G.I.-30 · SEPT. 1976

GEOCRES No. 31E-150

DIST. 52 REGION

W.P. No. 485-93-01
~~486-93-01~~

CONT. No.

W. O. No.

STR. SITE No. 44-398N

HWY. No. 11

LOCATION Ontario St. Overpass

No of PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT
FOR
PROPOSED ONTARIO STREET OVERPASS, NBL
STRUCTURE SITE NO. 44-398N
DISTRICT 52, HUNTSVILLE
W.P. 485-93-01

Submitted To:

Delcan Corporation
133 Wynford Drive
North York, Ontario, M3C 1K1
Canada

Submitted By:

AGRA
104 Crockford Blvd.
Scarborough, Ontario, M1R 3C6
Canada

February 2000
TT98820F

AGRA
ENGINEERING GLOBAL SOLUTIONS

AGRA
ENGINEERING GLOBAL SOLUTIONS

AGRA Earth &
Environmental Limited
104 Crockford Blvd.
Scarborough, Ontario
Canada M1R 3C6
Tel (416) 751-6565
Fax (416) 751-7592

February 9, 2000.
Ref. No.: TT98820F

Delcan Corporation
133 Wynford Drive
North York, Ontario, M3C 1K1
Canada

Attention: Mr. Khaled El-Dalati, P. Eng.

Dear Sir:

Re: FOUNDATION INVESTIGATION REPORT
FOR
PROPOSED ONTARIO STREET OVERPASS, NBL
STRUCTURE SITE NO. 44-398N
DISTRICT 52, HUNTSVILLE
W.P. 47x-xx-xx

We take pleasure in enclosing eight (8) copies of our Foundation Investigation Report carried out for the above mentioned project and we will be glad to discuss any questions arising from this work.

Soil samples will be retained for a period of one year, and will thereafter be disposed of unless we are otherwise instructed.

We thank you for giving us this opportunity to be of service to you.

Sincerely,

George S.W. Chow, P. Eng.,
Senior Vice President

AD/dee

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1.0 INTRODUCTION

AGRA, Consulting Geotechnical Engineers, was retained by Delcan Corporation to conduct a foundation investigation at the site of a proposed bridge that will carry the proposed northbound lanes (NBL) of Highway 11 and associated interchange ramps over the proposed realigned Ontario Street. The site is located near the Village of Burk's Falls, about 200 m north of the existing Ontario Street intersection with Highway 11, in the Township of Armour, Lot 5, Concession 10 in MTO District 52 - Huntsville (see Key Plan, Drawing No. 1). The proposed bridge will be an approximately 33 m long, three lane, single span structure.

The purpose of the investigation has been to obtain information about the subsurface conditions at the site of the proposed bridge and approach embankments by means of exploratory boreholes and testpits, and based on the findings, to provide recommendations for the foundation design of the proposed structure and approach fills/cuts.

2.0 SITE DESCRIPTION AND PHYSIOGRAPHY

The site is located about 200 m north of the intersection of Highway 11 and existing Ontario Street, near the Village of Burk's Falls. Existing Highway 11 alignment is parallel and located to the west of the proposed bridge. An existing rock cut parallels the bridge alignment along Highway 11, with a maximum rock face height of about 5 m. The ground surface slopes to the east and gently to the south and north. The area to the east is sparsely wooded.

Based on available geologic information, the site is in an area of discontinuous thin drift deposits over bedrock. The drift in the area is a mixture of glacial till, glaciolaustrine and glaciofluvial sediments. Generally after the last glacial withdrawal, ice-contact sediments (sands and gravels) followed by glaciofluvial sediments (ranging from deltaic and nearshore sands and gravels to prodeltaic and lake bottom silts and clays) were deposited on top of the existing sandy glacial till or Precambrian bedrock. The area was then inundated by glacial Lake Algonquin, depositing sands, silts and clays in the low lying areas.

Published information show that the bedrock can be expected to be composed of strongly foliated, gneissic to migmatic rocks which form part of the Central Gneiss Belt of the Grenville Province (a structural subdivision of the Canadian Shield).

3.0 INVESTIGATION PROCEDURES

The field work for the investigation was carried out during the period of May 5, 6, 8 and 9, and June 28, 1999, and consisted of drilling and coring two boreholes (Borehole Nos. ON1 and ON2) to depths of 7.6 to 15.3 m below the ground surface, thirteen auger probes (NBS1 through 7 and NBN1 through 6) and nine testpits (ON3 through ON11).

The plan locations of the boreholes and testpits, along with stratigraphic sections are shown on Drawing No. 2. Details of the subsurface conditions encountered at each borehole and testpit location, including the results of in-situ testing, are presented on the Borehole and Testpit Log Sheets. The results of the auger probes are tabulated in Appendix A.

The boreholes were advanced using solid and hollow stem continuous flight augers with a track-mounted power auger drilling rig (CME 75) owned and operated by Canadian Soil Drilling Inc., and a track-mounted power auger drilling rig (BOA 6M) owned and operated by Groundworks Drilling Inc., under the full-time supervision of experienced geotechnical personnel from AGRA.

Sampling in the boreholes was effected at frequent intervals of depth by the Standard Penetration Test Method (SPT), as specified in ASTM Method D 1586. This consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a 51 mm diameter o.d. split barrel (split-spoon) sampler into the ground. The number of blows of the hammer to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.30 m is recorded as the Standard Penetration Resistance or the 'N'-value of the soil and this gives an indication of the consistency or the compactness condition of the soil deposit.

Coring of the bedrock was effected by diamond drilling methods, using an NQ size core barrel.

The testpits were advanced using a rubber-tire backhoe owned and operated by Stevenson Excavating Limited, supervised by a Professional Engineer from AGRA.

The borehole locations were established in the field by our engineering staff, in relation to the already staked out proposed centre-line of the northbound lane of Highway 11 (by Dearden and Stanton Limited). The borehole geodetic elevations and co-ordinates were subsequently taken by surveyors from Dearden and Stanton Limited and supplied to us.

The soil samples and rock cores were shipped to our geotechnical laboratory in Toronto (Scarborough) for further examination and classification. A laboratory testing programme, consisting of natural moisture content determinations, Atterberg Limits tests and grain size analyses, was performed on selected representative soil samples. The results of the laboratory tests are presented on the appropriate Borehole and Testpit Log Sheets and also in Figure Nos. 1, 2 and 3.

A standpipe piezometer was installed in Borehole ON2 to monitor the water level over a prolonged period of time. Borehole ON1 was grouted on completion.

4.0 SUBSURFACE CONDITIONS

The subsurface conditions were explored at two borehole locations (Borehole Nos. ON1 and ON2), thirteen auger probes and nine testpits. The locations of the boreholes and testpits are shown on the Plan and Profile Drawing No. 2 and are also indicated on the individual Borehole and Testpit Log Sheets. Cross-sections of inferred subsurface stratigraphy are given on Drawing No. 2. The results of the auger probes are tabulated in Appendix A.

The ground surface at the proposed site slopes to the east and drops towards the existing Highway 11 surface to the west, with the ground elevation at the proposed bridge location generally ranging from about 324.5 to 321.5 m.

Below a surficial topsoil layer, the overburden, where encountered, generally consists of cohesionless silty sand, sand and sand & gravel deposits to depths ranging from 0.5 to 4.3 m below existing grade. A cohesive varved-like layered clayey silt deposit was also contacted along the southern approach area. Below the overburden soils is the Precambrian bedrock. Along the west alignment of the bridge site, the overburden soils have been stripped along the top of the existing rock cut. At the time of the investigation no groundwater was encountered within the overburden.

Details of the subsurface conditions encountered in the boreholes are presented on the Borehole and Testpit Log Sheets. Descriptions of various strata are given in the following paragraphs.

4.1 TOPSOIL

A surficial topsoil layer, ranging in thickness from 0.15 to 0.6 m, was encountered in the boreholes and all testpits, except at Testpit ON8 were the bedrock is exposed and at Borehole ON1 where no topsoil was found overlying the sand overburden.

In our experience the thickness of topsoil frequently varies in between and beyond the borehole and testpit locations.

4.2 SILTY SAND

Underlying the topsoil or a surficial sand deposit in the boreholes and most testpits (except for ON3, ON6 and ON7), a silty sand deposit was encountered to depths ranging between 0.4 and 1.5 m below existing grade. In Testpit ON9, a second silty sand layer was contacted below 3.7 m, immediately overlying the bedrock. The thickness of this fine-grained granular (cohesionless) deposit ranged from 0.3 to 0.9 m. The colour of the deposit is brown, except in Testpit ON9, immediately above the bedrock at about 4 m depth, where it was found to change from brown to grey.

In the boreholes the measured 'N'-values within this deposit range from 3 to 23 blows/0.3 m, indicating a very loose to compact condition. The very loose to loose condition was contacted near the ground surface.

Measured natural moisture contents of samples from the deposit range from 12 to 13%.

4.3 SAND

A surficial deposit of sand was contacted in Borehole ON1, Testpits ON3 and ON6, immediately beneath the topsoil or the ground surface and extended to depths ranging between 0.6 and 1.5 m below the ground surface. The deposit was also encountered in Borehole ON2, but underlying the surficial silty sand deposit, below 0.8 m. Here it extended to 2.1 m below the ground surface.

One grain size analysis was conducted on a sample from this deposit in Borehole ON6, and the results are presented in Figure No. 1. The results indicate 20% gravel, 62% sand and 18 % fines.

This is a granular (cohesionless) deposit and it's colour is brown. Standard Penetration tests performed in the boreholes in this deposit gave 'N'-values of 23 and 27 blows/0.3 m, indicating a compact condition.

4.4 SAND & GRAVEL

A layer of brown sand & gravel was contacted in Boreholes ON1, ON2 and Testpit ON11 at depths ranging from 0.7 to 2.1 m below the ground surface. The thickness of this granular (cohesionless) deposit in the boreholes and the testpit ranges between 1.2 and 1.5 m and the material extends to depths ranging from 2.0 to 3.6 m below the ground surface.

This unit is basically similar to the sand deposit described in Section 4.3 but is somewhat coarser in that it contains more gravel size particles. Two grain size analyses were conducted on samples from this deposit, and the results are presented in Figure No. 2. The results indicate 37 to 40% gravel, 47 to 49% sand, and 11 to 16% fines.

In the boreholes 'N'-values of 48 to in excess of 50 blows/0.3 m were recorded, indicating a dense to very dense compactness condition. It should also be mentioned that the presence of frequent cobbles and boulders was inferred while drilling the boreholes and was observed in the testpit (i.e. Testpit ON11). In addition, in Borehole ON1, auger refusal was encountered in this deposit due to cobbles and boulders. Rock coring was used in this borehole to advance through the cobbles and boulders from 1.8 to 2.7 m (bedrock surface) below the ground surface.

4.5 CLAYEY SILT

Below the surficial topsoil and silty sand deposit in Testpits ON8 and ON9, a clayey silt deposit was encountered at a depth of about 0.4 to 0.5 m below the ground surface and the deposit extended to depths of 2.8 m or Elevation 319.4 m and 3.7 m or Elevation 317.0 m, respectively. The cohesive deposit displays a varve-like structure, with alternating brown and grey clay layers, about 1 to 10 mm in thickness. An Atterberg Limits test was conducted on a sample from the material and the results are presented in Figure No. 3. The analyses indicate:

Liquid Limit:	32%
Plastic Limit:	20%
Plasticity Index:	12%
Moisture Content:	27%

These index values are characteristic of clayey silts of low plasticity.

Pocket penetrometer tests performed on samples recovered from the testpits gave an undrained shear strength value in excess of 220 kPa, indicating a generally hard consistency.

4.6 BEDROCK

Below the overburden soils, bedrock was encountered and cored to obtain NQ size cores in Boreholes ON1 and ON2 at depths of 2.7 m or Elevation 319.8 m and 3.6 m or Elevation 318.2 m, respectively.

Auger probes and testpits were advanced at the site to attempt to delineate the undulating bedrock surface. Auger refusal on probable bedrock was encountered in the thirteen auger probes and nine testpits advanced at the site. The auger probe results are given in Appendix A. The findings show that the recorded refusal depths range from exposed bedrock along the existing Highway 11 rock cut or Elevation 324 to 322 ± m to 4.3 m or Elevation 316.4 m at Testpit ON9. It is believed that while in most cases the refusals represent the depths to the surface of the bedrock, in some cases they may be due to cobbles and boulders in the overburden (probably immediately above the bedrock elevation).

From the results it can be surmized that in the general area of the proposed north abutment location the presumed bedrock surface elevation generally ranges from 323 to 321 ± m. In the general area of the south abutment location the presumed bedrock surface generally ranges from 323 to 318 ± m, generally dipping in an east to south-easterly direction.

The depth to the surface of the bedrock at the foundation element locations will also depend on the width of the footing.

The rock was cored for a vertical distance of 4.9 m at Borehole ON1 and 11.7 m at Borehole ON2.

From the recovered rock cores the bedrock is a massive, closely to moderately closely jointed, Precambrian gneiss. It is generally sound, except for the surficial zone (e.g. in Borehole ON2 the upper 0.1 m is fractured). Frequent mica inclusions and zones were encountered throughout the bedrock. Occasional sand and silt infillings were found at depth in the bedrock.

In Boreholes ON1 and ON2 the bedrock has a rock quality designation (RQD) of 38 to 100%. Core recovery ranged from 65 to 100%. Based on these results, and a visual examination of the rock cores, the bedrock is of poor to excellent quality, but generally good.

From the results of the boreholes, testpits and auger probes, the bedrock surface in the general area appears to be dipping toward the east and the south. To the west, the bedrock drops to the existing Highway 11 shoulder, having been excavated for the construction of the highway. It should be noted that due to undulations in the surface of the bedrock, which is not uncommon in Northern Ontario, the bedrock elevation in between and beyond the boreholes and testpits may vary considerably.

4.7 GROUNDWATER CONDITIONS

Groundwater conditions in the open boreholes and testpits were observed during and at the completion of sampling. No groundwater was observed in the overburden in any of the boreholes drilled or testpits excavated. Based on these observations and the measured natural moisture contents of the recovered samples it is our opinion that the groundwater level at the time of our investigation was below the overburden. One standpipe piezometer was installed in Borehole ON2 to monitor the water level without inference from surface water. A water level of 7.3 m (or Elevation 314.5 m) below existing ground surface was measured two months later, likely indicating the groundwater table within the bedrock.

It should, however, be pointed out that the groundwater at the site would fluctuate seasonally and in response to major weather events. A perched water table may occur in the sand overburden overlying the bedrock or clayey silt layer.

5.0 CLOSURE

Sincerely,

Andrew Drevininkas, P. Eng.

LICENSED PROFESSIONAL ENGINEER
A. R. DREVININKAS
PROVINCE OF ONTARIO

Eric Chung, M. Eng., P. Eng.
MTO Designated Contact

REGISTERED PROFESSIONAL ENGINEER
E. Y. CHUNG
PROVINCE OF ONTARIO

AD/dee

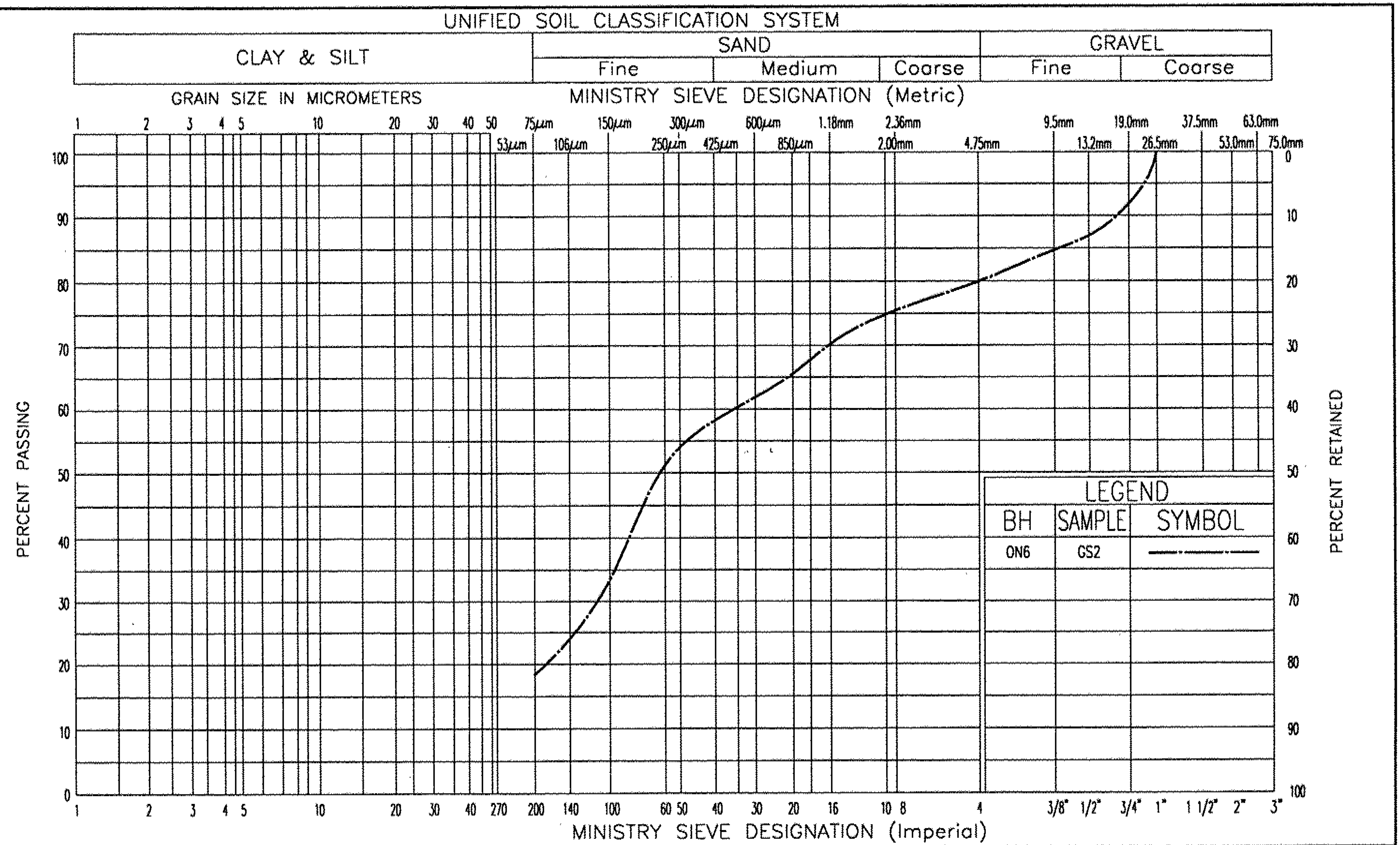
.../...

