

PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT
HWY 403/Q.E.W N-E RAMP
QUEEN ELIZABETH WAY/HIGHWAY 403 IMPROVEMENTS
OAKVILLE, ONTARIO

W.O. 09-20007

Geocres Number: 30M5-294

Report to

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a preliminary foundation investigation conducted for the proposed structure which will connect westbound (WB) Highway 403 to eastbound Queen Elizabeth Way (QEW) in the Town of Oakville, Ontario. This investigation is part of the QEW/Highway 403 Improvements project, from Trafalgar Road to Winston Churchill Boulevard.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, a stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

The information collected in the course of this investigation and presented in this report is intended for preliminary design purposes only. Additional site investigation, field testing and engineering analysis may be required at the detailed design phase. The extent of the additional investigation will depend on the final location and General Arrangement (GA) of the structure.

Thurber carried out the investigation as a sub-consultant to McCormick Rankin, under the Ministry of Transportation Ontario (MTO) Work Order Number 09-20007.

2 SITE DESCRIPTION

The proposed structure will form part of the improved Highway 403/QEW Interchange. The west abutment is to be located between the EB and WB lanes of Highway 403 approximately 160 m north of Upper Middle Road. The proposed structure stretches to the east on a curve and the east abutment is to be located on the south side of the existing EB lanes of QEW. This structure will

cross over the EB lanes of Highway 403, Upper Middle Road, WB QEW off ramp to Ford Drive, QEW mainlanes, and on ramp from Ford Drive to EB QEW.

The lands immediately adjacent to the structure site consist primarily of undeveloped lands within the MTO right-of-way. Upper Middle Road, which will be crossed by the proposed structure is a Region of Halton road.

The site lies within the South Slope physiographic region, characterized by glacially deposited overburden overlying shale bedrock of the Queenston and Dundas Formations of the upper Ordovician age.

Photographs included in Appendix D show the site of the proposed structure.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out between May 7 and 30, 2013. A total of nine boreholes were drilled and sampled at this site, identified as 13-08 to 13-16. Borehole 13-08 was drilled near the proposed west abutment and Borehole 13-16 was drilled near the proposed east abutment. Boreholes 13-09 to 13-15 were drilled for Pier #1 through Pier #7. The borehole depths ranged from 5.5 m to 6.1 m. The Record of Borehole sheets are included in Appendix A.

The approximate locations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing included in Appendix E. The coordinates and elevations of the boreholes are given on the drawings and on the individual Record of Borehole sheets.

The borehole locations were marked in the field and utility clearances were obtained prior to commencement of drilling operations. A Regional Municipality of Halton Road Occupancy Permit was obtained for unloading and loading the drill rig on the shoulder of Upper Middle Road for accessing Boreholes 13-08 to 13-11. A Town of Oakville Temporary Street Occupancy Permit was obtained for accessing Boreholes 13-15 and 13-16 from South Sheridan Way.

Eight of the boreholes were drilled using a track-mounted CME 55 drill rig and one borehole (13-14) was drilled on the existing QEW with a truck-mounted rig. A combination of solid-stem augers and NQ coring methods were used to advance the boreholes. Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). All rock cores were logged, and the Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

The drilling and sampling operations were supervised on a full time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil and bedrock samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions were observed in the open boreholes during the drilling operations. Standpipe piezometers, consisting of 25 mm diameter PVC pipe with slotted screen, were

installed in four boreholes drilled for this structure. The installation details of the piezometers and borehole completion details for boreholes without piezometer installation are summarized in Table 3.1.

Table 3.1 – Borehole Completion and Piezometer Installation Details

Borehole	Tip Position		Borehole Completion and Piezometer Installation Details
	Depth (m)	Elevation (m)	
BH13-08	5.5	146.3	Sand filter from 5.5 to 3.7 m and bentonite holeplug to surface.
BH13-09	None installed		Backfilled with bentonite holeplug to surface.
BH13-10	5.5	145.3	Sand filter from 5.5 to 3.7 m and bentonite holeplug to surface.
BH13-11	None installed		Backfilled with bentonite holeplug to surface.
BH13-12	None installed		Backfilled with bentonite holeplug to surface.
BH13-13	6.1	143.8	Sand filter from 6.1 to 4.1 m and bentonite holeplug to surface.
BH13-14	None installed		Backfilled with bentonite holeplug from 6.1 m to 0.3 m, concrete from 0.3 m to 0.15 m, and then asphalt patch to surface.
BH13-15	None installed		Backfilled with bentonite holeplug to surface.
BH13-16	5.9	144.0	Sand filter from 5.9 to 1.5 m and bentonite holeplug to surface.

