granular material or rock fill should be used as backfill behind the walls. The following parameters are recommended for design:

PARAMETER	GRANULAR "A"	GRANULAR "B"	ROCK FILL
Angle of Internal Friction (degrees)	35	32	40
Unit Weight (kN/m^3)	22.8	21.2	18.0
Active Earth Pressure Coefficient (K_a)	0.27	0.31	0.22
At Rest Earth Pressure Coefficient (K_o)	0.43	0.47	0.36
Passive Earth Pressure Coefficient (K_p)	3.69	3.25	4.55

The earth pressure coefficients should be reviewed if the slope of the backfill exceeds 10° to the horizontal. Alternatively the material above the level of the top of the wall could be treated as a surcharge load (q in the preceding equation).

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

The horizontal force of the fill behind the walls will be resisted in part by the friction force developed between the underside of footing and the bedrock (south abutment) or battered piles (north abutment). Refer to Sections 2.1 and 2.2 for further comments in this regard.

4. APPROACH EMBANKMENTS

With the exception of the area in the immediate vicinity of the north abutment foundation (refer to Section 2.2), it is anticipated that the embankments will be constructed with rock fill, be about 1.1 m high at the south abutment and 9.2 m high at the north abutment. The rock fill will be generally placed on a thin soil cover and/or bedrock. In the immediate vicinity of the north abutment, the soil cover is about 7.6 m to bedrock. The soil cover decreases westerly to 3.4 m (borehole 102-4M) and northerly to 0.90 m (borehole ST1N-17A) and increases easterly to over 14.3 m (borehole 102-5N).

No settlement or bearing capacity problems due to placing the approach embankment fill on the bedrock are anticipated. The upper layers of the soil cover in the north approach embankment footprint comprise very loose to loose silty sand/sand deposits that extend to between 3.0 m in the west to 9.0 m in the east. The upper layer of the very loose to loose materials should be removed to about 1.5 m depth (elevation 192.0 at the abutment and east edge of the fill) before placing the rock fill or compacted granular fill for pile driving recommended in Section 2.2 due to excessive settlements and bearing capacity concerns. Settlements of the embankment fill and remaining native soils are estimated at 200 to 300 mm and expected to occur during construction of the embankment.

Backfilling adjacent to the bridge abutments should be carried out in conformance with Ontario Provincial Standards for granular or rock backfill at abutments (OPSD 3501 and 3505).

The embankments should be constructed in accordance with OPSD 200.010, 200.020, 201.010, 201.020 and 202.010, 206.010, 206.080 and 208.010. The side slopes of approach embankments should be inclined no steeper than 2:1 (H:V) for earth fill and 1.25:1 for rock fill. For high rock fill embankments, provide 2.0 m wide benches so that no uninterrupted rock slope is greater than 6.0 m high in accordance with the Northern Region Pavement Design Practices and Guidelines.

Where slope flattening is proposed, a drainage gap should be provided in accordance with OPSD 202.020 (enclosed). Where slopes are flattened to eliminate the need for a guide rail, a granular infilled drainage gap should be provided in accordance with Northern Region Pavement Design Practices and Guidelines (see Figure A). OPSS Granular "B" Type II is the recommended granular infill material for this project.

The south approach embankment will essentially be constructed on rock, therefore the road platform width should be widened by 1 m on each side. The north approach embankment within 10 m of the abutment will be construction on competent native soil; its road platform width should be widened by 2 m on each side in accordance with Northern Region Pavement Design Practices and Guidelines.

5. EXCAVATION AND GROUNDWATER CONTROL

Excavations for construction of footings and pile caps will be 1.0 to 5.5 m deep and carried out within fill, peat, topsoil, sand and bedrock. Excavation of the soil cover is expected to be straightforward. The soil cover materials are generally classified as Type 3 soils according to Occupational Health and Safety Act (OHSA, Ontario Regulation 213/91, August 1997 edition) criteria. The bedrock is classified as Type 1 and very loose cohesionless sands as Type 4.