APPENDIX A

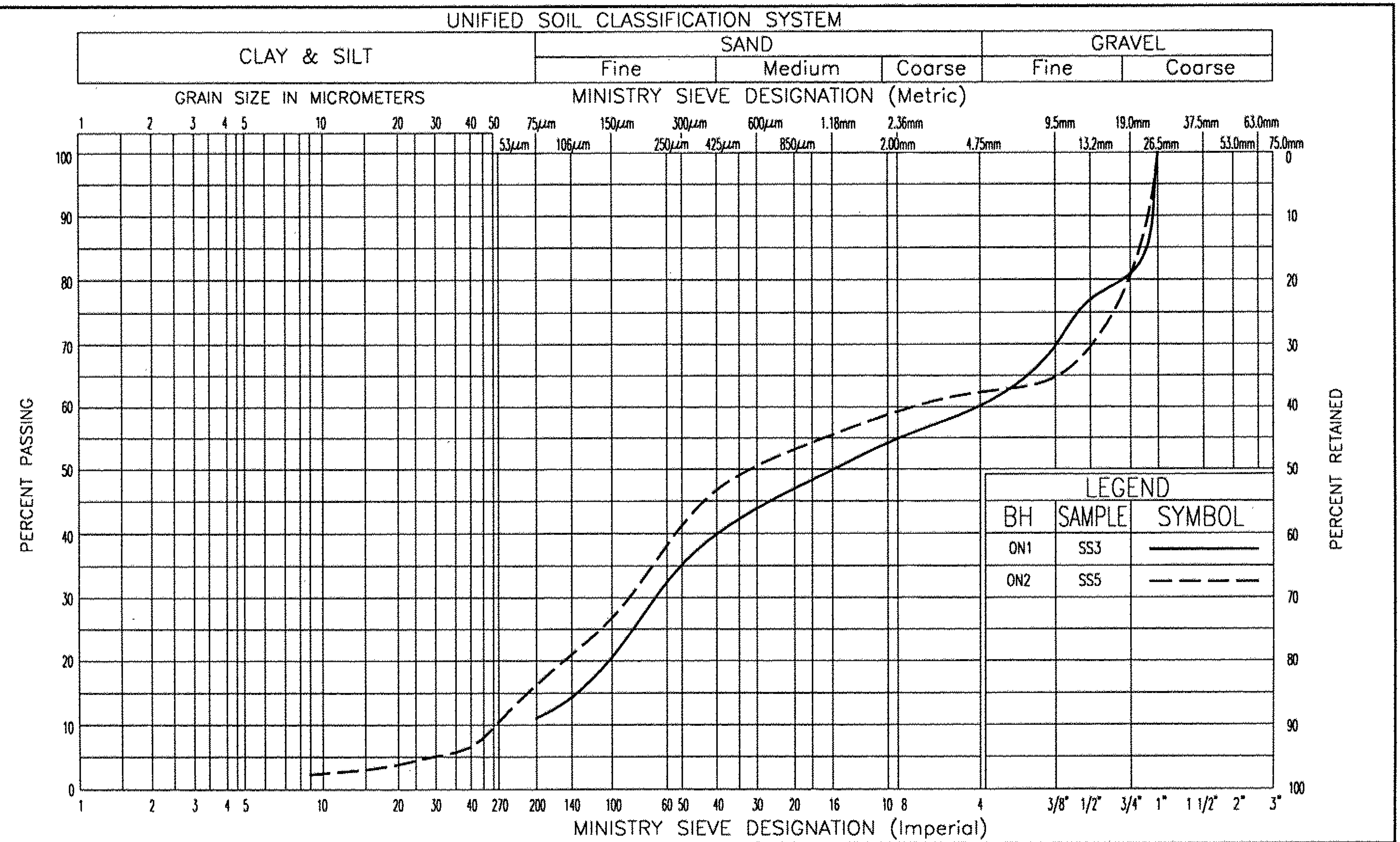
PROBE NO.	STATION	OFFSETS	APPROXIMATE GROUND SURFACE ELEVATION (m)	DEPTH OF AUGER REFUSAL (m)	APPROXIMATE AUGER REFUSAL ELEVATION (m)
	SOUTH ABUTMENT				
NBS1	21+092	8 RT Centerline	322 ±	3.4	319 ±
NBS2	21+100	Centerline	323 ±	0.9	322 ±
NBS3	21+103	10 RT of Centerline	322 ±	2.3	320 ±
NBS4	21+105	Centerline	324 ±	1.5	322 ±
NBS5	21+105	6.5 LT of Centerline	324 ±	1.7	322 ±
NBS6	21+108	6.5 LT of Centerline	324 ±	2.0	322 ±
NBS7	21+111	6.5 LT of Centerline	325 ±	2.4	323 ±
	NORTH ABUTMENT				
NBN1	21+127	10 RT of Centerline	322 ±	0.6	321 ±
NBN2	21+129	10 RT of Centerline	322 ±	0.6	321 ±
NBN3	21+135	Centerline	324 ±	0.8	323 ±
NBN4	21+136	6.5 LT of Centerline	324 ±	1.1	323 ±
NBN5	21+138	Centerline	324 ±	0.6	323 ±
NBN6	21+142	6.5 LT of Centerline	322 ±	1.2	321 ±

FIGURES

AGRA
ENGINEERING GLOBAL SOLUTIONS



AGRA	GRAIN SIZE DISTRIBUTION SAND	FIG No 1 W P 485-93-01

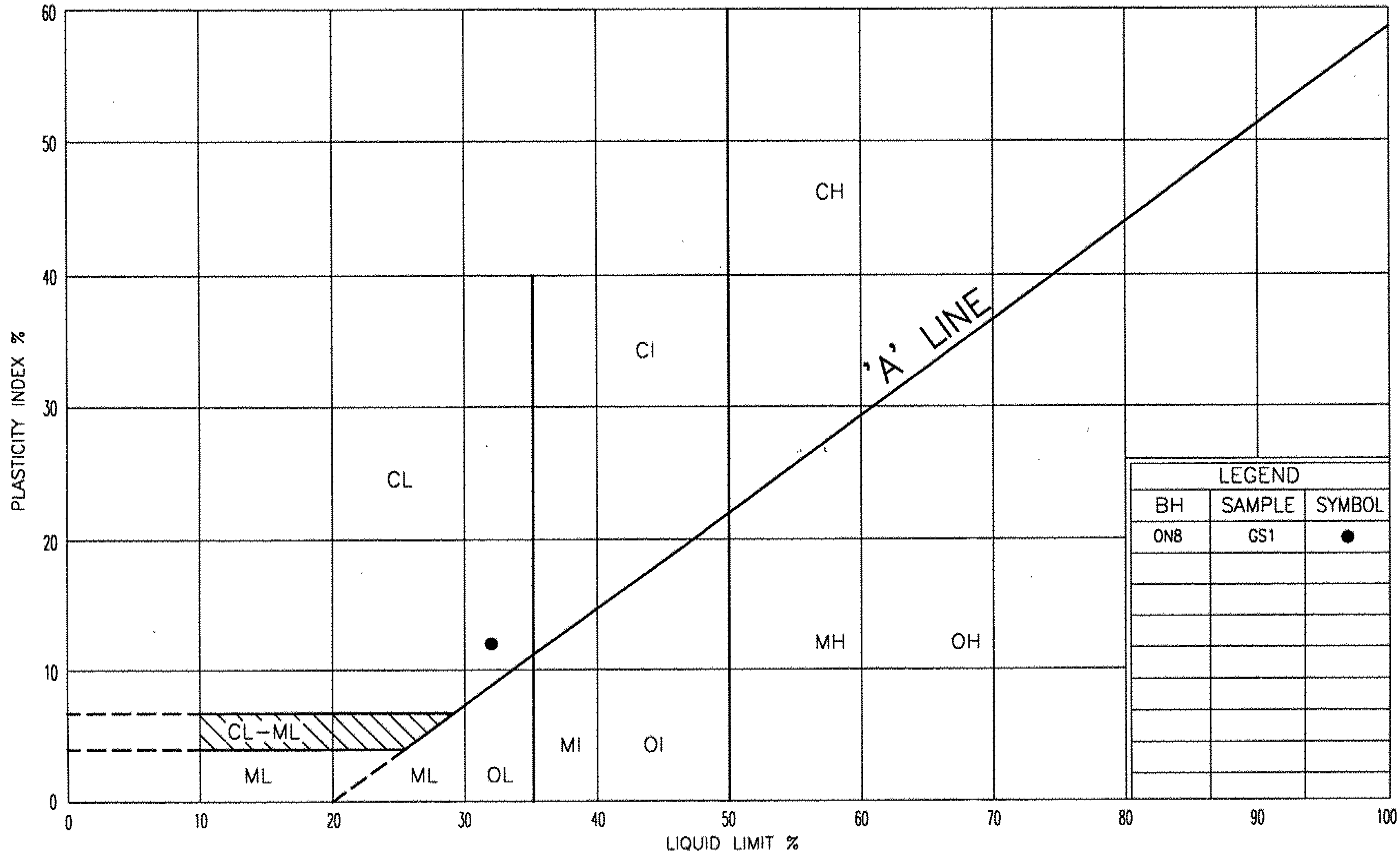


AGRA

GRAIN SIZE DISTRIBUTION
SAND & GRAVEL

FIG No 2

W P 485-93-01



LEGEND		
BH	SAMPLE	SYMBOL
ON8	GS1	●

AGRA

PLASTICITY CHART
CLAYEY SILT

FIG No 3

W P 485-93-01

ENCLOSURES

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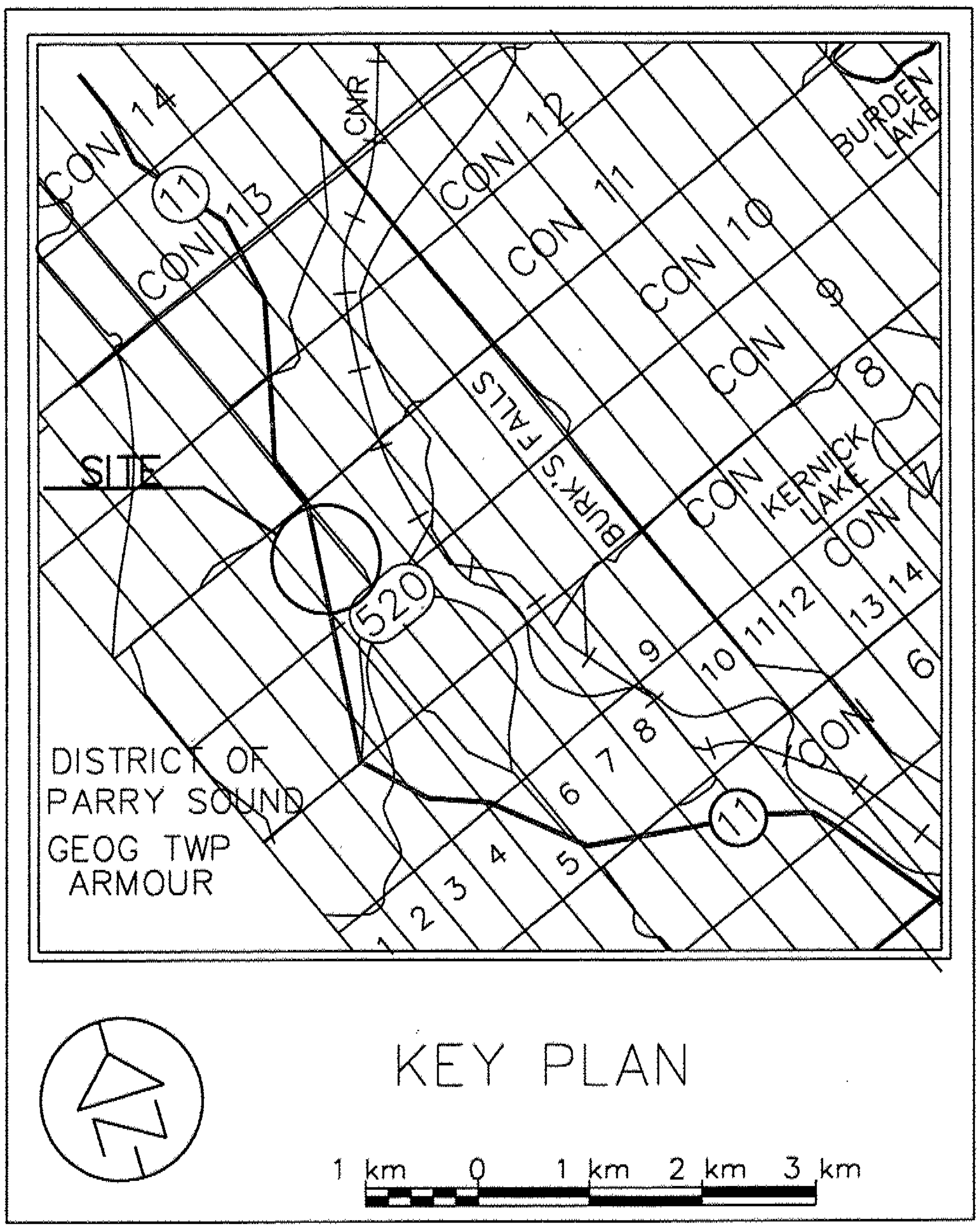

NBL & REALIGNED ONTARIO STREET CROSSING KEY PLAN	Dwg. No 1	AGRA

AGRA

RECORD OF BOREHOLE No OS1

METRIC

W.P. 486-93-01 | LOCATION Site No. 44-398S N5054757 E311524 | ORIGINATED BY AD

DIST 52 HWY 11 | BOREHOLE TYPE Hollow Stem | COMPILED BY AD

DATUM Geodetic | DATE 5 May 1999 | CHECKED BY EYC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)
328.6 / 0.0	brown brown,**SAND** with cobbles and boulders trace Silt, compact, damp	1	SS	22	328	STATION 21+180 8 LT SBL C/L
327.1 / 1.5	**GNEISS BEDROCK** massive, occasional Mica inclusions closely to moderately closely jointed	2	RC		327, 326	RC2: REC=100% RQD=100%
		3	RC		325	RC3: REC=100% RQD=100%
		4	RC		324, 323	RC4: REC=100% RQD=97%
		5	RC		322	RC5: REC=100% RQD=95%
		6	RC		321, 320	RC6: REC=100% RQD=88%
		7	RC		319	RC7: REC=100% RQD=90%
		8	RC		318, 317	RC8: REC=100% RQD=86%
		9	RC		316	RC9: REC=100% RQD=99%
		10	RC		315, 314	RC10: REC=100% RQD=90%
313.4 / 15.2	END OF BOREHOLE Water Level in PIEZOMETER July 9/99: 8.3m					

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 (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 (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

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

AGRA

Foundation Design

RECORD OF BOREHOLE No OS2

METRIC

W.P. 486-93-01 LOCATION Site No. 44-398S N 5054710 E 311546 ORIGINATED BY AD

DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem COMPILED BY AD

DATUM Geodetic DATE 5 May 1999 CHECKED BY EYC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)
322.7							
0.0	0.1m ASPHALTIC CONCRETE brown **SAND FILL** with Gravel, damp compact	1	SS	59		322	STATION 21+130 10RT SBL C/L
321.9 0.8	Highly fractured --------------- **GNEISS BEDROCK** massive, occasional Mica inclusions closely to moderately closely jointed	2	RC			321	RC2: REC=40% RQD=13%
		3	RC			320	RC3: REC=90% RQD=50%
		4	RC			319	RC4: REC=100% RQD=90%
		5	RC			318 317	RC5: REC=100% RQD=83%
316.8 5.9	END OF BOREHOLE No water in borehole before coring						

Other chart column headings: 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 (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; GR SA SI CL.

Water content sample 1: ○ plotted at approx. 3%.

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

AGRA

Foundation Design

RECORD OF BOREHOLE No OS3

METRIC

W.P.	486-93-01	LOCATION	Site No. 44-398S N 5054710 E 311535	ORIGINATED BY	AD
DIST 52	HWY 11	BOREHOLE TYPE	Backhoe	COMPILED BY	AD
DATUM	Geodetic	DATE	28 June 1999	CHECKED BY	EYC

SOIL PROFILE: ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE (20 40 60 80 100)	PLASTIC LIMIT W_p, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
330.7											
0.0	brown **SAND & GRAVEL** trace Organics, Silt damp		1	GS							
330.4 / 0.3	fractured **GNEISS BEDROCK**										
330.1 / 0.6	END OF TESTPIT ON BEDROCK Water Level on Completion: dry						330				STATION 21+131 2 LT SBL C/L

$+^3, \times^3$: Numbers refer to Sensitivity

$O^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No OS4

METRIC

W.P. 486-93-01 LOCATION Site No. 44-398S N 5054743 E 311535 ORIGINATED BY AD

DIST 52 HWY 11 BOREHOLE TYPE Backhoe COMPILED BY AD

DATUM Geodetic DATE 28 June 1999 CHECKED BY EYC

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER (SAMPLES)	TYPE (SAMPLES)	"N" VALUES (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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
328.2											
0.0	0.4m **TOPSOIL** with cobbles and boulders						328				
327.7 / 0.6	0.15m **SAND & GRAVEL** damp										
	END OF TESTPIT ON BEDROCK Water Level on Completion: dry										STATION 21+165 1 RT SBL C/L

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

RECORD OF BOREHOLE No OS5

METRIC

W.P. 486-93-01 LOCATION Site No. 44-398S N 5054739 E 311539 ORIGINATED BY AD

DIST 52 HWY 11 BOREHOLE TYPE Backhoe COMPILED BY AD

DATUM Geodetic DATE 28 June 1999 CHECKED BY EYC

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 ○ 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 (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
327.5											
327.3 0.0	brown, damp **SAND & GRAVEL**		1	GS					○		
0.2	END OF TESTPIT ON BEDROCK						327				
	Water Level on Completion: dry										STATION 21+160 5RT SBL C/L

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

AGRA

RECORD OF BOREHOLE No OS6

 METRIC

W.P. 486-93-01	LOCATION Site No. 44-398S N 5054762 E 311532	ORIGINATED BY AD
DIST 52 HWY 11	BOREHOLE TYPE Backhoe	COMPILED BY AD
DATUM Geodetic	DATE 28 June 1999	CHECKED BY EYC

SOIL PROFILE: ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE (20 40 60 80 100)	PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
327.5											
0.0	0.1m TOPSOIL red-brown **SILTY SAND** with cobbles and boulders, damp										STATION 21+184 SBL C/L
327.1 / 0.5	brown **SAND & GRAVEL** damp		1	GS			327		~10		
326.7 / 0.9	END OF TESTPIT ON BEDROCK Water Level on Completion: dry										

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

RECORD OF BOREHOLE No OS7

1 OF 1 **METRIC**

W.P. 486-93-01 LOCATION Site No. 44-398S N 5054688 E 311540 ORIGINATED BY AD

DIST 52 HWY 11 BOREHOLE TYPE Backhoe COMPILED BY AD

DATUM Geodetic DATE 28 June 1999 CHECKED BY EYC

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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
321.2											
321.0 0.2	brown **Sand with Gravel FILL** some Organics, damp		1	GS			321				
	END OF TESTPIT ON BEDROCK Water Level on Completion: dry										STATION 21+112 2 RT SBL C/L

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

FOUNDATION INVESTIGATION AND DESIGN REPORT
FOR
PROPOSED ONTARIO STREET OVERPASS, NBL
STRUCTURE SITE NO. 44-398N
DISTRICT 52, HUNTSVILLE
W.P. 485-93-01

Submitted To:

Delcan Corporation
133 Wynford Drive
North York, Ontario, M3C 1K1
Canada

Submitted By:

AGRA
104 Crockford Blvd.
Scarborough, Ontario, M1R 3C6
Canada

February 2000
TT98820F

AGRA
ENGINEERING GLOBAL SOLUTIONS

AGRA
ENGINEERING GLOBAL SOLUTIONS

AGRA Earth & Environmental Limited
104 Crockford Blvd.
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Canada M1R 3C6
Tel (416) 751-6565
Fax (416) 751-7592

February 9, 2000.
Ref. No.: TT98820F

Delcan Corporation
133 Wynford Drive
North York, Ontario, M3C 1K1
Canada

Attention: Mr. Khaled El-Dalati, P. Eng.

Dear Sir:

Re: FOUNDATION INVESTIGATION AND DESIGN REPORT FOR PROPOSED ONTARIO STREET OVERPASS, NBL STRUCTURE SITE NO. 44-398N DISTRICT 52, HUNTSVILLE W.P. 47x-xx-xx

We take pleasure in enclosing eight (8) copies of our Foundation Investigation and Design Report carried out for the above mentioned project and we will be glad to discuss any questions arising from this work.

Soil samples will be retained for a period of one year, and will thereafter be disposed of unless we are otherwise instructed.

We thank you for giving us this opportunity to be of service to you.

Sincerely,

George S.W. Chow, P. Eng.,
Senior Vice President

AD/dee

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1.0 INTRODUCTION

AGRA, Consulting Geotechnical Engineers, was retained by Delcan Corporation to conduct a foundation investigation at the site of a proposed bridge that will carry the proposed northbound lanes (NBL) of Highway 11 and associated interchange ramps over the proposed realigned Ontario Street. The site is located near the Village of Burk's Falls, about 200 m north of the existing Ontario Street intersection with Highway 11, in the Township of Armour, Lot 5, Concession 10 in MTO District 52 - Huntsville (see Key Plan, Drawing No. 1). The proposed bridge will be an approximately 33 m long, three lane, single span structure.