4 LABORATORY TESTING

All recovered soil samples were subjected to Visual Identification (VI) and moisture content determinations. Selected samples were also subjected to grain size distribution analyses (sieve and hydrometer). The results of this testing program are summarized on the Record of Borehole sheets included in Appendix A and are presented on the figures included in Appendix B.

Point load tests were conducted on selected portions of the rock cores. The UCS values of the rock were assessed from the point load data and these values are reported on the borehole logs (as average UCS per run).

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A, and the Borehole Locations and Soil Strata Drawings in Appendix E. An overall description of the stratigraphy based on the conditions encountered in the boreholes is given in the following paragraphs.

However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions.

The stratigraphy encountered at this site generally consists of a thin layer of topsoil overlying a thin layer of fill (either silty clay or sand and gravel), underlain by shale bedrock at a shallow depth. More detailed descriptions of the individual strata encountered at the proposed structure site are presented below.

5.1 Topsoil

A thin layer of topsoil was encountered at the surface in all boreholes, except Borehole 13-14 which was drilled on the existing QEW. The thickness of the surficial topsoil layer ranged from 25 to 125 mm. The thickness of the topsoil may vary between and beyond the borehole locations.

5.2 Asphalt and Concrete

Asphalt was encountered at the surface in Boreholes 13-14 which was drilled on the existing westbound QEW. The asphalt layer was approximately 150 mm thick at the borehole location.

The asphalt encountered in Borehole 13-14 was underlain by 300 mm of concrete.

5.3 Sand and Gravel Fill

Sand and gravel fill was encountered below the concrete in Borehole 13-14 and below the topsoil in Borehole 13-15. Borehole 13-14 was drilled on the existing QEW and Borehole 13-15 was drilled immediately south of the abandoned service road south of QEW, east of Highway 403. The sand and gravel fill was brown to reddish brown in colour and contained trace fines.

The thickness of the sand and gravel fill ranged from 0.4 to 0.6 m, with the lower boundary of the fill encountered at depths of 0.6 and 0.9 m (elevation 149.6 and 149.3).

A single SPT N-value of 11 blows for 0.3 m penetration was recorded in the sand and gravel fill in Borehole 13-15, indicating a compact relative density. The moisture content of the sand and gravel fill sample collected from Borehole 13-15 was 6%.

Grain size distribution analysis was carried out on one sample of the sand and gravel fill. The results of these tests are presented on the Record of Borehole sheets included in Appendix A and are summarized below. The grain size distribution curve for this sample of the sand and gravel fill is plotted on Figure B1, Appendix B.

Gravel %	46
Sand %	42
Silt and Clay %	12

5.4 Silty Clay Fill

Brown to reddish brown silty clay fill was encountered below the surficial topsoil layer in Boreholes 13-08 to 13-13 and 13-16. The silty clay fill contained trace to some sand, occasional shale fragments, and occasional rootlets near the surface. This silty clay has been described as fill since the ground at this site was likely re-worked during construction of the existing QEW/Highway 403 interchange.

The thickness of the silty clay fill layer ranged from 0.5 to 0.9 m, with the lower boundary of the silty clay fill also encountered at depths of 0.5 to 0.9 m at elevation 151.3 to 149.0.

SPT N-values recorded in the silty clay fill ranged from 8 to 22 blows for 0.3 m penetration, indicating a stiff to very stiff consistency. Moisture contents of the silty clay fill ranged from 13 to 25%.

Three samples of the silty clay fill underwent grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A. The grain size distribution curves for these samples are plotted on Figure B2, Appendix B.

Gravel %	0
Sand %	0 to 6
Silt %	58 to 63
Clay %	34 to 37

5.5 Shale Bedrock

Bedrock was encountered below the silty clay fill in Boreholes 13-08 to 13-13, and 13-16, below the sand and gravel fill in Boreholes 13-14 and 13-15. The depths and elevations at which bedrock was encountered in the boreholes are summarized in Table 5.1.

