FOUNDATION INVESTIGATION REPORT
EXTENSION OF EAST ABUTMENT
CENTRAL PARKWAY OVERPASS AT HIGHWAY 403
MISSISSAUGA BUS RAPID TRANSIT (BRT) PROJECT
MISSISSAUGA, ONTARIO

Geocres Number: 30M12-307

Report to

McCormick Rankin Corporation

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July 2, 2010
File: 19-1351-160

H:\19\1351\160 Mississauga BRT Detailed Design\Reports & Memos\Central Parkway\Central Parkway-Hwy 403 FIR Final.doc

TABLE OF CONTENTS

PART 1 FACTUAL INFORMATION

Appendices

FOUNDATION INVESTIGATION REPORT
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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted for the proposed extension of the east abutment at the existing Highway 403 - Central Parkway overpass structure in Mississauga, Ontario. Extension of the abutment has been requested by MTO as part of the proposed Bus Rapid Transit (BRT) project to be constructed along the south side of the highway.

The purpose of the investigation was to explore the subsurface conditions at the site and, based on the data obtained, provide a borehole location plan, borehole logs, stratigraphic profile and a written description of the subsurface conditions. A model of the subsurface conditions was developed to describe the geotechnical conditions influencing design and construction of the foundations and approach embankment for the structure.

Thurber carried out the investigation as a sub-consultant to McCormick Rankin Corporation under their Sub-consultant Agreement for Project Number 7493.

2 PROJECT AND SITE DESCRIPTION

The BRT project involves a fully grade-separated, two-lane bus-only roadway located in the City of Mississauga, extending from the City Centre Station (Highway 403 at Hurontario Street) to the Renforth Drive Station (Renforth Drive at Eglinton Avenue). The total length is approximately 9.5 km.

The segment of the BRT at Central Parkway will include a bus station and a grade separation structure to carry the proposed BRT over Central Parkway. The space between the completed station and the existing Highway 403 overpass structure to the north will be limited, and therefore extension of the east abutment will be carried out as part of busway construction, in anticipation of future widening of Highway 403.

Currently the BRT site is a vacant strip of land bordered on the north by Highway 403 and on the south by residential development. Vegetation consists mainly of tall grass and occasional shrubs.

A photograph of the site is included in Appendix C, showing the general nature of the site.

The site is situated within the South Slope physiographic region. The geology generally comprises a till plain consisting of clayey silt to silty clay till (Halton Till) overlying bedrock at relatively shallow depth. The bedrock consists of grey shale, siltstone and limestone of the Georgian Bay Formation.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation was carried out on April 9, 2010 and consisted of one borehole drilled and cored to a total depth of 5.4 m adjacent to the south end of the existing abutment. The borehole was numbered 10-04 after several boreholes drilled at the same time for other components of the BRT project.

The approximate borehole location is shown on the Borehole Locations and Soil Strata Drawing in Appendix D. The coordinates and elevation of the borehole are given on this drawing and on the Record of Borehole Sheet in Appendix A. Also provided in Appendix D is the borehole plan and soil strata drawing for this section of the BRT previously prepared for the overall corridor report.

Prior to commencement of drilling, utility clearances were obtained for the borehole location.

Solid stem augers were used to advance the borehole in the overburden and into the shale. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). NQ rock coring equipment was used to recover a 3.0 m length of core from the underlying shale bedrock.

A member of Thurber's engineering staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the borehole, visually examined the recovered samples, and transported them to Thurber's laboratory for further examination and testing.

All rock cores were logged, and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

Groundwater conditions in the open borehole were observed throughout the drilling operations. A standpipe piezometer consisting of 25 mm PVC pipe with screen was installed in the borehole to permit monitoring of groundwater levels. Details of the piezometer installation are as shown in Table 3.1.

Table 3.1 – Borehole Completion Details

Borehole	Piezometer Tip Depth/ Elevation (m)	Completion Details
10-04	5.4/137.4	Piezometer with 1.5 m slotted screen installed with sand filter to 3.3 m, bentonite from 3.3 m to 0.2 m, then concrete to surface.

4 LABORATORY TESTING

All recovered soil samples were subjected to Visual Identification (VI) and rock samples to geological logging. At least 25% of the recovered samples of soil were also subjected to grain size distribution analyses (sieve and hydrometer) and Atterberg Limits testing where appropriate. Moisture content determinations were carried out on all soil samples. The results of this testing program are shown on the Record of Borehole sheet in Appendix A and on the figures contained in Appendix B.