The purpose of the investigation has been to obtain information about the subsurface conditions at the site of the proposed bridge and approach embankments by means of exploratory boreholes and testpits, and based on the findings, to provide recommendations for the foundation design of the proposed structure and approach fills/cuts.

2.0 SITE DESCRIPTION AND PHYSIOGRAPHY

The site is located about 200 m north of the intersection of Highway 11 and existing Ontario Street, near the Village of Burk's Falls. Existing Highway 11 alignment is parallel and located to the west of the proposed bridge. An existing rock cut parallels the bridge alignment along Highway 11, with a maximum rock face height of about 5 m. The ground surface slopes to the east and gently to the south and north. The area to the east is sparsely wooded.

Based on available geologic information, the site is in an area of discontinuous thin drift deposits over bedrock. The drift in the area is a mixture of glacial till, glaciolaustrine and glaciofluvial sediments. Generally after the last glacial withdrawal, ice-contact sediments (sands and gravels) followed by glaciofluvial sediments (ranging from deltaic and nearshore sands and gravels to prodeltaic and lake bottom silts and clays) were deposited on top of the existing sandy glacial till or Precambrian bedrock. The area was then inundated by glacial Lake Algonquin, depositing sands, silts and clays in the low lying areas.

Published information show that the bedrock can be expected to be composed of strongly foliated, gneissic to migmatic rocks which form part of the Central Gneiss Belt of the Grenville Province (a structural subdivision of the Canadian Shield).

3.0 INVESTIGATION PROCEDURES

The field work for the investigation was carried out during the period of May 5, 6, 8 and 9, and June 28, 1999, and consisted of drilling and coring two boreholes (Borehole Nos. ON1 and ON2) to depths of 7.6 to 15.3 m below the ground surface, thirteen auger probes (NBS1 through 7 and NBN1 through 6) and nine testpits (ON3 through ON11).

The plan locations of the boreholes and testpits, along with stratigraphic sections are shown on Drawing No. 2. Details of the subsurface conditions encountered at each borehole and testpit location, including the results of in-situ testing, are presented on the Borehole and Testpit Log Sheets. The results of the auger probes are tabulated in Appendix A.

The boreholes were advanced using solid and hollow stem continuous flight augers with a track-mounted power auger drilling rig (CME 75) owned and operated by Canadian Soil Drilling Inc., and a track-mounted power auger drilling rig (BOA 6M) owned and operated by Groundworks Drilling Inc., under the full-time supervision of experienced geotechnical personnel from AGRA.

Sampling in the boreholes was effected at frequent intervals of depth by the Standard Penetration Test Method (SPT), as specified in ASTM Method D 1586. This consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a 51 mm diameter o.d. split barrel (split-spoon) sampler into the ground. The number of blows of the hammer to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.30 m is recorded as the Standard Penetration Resistance or the 'N'-value of the soil and this gives an indication of the consistency or the compactness condition of the soil deposit.

Coring of the bedrock was effected by diamond drilling methods, using an NQ size core barrel.

The testpits were advanced using a rubber-tire backhoe owned and operated by Stevenson Excavating Limited, supervised by a Professional Engineer from AGRA.

The borehole locations were established in the field by our engineering staff, in relation to the already staked out proposed centre-line of the northbound lane of Highway 11 (by Dearden and Stanton Limited). The borehole geodetic elevations and co-ordinates were subsequently taken by surveyors from Dearden and Stanton Limited and supplied to us.

The soil samples and rock cores were shipped to our geotechnical laboratory in Toronto (Scarborough) for further examination and classification. A laboratory testing programme, consisting of natural moisture content determinations, Atterberg Limits tests and grain size analyses, was performed on selected representative soil samples. The results of the laboratory tests are presented on the appropriate Borehole and Testpit Log Sheets and also in Figure Nos. 1, 2 and 3.

A standpipe piezometer was installed in Borehole ON2 to monitor the water level over a prolonged period of time. Borehole ON1 was grouted on completion.

4.0 SUBSURFACE CONDITIONS

The subsurface conditions were explored at two borehole locations (Borehole Nos. ON1 and ON2), thirteen auger probes and nine testpits. The locations of the boreholes and testpits are shown on the Plan and Profile Drawing No. 2 and are also indicated on the individual Borehole and Testpit Log Sheets. Cross-sections of inferred subsurface stratigraphy are given on Drawing No. 2. The results of the auger probes are tabulated in Appendix A.

The ground surface at the proposed site slopes to the east and drops towards the existing Highway 11 surface to the west, with the ground elevation at the proposed bridge location generally ranging from about 324.5 to 321.5 m.

Below a surficial topsoil layer, the overburden, where encountered, generally consists of cohesionless silty sand, sand and sand & gravel deposits to depths ranging from 0.5 to 4.3 m below existing grade. A cohesive varved-like layered clayey silt deposit was also contacted along the southern approach area. Below the overburden soils is the Precambrian bedrock. Along the west alignment of the bridge site, the overburden soils have been stripped along the top of the existing rock cut. At the time of the investigation no groundwater was encountered within the overburden.

Details of the subsurface conditions encountered in the boreholes are presented on the Borehole and Testpit Log Sheets. Descriptions of various strata are given in the following paragraphs.

4.1 TOPSOIL

A surficial topsoil layer, ranging in thickness from 0.15 to 0.6 m, was encountered in the boreholes and all testpits, except at Testpit ON8 were the bedrock is exposed and at Borehole ON1 where no topsoil was found overlying the sand overburden.

In our experience the thickness of topsoil frequently varies in between and beyond the borehole and testpit locations.

4.2 SILTY SAND

Underlying the topsoil or a surficial sand deposit in the boreholes and most testpits (except for ON3, ON6 and ON7), a silty sand deposit was encountered to depths ranging between 0.4 and 1.5 m below existing grade. In Testpit ON9, a second silty sand layer was contacted below 3.7 m, immediately overlying the bedrock. The thickness of this fine-grained granular (cohesionless) deposit ranged from 0.3 to 0.9 m. The colour of the deposit is brown, except in Testpit ON9, immediately above the bedrock at about 4 m depth, where it was found to change from brown to grey.

In the boreholes the measured 'N'-values within this deposit range from 3 to 23 blows/0.3 m, indicating a very loose to compact condition. The very loose to loose condition was contacted near the ground surface.

Measured natural moisture contents of samples from the deposit range from 12 to 13%.

4.3 SAND

A surficial deposit of sand was contacted in Borehole ON1, Testpits ON3 and ON6, immediately beneath the topsoil or the ground surface and extended to depths ranging between 0.6 and 1.5 m below the ground surface. The deposit was also encountered in Borehole ON2, but underlying the surficial silty sand deposit, below 0.8 m. Here it extended to 2.1 m below the ground surface.

One grain size analysis was conducted on a sample from this deposit in Borehole ON6, and the results are presented in Figure No. 1. The results indicate 20% gravel, 62% sand and 18 % fines.

This is a granular (cohesionless) deposit and it's colour is brown. Standard Penetration tests performed in the boreholes in this deposit gave 'N'-values of 23 and 27 blows/0.3 m, indicating a compact condition.

4.4 SAND & GRAVEL

A layer of brown sand & gravel was contacted in Boreholes ON1, ON2 and Testpit ON11 at depths ranging from 0.7 to 2.1 m below the ground surface. The thickness of this granular (cohesionless) deposit in the boreholes and the testpit ranges between 1.2 and 1.5 m and the material extends to depths ranging from 2.0 to 3.6 m below the ground surface.

This unit is basically similar to the sand deposit described in Section 4.3 but is somewhat coarser in that it contains more gravel size particles. Two grain size analyses were conducted on samples from this deposit, and the results are presented in Figure No. 2. The results indicate 37 to 40% gravel, 47 to 49% sand, and 11 to 16% fines.

In the boreholes 'N'-values of 48 to in excess of 50 blows/0.3 m were recorded, indicating a dense to very dense compactness condition. It should also be mentioned that the presence of frequent cobbles and boulders was inferred while drilling the boreholes and was observed in the testpit (i.e. Testpit ON11). In addition, in Borehole ON1, auger refusal was encountered in this deposit due to cobbles and boulders. Rock coring was used in this borehole to advance through the cobbles and boulders from 1.8 to 2.7 m (bedrock surface) below the ground surface.

4.5 CLAYEY SILT

Below the surficial topsoil and silty sand deposit in Testpits ON8 and ON9, a clayey silt deposit was encountered at a depth of about 0.4 to 0.5 m below the ground surface and the deposit extended to depths of 2.8 m or Elevation 319.4 m and 3.7 m or Elevation 317.0 m, respectively. The cohesive deposit displays a varve-like structure, with alternating brown and grey clay layers, about 1 to 10 mm in thickness. An Atterberg Limits test was conducted on a sample from the material and the results are presented in Figure No. 3. The analyses indicate:

Liquid Limit:	32%
Plastic Limit:	20%
Plasticity Index:	12%
Moisture Content:	27%

These index values are characteristic of clayey silts of low plasticity.

Pocket penetrometer tests performed on samples recovered from the testpits gave an undrained shear strength value in excess of 220 kPa, indicating a generally hard consistency.

4.6 BEDROCK

Below the overburden soils, bedrock was encountered and cored to obtain NQ size cores in Boreholes ON1 and ON2 at depths of 2.7 m or Elevation 319.8 m and 3.6 m or Elevation 318.2 m, respectively.

Auger probes and testpits were advanced at the site to attempt to delineate the undulating bedrock surface. Auger refusal on probable bedrock was encountered in the thirteen auger probes and nine testpits advanced at the site. The auger probe results are given in Appendix A. The findings show that the recorded refusal depths range from exposed bedrock along the existing Highway 11 rock cut or Elevation 324 to 322 ± m to 4.3 m or Elevation 316.4 m at Testpit ON9. It is believed that while in most cases the refusals represent the depths to the surface of the bedrock, in some cases they may be due to cobbles and boulders in the overburden (probably immediately above the bedrock elevation).

From the results it can be surmized that in the general area of the proposed north abutment location the presumed bedrock surface elevation generally ranges from 323 to 321 ± m. In the general area of the south abutment location the presumed bedrock surface generally ranges from 323 to 318 ± m, generally dipping in an east to south-easterly direction.

The depth to the surface of the bedrock at the foundation element locations will also depend on the width of the footing.

The rock was cored for a vertical distance of 4.9 m at Borehole ON1 and 11.7 m at Borehole ON2.

From the recovered rock cores the bedrock is a massive, closely to moderately closely jointed, Precambrian gneiss. It is generally sound, except for the surficial zone (e.g. in Borehole ON2 the upper 0.1 m is fractured). Frequent mica inclusions and zones were encountered throughout the bedrock. Occasional sand and silt infillings were found at depth in the bedrock.

In Boreholes ON1 and ON2 the bedrock has a rock quality designation (RQD) of 38 to 100%. Core recovery ranged from 65 to 100%. Based on these results, and a visual examination of the rock cores, the bedrock is of poor to excellent quality, but generally good.

From the results of the boreholes, testpits and auger probes, the bedrock surface in the general area appears to be dipping toward the east and the south. To the west, the bedrock drops to the existing Highway 11 shoulder, having been excavated for the construction of the highway. It should be noted that due to undulations in the surface of the bedrock, which is not uncommon in Northern Ontario, the bedrock elevation in between and beyond the boreholes and testpits may vary considerably.

4.7 GROUNDWATER CONDITIONS

Groundwater conditions in the open boreholes and testpits were observed during and at the completion of sampling. No groundwater was observed in the overburden in any of the boreholes drilled or testpits excavated. Based on these observations and the measured natural moisture contents of the recovered samples it is our opinion that the groundwater level at the time of our investigation was below the overburden. One standpipe piezometer was installed in Borehole ON2 to monitor the water level without inference from surface water. A water level of 7.3 m (or Elevation 314.5 m) below existing ground surface was measured two months later, likely indicating the groundwater table within the bedrock.

It should, however, be pointed out that the groundwater at the site would fluctuate seasonally and in response to major weather events. A perched water table may occur in the sand overburden overlying the bedrock or clayey silt layer.

5.0 DISCUSSION AND RECOMMENDATIONS

This report contains the findings of our geotechnical investigation, together with our recommendations and comments. These recommendations and comments are based on factual information and are intended only for use of the design engineers. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The anticipated construction conditions are also discussed, but only to the extent that they may influence design decisions. Construction methods discussed, however, express our opinion only and are not intended to direct the contractors on how to carry out the construction. Contractors should also be aware that the data and their interpretation presented in this report may not be sufficient to assess all the factors that may have an effect upon the construction.

The proposed Highway 11 realignment will consist of a four lane divided highway with an approximately 30 m wide median. The grade for Highway 11 will be lowered by about 4 to 5 m from the existing and the Ontario Street grade will be another 8± m below the Highway 11 elevation. The proposed bridge will carry the northbound lane of Highway 11 and associated interchange ramps over the proposed realigned Ontario Street. It will be an approximately 33 m long, 3-lane, (i.e. two-lanes for Highway 11 northbound and one-lane for the W-N Ramp of the Ontario Street interchange) single span structure. As shown on Drawing No. 2, the bridge will be at a skew to the Ontario Street alignment. In general the existing ground elevation at the bridge site is 324.5 to 321.5 m, generally dipping to the east, while the grade beyond the bridge site drops to the east and gently to the south. The proposed grade of Highway 11 at the bridge site is approximately Elevation 319 to 318 m, whereas the proposed grade of Ontario Street at the bridge site is approximately Elevation 311 to 310 m. The existing grades under the proposed bridge will therefore be lowered by up to about 14 m.

In general, below a surficial topsoil layer, cohesionless soils (except for a varved clayey silt deposit contacted at the south approach), ranging in depth from 0.5 to 4.3 m below the existing grade, overlie the Precambrian gneiss bedrock. At the time of the investigation no groundwater table was encountered within the overburden.

5.1 FOUNDATIONS

5.1.1 Spread Footing Foundations

All footings can be founded on sound bedrock. For this purpose all loose or weathered rock under the footprint of the footing should be removed and replaced with concrete. Mass concrete may be placed to raise the grade to the founding level, where necessary.

Information provided to us indicates that the abutment footing elevation for the bridge will likely be about 316 to 315 m. Based on the findings of the boreholes, testpits and auger probes advanced in the area of the proposed foundation elements, the surface of the bedrock can be assumed (along the east-west axis of the centre-line of each foundation element) at the elevations noted below :

TABLE I

FOUNDATION LOCATION	REFERENCE BOREHOLE	APPROXIMATE DEPTH TO PRESUMED BEDROCK SURFACE (m)	PRESUMED BEDROCK SURFACE ELEVATION (m)
North Abutment			
West Side	Auger Probe Nos. NBN4, NBN6 and Testpit ON7	0 - 1.2 ±	323.6 - 321 ±
Centre	Auger Probe Nos. NBN3, NBN5 and Testpit ON6	0.6 - 1.2 ±	323 ±
East Side	Auger Probe Nos. NBN1, NBN2 and Testpit ON5	0.6 - 1.4 ±	321 ±
South Abutment			
West Side	Auger Probe Nos. NBS5, NBS6 and NBS7	1.7 - 2.4 ±	323 - 322 ±
Centre	Auger Probe Nos. NBS2, NBS4 and Testpit ON3	0.9 - 1.5 ±	322 - 321 ±
East Side	Auger Probe Nos. NBS1, NBS3 and Borehole ON2	2.3 - 3.6 ±	320 - 318 ±

It should also be noted that in between and beyond the borehole locations, testpits and auger probes, the bedrock surface may vary considerably. Additionally, the auger probe refusal depths may be due to refusal on cobbles or boulders within the overburden and the actual bedrock surface may be lower than anticipated.

As the anticipated founding elevation (e.g. ~316 to 315 m) will be below the inferred (or proven) bedrock surface levels the foundations will rest on sound bedrock and for design purposes the following O.H.B.D.C. bearing resistances may be used:

Factored Bearing Resistance at U.L.S. of up to 10,000 kPa
Bearing Resistance at S.L.S. will not govern

No frost protection is required for footings placed on massive bedrock, provided blasting of the bedrock is monitored closely to ensure no fracturing of the founding rock occurs. Bedrock would however be prone to possible deterioration due to opening of existing joints or fractures in the bedrock, as a result of frost action. Provided that surface water is diverted away from the footings, frost protection need not be provided for footings placed on massive, sound bedrock, although for added protection an earth cover of at least 0.3 m is recommended. The surface of the earth protection should be clayey to minimize the infiltration of surface water or the protection could be provided by concrete. If however, the bedrock is not massive and water can accumulate in the joints or fractures of the rock (thus causing deterioration of the founding medium by expansion due to freezing) then there may be a requirement to provide some frost protection. For this purpose, the proposed bearing surface should be inspected by qualified engineering personnel, with experience in rock mechanics and familiar with the findings of this investigation. If the rock is not massive, then the excavation can be extended deeper until acceptable rock is found which, based on our experience, seldom exceeds 0.6 m.

Sliding resistance can be provided by penetrating into the bedrock (i.e. keying-in and utilizing passive rock resistance), utilizing the sliding resistance between concrete and bedrock, shear in grouted dowels and/or rock anchors. For the evaluation of the sliding resistance of the foundation (O.H.B.D.C. 6-8.4.3) the ultimate angle of friction between the underside of the foundations and the clean, intact bedrock surface can be taken as 30 degrees. If additional horizontal resistance is required or if the rock surface is not sufficiently level, dowelling or keying-in into the bedrock can be considered. Alternatively, the surface of the bedrock can be chiseled (i.e. roughened), increasing the ultimate angle of friction to 35 degrees. This, in our opinion, is likely to be the most cost effective method. On the other hand if the presence of weaker rock zones/seams/layers is noted during construction, especially with an unfavourable orientation, then dowelling may be a more suitable solution.

If there are net uplift forces which need to be resisted by rock anchors, or for increasing sliding resistance, for design purposes, the following O.H.B.D.C. capacities may be assumed for the bond between bedrock and grout.

Factored Bearing Capacity @ U.L.S. = 500 kPa
Bearing Capacity @ S.L.S. will not govern

The upper 0.1m of the rock should not be included in calculating the resistance and the minimum dowel embedment should be 1.5 m. Neither the structural strength of the dowel, nor the compressive strength of the grout should be exceeded. The annular space around the dowel which will be grouted should be in the order of 2 cm wide (between the dowel and the bedrock). The anchors should also be checked for rock wedge pull out assuming a 60 degree cone/wedge and the anchor group resistance should also be checked.

The horizontal capacity of rock that can be derived from a shear key extending from the base of a footing depends on many factors including the degree of fracture of the upper portion of bedrock (massiveness), joint orientation and properties, the proximity of weaker zones, seams and layers. As outlined above, the proposed bearing surface should be inspected during construction by experienced personnel to determine if the shear key option is feasible.

Under inclined loading conditions the Bearing Resistance at U.L.S. should be reduced in accordance with Clause 6-8.4.2 of O.H.B.D.C., 3rd Edition.

Details of foundation conditions at each support location are discussed below.

5.1.1.1 North Abutment

The north abutment can be founded directly on sound bedrock. From the probe results the rock surface appears to be sloping towards the east and to a certain extent to the south, following the ground surface. Since the proposed highway grade at the north abutment is about elevation 319 m, and the proposed bottom of the bridge deck is about elevation 317 m, the founding elevation will probably be 316 m $\pm$. The findings indicate that this will involve rock excavation generally between 5 and 8 m.

In order to ensure the stability at the north abutment, the footing should be located far enough from the face of any proposed rock cuts along Highway 11 and Ontario Street. For this purpose, the outside edge of the footing should be no closer than 1.5 m to the face of the rock cut. The rock portion of the cut slope can be maintained at nearly vertical slopes but depending on the orientation of joints and fractures, rock bolting of the rock face and/or rock dowelling along the crest of the cut adjacent to the footings may be required. As mentioned before, when the exposed faces are inspected, the possible presence of weaker zones or layers (such as highly micaceous material evidenced in the rock cores) with unfavourable orientation should be checked.