Excavation of the rock will require standard methods of rock excavation such as blasting and jack-hammering. The actual equipment required and method of excavation within the bedrock will be dependent upon the geometry of cut and relative depth of excavation into the bedrock.

The rock excavation method should minimize fracturing of the bedrock surface on which the proposed foundations will bear. Consequently, it is important that blasting/excavation of the rock is controlled to prevent disturbance to the rock. The excavation specifications should call for the contractor to retain a blasting specialist to establish blast criteria/procedures to prevent disturbance. It should be stipulated that payment is limited to excavation to the limits shown on the drawing, overblasting/excavation will be the responsibility of the contractor and all loosened rock is to be removed.

Mechanical means should be employed to excavate the loosened rock at the footing. A large excavator equipped with a "tiger tooth" bucket in conjunction with a jackhammer or hoe ram is the preferred method of excavation to shallow depths in rock at foundation locations. Mass concrete could be employed to level minor variations in the bedrock surface.

Construction of the pier foundations, particularly the south and centre piers which are adjacent to Portage Lake, may require excavations some 2 to 3 m below the lake water level (up to 6 m at the south pier if spread footings founded on bedrock are constructed). The soil at these locations typically consists of relatively pervious cohesionless sand/silty sand. Installation of steel sheeting may be required to effectively control seepage of water into the excavations.

The sheet piles should extend to a depth equal to at least 2 times the excavation depth below the lake water level or to bedrock, whichever is shallowest, to minimize the potential for bottom heave. The specification should call for a groundwater control specialist and clearly state that control of water is the contractor's responsibility.

The sheet pile design should be based on the following geotechnical parameters:

Parameter	South and Centre Piers
Unit weight of soil above water table, γ (kN/m^3)	18.0
Unit weight of soil below water table, γ' (kN/m^3)	9.5
Active Earth pressure coefficient, K_a	0.3
Passive earth pressure coefficient, K_p	3.0

Seepage or surface water that enters the other excavations should be controllable by conventional sump pumping techniques.

All work should be carried out in accordance with OHSA and with local/MTO regulations.

6. CLOSURE

This report was written by Mr. C.M.P. Nascimento, P.Eng., Senior Project Engineer and reviewed by Mr. D.W. Kerr, M.Eng., P.Eng., Chief Foundation Engineer. Mr. B.R. Gray, M.Eng, P.Eng., President of Peto MacCallum Ltd., conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

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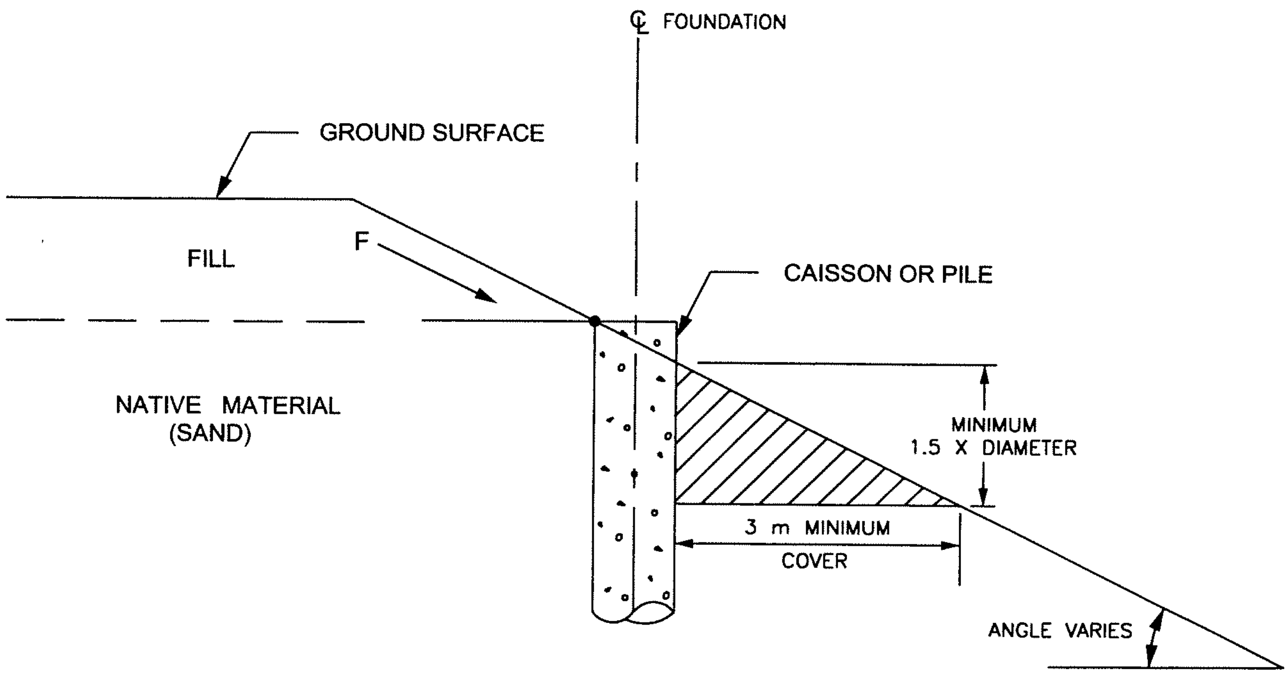
FOUNDATION ON SLOPE