Table 5.1 – Depths and Elevations of Bedrock Surface

Foundation Element	Borehole	Bedrock Surface	
		Depth (m)	Elevation (m)
West Abutment	13-08	0.5	151.3
Pier #1	13-09	0.8	150.0
Pier #2	13-10	0.9	149.8
Pier #3	13-11	0.7	149.4
Pier #4	13-12	0.8	148.2
Pier #5	13-13	0.9	149.0
Pier #6	13-14	0.9	149.3

Pier #7	13-15	0.6	149.6
East Abutment	13-16	0.5	149.4

The bedrock was described as thinly laminated reddish brown shale containing frequent hard grey limestone interbeds up to 150 mm in thickness. The shale was generally described as highly weathered at the soil-bedrock interface and described as slightly weathered to fresh within 1 to 2 m of the soil-bedrock interface. Frequent horizontal fractures and occasional vertical fractures, highly broken zones, and clay seams were observed in the bedrock cores.

Total Core Recovery (TCR) in the bedrock ranged from 93 to 100%. The Rock Quality Designation (RQD) values ranged from 37 to 100%, indicating a variable rock quality ranging from poor to excellent. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, typically ranged from 0 to 5. FI values of greater than 10 were recorded for highly fractured zones.

The average estimated unconfined compression strength (UCS) of the shale, interpreted from point load tests conducted on intact cores, ranged from 5 to 18 MPa, indicating a very weak to weak rock strength classification. In most boreholes there were limestone interbeds that were sufficiently thick for representative point load testing. The UCS of the limestone interbeds ranged from 46 to 145 MPa, indicating a medium strong to very strong rock strength classification.

5.6 Water Levels

All boreholes were dry upon completion of augering, prior to adding water into the boreholes for the coring operations. Standpipe piezometers were installed four of the boreholes drilled for this structure. The water levels measured in the open boreholes and piezometers are summarized below.

Table 5.2 – Groundwater Depths and Elevations

Borehole	Date of Reading	Water Level		Comment
		Depth (m)	Elev. (m)	
13-08	May 7, 2013	Dry		Open borehole – prior to coring Piezometer Piezometer
	May 30, 2013	5.5	146.3	
	June 26, 2013	4.3	147.5	
13-09	May 8, 2013	Dry		Open borehole – prior to coring
13-10	May 9, 2013	Dry		Open borehole – prior to coring Piezometer Piezometer
	May 30, 2013	4.9	145.9	
	June 26, 2013	5.5	145.3	
13-11	May 10, 2013	Dry		Open borehole – prior to coring

13-12	May 28, 2013	Dry		Open borehole – prior to coring
13-13	May 28, 2013	Dry		Open borehole – prior to coring
	May 30, 2013	3.0	146.9	Piezometer
	June 26, 2013	2.7	147.2	Piezometer
13-14	May 23, 2013	Dry		Open borehole – prior to coring
13-15	May 14, 2013	Dry		Open borehole – prior to coring
13-16	May 14, 2013	Dry		Open borehole – prior to coring
	May 30, 2013	2.8	147.1	Piezometer
	June 26, 2013	2.8	147.1	Piezometer

It should be noted that ground water level is susceptible to seasonal fluctuations. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

6 MISCELLANEOUS

Borehole locations were selected and established in the field by Thurber Engineering Ltd. Surveyors from MMM Group provided co-ordinates and the ground surface elevations at the boreholes drilled.

DBW Drilling Ltd. from Ajax, Ontario supplied the track-mounted and truck-mounted drill rigs and conducted the drilling, sampling and in-situ testing operations.

Overall planning and supervision of the field program was conducted by Ms. Lindsey Blaine, P.Eng. The field investigation was supervised by Mr. George Azzopardi and Ms. Lindsey Blaine, P.Eng. of Thurber.

Routine laboratory testing was carried out by Thurber Engineering Ltd.