5.1.1.2 South Abutment

The south abutment can be founded directly on suitable bedrock. From the probe results the rock surface appears to be sloping towards the east and south, following the ground surface. Since the proposed highway grade at the south abutment is about elevation 318 m, and the proposed bottom of the bridge deck is about elevation 316 m. the founding level will be below this elevation (e.g. Elevation 315 m $\pm$). As the borehole, testpit and auger probe results indicate rock surface elevations generally ranging from 332 to 318 m, rock excavation depths generally ranging between 4 and 7 m can be expected.

As mentioned for the north abutment foundation, to maintain the stability at the south abutment, the footing should be located far enough from the face of any proposed rock cuts along Highway 11 and Ontario Street. For this purpose, the outside edge of the footing should be no closer than 1.5 m to the face of the rock cut. The rock portion of the cut slope can be maintained at nearly vertical slopes but depending on the orientation of joints and fractures, rock bolting of the rock face and/or rock dowelling along the crest of the cut adjacent to the footings may be required. When inspecting the faces for possible weaknesses the engineer should be cognizant of the fact that the presence of possible weaker zones (e.g. highly micaceous) may cause future problems, especially when they are unfavourably orientated. Once these characteristics of the rock face are examined, the horizontal capacity of the rock and protection of the rock face (if required) can be determined.

We recommend that an NSSP for rock dowels and/or rock slope protection be included in the contract documents.

5.1.2 Deep Foundations

Due to the shallow bedrock depths at the proposed foundation elements, the use of deep foundations is considered not to be a viable alternative.

5.2 LATERAL EARTH PRESSURES

Backfill behind abutments and retaining walls should consist of non-frost susceptible, free draining granular materials in accordance with the Ontario Ministry of Transportation Standards.

Free-draining backfill materials (i.e. Granular 'A' or Granular 'B') and the provision of drain pipes and weep holes, etc., should prevent hydrostatic pressure build-up. Computation of earth pressures should be in accordance with O.H.B.D.C. Because of the presence of sound rock for a substantial portion of the excavated faces behind the retaining structures, the applicable earth pressure parameters will be difficult to determine. However, for design purposes, the following unfactored parameters can be used (which will generally be relatively conservative values).

Compacted Granular 'A'

Unit Weight = 22 kN/m^3
Coefficient of Lateral Earth Pressures:
$K_a = 0.27$
$K_o = 0.43$

Compacted Granular 'B'

Unit Weight = 21 kN/m^3
Coefficient of Lateral Earth Pressures:
$K_a = 0.31$
$K_o = 0.47$

Rock Fill

Unit Weight = 18 kN/m^3
Coefficient of Lateral Earth Pressures:
$K_a = 0.27$
$K_o = 0.43$

These values are based on the assumption that the backfill behind the retaining structure is free-draining and adequate drainage is provided. As well, it is assumed that the ground behind the retaining structure is level.

The earth pressure coefficient adopted will depend on whether the retaining structure is restrained or movements can be allowed such that the active state of earth pressure can develop. If the abutment is restrained and does not allow lateral yielding, then at rest pressures should be used as per Clause C6-7.1 of the O.H.B.D.C., 3rd Edition. The effect of compaction should also be taken into account in the selection of the appropriate earth pressure coefficients in accordance with Clause 6-7.4.3 of the O.H.B.D.C., 3rd Edition.

Foundations on bedrock will be unyielding and in that case the at-rest condition will govern the earth pressure.

Vibratory equipment for use behind abutments and retaining walls should be restricted in size as per current MTO practice and as specified in OPSS 501.

Some rock will likely be excavated for the highway cut in the area. If rock fill is used for backfill, special care is required to prevent damage to the retaining structures. In such a case, a cushion of Granular 'A' material or finely graded rock fill (e.g. less than 200 mm normal diameter) should be placed between the structure and the rock fill. This cushion should be as per O.P.S.D. 3505.0 and if Granular 'A' is used, proper filtering should be provided to prevent the loss of finer particles from the Granular 'A' cushion into the coarse rock fill.

As an alternative to conventional retaining walls, MTO's Retained Soil System may be used. The following should be included in the Contract Documents:

- identify longitudinal extent in plan of the Retained Soil System
- identify in plan transverse space constraints (top of wall and bottom of wall)
- identify elevation of top of wall and bottom of wall
- include NSSP for Retained Soil Systems in Contract Documents

The Retained Soil System should be of high performance and moderate to high appearance.

5.3 APPROACH EMBANKMENTS

The proposed grades indicate that up to about 14 m deep cuts will be required at the immediate vicinity of the abutments (e.g. forward slopes). At the immediate approaches between 4 and 5 m cuts will be required for the construction of Highway 11 northbound lane.

Permanent cut slopes in the granular overburden soils above the water table will be stable at 2H:1V. Cut slopes should be inspected after construction and where deemed necessary, measures such as granular blanket (sheeting) should be provided. Testpits ON8 and ON9 put down about 10 to 20 m south of the proposed south abutment location showed the presence of a clayey silt deposit with a varved-like layered structure. Within our terms of reference (i.e. within 20 m of the structure) the depth of cut in the overburden, will generally range from about 4 m on the west side to about 2 m on the east side. Side slopes of 2H:1V are considered stable and the conditions beyond the 20 m limit (i.e. further south) will be covered in our Pavement Design Report.

.../...

For slopes in the overburden proper erosion measures should be implemented both during the construction and permanently. This can be achieved by immediate seeding or sodding (OPSS 572).

Rock cut slopes should be stable at nearly vertical faces providing that blasting is carefully controlled and unfavourable orientation of joints and fractures is not encountered. This aspect is further elaborated in the next section of this report.

5.4 CONSTRUCTION COMMENTS

No groundwater was encountered in the overburden of the boreholes or testpits and, based on this, no problems with groundwater seepage are anticipated at the site. Any surface water seepage, if necessary, can easily be handled by gravity drainage and pumping from open sumps.

All excavations should be carried out in accordance with the Occupational Health & Safety Acts of Ontario, including regulations for Construction Projects and Regulations for Mines and Mining Plants (in bedrock).

Excavation of the bedrock by mechanical methods such as hoe-ramming or ripping will probably only be feasible within the uppermost weathered and fractured rock. In our opinion, therefore blasting will be necessary. Blasting should however be carried out in a manner to minimize damage to the founding bedrock and permanent rock face. Controlled perimeter (line) blasting (or a similarly acceptable method) is recommended in order to provide a neat excavation line, minimize over break, minimize face instabilities and long term maintenance problems. It is recommended that an NSSP on blasting requirements be included in the contract documents.

Temporary rock slopes should be stable at near vertical faces, but adequate precaution should be taken to protect workers from spalling rock. The stability of rock faces will also depend on the inclination of planes of weakness in the rock mass.

To reduce the excavation depths and to facilitate the construction of spread footing foundations it would be advisable to carry out the cut for Ontario Street before the construction of the abutment support elements. We recommend that all blasting, for rock cuts be completed prior to the construction of the footings.

Consideration should be given to excavating to the founding level at the proposed future widening area during this construction, to eliminate possible problems with rock excavation after the structure is in place.

Where blasting is required for ditch construction (i.e. rock shatter) we recommend that measures be taken to protect the toe of the cut slope to prevent weakening of the rock slope.

All rock excavations, foundation bases and bearing surfaces should be inspected and approved by qualified engineering personnel with expertise in rock mechanics and familiar with the findings of this report. The rock surface which will receive the foundation and/or mass concrete should be properly cleared of all overburden, debris and shattered, unsuitable rock in order to provide a suitable bond between the concrete and the rock surface. Similarly the surface of the mass concrete should be properly cleaned to achieve a good bond with the foundation concrete.

6.0 CLOSURE

We recommend that once the details of the structure are finalized, our recommendations be reviewed for their specific applicability.

Sincerely,

Andrew Drevininkas, P. Eng.

LICENSED PROFESSIONAL ENGINEER
A. R. DREVININKAS
PROVINCE OF ONTARIO

Eric Chung, M. Eng., P. Eng.
MTO Designated Contact

REGISTERED PROFESSIONAL ENGINEER
E. Y. CHUNG
PROVINCE OF ONTARIO

AD/dee

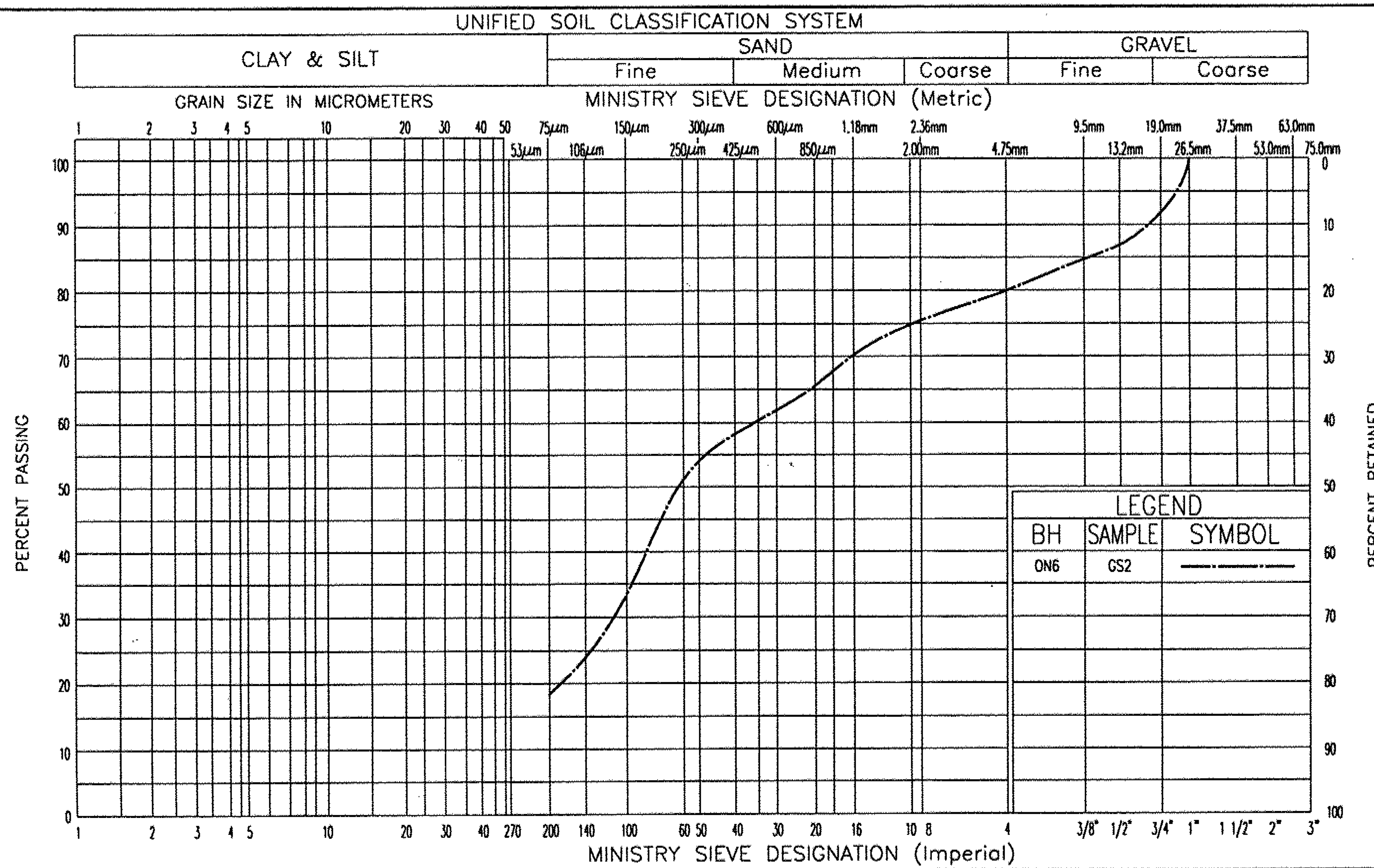
APPENDIX A

AGRA
ENGINEERING GLOBAL SOLUTIONS

PROBE NO.	STATION	OFFSETS	APPROXIMATE GROUND SURFACE ELEVATION (m)	DEPTH OF AUGER REFUSAL (m)	APPROXIMATE AUGER REFUSAL ELEVATION (m)
	SOUTH ABUTMENT				
NBS1	21+092	8 RT Centerline	322 ±	3.4	319 ±
NBS2	21+100	Centerline	323 ±	0.9	322 ±
NBS3	21+103	10 RT of Centerline	322 ±	2.3	320 ±
NBS4	21+105	Centerline	324 ±	1.5	322 ±
NBS5	21+105	6.5 LT of Centerline	324 ±	1.7	322 ±
NBS6	21+108	6.5 LT of Centerline	324 ±	2.0	322 ±
NBS7	21+111	6.5 LT of Centerline	325 ±	2.4	323 ±
	NORTH ABUTMENT				
NBN1	21+127	10 RT of Centerline	322 ±	0.6	321 ±
NBN2	21+129	10 RT of Centerline	322 ±	0.6	321 ±
NBN3	21+135	Centerline	324 ±	0.8	323 ±
NBN4	21+136	6.5 LT of Centerline	324 ±	1.1	323 ±
NBN5	21+138	Centerline	324 ±	0.6	323 ±
NBN6	21+142	6.5 LT of Centerline	322 ±	1.2	321 ±