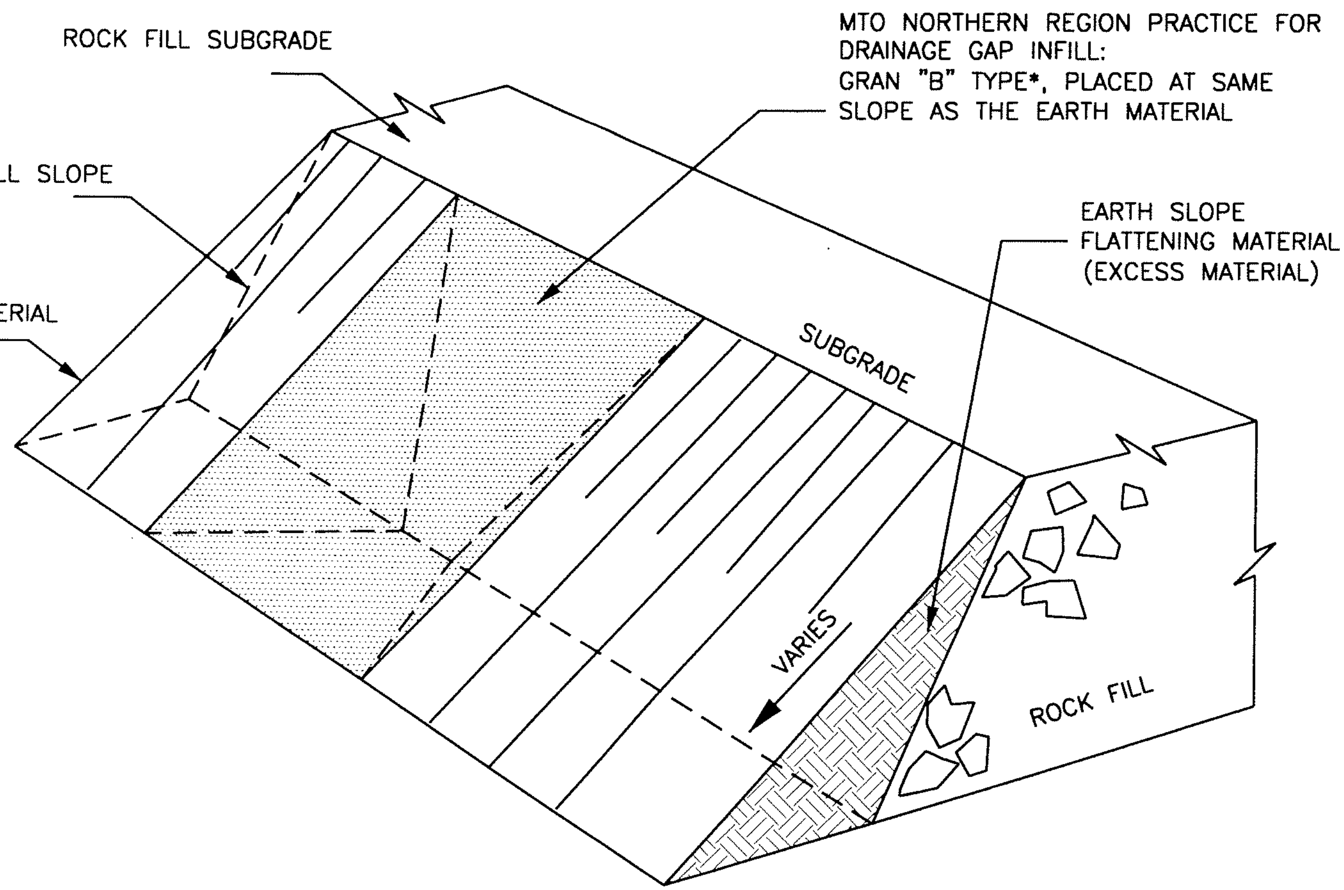


LEGEND

F	ADDITIONAL EARTH PRESSURE FROM SLOPING SURFACE
(hatched zone)	ASSUME NO PASSIVE RESISTANCE DEVELOPED IN THIS ZONE

Peto MacCallum Ltd.
CONSULTING ENGINEERS

DATE	SCALE	JOB NO.	FIGURE NO.
NOV. 2002	NTS	01TF012A	1



ISOMETRIC VIEW

NOTES

* – GRAN "B' TYPE I OR TYPE II AS RECOMMENDED FOR PROJECT

* – REFER TO OPSD – 202-020, DRAINAGE GAP FOR SLOPE FLATTENING ON ROCK OR GRANULAR EMBANKMENT FOR GEOMETERY AND SPECIFICATIONS.