Core samples of the shale bedrock were carefully protected to prevent drying during transport to the laboratory. Point load tests were carried out on selected samples of intact limestone interbeds upon arrival at the laboratory to assist in evaluation of the uniaxial compressive strength (UCS) of the bedrock. The results of the point load tests are shown in the borehole logs.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheet in Appendix A. Details of the encountered soil and rock stratigraphy are presented in this appendix and on the Borehole Locations and Soil Strata Drawing in Appendix D. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheet governs any interpretation of the site conditions.

The soil stratigraphy encountered at this site comprises a surficial pavement structure overlying native silty clay till, which is in turn underlain by weathered shale bedrock. More detailed descriptions of the individual strata are presented below.

The conditions encountered in Borehole 10-04 drilled for the current investigation are consistent with those documented during earlier investigation for the overall BRT project, as illustrated on the Borehole Locations and Soil Strata drawing from the BRT report, Drawing No. 19-1351-160-2 included in Appendix D

5.1 Pavement Structure

Borehole 10-04 was drilled on Central Parkway. The pavement structure encountered in the borehole consisted of 180 mm of asphalt over approximately 1.0 m of compact to dense sand and gravel fill. The moisture content of the granular fill ranges from 3 to 5%.

5.2 Silty Clay Till

Native brown silty clay till was contacted below the pavement structure. The clay till layer was 0.9 m thick with a lower boundary at 2.1 m depth (Elevation 140.7 m).

An SPT 'N' value of 13 blows/0.3 m was obtained in the clay till, indicating a stiff consistency. The natural moisture content of a single sample was 19%.

The results of a grain size distribution analysis and Atterberg Limits testing are presented on the Record of Borehole sheets and on Figures B1 and B2 of Appendix B. The results are summarized as follows:

Soil Particles	(%)
Gravel	1
Sand	15
Silt	64
Clay	20

Liquid Limit	35
Plastic Limit	22

The above results show that the silty clay till is of low to medium plasticity with group symbols of CL-CI.

Glacial tills inherently contain cobbles and boulders and the lower part of the till may contain pieces and slabs of bedrock.

5.3 Bedrock

The glacial till was underlain by shale bedrock of the Georgian Bay Formation, encountered at 2.1 m depth (Elevation 140.7 m). The shale recovered in the rock cores was described as thinly bedded, highly weathered to a depth of about 0.6 m below the bedrock surface, and slightly weathered to fresh below this level. Occasional hard limestone interbeds were observed and a 100 mm thick layer of highly broken rock was noted at 2.4 m depth.

Total core recovery (TCR) in the bedrock was 100%, and RQD values of 89 and 95% were recorded, indicating a good to excellent rock quality. The fracture Index (FI), expressed as fractures per 0.3 m of core, ranged from 0 to 3, locally greater than 5 in the uppermost 0.3 m of the initial run.

The unconfined compressive strength of the interbedded limestone assessed from Point Load testing on recovered core Run 2 was 111 MPa, indicating a very strong rock. Point load tests were possible only on the limestone interbeds as the more typical weathered shale cores tended to split along bedding planes and were not suitable for testing. Based on point load and unconfined compression testing carried out on shale cores from other areas of the BRT project, the shale strength ranges from about 3 to 30 MPa, indicating a very weak to medium strong rock.

5.4 Groundwater Levels

Rock coring operations introduced water into the borehole. The unstabilized water level observed in the borehole upon completion of coring was at 0.7 m depth.

A standpipe piezometer was installed in the borehole to monitor water levels after completion of drilling. The water level measured in the piezometer approximately three weeks after drilling (April 30, 2010) was at 1.3 m depth (Elevation 141.6 m).

The measured water level is a short-term reading and seasonal fluctuations are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

6 MISCELLANEOUS

The location and ground surface elevation at the borehole were established by Thurber Engineering using a Trimble Pathfinder ProXRT GPS unit with a precision of 0.1 m.

The drilling and sampling equipment was supplied and operated by DBW Drilling of Ajax, Ontario. The fieldwork was supervised on a full time basis by Mr. George Azzopardi of Thurber Engineering Ltd. Overall supervision of the field program was conducted by Mr. Mark Farrant, P. Eng.

Laboratory testing was carried out at Thurber's laboratory in Oakville, Ontario.

Interpretation of the data and preparation of the report were carried out by Mr. Murray R. Anderson, P.Eng. Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects, reviewed the report.

THURBER ENGINEERING LTD.