Interpretation of the data and preparation of the report were carried out by Ms. Lindsey Blaine, P.Eng. and Mr. Alastair Gorman, P.Eng.. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

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Review Principal



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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

This report presents interpretation of the geotechnical data in the factual report and presents preliminary foundation recommendations to assist the design team to select and design a suitable foundation system for the new structure proposed for the Highway 403 and QEW N-E (403/QEW N-E) Ramp.

The 403/QEW N-E Ramp will cross over HWY 403, Upper Middle Road, the QEW E to Ford Dr N-S Ramp, and the QEW main lanes. The proposed finished grade of the 403/QEW N-E structure will be near elevations 158.7 and 159.7 at the west and east abutments, respectively. The existing ground surface within the proposed structure is near Elevations 146 at HWY 403 and around 150 for the remaining areas. The approach fills will be in the order of 7 to 10 m high.

The preliminary GA drawing (dated July 2013 from McCormick Rankin Corporation (MRC)) shows that the proposed 403/QEW N-E Ramp is an eight span structure supported by two abutments and seven piers. The ramp structure spans a distance of approximately 423.0 m and the bridge deck is approximately 18.2 m wide.

The discussion and recommendations presented in this report are based on the GA supplied by MRC and on the factual data obtained in the course of this investigation.

8 STRUCTURE FOUNDATIONS

The stratigraphy identified in the preliminary investigation consisted primarily of topsoil and fill overlying shale bedrock at shallow depth. The short term groundwater level measured in the piezometers was 2.7 m to 5.5 m below the ground surface (Elevations 147.2 to 145.3).

In the preparation of the preliminary foundation recommendations, consideration was given to the following foundation types:

- Spread footings bearing on bedrock
- Spread footings on engineered fill
- Steel H-piles
- Augered caissons socketed into bedrock

A comparison of the foundation alternatives based on advantages and disadvantages of each is included in Appendix C.

8.1 Spread Footings on Bedrock

Due to the shallow depth of overburden, spread footings founded on shale bedrock are considered feasible to support the structural loads.

As interpreted from the boreholes, spread footings should be founded on undisturbed, shale bedrock at the elevations summarized in Table 8.1.

Table 8.1 – Bearing Resistances for Spread Footings

Element	Borehole	Depth (m)	Elev.	ULS _f (kPa)	Soil/Rock
West Abutment	13-08	1.3	150.5	1000	Shale
Pier #1	13-09	1.5	149.3	1000	Shale
Pier #2	13-10	1.5	149.3	1000	Shale
Pier #3	13-11	1.5	148.5	1000	Shale
Pier #4	13-12	1.5	147.6	1000	Shale
Pier #5	13-13	1.5	148.4	1000	Shale
Pier #6	13-14	2.2	148.0	1000	Shale
Pier #7	13-15	1.2	149.0	1000	Shale
East Abutment	13-16	1.5	148.4	1000	Shale

The bearing resistances in Table 8.1 are for vertical, concentric loading and include a resistance factor of 0.5 as per Table 6.1 of the CHBDC. The SLS condition will not govern the design of footings founded on bedrock. In the case of eccentric or inclined loading, the bearing resistance must be adjusted as shown in the CHBDC (2006) Clause 6.7.3 and Clause 6.7.4.

Founding elevations presented in Table 8.1 are generally above the groundwater level observed during the investigation. However, if temporary excavations are required to construct these footings below the water table, local groundwater control will be required to construct the footings in the dry and prevent disturbance of the footing base.

8.2 Spread Footings on Engineered Fill

The use of spread footings bearing on engineered fill pads is considered to be feasible for the construction of perched abutment foundations.

For preliminary design purposes, it is recommended that the engineered fill be assumed to bear on bedrock, i.e. all existing fill overburden must be stripped prior to constructing the engineered fill.

If a footing on engineered fill bearing on bedrock is used, it may be designed on the basis of the following concentric, vertical geotechnical resistances:

- 900kPa at factored ULS
- 350kPa at SLS

The engineered fill must be founded on the top of the undisturbed shale bedrock at or below the elevations given in Table 8.1. The engineered fill must consist of OPSS Granular “A” or Granular “B” Type II placed in 150 mm lifts and compacted to 100% of its SPMDD at $\pm 2\%$ of optimum moisture content and generally conforming to the geometry illustrated in Figure 1.