INFILL OF DRAINAGE GAP

FOR ROCK FILL EMBANKMENTS
IN SLOPE FLATTENED AREAS

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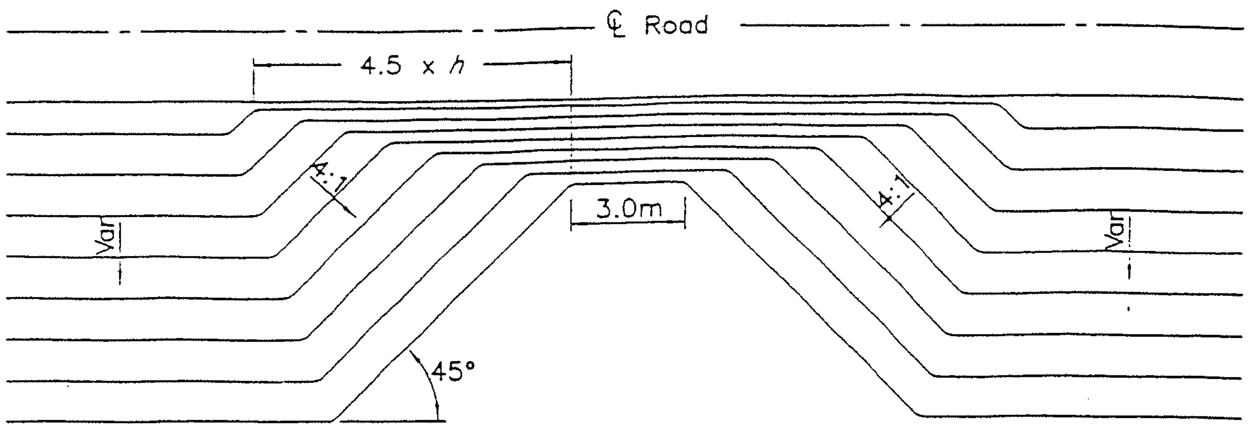
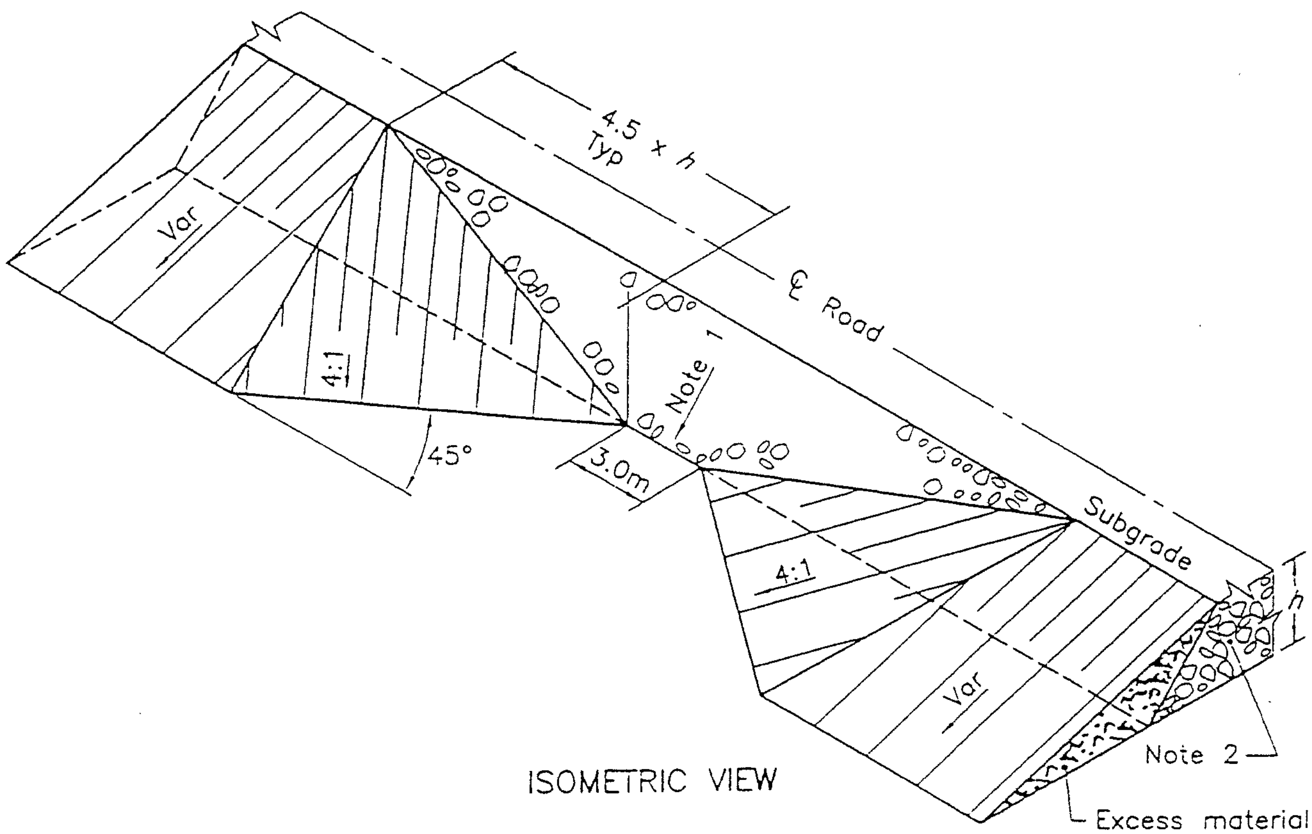
DATE	SCALE	JOB NO.	FIGURE NO.
MAR., 2002	NTS	01TF012AN	A



CONTOUR PLAN



ISOMETRIC VIEW

NOTES:

1 Slope determined by type of fill material.

2 Embankment material is rock fill or other permeable material for which a drainage gap is required.

A Height of fill is the vertical difference between top of subgrade and top of original ground measured at new road centreline.

B All dimensions are in millimetres or metres unless otherwise shown.

LEGEND:

h – Height of fill

ONTARIO PROVINCIAL STANDARD DRAWING	1998 03 01	Rev
DRAINAGE GAP FOR SLOPE FLATTENING ON ROCK OR GRANULAR EMBANKMENT		
	OPSD – 202.020	