Murray R. Anderson, P.Eng., M.Eng.
Senior Foundations Engineer

P.K. Chatterji, P.Eng., Ph.D.
Review Principal

Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT[(1)] 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

1) Laboratory Triaxial Testing
2) Field Insitu Vane Testing
3) Laboratory Vane Testing
4) SPT value
5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE

SS Split Spoon Sample WS Wash Sample AS Auger (Grab) Sample
TW Thin Wall Shelby Tube Sample TP Thin Wall Piston Sample
PH Sampler Advanced by Hydraulic Pressure PM Sampler Advanced by Manual Pressure
WH Sampler Advanced by Self Static Weight RC Rock Core SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

$\underline{\blacktriangledown}$ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

(1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.

(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

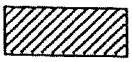
MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

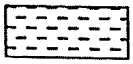
EXPLANATION OF ROCK LOGGING TERMS

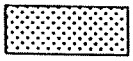
ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.

SYMBOLS


CLAYSTONE


SILTSTONE


SANDSTONE


COAL


Bedrock (general)

DISCONTINUITY SPACING

Bedding	Bedding Plane Spacing
Very thickly bedded	Greater than 2m
Thickly bedded	0.6 to 2m
Medium bedded	0.2 to 0.6m
Thinly bedded	60mm to 0.2m
Very thinly bedded	20 to 60mm
Laminated	6 to 20mm
Thinly Laminated	Less than 6mm

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)	(psi)	Field Estimation of Hardness*
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

THURBER

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 10-04 1 OF 1 METRIC

G.W.P. 19-1351-160 LOCATION N 4 829 221.8 E 610 040.4 ORIGINATED BY GA
HWY 403 / BRT BOREHOLE TYPE Solid Stem Augers / NQ Coring COMPILED BY AN
DATUM DATE 2010.04.09 - 2010.04.09 CHECKED BY MA

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, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
142.9											
0.0	**ASPHALT:** (180mm)										
0.2	**SAND** and **GRAVEL** Compact to Dense Brown Dry (FILL)		1	SS	50/ 0.150				o		
141.6			2	SS	20		142		o		
1.2	Silty **CLAY**, some sand, trace gravel Stiff Brown (TILL)		3	SS	13		141		o		1 15 64 20
140.7											
2.1	**SHALE**, highly weathered, thinly bedded, very weak to weak, grey, occasional very strong limestone interbeds slightly weathered to fresh 100mm highly broken zone at 2.4m		4	SS	50/ 0.150				o	FI	
			1	RUN			140			>5 1 1 1 0	RUN 1# TCR=100%, SCR=93%, RQD=89%
			2	RUN			139			0 0 1	RUN 2# TCR=100%, SCR=100%, RQD=95% UCS=111MPa (Limestone)
137.4							138			1 3	
5.4	END OF BOREHOLE AT 5.4m. BOREHOLE OPEN TO 5.4m AND WATER LEVEL AT 0.7m UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2010.04.30 1.3 141.6										