FIGURES

AGRA
ENGINEERING GLOBAL SOLUTIONS

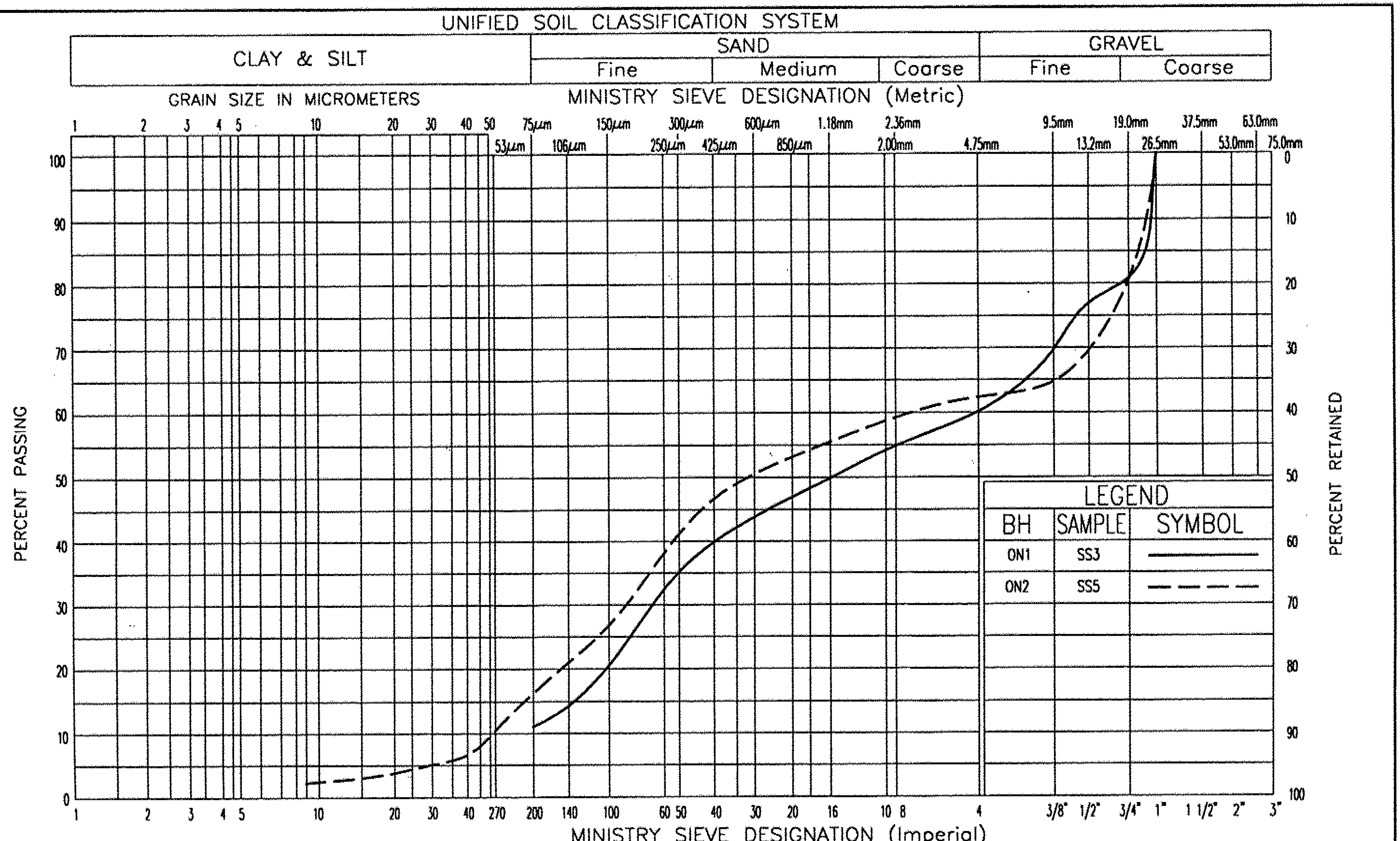


AGRA

GRAIN SIZE DISTRIBUTION
SAND

FIG No 1

W P 485-93-01

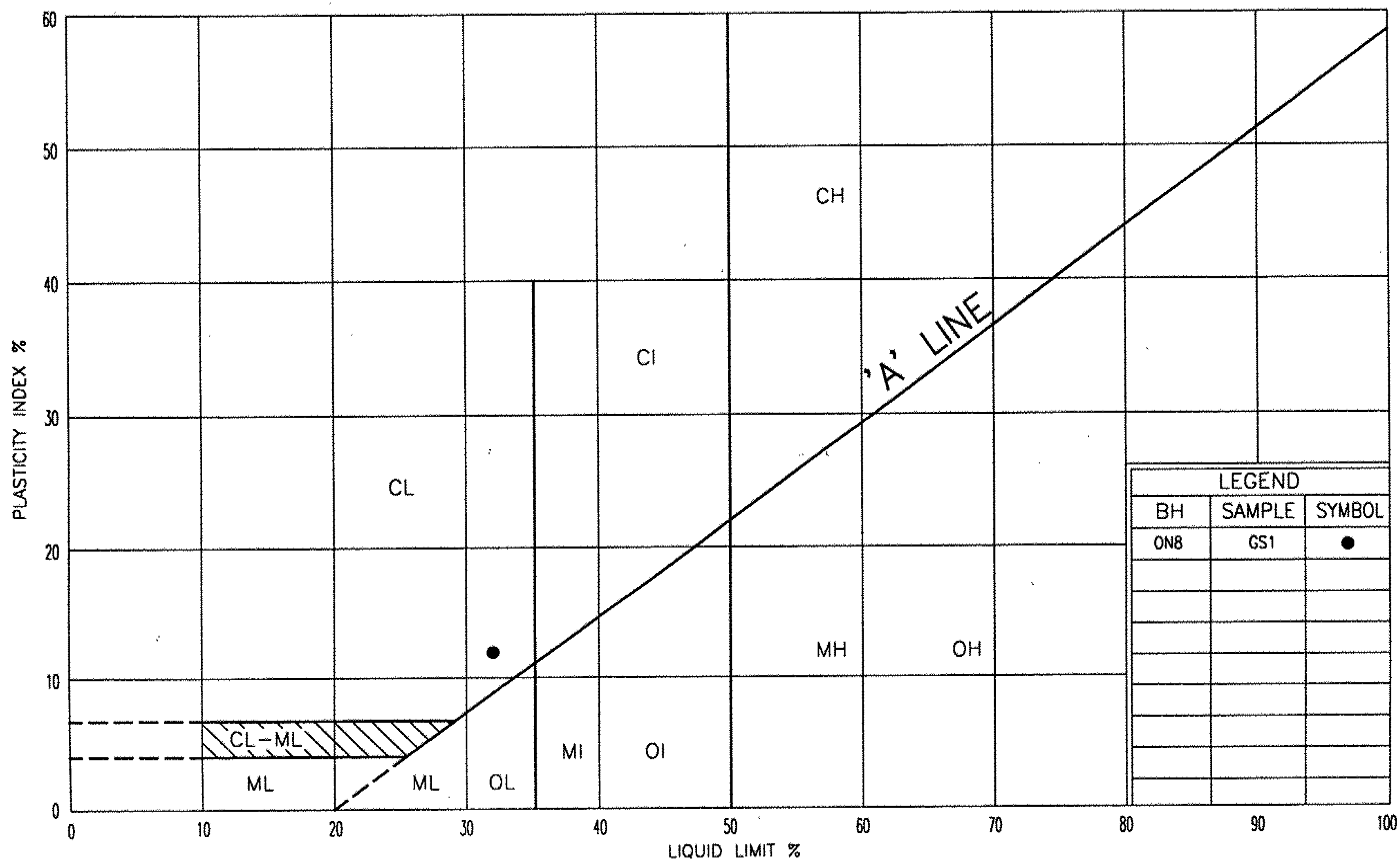


AGRA

GRAIN SIZE DISTRIBUTION
SAND & GRAVEL

FIG No 2

W P 485-93-01



AGRA

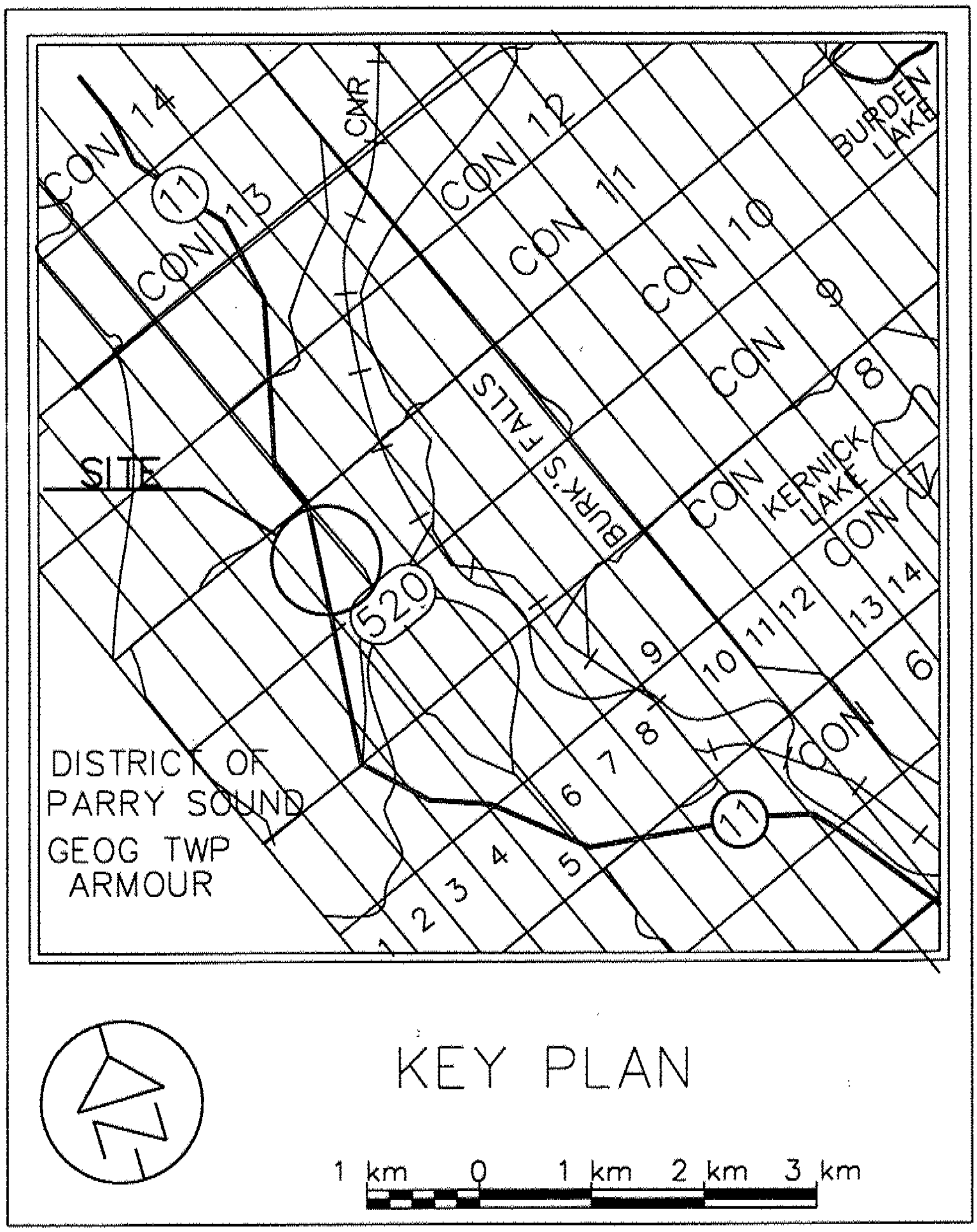
PLASTICITY CHART
CLAYEY SILT

FIG No 3

W P 485-93-01

ENCLOSURES

AGRA
ENGINEERING GLOBAL SOLUTIONS



NBL & REALIGNED ONTARIO STREET CROSSING KEY PLAN	Dwg. No 1	AGRA

AGRA

Foundation Design

RECORD OF BOREHOLE No ON1

METRIC

W.P. 485-93-01 LOCATION Site No. 44-398N N 5054702 E 311583 ORIGINATED BY AD

DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem COMPILED BY AD

DATUM Geodetic DATE 5 May 1999 CHECKED BY EYC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
322.5						
0.0	brown **SAND** with Gravel, trace Rootlets compact, damp	1	SS	23	o	STATION 21+121 8 RT NBL C/L
321.9 / 0.6	brown **SILTY SAND** some gravel trace Rootlets very dense, damp	2	SS	82/29	o	
321.0 / 1.5	brown **SAND & GRAVEL** frequent cobbles, some Silt very dense, moist	3	SS	50/13	o	40 49 (11)
		4	RC			
319.8 / 2.7	**GNEISS BEDROCK** massive, with frequent mica inclusions closely to moderately closely jointed	5	RC			RC5: REC=65% RQD=60%
		6	RC			RC6: REC=100% RQD=100%
		7	RC			RC7: REC=100% RQD=83%
		8	RC			RC8: REC=100% RQD=100%
	occasional silt infillings	9	RC			RC9: REC=100% RQD=39%
314.9 / 7.6	END OF BOREHOLE No water in borehole prior to coring.					

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (322, 321, 320, 319, 318, 317, 316, 315); 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 (%) 10 20 30; UNIT WEIGHT γ kN/m³

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

AGRA

RECORD OF BOREHOLE No ON2

METRIC

W.P. 485-93-01 | LOCATION Site No. 44-398N N 5054669 E 311584 | ORIGINATED BY AD

DIST 52 HWY 11 | BOREHOLE TYPE Hollow Stem | COMPILED BY AD

DATUM Geodetic | DATE 8 May 1999 | CHECKED BY EYC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS
321.8					
0.0	0.2m TOPSOIL brown **SILTY SAND** very loose, damp	1	SS	3	STATION 21+088 9 RT NBL C/L
321.0 / 0.8	brown **SAND** some Silt compact, damp	2	SS	27	
		3	SS	27	
319.7 / 2.1	SILT; brown **SAND & GRAVEL** frequent cobbles and boulders some Silt dense to very dense, damp	4	SS	50/4	N=50/4 denotes 50 blows for 4 cm penetration
		5	SS	48	37 47 (16)
		6	SS	50/13	
318.2 / 3.6	0.1 m fractured; **GNEISS BEDROCK** massive occasional Mica zones closely to moderately closely jointed	7	RC		RC7: REC=97% RQD=90%
		8	RC		RC8: REC=89% RQD=72%
		9	RC		RC9: REC=96% RQD=66%
		10	RC		RC10: REC=97% RQD=60%
	frequent Mica zones 0.1 to 0.2 m thick	11	RC		RC11: REC=100% RQD=67%
		12	RC		RC12: REC=79% RQD=55%
		13	RC		RC13: REC=94% RQD=38%
		14	RC		RC14: REC=97% RQD=69%
	occasional Sand infillings	15	RC		RC15: REC=100% RQD=100%
306.5 / 15.3	END OF BOREHOLE. Water Level in PIEZOMETER July 9/99: 7.3m				

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (321 to 307); 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 (%) (10 20 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

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

RECORD OF BOREHOLE No ON3

METRIC

W.P. 485-93-01 LOCATION Site No. 44-398N N 5054682 E 311576 ORIGINATED BY AD

DIST 52 HWY 11 BOREHOLE TYPE Backhoe COMPILED BY AD

DATUM Geodetic DATE 28 June 1999 CHECKED BY EYC

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 (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
323.1											
0.0	**TOPSOIL** with cobbles and boulders						323				STATION 21+101 1 RT NBL C/L
322.5 / 0.6	brown **SAND** with Gravel frequent cobbles, boulders damp						322				
321.6 / 1.5	END OF TESTPIT ON BEDROCK Water Level on Completion: dry										

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

AGRA

Foundation Design

RECORD OF BOREHOLE No ON4

METRIC

W.P. 485-93-01
LOCATION Site No. 44-398N N 5054692 E 311573
ORIGINATED BY AD

DIST 52 HWY 11
BOREHOLE TYPE Backhoe
COMPILED BY AD

DATUM Geodetic
DATE 28 June 1999
CHECKED BY EYC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
324.0											
0.0	0.15 m TOPSOIL brown **SILTY SAND** some cobbles and boulders damp										STATION 21+112 2 LT NBL C/L
323.1 0.9	END OF TESTPIT ON BEDROCK Water Level on Completion: dry										

+³, ×³: Numbers refer to Sensitivity   O³% STRAIN AT FAILURE

AGRA

RECORD OF BOREHOLE No ON5

METRIC

W.P. 485-93-01 | LOCATION Site No. 44-398N N 5054705 E 311585 | ORIGINATED BY AD

DIST 52 HWY 11 | BOREHOLE TYPE Backhoe | COMPILED BY AD

DATUM Geodetic | DATE 28 June 1999 | CHECKED BY EYC

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	STRAT PLOT	SAMPLES – NUMBER	SAMPLES – TYPE	SAMPLES – "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
322.2											
0.0	0.3m TOPSOIL brown, **SILTY SAND** with cobbles and boulders some organics, damp						322 321				STATION 21+124 11 RT NBL C/L
320.8 1.4	END OF TESTPIT ON BEDROCK Water Level on Completion: dry										

+³, ×³: Numbers refer to Sensitivity

O³% STRAIN AT FAILURE

AGRA

Foundation Design

RECORD OF BOREHOLE No ON6 — 1 OF 1 — METRIC

W.P. 485-93-01 LOCATION Site No. 44-398N N 5054713 E 311575 ORIGINATED BY AD

DIST 52 HWY 11 BOREHOLE TYPE Backhoe COMPILED BY AD

DATUM Geodetic DATE 28 June 1999 CHECKED BY EYC

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 (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
324.4											
0.0	0.3m TOPSOIL brown **SAND** some Gravel, some Silt with cobbles and boulders damp		1	GS			324		o (~10)		
			2	GS					o (~7)		20 62 (18)
323.2 1.2	END OF TESTPIT ON BEDROCK Water Level on Completion: dry										STATION 21+132 1 RT NBL C/L

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

RECORD OF BOREHOLE No ON7

METRIC

W.P. 485-93-01
LOCATION Site No. 44-398N N 5054718 E 311568
ORIGINATED BY AD
DIST 52 HWY 11
BOREHOLE TYPE Backhoe
COMPILED BY AD
DATUM Geodetic
DATE 28 June 1999
CHECKED BY EYC

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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
323.6											
0.0	EXPOSED BEDROCK AT SURFACE										
							323				
											STATION 21+138 5 LT NBL C/L

$+^3, \times^3$: Numbers refer to Sensitivity

$O^{3\%}$ STRAIN AT FAILURE

AGRA

RECORD OF BOREHOLE No ON8

METRIC

W.P. 485-93-01 LOCATION Site No. 44-398N N 5054666 E 311574 ORIGINATED BY AD

DIST 52 HWY 11 BOREHOLE TYPE Backhoe COMPILED BY AD

DATUM Geodetic DATE 28 June 1999 CHECKED BY EYC

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 (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
322.2											
0.0	0.2m TOPSOIL brown **SILTY SAND** with cobbles and boulders						322				
321.7 / 0.5	grey/brown **CLAYEY SILT** varve-like structure hard		1	GS							
			2	GS			321				STATION 21+085 1 LT NBL C/L
							320				
319.4 / 2.8	END OF TESTPIT ON BEDROCK Water Level on Completion: dry										

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

AGRA

Foundation Design

RECORD OF BOREHOLE No ON9

METRIC

W.P. 485-93-01 | LOCATION Site No. 44-398N N 5054662 E 311587 | ORIGINATED BY AD

DIST 52 HWY 11 | BOREHOLE TYPE Backhoe | COMPILED BY AD

DATUM Geodetic | DATE 28 June 1999 | CHECKED BY EYC

ELEV / DEPTH	DESCRIPTION	REMARKS & GRAIN SIZE DISTRIBUTION (%)
320.7		
0.0	0.15m TOPSOIL brown **SILTY SAND** with cobbles and boulders	
320.3 / 0.4	grey/brown **CLAYEY SILT** varve-like structure hard	STATION 21+082 12 RT NBL C/L
317.0 / 3.7	brown/grey **SILTY SAND**	
316.4 / 4.3	END OF TESTPIT ON BEDROCK Water Level on Completion: dry	

Column headings: SOIL PROFILE (ELEV/DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (320, 319, 318, 317); 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 (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

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

RECORD OF BOREHOLE No ON10

METRIC

W.P. 485-93-01 LOCATION Site No. 44-398N N 5054731 E 311574 ORIGINATED BY AD

DIST 52 HWY 11 BOREHOLE TYPE Backhoe COMPILED BY AD

DATUM Geodetic DATE 28 June 1999 CHECKED BY EYC

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 (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
324.5											
0.0	0.3m TOPSOIL										
324.1	brown, **SILTY SAND** with cobbles and boulders						324				
0.5	END OF TESTPIT ON BEDROCK										
	Water Level on Completion: dry										STATION 21+150 2 RT NBL C/L

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

RECORD OF BOREHOLE No ON11

METRIC

W.P.	485-93-01	LOCATION	Site No. 44-398N N 5054731 E 311587	ORIGINATED BY	AD
DIST 52	HWY 11	BOREHOLE TYPE	Backhoe	COMPILED BY	AD
DATUM	Geodetic	DATE	28 June 1999	CHECKED BY	EYC

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 (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
321.8											
0.0	0.2m TOPSOIL brown **SILTY SAND** with gravel, cobbles and boulders										
321.1 0.7	brown/grey **SAND & GRAVEL** with cobbles and boulders		1	GS			321				STATION 21+149 12 RT NBL C/L
	with silt						320				
319.8 2.0	END OF TESTPIT ON BEDROCK Water Level on Completion: dry										

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

OVERSIZE DRAWING(S)

FOUNDATION INVESTIGATION REPORT
FOR
PROPOSED ONTARIO STREET OVERPASS, SBL
STRUCTURE SITE NO. 44-398S
DISTRICT 52, HUNTSVILLE
W.P. 486-93-01

Submitted To:

Delcan Corporation
133 Wynford Drive
North York, Ontario, M3C 1K1
Canada

Submitted By:

AGRA
104 Crockford Blvd.
Scarborough, Ontario, M1R 3C6
Canada

February 2000
TT98820G

AGRA
ENGINEERING GLOBAL SOLUTIONS

AGRA
ENGINEERING GLOBAL SOLUTIONS

AGRA Earth & Environmental Limited
104 Crockford Blvd.
Scarborough, Ontario
Canada M1R 3C6
Tel (416) 751-6565
Fax (416) 751-7592

February 9, 1999.
Ref. No.: TT98820G

Delcan Corporation
133 Wynford Drive
North York, Ontario, M3C 1K1
Canada

Attention: **Mr. Khaled El-Dalati, P. Eng.**

Dear Sir:

Re: **FOUNDATION INVESTIGATION REPORT FOR PROPOSED ONTARIO STREET OVERPASS, SBL STRUCTURE SITE NO. 44-398S DISTRICT 52, HUNTSVILLE W.P. 473-93-00**

We take pleasure in enclosing eight (8) copies of our Foundation Investigation Report carried out for the above mentioned project and we will be glad to discuss any questions arising from this work.

Soil samples will be retained for a period of one year, and will thereafter be disposed of unless we are otherwise instructed.

We thank you for giving us this opportunity to be of service to you.

Sincerely,

George S. Chow, P. Eng.,
Designated MTO Contact.

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APPENDICES

APPENDIX A: **Auger Probe Results**

ENCLOSURES

KEY PLAN DWG. NO. 1
BOREHOLE AND TESTPIT LOG SHEETS
BOREHOLE LOCATIONS AND SOIL STRATA DWG. NO. 2

1.0 INTRODUCTION

AGRA, Consulting Geotechnical Engineers, was retained by Delcan Corporation to conduct a foundation investigation at the site of a proposed bridge that will carry the proposed southbound lanes (SBL) of Highway 11 and associated interchange ramps over the proposed realigned Ontario Street. The site is located near the Village of Burk's Falls, about 200 m north of the existing Ontario Street intersection with Highway 11, in the Township of Armour, Lot 5, Concession 10 in MTO District 52 - Huntsville (see Key Plan, Drawing No. 1). The proposed bridge will be an approximately 33 m long, three lane, single span structure.

The purpose of the investigation has been to obtain information about the subsurface conditions at the site of the proposed bridge and approach embankments by means of exploratory boreholes, and testpits and based on the findings, to provide recommendations for the foundation design of the proposed structure and approach fills/cuts.

2.0 SITE DESCRIPTION AND PHYSIOGRAPHY

The site is located about 200 m north of the intersection of the existing Highway 11 and existing Ontario Street, near the Village of Burk's Falls. Existing Highway 11 alignment is parallel and located to the east of the proposed bridge. An existing rock cut parallels the bridge alignment along Highway 11, with a maximum rock face height of about 7.5 m. The ground surface rises to the southwest and slopes to the north. The area to the west is sparsely wooded.

Based on available geologic information, the site is in an area of discontinuous thin drift deposits over bedrock. The drift in the area is a mixture of glacial till, glaciolacustrine and glaciofluvial sediments. Generally after the last glacial withdrawal, ice-contact sediments (sands and gravels) followed by glaciofluvial sediments (ranging from deltaic and nearshore sands and gravels to prodeltaic and lake bottom silts and clays) were deposited on top of the existing sandy to clayey glacial till or Precambrian bedrock. The area was then inundated by glacial Lake Algonquin depositing sands, silts and clays in the low lying areas.

Published information show that the bedrock can be expected to be composed of strongly foliated, gneissic to migmatic rocks which form part of the Central Gneiss Belt of the Grenville Province (a structural subdivision of the Canadian Shield).

3.0 INVESTIGATION PROCEDURES

The field work for the investigation was carried out during the period of May 5, 6, 8 and 9, and June 28, 1999, and consisted of drilling and coring two boreholes (Borehole Nos. OS1 and OS2) to depths of 15.2 and 5.9 m below the ground surface, twelve auger probes and five testpits (OS3 through OS7).

The plan locations of the boreholes and testpits, along with stratigraphic sections are shown on Drawing No. 2. Details of the subsurface conditions encountered at each borehole and testpit location, including the results of in-situ testing, are presented on the Borehole and Testpit Log Sheets. The results of the auger probes are tabulated in Appendix A.

The boreholes were advanced using solid and hollow stem continuous flight augers with a track-mounted power auger drilling rig (CME 75) owned and operated by Canadian Soil Drilling Inc., and a track-mounted power auger drilling rig (BOA 6M) owned and operated by Groundworks Drilling Inc., under the full-time supervision of experienced geotechnical personnel from AGRA.