The resistance values above are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance used in design must be reduced in accordance with the CHBDC Clause 6.7.3 and Clause 6.7.4.

Dewatering is not expected to be required for the excavation and construction of the engineered fill. However, any water accumulating in the excavation must be pumped out prior to placing the engineered fill.

8.3 Steel H-Piles

In view of the shallow depth to bedrock, driven piles are not considered to be feasible foundation option at the piers. However, they could be considered for the east and west abutments, where there will be approximately 8 m of fill over the shale bedrock.

It is recommended that the piles be driven to refusal in the shale bedrock at the depths and tip elevations shown in Table 8.2

Table 8.2 – Estimated Pile Tip Elevation

Element	Pile Tip Depth (m)	Pile Tip Elevation
West Abutment (BH 13-08)	2.0 (below OGL)	149.8
East Abutment (BH 13-16)	2.0 (below OGL)	147.9

For preliminary design, the vertical, axial, factored geotechnical resistance at ULS for two pile sections when installed in the bedrock are presented in Table 8.3. The SLS condition will not govern for piles driven to bedrock.

Table 8.3 – Axial Resistance of Two Pile Sections Founded on Bedrock

Pile Section	Factored Geotechnical Resistance at ULS (kN)
HP 310 X 110	2,000
HP 310 X 132	2,400

The resistance values in Table 8.3 include a geotechnical resistance factor of 0.4 as per the CHBDC. The structural resistance of the pile must be checked by the structural designer. Downdrag on the piles is not considered to be an issue at this site.

These are preliminary recommendations and may change during detail design based on the final alignment, final bridge arrangement and the results of the investigation and field testing to be completed at that time.

8.4 Augered Caissons

Drilled shaft foundations socketed into shale bedrock are not considered appropriate for this site and have not been developed further.

8.5 Abutment Design Considerations

From a geotechnical perspective, the conditions at this site are considered to be suitable for conventional or semi-integral abutment design, principally due to the shallow depth to bedrock. Based on geotechnical considerations and the preliminary grade for the ramp, integral abutment design could also be considered.

8.6 Frost Cover

The design depth of frost penetration at this site is 1.2 m. It is recommended that all footings be provided with a minimum of 1.2 m of earth cover above the underside of the pile cap or footing. Frost protection is required for footings founded on shale bedrock.

8.7 Recommended Foundation

From a geotechnical perspective, and based on current information, the recommended foundation consists of spread footing bearing on undisturbed, sound shale bedrock for the piers. At the abutments, footings bearing on engineered fill are recommended. Driven piles may also be feasible at the abutments.

9 DEWATERING

Excavations for footings to depths indicated in Table 8.1 are not expected to penetrate below the groundwater level. However, if deeper excavations are required they may penetrate below the groundwater level and some seepage into the excavation may occur. However, due to the relatively low permeability of the shale, the volumes of water are expected to be small. Similarly, some seepage from the fill may be encountered and surface water flow may enter the excavations.

Given the small volumes of water that are expected, it is considered that pumping from sumps will be adequate for dewatering excavations at this site. The exposed shale at the base of the foundation excavation must be protected from deterioration.

10 APPROACH EMBANKMENTS

Based on the current boreholes drilled at the site, the 7 to 10 m high approach embankments will be constructed over stiff to very stiff silty clay fill or compact sand and gravel fill over shale bedrock. The embankment foundation soils are considered to provide adequate stability if the approach embankment is constructed at maximum side slopes of 2H:1V using SSM or granular fill.

Constructing the approach embankments with cohesive fill may be possible but will be dependent on the mechanical properties of the material. An embankment constructed of cohesive material will typically not perform as well as an embankment constructed using SSM or granular fill and will require flatter side slopes which will extend the footprint of the embankment.

Preliminary analysis indicates that settlement of the foundations soils under the imposed embankment loading is expected to be less than 25 mm. Considering the competency of the foundation soils the settlement will be essentially completed when construction of the fill is completed.

Settlement analysis and the global, internal and surficial stability of the approach embankment fills should be further evaluated during the detailed design phase. Additionally, permanent drainage and slope protection requirements must be addressed during the detailed design.