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

ONTMT4S 1160(MTO).GPJ 5/18/10

Appendix B

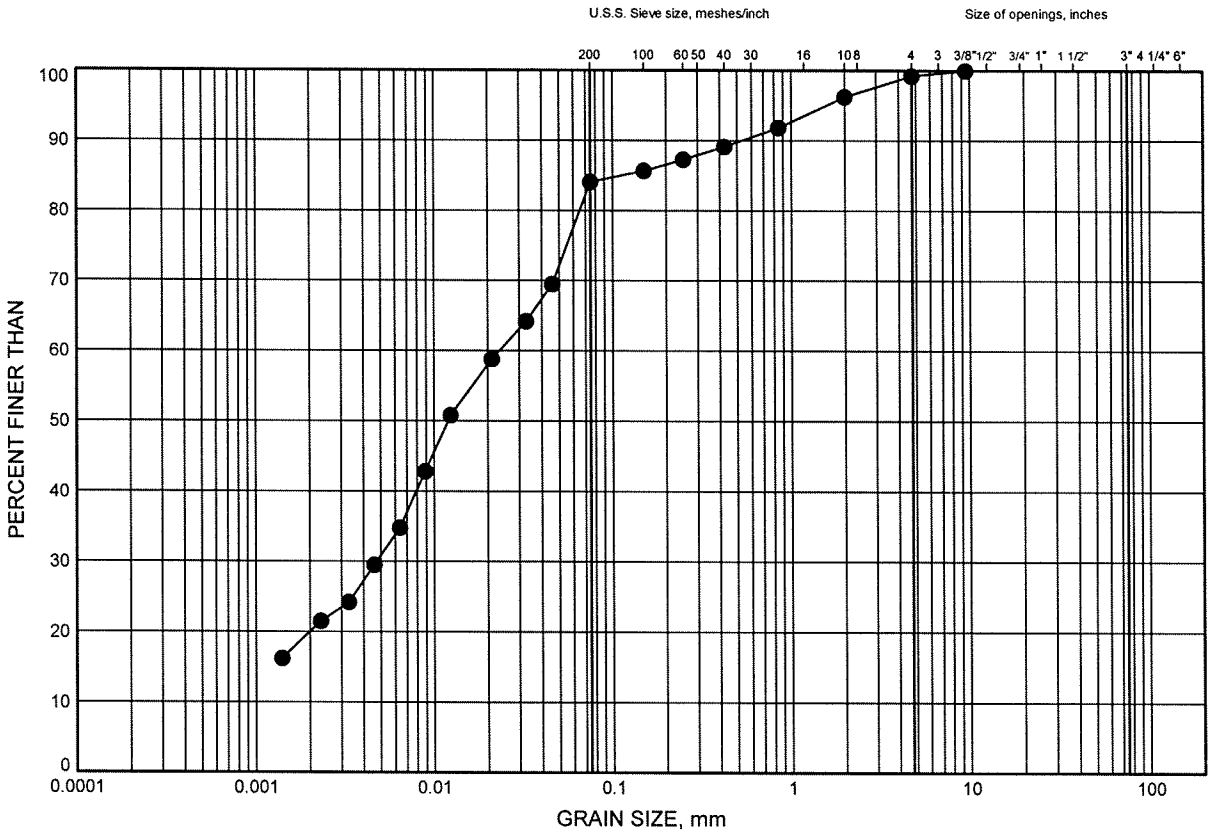
Laboratory Test Results

Mississauga BRT East

GRAIN SIZE DISTRIBUTION

FIGURE B1