Sampling in the boreholes was effected at frequent intervals of depth by the Standard Penetration Test Method (SPT), as specified in ASTM Method D 1586. This consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a 51 mm diameter o.d. split barrel (split-spoon) sampler into the ground. The number of blows of the hammer to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.30 m is recorded as the Standard Penetration Resistance or the 'N'-value of the soil and this gives an indication of the consistency or the compactness condition of the soil deposit.

Coring of the bedrock was effected by diamond drilling methods, using an NQ size core barrel.

The testpits were advanced using a rubber-tire backhoe owned and operated by Stevenson Excavating Limited, supervised by a Professional Engineer from AGRA.

The borehole locations were established in the field by our engineering staff, in relation to the already staked out proposed centre-line of the southbound lane of Highway 11 (by Dearden and Stanton Limited). The borehole geodetic elevations and co-ordinates were subsequently taken by surveyors from Dearden and Stanton Limited and supplied to us.

The soil samples and rock cores were shipped to our geotechnical laboratory in Toronto (Scarborough) for further examination and classification. A laboratory testing programme, consisting of natural moisture content determinations was performed on selected representative soil samples. The results of the laboratory tests are presented on the appropriate Borehole and Testpit Log Sheets.

A standpipe piezometer was installed in Borehole OS1 to monitor the water level over a prolonged period of time. Borehole OS2 was grouted on completion.

.../...

4.0 SUBSURFACE CONDITIONS

The subsurface conditions were explored at two borehole locations (Borehole Nos. OS1 and OS2), twelve auger probes and five testpits. The locations of the boreholes and testpits are shown on the Plan and Profile Drawing No. 2 and are also indicated on the individual Borehole and Testpit Log Sheets. Cross-sections of inferred subsurface stratigraphy are given on Drawing No. 2. The results of the auger probes are tabulated in Appendix A.

The ground surface at the proposed site slopes to the north and drops to the existing grade of Highway 11 surface to the east, with the ground elevation at the proposed bridge location generally ranging from about 333.0 to 322.0 m.

Below a surficial topsoil layer, the overburden, where encountered, generally consists of silty sand, sand, and sand & gravel deposits to depths ranging from 0.2 to 1.5 m below existing grade. Granular fill was encountered at the southeast corner of the proposed bridge at the base of the rock cut. Below the overburden soils is the Precambrian bedrock. Along the east alignment of the bridge site, the overburden soils have been stripped along the top of the existing rock cut. At the time of the investigation, no groundwater was encountered within the overburden.

Details of the subsurface conditions encountered in the boreholes are presented on the Borehole and Testpit Log Sheets. Descriptions of various strata are given in the following paragraphs.

4.1 TOPSOIL

A surficial topsoil layer, ranging in thickness from 0.1 to 0.4 m, was encountered in Testpits OS4 and OS6, respectively.

In our experience the thickness of topsoil frequently varies in between and beyond the borehole and testpit locations.

4.2 SILTY SAND TO SAND TO SAND & GRAVEL

Underlying the topsoil in Testpits OS4 and OS6, and at the surface in Testpits OS3 and OS5 and Borehole OS1, silty sand, sand, and sand & gravel deposits were encountered to a depth of 0.3 to 1.5 m (Elevation 330.4 to 326.7 m) below existing grade.

An 'N' value of 22 blows/0.3 m was measured in Borehole OS1 within this deposit indicating a compact condition. Occasional cobbles and boulders were encountered in the boreholes and testpits.

4.3 SAND FILL

At the base of the existing rock cut, Borehole OS2 and Testpit OS7 were advanced, encountering 0.2 to 0.8 m of sand with gravel pavement fill. An 'N'-value of 59 blows/0.3 m was measured within this fill in Borehole OS2 indicating that the fill has received some compactive effort.

4.4 BEDROCK

Below the overburden, bedrock was encountered and cored to obtain NQ size cores in Boreholes OS1 and OS2 at depths of 1.5 m or Elevation 327.1 m and 0.8 m or Elevation 321.9 m, respectively.

Auger probes and testpits were advanced at the site to attempt to delineate the undulating bedrock surface. Auger and excavation refusal on probable bedrock was encountered in the twelve auger probes and five testpits advanced at the site, respectively. The probe results are given in Appendix A. The findings show that the recorded refusal depths range from exposed bedrock along the rock cut or Elevation 330 to 321 ± m, to 0.8 m or Elevation 321.9 m at Borehole OS2. It is believed that while in most cases the refusal depths represent the surface of the bedrock, in some cases they may be due to cobbles and boulders in the overburden (probably immediately above the bedrock elevation).

From the results, it can be surmised that in the general area of the proposed north abutment location, the presumed bedrock surface elevation generally ranges from 328 to 327 ± m. In the general area of the south abutment location the presumed bedrock surface generally ranges from 332 to 322 ± m.

The rock was cored for a vertical distance of 13.7 m at Borehole OS1 and 5.1 m at Borehole OS2.

From the recovered rock cores the bedrock is a massive, closely to moderately closely jointed, Precambrian gneiss. It is generally sound, while in the surficial zone in some areas (Testpit OS3) the upper 0.3 m is fractured. The bedrock at the base of the existing rock cut is highly fractured to a depth of 0.8 m (Borehole OS2), likely due to rock shatter during blasting for construction of the existing highway. Occasional mica inclusions were encountered throughout the bedrock.

In Boreholes OS1 and OS2 the bedrock has a Rock Quality Designation (RQD) of 83 to 100%, except within the top 2.3 m of Borehole OS2 (the first two core runs) where RQD measurements of 13 and 50% were obtained, likely due to blast damage during the excavation of the rock cut. Core recovery was 90 to 100%, except within a highly fractured zone (the top 0.8 m of Borehole OS2) where core recovery was 40%. Based on these results, and visual examination of the rock cores, the bedrock is of good to excellent quality, but very poor within the rock shatter zone in Borehole OS2.

From the results of the boreholes, testpits and auger probes, the bedrock surface in the general area appears to be dipping toward the north and east. To the east, the bedrock drops to the existing Highway 11 shoulder, having been excavated for the construction of the highway. It should be noted that due to undulations at the surface of the bedrock, which is not uncommon in Northern Ontario, the bedrock elevation in between and beyond the boreholes and testpits may vary considerably.

4.5 GROUNDWATER CONDITIONS

Groundwater conditions in the open boreholes and testpits were observed during drilling and at the completion of sampling. No groundwater was observed in the overburden of any of the boreholes drilled or testpits excavated, which was confirmed by the measured natural moisture contents of the recovered samples. One standpipe piezometer was installed in Borehole OS1 to monitor the water level without interference from surface water. A water level of 8.3 m (or Elevation 320.3 m) below existing ground surface was measured two months after installation, likely indicating the groundwater table within the bedrock.

It should, however, be pointed out that the groundwater at the site would fluctuate seasonally and in response to major weather events. A perched water table may exist in the sand overburden overlying the bedrock.

5.0 CLOSURE

Sincerely,

Andrew Drevininkas, P. Eng.

LICENSED PROFESSIONAL ENGINEER
A. R. DREVININKAS
PROVINCE OF ONTARIO

Eric Chung, M. Eng., P. Eng.
MTO Designated Contact

REGISTERED PROFESSIONAL ENGINEER
E. Y. CHUNG
PROVINCE OF ONTARIO

APPENDIX A

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PROBE NO.	STATION	OFFSETS	APPROXIMATE GROUND SURFACE ELEVATION (m)	DEPTH OF AUGER REFUSAL (m)	APPROXIMATE AUGER REFUSAL ELEVATION (m)
	SOUTH ABUTMENT				
SBS1	21+133	Centerline	329 ±	0	329 ±
SBS2	21+135	Centerline	329 ±	0	329 ±
SBS3	21+135	11 LT of Centerline	332 ±	0	332 ±
SBS4	21+141	11 LT of Centerline	331 ±	0	331 ±
SBS5	21+135	10 RT of Centerline	323 ±	0.8	322 ±
SBS6	21+129	10 RT of Centerline	323 ±	1.1	322 ±
	NORTH ABUTMENT				
SBN1	21+157	6.5 RT of Centerline	327 ±	0	327 ±
SBN2	21+160	Centerline	328 ±	0.2	328 ±
SBN3	21+163	6.5 RT of Centerline	327 ±	0	327 ±
SBN4	21+167	Centerline	328 ±	1.1	327 ±
SBN5	21+176	8 LT Centerline	329 ±	0.6	328 ±
SBN6	21+171	8 LT Centerline	329 ±	1.2	328 ±

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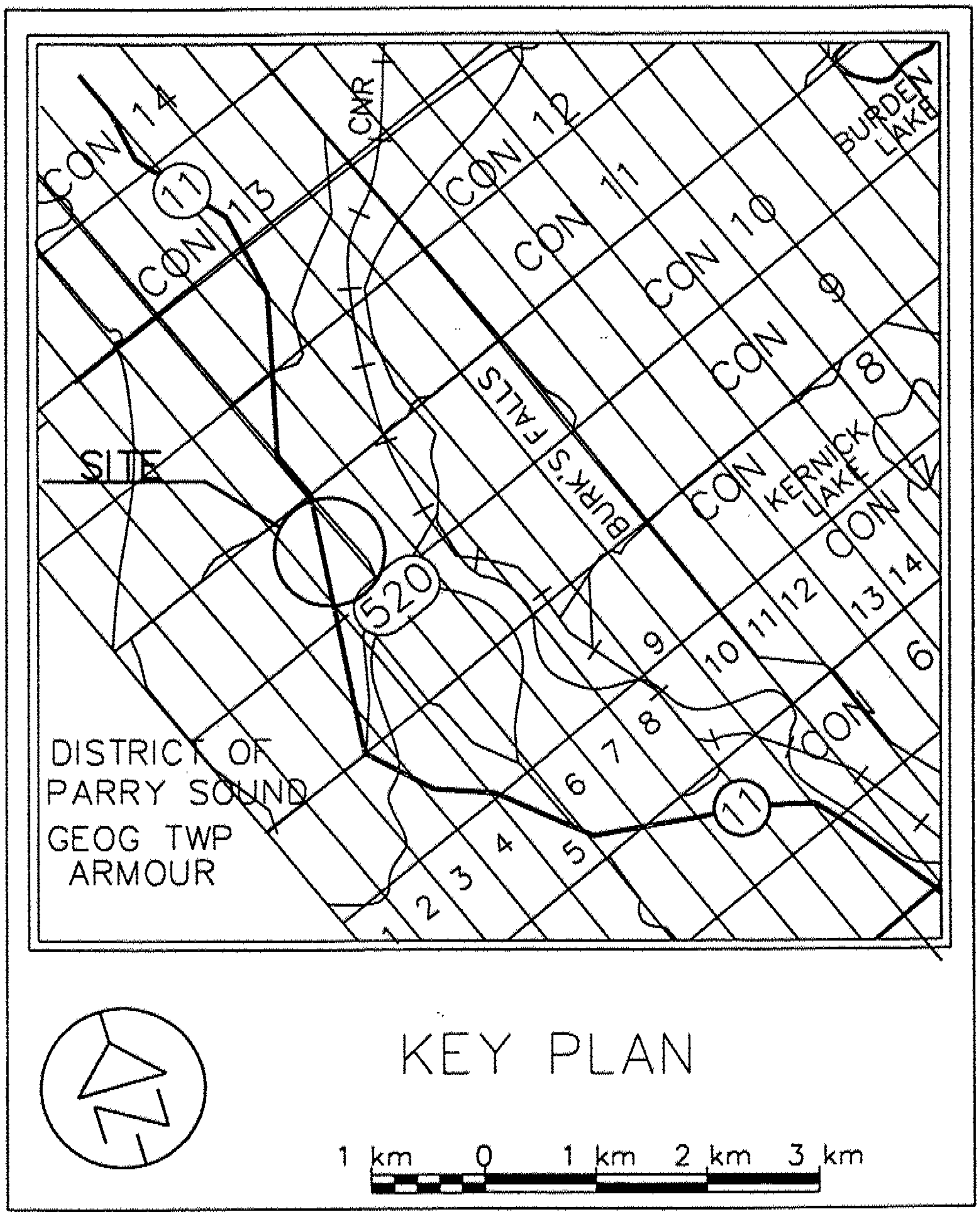

KEY PLAN

SBL & REALIGNED ONTARIO STREET CROSSING KEY PLAN	Dwg. No 1	AGRA

RECORD OF BOREHOLE No ON1

METRIC

W.P. 485-93-01 LOCATION Site No. 44-398N N 5054702 E 311583 ORIGINATED BY AD

DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem COMPILED BY AD

DATUM Geodetic DATE 5 May 1999 CHECKED BY EYC

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
322.5							STATION 21+121 8 RT NBL C/L
0.0	brown **SAND** with Gravel, trace Rootlets compact, damp	1	SS	23	322	o	
321.9 / 0.6	brown **SILTY SAND** some gravel trace Rootlets very dense, damp	2	SS	82/29		o	
321.0 / 1.5	brown **SAND & GRAVEL** frequent cobbles, some Silt very dense, moist	3	SS	50/13	321	o	40 49 (11)
		4	RC		320		
319.8 / 2.7	**GNEISS BEDROCK** massive, with frequent mica inclusions closely to moderately closely jointed	5	RC				RC5: REC=65% RQD=60%
		6	RC		319		RC6: REC=100% RQD=100%
		7	RC		318		RC7: REC=100% RQD=83%
		8	RC		317		RC8: REC=100% RQD=100%
	occasional silt infillings	9	RC		316		RC9: REC=100% RQD=39%
314.9 / 7.6	END OF BOREHOLE No water in borehole prior to coring.				315		

Column headings: SOIL PROFILE; STRAT PLOT; 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 (%) 10 20 30; UNIT WEIGHT γ kN/m³.

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

AGRA

RECORD OF BOREHOLE No ON2

METRIC

W.P. 485-93-01	LOCATION Site No. 44-398N N 5054669 E 311584		ORIGINATED BY AD
DIST 52	HWY 11	BOREHOLE TYPE Hollow Stem	COMPILED BY AD
DATUM Geodetic	DATE 8 May 1999		CHECKED BY EYC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT / LIMITS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
321.8 / 0.0	0.2m TOPSOIL brown **SILTY SAND** very loose, damp	1	SS	3			STATION 21+088 9 RT NBL C/L
321.0 / 0.8	brown **SAND** some Silt compact, damp	2	SS	27	321		
		3	SS	27	320		
319.7 / 2.1	SILT; brown **SAND & GRAVEL** frequent cobbles and boulders some Silt dense to very dense, damp	4	SS	50/4			N=50/4 denotes 50 blows for 4 cm penetration
		5	SS	48	319		37 47 (16)
318.2 / 3.6		6	SS	50/13			
	0.1 m fractured; **GNEISS BEDROCK** massive occasional Mica zones closely to moderately closely jointed	7	RC		318		RC7: REC=97% RQD=90%
		8	RC		317 / 316		RC8: REC=89% RQD=72%
		9	RC		315		RC9: REC=96% RQD=66%
		10	RC		314 / 313		RC10: REC=97% RQD=60%
	frequent Mica zones 0.1 to 0.2 m thick	11	RC		312 / 311		RC11: REC=100% RQD=67%
		12	RC		310		RC12: REC=79% RQD=55%
		13	RC		309		RC13: REC=94% RQD=38%
		14	RC		308		RC14: REC=97% RQD=69%
	occasional Sand infillings	15	RC		307		RC15: REC=100% RQD=100%
306.5 / 15.3	END OF BOREHOLE Water Level in PIEZOMETER July 9/99: 7.3m						

Column headings: SOIL PROFILE; STRAT PLOT; 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 (%) 10 20 30; UNIT WEIGHT γ kN/m³

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

AGRA

Foundation Design

RECORD OF BOREHOLE No ON3

METRIC

W.P. 485-93-01 | LOCATION Site No. 44-398N N 5054682 E 311576 | ORIGINATED BY AD

DIST 52 HWY 11 | BOREHOLE TYPE Backhoe | COMPILED BY AD

DATUM Geodetic | DATE 28 June 1999 | CHECKED BY EYC

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 (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
323.1											
0.0	**TOPSOIL** with cobbles and boulders						323				STATION 21+101 1 RT NBL C/L
322.5 / 0.6	brown **SAND** with Gravel frequent cobbles, boulders damp						322				
321.6 / 1.5	END OF TESTPIT ON BEDROCK Water Level on Completion: dry										

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

AGRA

RECORD OF BOREHOLE No ON4

METRIC

W.P. 485-93-01 LOCATION Site No. 44-398N N 5054692 E 311573 ORIGINATED BY AD

DIST 52 HWY 11 BOREHOLE TYPE Backhoe COMPILED BY AD

DATUM Geodetic DATE 28 June 1999 CHECKED BY EYC

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 (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
324.0											
0.0	0.15 m TOPSOIL brown **SILTY SAND** some cobbles and boulders damp										STATION 21+112 2 LT NBL C/L
323.1 0.9	END OF TESTPIT ON BEDROCK Water Level on Completion: dry										

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

RECORD OF BOREHOLE No ON5

METRIC

W.P. 485-93-01 LOCATION Site No. 44-398N N 5054705 E 311585 ORIGINATED BY AD

DIST 52 HWY 11 BOREHOLE TYPE Backhoe COMPILED BY AD

DATUM Geodetic DATE 28 June 1999 CHECKED BY EYC

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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
322.2											
0.0	0.3m TOPSOIL brown, **SILTY SAND** with cobbles and boulders some organics, damp						322				STATION 21+124 11 RT NBL C/L
320.8							321				
1.4	END OF TESTPIT ON BEDROCK Water Level on Completion: dry										

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

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Foundation Design

RECORD OF BOREHOLE No ON6

METRIC

W.P. 485-93-01 LOCATION Site No. 44-398N N 5054713 E 311575 ORIGINATED BY AD

DIST 52 HWY 11 BOREHOLE TYPE Backhoe COMPILED BY AD

DATUM Geodetic DATE 28 June 1999 CHECKED BY EYC

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 (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
324.4											
0.0	0.3m TOPSOIL brown **SAND** some Gravel, some Silt with cobbles and boulders damp		1 2	GS GS			324				20 62 (18) STATION
323.2 1.2	END OF TESTPIT ON BEDROCK Water Level on Completion: dry										21+132 1 RT NBL C/L

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

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Foundation Design

RECORD OF BOREHOLE No ON7

METRIC

W.P.	485-93-01	LOCATION	Site No. 44-398N N 5054718 E 311568	ORIGINATED BY	AD
DIST 52	HWY 11	BOREHOLE TYPE	Backhoe	COMPILED BY	AD
DATUM	Geodetic	DATE	28 June 1999	CHECKED BY	EYC

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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
323.6 / 0.0	EXPOSED BEDROCK AT SURFACE						323				STATION 21+138 5 LT NBL C/L

+3, ×3: Numbers refer to Sensitivity

O 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No ON8

1 OF 1 **METRIC**

W.P. 485-93-01 LOCATION Site No. 44-398N N 5054666 E 311574 ORIGINATED BY AD

DIST 52 HWY 11 BOREHOLE TYPE Backhoe COMPILED BY AD

DATUM Geodetic DATE 28 June 1999 CHECKED BY EYC

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES 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
322.2											
0.0	0.2m TOPSOIL brown **SILTY SAND** with cobbles and boulders						322				
321.7 0.5	grey/brown **CLAYEY SILT** varve-like structure hard		1	GS					Wp–w–WL plotted (approx. 20–32)		STATION 21+085 1 LT NBL C/L
			2	GS			321				
							320				
319.4 2.8	END OF TESTPIT ON BEDROCK Water Level on Completion: dry										

Legend: 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 (%) 10 20 30

+3, X3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No ON9

METRIC

W.P. 485-93-01 LOCATION Site No. 44-398N N 5054662 E 311587 ORIGINATED BY AD

DIST 52 HWY 11 BOREHOLE TYPE Backhoe COMPILED BY AD

DATUM Geodetic DATE 28 June 1999 CHECKED BY EYC

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
320.7											
0.0	0.15m TOPSOIL										
320.3 / 0.4	brown **SILTY SAND** with cobbles and boulders										
	grey/brown **CLAYEY SILT** varve-like structure hard						320				STATION 21+082 12 RT NBL C/L
							319				
							318				
317.0 / 3.7	brown/grey **SILTY SAND**						317				
316.4 / 4.3	END OF TESTPIT ON BEDROCK Water Level on Completion: dry										

Legend: O UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; X LAB VANE. Plastic limit W_P, natural moisture content w, liquid limit W_L.