11 ROADWAY PROTECTION

Excavation support systems may be required for temporary roadway protection during foundation construction where stable slopes cannot be constructed. The temporary excavation support system should be designed and constructed in accordance with OPSS 539. In general, the lateral movement of the temporary shoring system should meet Performance Level 2 as specified in OPSS 539. The feasibility of installing protection systems should be assessed once further subsurface investigation is carried out during detailed design.

12 CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to the following:

- The shale bedrock exposed in foundations must be concreted within 24 hours once the bedrock surface has been properly prepared and is free of loose debris to prevent softening and deterioration. Shale exposed below engineered fill is less critical but fill must be placed within one week of completing excavation.

13 INVESTIGATION FOR DETAIL DESIGN

During the detail design phase of the project, additional site investigation and field testing may be required. The scope and results of this investigation must be reviewed at that time to determine if they meet the current Ministry requirements and if additional investigation and analysis is necessary.

14 CLOSURE

Engineering analysis and preparation of the report were carried out by Mr. Lukasz Gilarski, P.Eng. and Mr. Alastair Gorman, P.Eng.. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

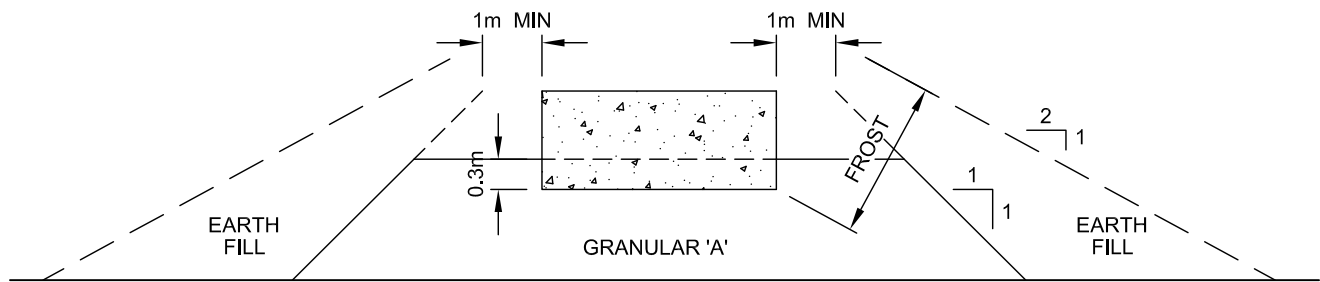
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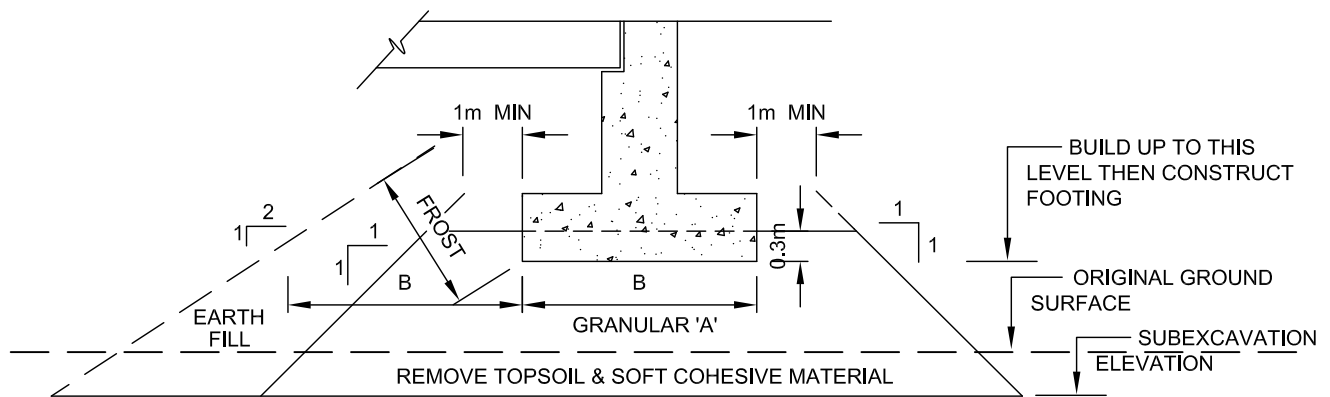


P.K. Chatterji, P.Eng., Ph.D.
Review Principal





CROSS-SECTION



LONGITUDINAL SECTION

NOTES:

1. REMOVE TOPSOIL AND OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' AND EARTH FILL.
2. PLACE GRANULAR 'A' AND EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO O.P.S.S. 501.
3. CONSTRUCT CONCRETE FOOTING.
4. PLACE REMAINDER OF GRANULAR 'A' AND EARTH FILL AS REQUIRED.
5. SOURCE M.T.C. 1982.