SILTY CLAY TILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	10-04	1.83	141.03

W.P.# 19-1351-160
Prepared By MFA
Checked By MRA

THURBER

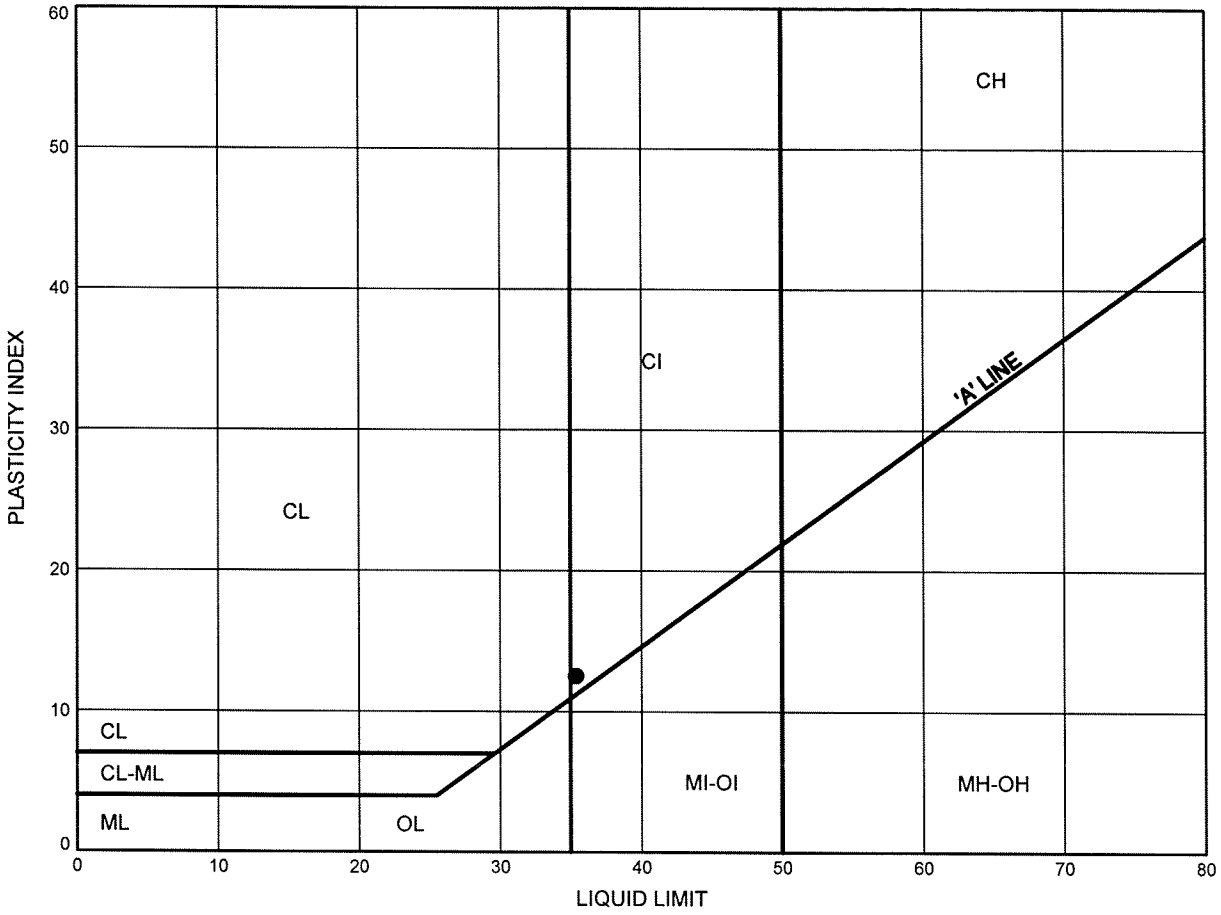
GRAIN SIZE DISTRIBUTION - THURBER 1160(MTO).GPJ 5/18/10