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

RECORD OF BOREHOLE No ON10

METRIC

W.P. 485-93-01 LOCATION Site No. 44-398N N 5054731 E 311574 ORIGINATED BY AD

DIST 52 HWY 11 BOREHOLE TYPE Backhoe COMPILED BY AD

DATUM Geodetic DATE 28 June 1999 CHECKED BY EYC

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 (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
324.5											
0.0	0.3m TOPSOIL										
324.1 / 0.5	brown, **SILTY SAND** with cobbles and boulders						324				
	END OF TESTPIT ON BEDROCK										STATION 21+150 2 RT NBL C/L
	Water Level on Completion: dry										

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

RECORD OF BOREHOLE No ON11

METRIC

W.P. 485-93-01 LOCATION Site No. 44-398N N 5054731 E 311587 ORIGINATED BY AD

DIST 52 HWY 11 BOREHOLE TYPE Backhoe COMPILED BY AD

DATUM Geodetic DATE 28 June 1999 CHECKED BY EYC

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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
321.8											
0.0	0.2m TOPSOIL brown **SILTY SAND** with gravel, cobbles and boulders										
321.1 0.7	brown/grey **SAND & GRAVEL** with cobbles and boulders		1	GS			321				STATION 21+149 12 RT NBL C/L
	--------------- with silt						320				
319.8 2.0	END OF TESTPIT ON BEDROCK Water Level on Completion: dry										

$+^3, \times^3$: Numbers refer to Sensitivity

$O^{3\%}$ STRAIN AT FAILURE

FOUNDATION INVESTIGATION AND DESIGN REPORT
FOR
PROPOSED ONTARIO STREET OVERPASS, SBL
STRUCTURE SITE NO. 44-398S
DISTRICT 52, HUNTSVILLE
W.P. 486-93-01

Submitted To:

Delcan Corporation
133 Wynford Drive
North York, Ontario, M3C 1K1
Canada

Submitted By:

AGRA
104 Crockford Blvd.
Scarborough, Ontario, M1R 3C6
Canada

February 2000
TT98820G

AGRA
ENGINEERING GLOBAL SOLUTIONS

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February 9, 1999.
Ref. No.: TT98820G

Delcan Corporation
133 Wynford Drive
North York, Ontario, M3C 1K1
Canada

Attention: Mr. Khaled El-Dalati, P. Eng.

Dear Sir:

Re: FOUNDATION INVESTIGATION AND DESIGN REPORT
FOR
PROPOSED ONTARIO STREET OVERPASS, SBL
STRUCTURE SITE NO. 44-398S
DISTRICT 52, HUNTSVILLE
W.P. 473-93-00

We take pleasure in enclosing eight (8) copies of our Foundation Investigation and Design Report carried out for the above mentioned project and we will be glad to discuss any questions arising from this work.

Soil samples will be retained for a period of one year, and will thereafter be disposed of unless we are otherwise instructed.

We thank you for giving us this opportunity to be of service to you.

Sincerely,

George S. Chow, P. Eng.,
Designated MTO Contact.

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1.0 INTRODUCTION

AGRA, Consulting Geotechnical Engineers, was retained by Delcan Corporation to conduct a foundation investigation at the site of a proposed bridge that will carry the proposed southbound lanes (SBL) of Highway 11 and associated interchange ramps over the proposed realigned Ontario Street. The site is located near the Village of Burk's Falls, about 200 m north of the existing Ontario Street intersection with Highway 11, in the Township of Armour, Lot 5, Concession 10 in MTO District 52 - Huntsville (see Key Plan, Drawing No. 1). The proposed bridge will be an approximately 33 m long, three lane, single span structure.

The purpose of the investigation has been to obtain information about the subsurface conditions at the site of the proposed bridge and approach embankments by means of exploratory boreholes, and testpits and based on the findings, to provide recommendations for the foundation design of the proposed structure and approach fills/cuts.

2.0 SITE DESCRIPTION AND PHYSIOGRAPHY

The site is located about 200 m north of the intersection of the existing Highway 11 and existing Ontario Street, near the Village of Burk's Falls. Existing Highway 11 alignment is parallel and located to the east of the proposed bridge. An existing rock cut parallels the bridge alignment along Highway 11, with a maximum rock face height of about 7.5 m. The ground surface rises to the southwest and slopes to the north. The area to the west is sparsely wooded.

Based on available geologic information, the site is in an area of discontinuous thin drift deposits over bedrock. The drift in the area is a mixture of glacial till, glaciolacustrine and glaciofluvial sediments. Generally after the last glacial withdrawal, ice-contact sediments (sands and gravels) followed by glaciofluvial sediments (ranging from deltaic and nearshore sands and gravels to prodeltaic and lake bottom silts and clays) were deposited on top of the existing sandy to clayey glacial till or Precambrian bedrock. The area was then inundated by glacial Lake Algonquin depositing sands, silts and clays in the low lying areas.

Published information show that the bedrock can be expected to be composed of strongly foliated, gneissic to migmatic rocks which form part of the Central Gneiss Belt of the Grenville Province (a structural subdivision of the Canadian Shield).

3.0 INVESTIGATION PROCEDURES

The field work for the investigation was carried out during the period of May 5, 6, 8 and 9, and June 28, 1999, and consisted of drilling and coring two boreholes (Borehole Nos. OS1 and OS2) to depths of 15.2 and 5.9 m below the ground surface, twelve auger probes and five testpits (OS3 through OS7).

The plan locations of the boreholes and testpits, along with stratigraphic sections are shown on Drawing No. 2. Details of the subsurface conditions encountered at each borehole and testpit location, including the results of in-situ testing, are presented on the Borehole and Testpit Log Sheets. The results of the auger probes are tabulated in Appendix A.

The boreholes were advanced using solid and hollow stem continuous flight augers with a track-mounted power auger drilling rig (CME 75) owned and operated by Canadian Soil Drilling Inc., and a track-mounted power auger drilling rig (BOA 6M) owned and operated by Groundworks Drilling Inc., under the full-time supervision of experienced geotechnical personnel from AGRA.

Sampling in the boreholes was effected at frequent intervals of depth by the Standard Penetration Test Method (SPT), as specified in ASTM Method D 1586. This consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a 51 mm diameter o.d. split barrel (split-spoon) sampler into the ground. The number of blows of the hammer to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.30 m is recorded as the Standard Penetration Resistance or the 'N'-value of the soil and this gives an indication of the consistency or the compactness condition of the soil deposit.

Coring of the bedrock was effected by diamond drilling methods, using an NQ size core barrel.

The testpits were advanced using a rubber-tire backhoe owned and operated by Stevenson Excavating Limited, supervised by a Professional Engineer from AGRA.

The borehole locations were established in the field by our engineering staff, in relation to the already staked out proposed centre-line of the southbound lane of Highway 11 (by Dearden and Stanton Limited). The borehole geodetic elevations and co-ordinates were subsequently taken by surveyors from Dearden and Stanton Limited and supplied to us.

The soil samples and rock cores were shipped to our geotechnical laboratory in Toronto (Scarborough) for further examination and classification. A laboratory testing programme, consisting of natural moisture content determinations was performed on selected representative soil samples. The results of the laboratory tests are presented on the appropriate Borehole and Testpit Log Sheets.

A standpipe piezometer was installed in Borehole OS1 to monitor the water level over a prolonged period of time. Borehole OS2 was grouted on completion.

4.0 SUBSURFACE CONDITIONS

The subsurface conditions were explored at two borehole locations (Borehole Nos. OS1 and OS2), twelve auger probes and five testpits. The locations of the boreholes and testpits are shown on the Plan and Profile Drawing No. 2 and are also indicated on the individual Borehole and Testpit Log Sheets. Cross-sections of inferred subsurface stratigraphy are given on Drawing No. 2. The results of the auger probes are tabulated in Appendix A.

The ground surface at the proposed site slopes to the north and drops to the existing grade of Highway 11 surface to the east, with the ground elevation at the proposed bridge location generally ranging from about 333.0 to 322.0 m.

Below a surficial topsoil layer, the overburden, where encountered, generally consists of silty sand, sand, and sand & gravel deposits to depths ranging from 0.2 to 1.5 m below existing grade. Granular fill was encountered at the southeast corner of the proposed bridge at the base of the rock cut. Below the overburden soils is the Precambrian bedrock. Along the east alignment of the bridge site, the overburden soils have been stripped along the top of the existing rock cut. At the time of the investigation, no groundwater was encountered within the overburden.

Details of the subsurface conditions encountered in the boreholes are presented on the Borehole and Testpit Log Sheets. Descriptions of various strata are given in the following paragraphs.

4.1 TOPSOIL

A surficial topsoil layer, ranging in thickness from 0.1 to 0.4 m, was encountered in Testpits OS4 and OS6, respectively.

In our experience the thickness of topsoil frequently varies in between and beyond the borehole and testpit locations.

4.2 SILTY SAND TO SAND TO SAND & GRAVEL

Underlying the topsoil in Testpits OS4 and OS6, and at the surface in Testpits OS3 and OS5 and Borehole OS1, silty sand, sand, and sand & gravel deposits were encountered to a depth of 0.3 to 1.5 m (Elevation 330.4 to 326.7 m) below existing grade.

An 'N' value of 22 blows/0.3 m was measured in Borehole OS1 within this deposit indicating a compact condition. Occasional cobbles and boulders were encountered in the boreholes and testpits.

4.3 SAND FILL

At the base of the existing rock cut, Borehole OS2 and Testpit OS7 were advanced, encountering 0.2 to 0.8 m of sand with gravel pavement fill. An 'N'-value of 59 blows/0.3 m was measured within this fill in Borehole OS2 indicating that the fill has received some compactive effort.

4.4 BEDROCK

Below the overburden, bedrock was encountered and cored to obtain NQ size cores in Boreholes OS1 and OS2 at depths of 1.5 m or Elevation 327.1 m and 0.8 m or Elevation 321.9 m, respectively.

Auger probes and testpits were advanced at the site to attempt to delineate the undulating bedrock surface. Auger and excavation refusal on probable bedrock was encountered in the twelve auger probes and five testpits advanced at the site, respectively. The probe results are given in Appendix A. The findings show that the recorded refusal depths range from exposed bedrock along the rock cut or Elevation 330 to 321 ± m, to 0.8 m or Elevation 321.9 m at Borehole OS2. It is believed that while in most cases the refusal depths represent the surface of the bedrock, in some cases they may be due to cobbles and boulders in the overburden (probably immediately above the bedrock elevation).

From the results, it can be surmised that in the general area of the proposed north abutment location, the presumed bedrock surface elevation generally ranges from 328 to 327 ± m. In the general area of the south abutment location the presumed bedrock surface generally ranges from 332 to 322 ± m.

The rock was cored for a vertical distance of 13.7 m at Borehole OS1 and 5.1 m at Borehole OS2.

From the recovered rock cores the bedrock is a massive, closely to moderately closely jointed, Precambrian gneiss. It is generally sound, while in the surficial zone in some areas (Testpit OS3) the upper 0.3 m is fractured. The bedrock at the base of the existing rock cut is highly fractured to a depth of 0.8 m (Borehole OS2), likely due to rock shatter during blasting for construction of the existing highway. Occasional mica inclusions were encountered throughout the bedrock.

In Boreholes OS1 and OS2 the bedrock has a Rock Quality Designation (RQD) of 83 to 100%, except within the top 2.3 m of Borehole OS2 (the first two core runs) where RQD measurements of 13 and 50% were obtained, likely due to blast damage during the excavation of the rock cut. Core recovery was 90 to 100%, except within a highly fractured zone (the top 0.8 m of Borehole OS2) where core recovery was 40%. Based on these results, and visual examination of the rock cores, the bedrock is of good to excellent quality, but very poor within the rock shatter zone in Borehole OS2.

From the results of the boreholes, testpits and auger probes, the bedrock surface in the general area appears to be dipping toward the north and east. To the east, the bedrock drops to the existing Highway 11 shoulder, having been excavated for the construction of the highway. It should be noted that due to undulations at the surface of the bedrock, which is not uncommon in Northern Ontario, the bedrock elevation in between and beyond the boreholes and testpits may vary considerably.

4.5 GROUNDWATER CONDITIONS

Groundwater conditions in the open boreholes and testpits were observed during drilling and at the completion of sampling. No groundwater was observed in the overburden of any of the boreholes drilled or testpits excavated, which was confirmed by the measured natural moisture contents of the recovered samples. One standpipe piezometer was installed in Borehole OS1 to monitor the water level without interference from surface water. A water level of 8.3 m (or Elevation 320.3 m) below existing ground surface was measured two months after installation, likely indicating the groundwater table within the bedrock.

It should, however, be pointed out that the groundwater at the site would fluctuate seasonally and in response to major weather events. A perched water table may exist in the sand overburden overlying the bedrock.

5.0 DISCUSSION AND RECOMMENDATIONS

This report contains the findings of our geotechnical investigation, together with our recommendations and comments. These recommendations and comments are based on factual information and are intended only for use of the design engineers. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The anticipated construction conditions are also discussed, but only to the extent that they may influence design decisions. Construction methods discussed, however, express our opinion only and are not intended to direct the contractors on how to carry out the construction. Contractors should also be aware that the data and their interpretation presented in this report may not be sufficient to assess all the factors that may have an effect upon the construction.

The proposed Highway 11 realignment will consist of a four lane divided highway with an approximately 30 m wide median. The grade for Highway 11 SBL will be lowered by about 3 to 6 m from the existing top of rock and the Ontario Street grade will be another 10 ±m below the Highway 11 elevation. The proposed bridge will carry the southbound lane of Highway 11 and associated interchange ramp over the proposed realigned Ontario Street. It will be an approximately 33 m long, 3-lane (i.e. two-lanes for Highway 11 southbound and one-lane for the EW-S Ramp of the Ontario Street interchange), single span structure. As shown in Drawing No. 2, the bridge will be at a skew to the Ontario Street alignment. In general, the existing ground elevation at the bridge site is 333 to 322 m, generally dipping to the north. The proposed grade of Highway 11 at the bridge site is approximately Elevation 321.5 to 322 m, whereas the proposed grade of Ontario Street at the bridge site is approximately Elevation 311 to 312 m. The grade of the realigned Ontario Street under the proposed bridge will therefore be lowered by up to 20 m.

In general, below a surficial topsoil layer, cohesionless soils ranging from 0.2 to 1.5 m below existing ground surfaces, overlie the Precambrian gneiss bedrock. At the time of the investigation, no groundwater table was encountered within the overburden.

5.1 FOUNDATIONS

5.1.1 Spread Footing Foundations

All footings can be founded on sound bedrock. For this purpose all loose or weathered rock under the footprint of the footing should be removed and replaced with concrete. Mass concrete may be placed to raise the grade to the founding level, where necessary.

Based on the findings of the boreholes, testpits and auger probes advanced in the area of the proposed foundation elements, sound bedrock can be assumed for design purposes (along the east-west axis of the centre-line of each foundation element) at the elevations indicated below (except otherwise stated):

.../...

TABLE I

FOUNDATION LOCATION	REFERENCE BOREHOLE	APPROXIMATE DEPTH TO PRESUMED BEDROCK SURFACE (m)	PRESUMED BEDROCK SURFACE ELEVATION (m)
North Abutment			
West Side	Auger Probes SBN5, SBN6 and Borehole OS1	0.6 - 1.5 ±	328 - 327 ±
Centre	Auger Probes SBN2, SBN4 and Testpit OS4	0.2 - 1.1 ±	328 - 327 ±
East Side	Auger Probes SBN1, SBN3 and Testpit OS5	0 - 0.2 ±	327 ±
South Abutment			
West Side	Auger Probes SBS3 and SBS4	0 ±	332 - 331 ±
Centre	Auger Probes SBS1, SBS2 and Testpit OS3	0 - 0.3 ±	330 - 329 ±
East Side	Auger Probe SBS6 and Borehole OS2	0.8 - 1.1 ±	322 ± (fractured rock at base of existing cut)

It should also be noted that in between and beyond the borehole locations, testpits and auger probes, the bedrock surface may vary considerably. Additionally, the auger probe refusal depths may be due to refusal on cobbles or boulders within the overburden and the actual bedrock surface may be lower than anticipated.

As the anticipated founding elevation (~319 to 318 m) will be below the inferred (or proven) bedrock surface levels, the foundations will rest on sound bedrock (assuming no fracturing occurs due to blasting) and for design purposes the following O.H.B.D.C. bearing resistances may be used:

Factored Bearing Resistance at U.L.S. of up to 10,000 kPa
Bearing Resistance at S.L.S. will not govern

No frost protection is required for footings placed on massive bedrock, provided blasting of the bedrock is monitored closely to ensure no fracturing of the founding rock occurs. Bedrock would however be prone to possible deterioration due to opening of existing joints or fractures in the bedrock, as a result of frost action. Provided that surface water is diverted away from the footings, frost protection need not be provided for footings placed on massive, sound bedrock, although for added protection an earth cover of at least 0.3 m is recommended. The surface of the earth protection should be clayey to minimize the infiltration of surface water or the protection could be provided by concrete. If however, the bedrock is not massive and water can accumulate in the joints or fractures of the rock (thus causing deterioration of the founding medium by expansion due to freezing), then there may be a requirement to provide some frost protection. For this purpose, the proposed bearing surface should be inspected by qualified engineering personnel, with experience in rock mechanics and familiar with the findings of this investigation. If the rock is not massive, then the excavation can be extended deeper until acceptable rock is found which, based on our experience, seldom exceeds 0.6 m.

Sliding resistance can be provided by penetrating into the bedrock (i.e. keying-in and utilizing passive rock resistance), utilizing the sliding resistance between concrete and bedrock, shear in grouted dowels and/or rock anchors. For the evaluation of the sliding resistance of the foundation (O.H.B.D.C. 6-8.4.3) the ultimate angle of friction between the underside of the foundations and the clean, intact bedrock surface can be taken as 30 degrees. If additional horizontal resistance is required or if the rock surface is not sufficiently level, doweling or keying-in into the bedrock can be considered. Alternatively, the surface of the bedrock can be chiseled (i.e. roughened) to increase the ultimate angle of friction to 35 degrees. This, in our opinion, is likely to be the most cost effective method. On the other hand, if the presence of weaker rock zones/seams/layers is noted during construction, especially with an unfavourable orientation, then doweling may be a more suitable solution.

If there are net uplift forces which need to be resisted by rock anchors, or for increasing sliding resistance, for design purposes, the following O.H.B.D.C. capacities may be assumed for the bond between bedrock and grout.

Factored Bearing Capacity @ U.L.S. = 500 kPa
Bearing Capacity @ S.L.S. will not govern

The upper 0.1 m of the rock should not be included in calculating the resistance and the minimum dowel embedment should be 1.5 m. Neither the structural strength of the dowel, nor the compressive strength of the grout should be exceeded. The annular space around the dowel which will be grouted should be in the order of 2 cm wide (between the dowel and the bedrock). The anchors should also be checked for rock wedge pull out assuming a 60 degree cone/wedge and the anchor group resistance should also be checked.

The horizontal capacity of rock that can be derived from a shear key extending from the base of a footing depends on many factors including the degree of fracture of the upper portion of bedrock (massiveness), joint orientation and properties, the proximity of weaker zones, seams and layers. As outlined above, the proposed bearing surface should be inspected during construction by experienced personnel to determine if the shear key option is feasible.