Mississauga BRT East

ATTERBERG LIMITS TEST RESULTS

FIGURE B2

SILTY CLAY TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	10-04	1.83	141.03

Date May 2010

Project 19-1351-160

THURBER

Prep'd MFA

Chkd. MRA

THURBALT 1160(MTO).GPJ 5/18/10

Appendix C

Site Photograph

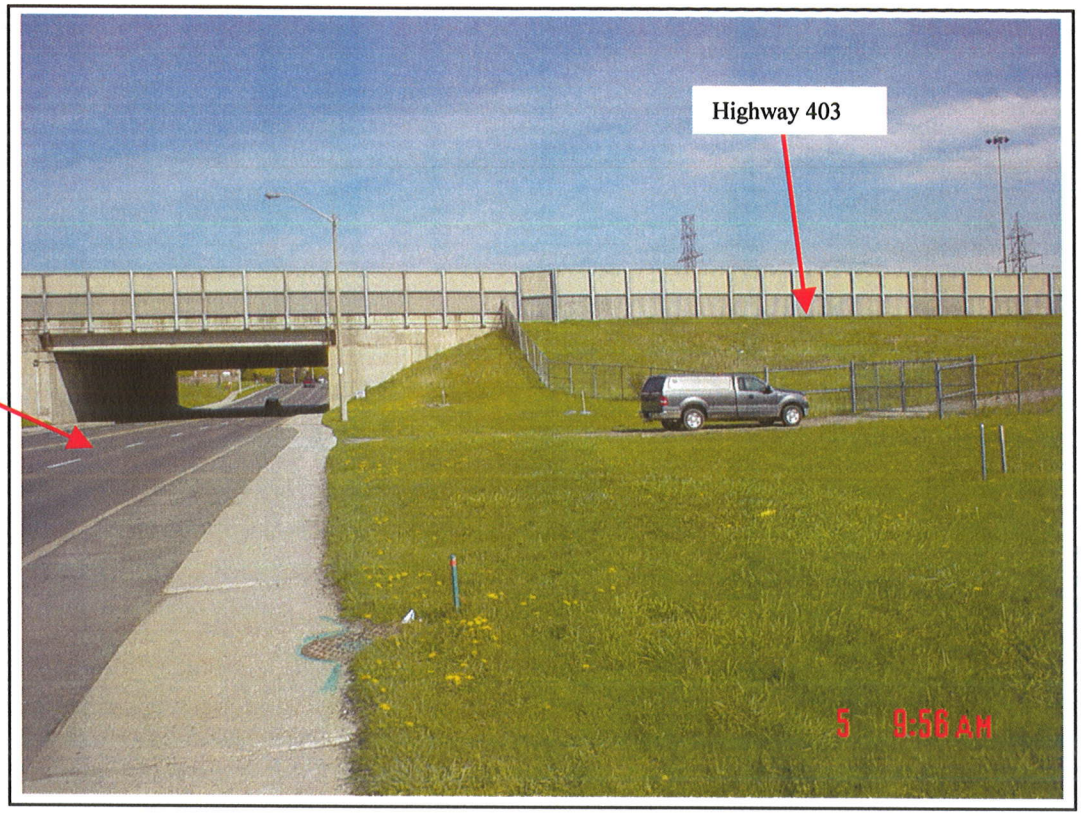
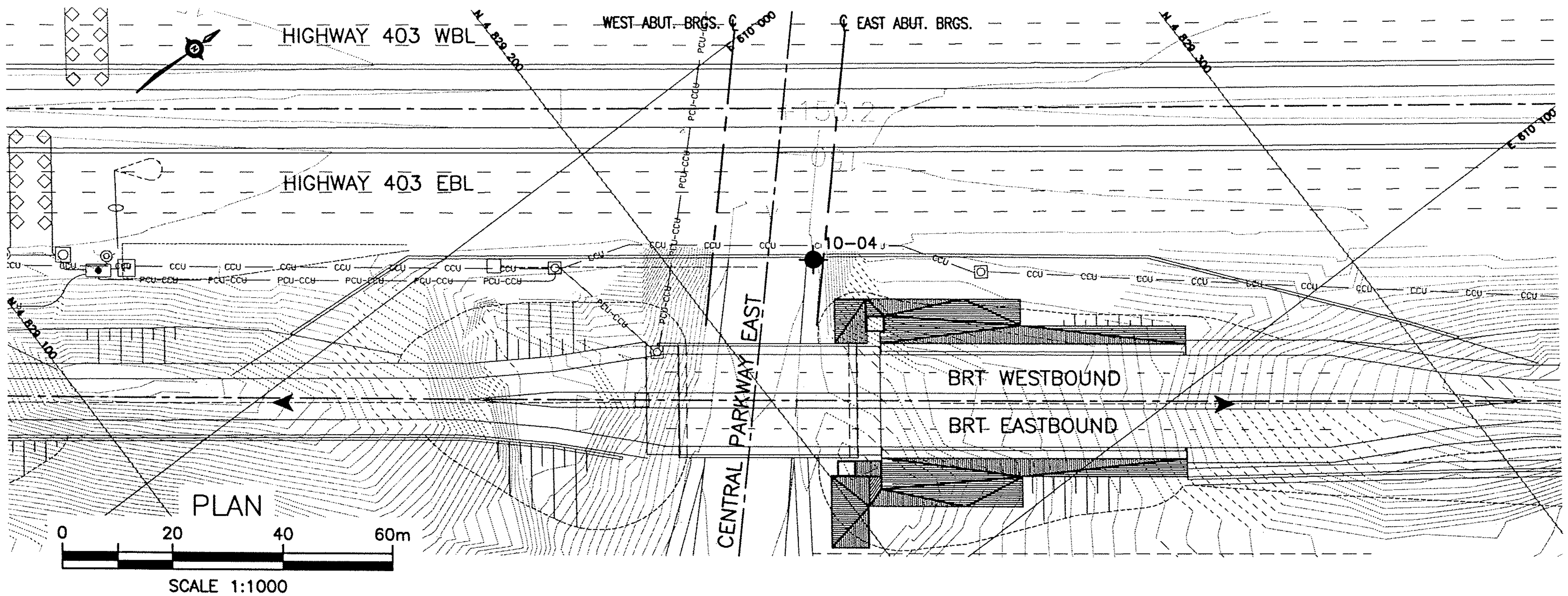


Photo 1. Looking at the south side of Highway 403 and Central Parkway intersection

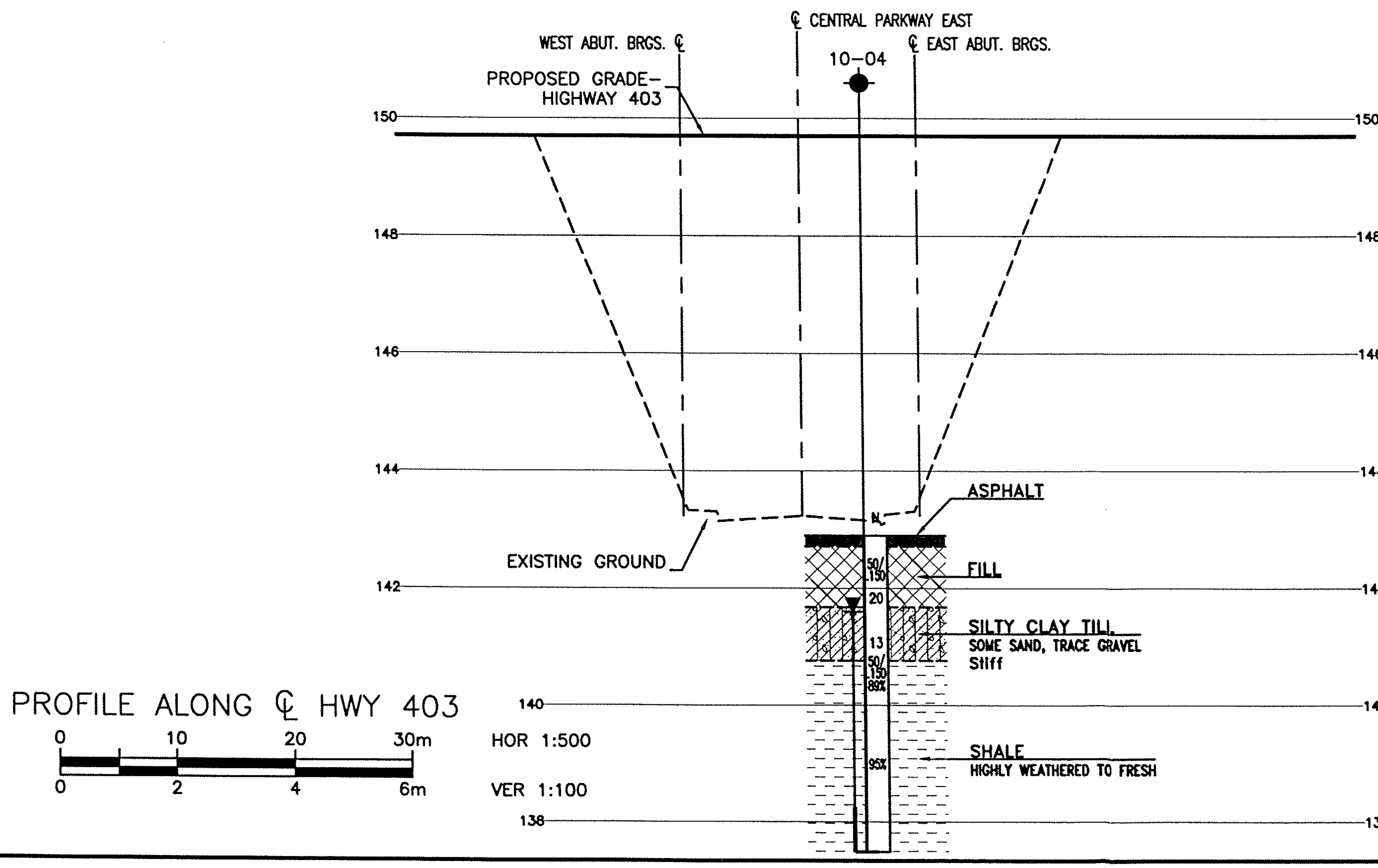
Appendix D

Borehole Locations and Soil Strata Drawing



METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



M. R. ANDERSON

P. K. CHATTERJI

LICENSED PROFESSIONAL ENGINEER — PROVINCE OF ONTARIO

CONT No

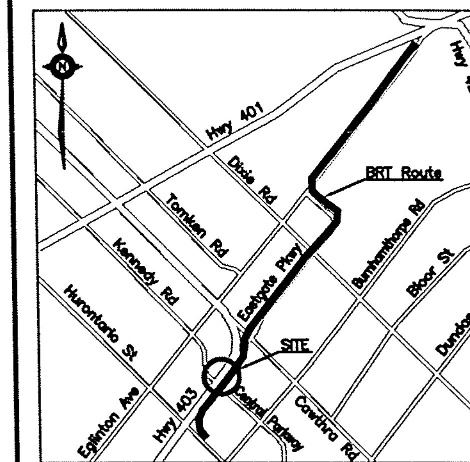
GWP No

MISSISSAUGA BRT EAST
HIGHWAY 403 / CENTRAL PARKWAY EAST OVERPASS
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

McCORMICK RANKIN CORPORATION

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS



KEYPLAN

LEGEND

⯁	Borehole
⯁	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
10-04	142.9	4 829 221.8	610 040.4