Under inclined loading conditions the Factored Bearing Resistance at U.L.S. should be reduced in accordance with Clause 6-8.4.2 of O.H.B.D.C., 3rd Edition.

Details of foundation conditions at each support location are discussed below.

.../...

5.1.1.1 North Abutment

The north abutment can be founded directly on suitable bedrock. From the probe results the rock surface appears to be sloping towards the east and north, following the ground surface. Since the proposed highway grade at the north abutment is at about Elevation 322 m, and the proposed bottom of the bridge deck is at about Elevation 320 m, the founding elevation will probably be 319 m $\pm$ or lower. The findings indicate that this will involve rock excavation generally between 8 and 9 m.

In order to ensure the stability at the north abutment, the footing should be located far enough from the face of any proposed rock cuts along Highway 11 and Ontario Street. For this purpose, the outside edge of the footing should be no closer than 1.5 m to the face of the rock cut. The rock portion of the cut slope can be maintained at nearly vertical slopes but depending on the orientation of joints and fractures, rock bolting of the rock face and/or rock doweling along the crest of the cut adjacent to the footings may be required. As mentioned before, when the exposed faces are inspected, the possible presence of weaker zones or layers (such as highly micaceous material evidenced in the rock cores) with unfavourable orientation should be checked.

5.1.1.2 South Abutment

The south abutment can be founded directly on suitable bedrock. From the probe results the rock surface appears to be sloping towards the east and north, following the ground surface. Since the proposed highway grade at the south abutment is at about Elevation 321 m, and the proposed bottom of the bridge deck is at about Elevation 319 m, the recommended foundation elevation is at 318 m $\pm$ or lower. The findings indicate that this will involve rock excavation generally between 4 and 14 m.

As mentioned for the north abutment foundation, to maintain the stability at the south abutment, the footing should be located far enough from the face of any proposed rock cuts along Highway 11 and Ontario Street. In addition, the outside edge of the footing should be no closer than 1.5 m to the face of the rock cut. The rock portion of the cut slope can be maintained at nearly vertical slopes but depending on the orientation of joints and fractures, rock bolting of the rock face and/or rock doweling along the crest of the cut adjacent to the footings may be required. When inspecting the faces for possible weaknesses, the engineer should be cognizant of the fact that the presence of possible weaker zones (e.g. highly micaceous) may cause future problems, especially when they are unfavourably orientated. Once these characteristics of the rock cut face are examined, the horizontal capacity of the rock and protection to the rock face (if required) can be determined.

We recommend that an NSSP for rock dowels and/or rock slope protection be included in the contract documents.

5.1.2 Deep Foundations

Due to the shallow bedrock depths at the proposed foundation elements, the use of deep foundations is considered not to be a viable alternative.

5.2 LATERAL EARTH PRESSURES

Backfill behind abutments and retaining walls should consist of non-frost susceptible, free draining granular materials in accordance with the Ontario Ministry of Transportation Standards.

Free-draining backfill materials (i.e. Granular 'A' or Granular 'B') and the provision of drain pipes and weep holes, etc., should prevent hydrostatic pressure build-up. Computation of earth pressures should be in accordance with the O.H.B.D.C. 3rd Edition, (1991). Because of the presence of sound rock for a substantial portion of the excavated faces behind the retaining structures, the applicable earth pressure parameters will be difficult to determine. However, for design purposes, the following unfactored parameters can be used (which will generally be relatively conservative values).

Compacted Granular 'A'

Unit Weight = 22 kN/m^3
Coefficient of Lateral Earth Pressures:
$K_a = 0.27$
$K_o = 0.43$

Compacted Granular 'B'

Unit Weight = 21 kN/m^3
Coefficient of Lateral Earth Pressures:
$K_a = 0.31$
$K_o = 0.47$

Rock Fill

Unit Weight = 18 kN/m^3
Coefficient of Lateral Earth Pressures:
$K_a = 0.27$
$K_o = 0.43$

These values are based on the assumption that the backfill behind the retaining structure is free-draining and adequate drainage is provided. As well, it is assumed that the ground behind the retaining structure is level.

The earth pressure coefficient adopted will depend on whether the retaining structure is restrained or movements can be allowed such that the active state of earth pressure can develop. If the abutment is restrained and does not allow lateral yielding, then at rest pressures should be used as per Clause C6-7.1 of the O.H.B.D.C., 3rd Edition. The effect of compaction should also be taken into account in the selection of the appropriate earth pressure coefficients in accordance with Clause 6-7.4.3 of the O.H.B.D.C., 3rd Edition.

Foundations on bedrock will be unyielding and in that case the at-rest condition will govern the earth pressure.

Vibratory equipment for use behind abutments and retaining walls should be restricted in size as per current MTO practice.

Some rock will likely be excavated for the highway cut in the area. If rock fill is used for backfill, special care is required to prevent damage to the retaining structures. In such a case, a cushion of Granular 'A' material or finely graded rock fill (e.g. less than 200 mm nominal diameter) should be placed between the structure and the rock fill. This cushion should be as per O.P.S.D. 3505.0 and if Granular 'A' is used, proper filtering should be provided to prevent the loss of finer particles from the Granular 'A' cushion into the coarse rock fill.

As an alternative to conventional retaining walls, MTO's Retained Soil System may be used. The following should be included in the Contract Documents:

- identify longitudinal extent in plan of the Retained Soil System
- identify in plan transverse space constraints (top of wall and bottom of wall)
- identify elevation of top of wall and bottom of wall
- include NSSP for Retained Soil Systems in Contract Documents

The Retained Soil System should be of high performance and moderate to high appearance.

5.3 APPROACH EMBANKMENTS

The proposed grades indicate that up to about 20 m deep cuts will be required at the immediate vicinity of the abutments (e.g. forward slopes). At the immediate approaches between 3 and 6 m cuts will be required for the construction of Highway 11 southbound lane.

Permanent cut slopes in the overburden soils above the water table will be stable at 2H:1V. Cut slopes should be inspected after construction and where deemed necessary, measures such as granular blanket (sheeting) should be provided.

For slopes in the overburden proper erosion measures should be implemented both during the construction and permanently. This can be achieved by immediate seeding or sodding (OPSS 572).

Rock cut slopes should be stable at nearly vertical faces providing that blasting is carefully controlled and unfavourable orientation of joints and fractures is not encountered. This aspect is further elaborated in the next section of this report.

5.4 CONSTRUCTION COMMENTS

No groundwater was encountered in the overburden of the boreholes or testpits and, based on this, no problems with groundwater seepage are anticipated at the site. Any surface water seepage, if necessary, can easily be handled by gravity drainage and pumping from open sumps.

All excavations should be carried out in accordance with the Occupational Health & Safety Acts of Ontario, including regulations for Construction Projects and Regulations for Mines and Mining Plants (in bedrock).

Excavation of the bedrock by mechanical methods such as hoe-ramming or ripping will probably only be feasible within the uppermost weathered and fractured rock. In our opinion, therefore, blasting will be necessary. Blasting should, however, be carried out in a manner to minimize damage to the founding bedrock and permanent rock face. Controlled perimeter (line) blasting (or a similarly acceptable method) is recommended in order to provide a neat excavation line, minimize over break, minimize face instabilities and long term maintenance problems. It is recommended that an NSSP on blasting requirements be included in the contract documents.

Temporary rock slopes should be stable at near vertical faces, but adequate precaution should be taken to protect workers from spalling rock. The stability of rock faces will also depend on the inclination of planes of weakness in the rock mass.

To reduce the excavation depths and to facilitate the construction of spread footing foundations, it would be advisable to carry out the cut for Ontario Street before the construction of the abutment support elements. We recommend that all blasting for rock cuts be completed prior to the construction of the footings.

Consideration should be given to excavating to the founding level at the proposed future widening area during this construction, in order to eliminate possible problems with rock excavation after the structure is in place.

Where blasting is required for ditch construction (i.e. rock shatter), we recommend that measures be taken to protect the toe of the cut slope to prevent weakening of the rock slope.

All rock excavations, foundation bases and bearing surfaces should be inspected and approved by qualified engineering personnel with expertise in rock mechanics and familiar with the findings of this report. The rock surface which will support the foundation and/or mass concrete should be properly cleared of all overburden, debris and shattered, unsuitable rock in order to provide a suitable bond between the concrete and the rock surface. Similarly the surface of the mass concrete should be properly cleaned to achieve a good bond with the foundation concrete.

6.0 CLOSURE

We recommend that once the details of the structure are finalized, our recommendations be reviewed for their specific applicability.

Sincerely,

Andrew Drevininkas, P. Eng.

LICENSED PROFESSIONAL ENGINEER
A. R. DREVININKAS
PROVINCE OF ONTARIO

Eric Chung, M. Eng., P. Eng.
MTO Designated Contact

REGISTERED PROFESSIONAL ENGINEER
E. Y. CHUNG
PROVINCE OF ONTARIO

APPENDIX A

AGRA
ENGINEERING GLOBAL SOLUTIONS

PROBE NO.	STATION	OFFSETS	APPROXIMATE GROUND SURFACE ELEVATION (m)	DEPTH OF AUGER REFUSAL (m)	APPROXIMATE AUGER REFUSAL ELEVATION (m)
	SOUTH ABUTMENT				
SBS1	21+133	Centerline	329 ±	0	329 ±
SBS2	21+135	Centerline	329 ±	0	329 ±
SBS3	21+135	11 LT of Centerline	332 ±	0	332 ±
SBS4	21+141	11 LT of Centerline	331 ±	0	331 ±
SBS5	21+135	10 RT of Centerline	323 ±	0.8	322 ±
SBS6	21+129	10 RT of Centerline	323 ±	1.1	322 ±
	NORTH ABUTMENT				
SBN1	21+157	6.5 RT of Centerline	327 ±	0	327 ±
SBN2	21+160	Centerline	328 ±	0.2	328 ±
SBN3	21+163	6.5 RT of Centerline	327 ±	0	327 ±
SBN4	21+167	Centerline	328 ±	1.1	327 ±
SBN5	21+176	8 LT Centerline	329 ±	0.6	328 ±
SBN6	21+171	8 LT Centerline	329 ±	1.2	328 ±

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	SOUTH ABUTMENT				
SBS1	21+133	Centerline	329 ±	0	329 ±
SBS2	21+135	Centerline	329 ±	0	329 ±
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ENCLOSURES

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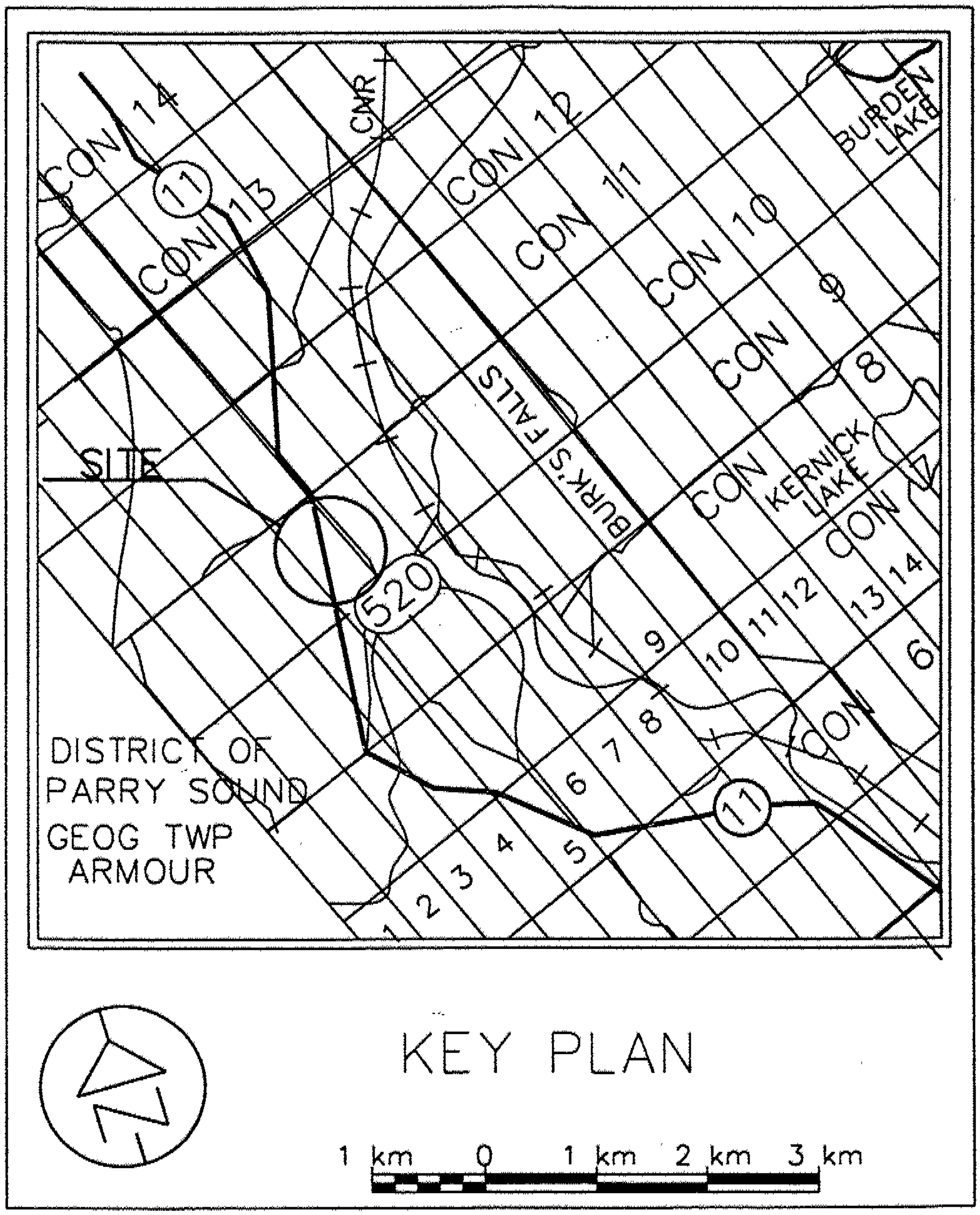
ENGINEERING GLOBAL SOLUTIONS



KEY PLAN

SBL & REALIGNED ONTARIO STREET CROSSING KEY PLAN	Dwg. No 1	AGRA

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Foundation Design

RECORD OF BOREHOLE No OS1

METRIC

W.P. 486-93-01 LOCATION Site No. 44-398S N5054757 E311524 ORIGINATED BY AD

DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem COMPILED BY AD

DATUM Geodetic DATE 5 May 1999 CHECKED BY EYC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)
328.6 / 0.0	brown, brown, **SAND** with cobbles and boulders, trace Silt, compact, damp	1	SS	22	328	STATION 21+180 8 LT SBL C/L
327.1 / 1.5	**GNEISS BEDROCK** massive, occasional Mica inclusions, closely to moderately closely jointed	2	RC		327	RC2: REC=100% RQD=100%
		3	RC		326, 325	RC3: REC=100% RQD=100%
		4	RC		324, 323	RC4: REC=100% RQD=97%
		5	RC		322	RC5: REC=100% RQD=95%
		6	RC		321, 320	RC6: REC=100% RQD=88%
		7	RC		319	RC7: REC=100% RQD=90%
		8	RC		318, 317	RC8: REC=100% RQD=86%
		9	RC		316	RC9: REC=100% RQD=99%
		10	RC		315, 314	RC10: REC=100% RQD=90%
313.4 / 15.2	END OF BOREHOLE. Water Level in PIEZOMETER July 9/99: 8.3m					

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; 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 (%) (10 20 30); UNIT WEIGHT γ kN/m³; GR SA SI CL

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

RECORD OF BOREHOLE No OS2

1 OF 1 **METRIC**

W.P. 486-93-01 LOCATION Site No. 44-398S N 5054710 E 311546 ORIGINATED BY AD

DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem COMPILED BY AD

DATUM Geodetic DATE 5 May 1999 CHECKED BY EYC

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)
322.7						
0.0	0.1m ASPHALTIC CONCRETE brown **SAND FILL** with Gravel, damp compact	1	SS	59	322	STATION 21+130 10RT SBL C/L
321.9 0.8	Highly fractured -------------------- **GNEISS BEDROCK** massive, occasional Mica inclusions closely to moderately closely jointed	2	RC			RC2: REC=40% RQD=13%
		3	RC		321 320	RC3: REC=90% RQD=50%
		4	RC		319	RC4: REC=100% RQD=90%
		5	RC		318 317	RC5: REC=100% RQD=83%
316.8 5.9	END OF BOREHOLE No water in borehole before coring					

Column headings: 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 (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; GR SA SI CL; STRAT PLOT; GROUND WATER CONDITIONS.

Water content plotted for sample 1: approx. 3% (o).

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

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RECORD OF BOREHOLE No OS3

METRIC

W.P. 486-93-01 | LOCATION Site No. 44-398S N 5054710 E 311535 | ORIGINATED BY AD

DIST 52 HWY 11 | BOREHOLE TYPE Backhoe | COMPILED BY AD

DATUM Geodetic | DATE 28 June 1999 | CHECKED BY EYC

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 (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
330.7											
330.4 / 0.0	brown **SAND & GRAVEL** trace Organics, Silt damp		1	GS							
330.1 / 0.3	fractured **GNEISS BEDROCK**										
0.6	END OF TESTPIT ON BEDROCK Water Level on Completion: dry						330				STATION 21+131 2 LT SBL C/L

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

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RECORD OF BOREHOLE No OS4

METRIC

W.P. 486-93-01 LOCATION Site No. 44-398S N 5054743 E 311535 ORIGINATED BY AD

DIST 52 HWY 11 BOREHOLE TYPE Backhoe COMPILED BY AD

DATUM Geodetic DATE 28 June 1999 CHECKED BY EYC

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: 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 (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
328.2											
0.0	0.4m **TOPSOIL** with cobbles and boulders						328				
327.7 / 0.6	0.15m **SAND & GRAVEL** damp										
	END OF TESTPIT ON BEDROCK Water Level on Completion: dry										STATION 21+165 1 RT SBL C/L

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

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RECORD OF BOREHOLE No OS5

METRIC

W.P. 486-93-01	LOCATION Site No. 44-398S N 5054739 E 311539	ORIGINATED BY AD
DIST 52 HWY 11	BOREHOLE TYPE Backhoe	COMPILED BY AD
DATUM Geodetic	DATE 28 June 1999	CHECKED BY EYC

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 (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
327.5											
329.0	brown, damp **SAND & GRAVEL**		1	GS					o		
0.2	END OF TESTPIT ON BEDROCK Water Level on Completion: dry						327				STATION 21+160 5RT SBL C/L

$+^3, \times^3$: Numbers refer to Sensitivity

$O^{3\%}$ STRAIN AT FAILURE

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RECORD OF BOREHOLE No OS6

METRIC

W.P. 486-93-01 | LOCATION Site No. 44-398S N 5054762 E 311532 | ORIGINATED BY AD

DIST 52 HWY 11 | BOREHOLE TYPE Backhoe | COMPILED BY AD

DATUM Geodetic | DATE 28 June 1999 | CHECKED BY EYC

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 (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
327.5											
0.0	0.1m TOPSOIL red-brown **SILTY SAND** with cobbles and boulders, damp										STATION 21+184 SBL C/L
327.1 / 0.5	brown **SAND & GRAVEL** damp		1	GS			327		~10		
326.7 / 0.9	END OF TESTPIT ON BEDROCK Water Level on Completion: dry										

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

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RECORD OF BOREHOLE No OS7

1 OF 1 **METRIC**

W.P. 486-93-01 LOCATION Site No. 44-398S N 5054688 E 311540 ORIGINATED BY AD

DIST 52 HWY 11 BOREHOLE TYPE Backhoe COMPILED BY AD

DATUM Geodetic DATE 28 June 1999 CHECKED BY EYC

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 (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
321.2											
321.0 / 0.2	brown **Sand with Gravel FILL** some Organics, damp		1	GS			321				
	END OF TESTPIT ON BEDROCK										
	Water Level on Completion: dry										STATION 21+112 2 RT SBL C/L

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

OVERSIZE DRAWING(S)