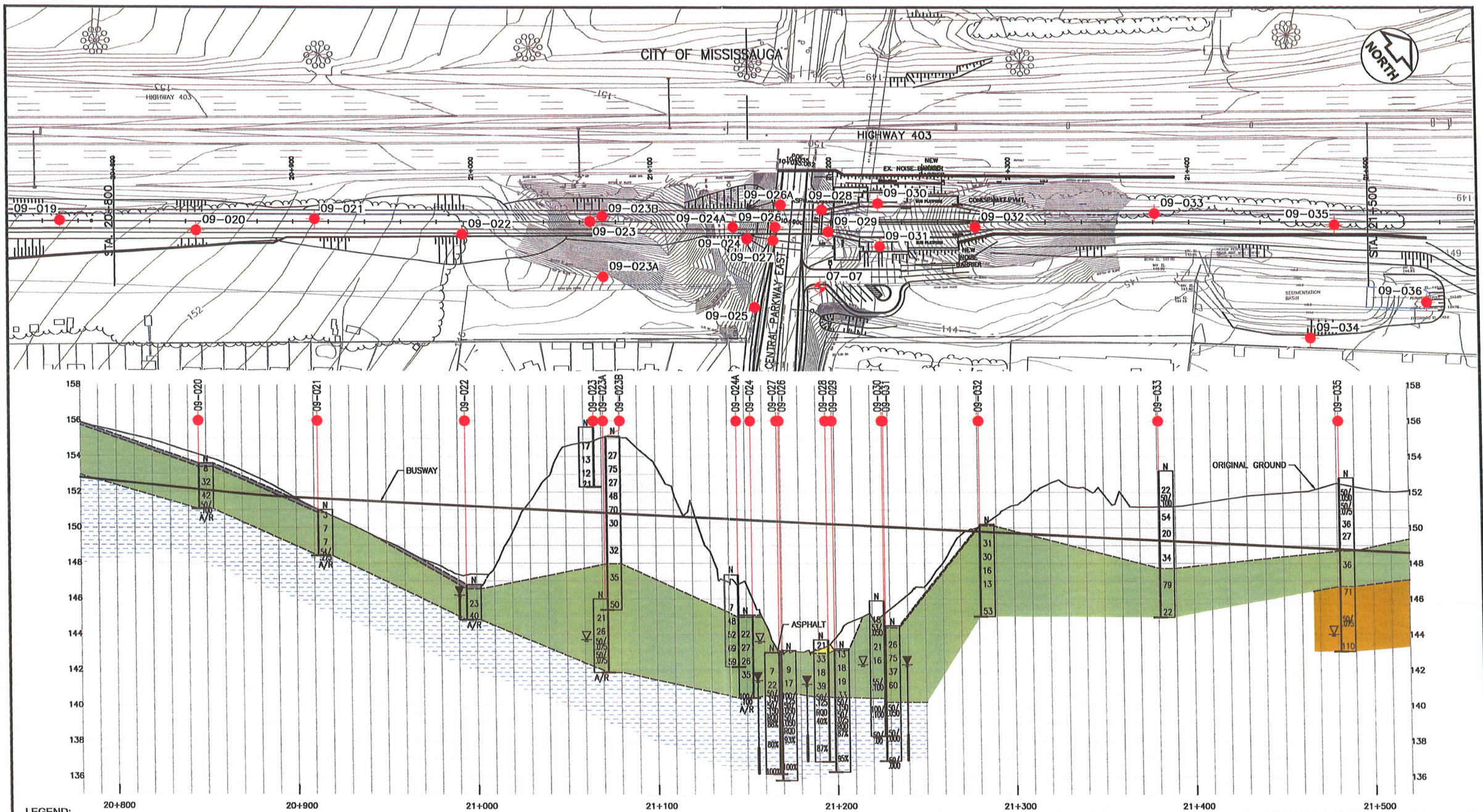
-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 30M12-307

REVISIONS	DATE	BY	DESCRIPTION	
DESIGN MRA	CHK PKC	CODE	LOAD	DATE JUN. 2010
DRAWN MFA	CHK AEG	SITE	STRUCT	DWG 1

FILENAME: O:\Drafting\19\1351\160\MTO Drawings\...
PLOTDATE: Jun 30, 2010 - 4:57pm



LEGEND:

- PRESENT BOREHOLE LOCATION
- PREVIOUS BOREHOLE LOCATION
- TOPSOIL
- FILL
- SILTY CLAY TILL / CLAYEY SILT TILL
- SILTY CLAY / CLAYEY SILT
- SANDY SILT TILL / SILTY SAND TILL
- SANDY SILT / SILTY SAND
- SAND / SAND AND GRAVEL
- BEDROCK (SHALE)
- GROUNDWATER LEVEL IN STANDPIPE PIEZOMETER
- OPEN BOREHOLE GROUNDWATER LEVEL (UNSTABILIZED)

McCORMICK RANKIN CORPORATION

MISSISSAUGA BUS RAPID TRANSIT - EAST SECTION
CENTRAL PARKWAY
STATION 20+800 TO 21+500
BOREHOLE LOCATIONS AND SOIL STRATA

19-1351-160

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

ENGINEER:	DRAWN:	APPROVED:
MEF	MFA	PKC
DATE: DECEMBER 2009	SCALE: 1:2000 HOR 1:200 VER	DRAWING No 19-1351-160-2

FILENAME: H:\Drafting\19\1351\160\tec1160(02)-Plan&Profile(20+800-21+500).dwg