ABUTMENT ON COMPACTED FILL
SHOWING GRANULAR 'A' CORE



THURBER ENGINEERING LTD.

ENGINEER:

LPG

DRAWN:

MFA

APPROVED:

AEG

DATE:

OCTOBER 2013

SCALE:

N.T.S.

DRAWING No.

FIGURE 1

Appendix A

Record of Borehole Sheets

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.

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

SYMBOLS

	CLAYSTONE
	SILTSTONE
	SANDSTONE
	COAL
	BEDROCK

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
	(MPa)	(psi)	
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

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 % 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.

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
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

SYMBOLS AND TERMS USED ON TEST HOLE LOGS

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 naked eye

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

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

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROX. SPT ⁽¹⁾ "N" VALUE
Very Soft	< 10	< 2
Soft	10 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	> 200	> 30

(1) Standard Penetration Test – the number of blows from a 63.5kg hammer falling through 0.76m to advance a 60 degree truncated cone 0.3m

TERMS DESCRIBING DENSITY(COHESIONLESS SOILS)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	< 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	> 50


HIERARCHY OF SOIL STRENGTH PREDICTION

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

LEGEND FOR TEST HOLE LOGS

 Shelby Tube
 A – Casing
  SPT
  Grab/Auger sample
  Core
  No Recovery

- MC – Moisture Content (% by Weight) as determined by sample

 Water Level
 C_{vane} Shear Strength Determination by Field Insitu Vane
 C_{pen} Shear Strength Determination by Pocket Penetrometer
 C_{lab} Shear Strength Determination using a Laboratory Vane Apparatus
 C_u Undrained Shear Strength determined by Unconfined Compression Test
 AS/GS/BS Auger Sample/Grab Sample/ Block Sample
 SS Split-spoon
 SC Soil core
 AED Oedometer test
 TXL Triaxial test

RECORD OF BOREHOLE No 13-08

1 OF 1

METRIC

W.P. _____ LOCATION N 4 817 953.6 E 290 550.0 ORIGINATED BY GA
 HWY 403/QEW BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2013.05.07 - 2013.05.07 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
151.8								20	40	60	80	100		
0.0	TOPSOIL: (50mm)													
151.3	Silty CLAY , some sand Very Stiff Brown (FILL)		1	SS	17									
0.5	SHALE , highly weathered, brown		2	SS	50/ 0.150		151							
			3	SS	50/ 0.150		150							
	Start coring at 2.4m													
	Moderately weathered to fresh, occasional limestone interbeds						149							
	Horizontal fractures at 2.5m, 2.6m, 2.7m, 2.9m, 3.0m, 3.2m, 3.3m, 3.4m, 3.7m, 3.8m		1	RUN										
	Limestone interbeds (25mm thick) at 3.0m, 3.2m, 3.4m, 3.7m						148							
	Limestone interbed (150mm) at 4.1m													
	Horizontal fractures at 4.0m, 4.1m, 4.2m, 4.3m, 4.4m, 4.5m, 4.7m, 5.0m, 5.1m, 5.2m		2	RUN			147							
	Limestone interbeds (25mm thick) at 3.9m, 4.3m, 4.4m, 4.5m, 4.6m, 5.3m, (75mm) at 4.7m													
146.3														
5.5	END OF BOREHOLE AT 5.5m. BOREHOLE OPEN TO 5.5m AND WATER LEVEL AT 0.9m UPON COMPLETION OF CORING. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.													
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) May 30/13 5.5 146.3 Jun 26/13 4.3 147.5													

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RECORD OF BOREHOLE No 13-09

1 OF 1

METRIC

W.P. _____ LOCATION N 4 817 924.3 E 290 584.6 ORIGINATED BY GA
 HWY 403/QEW BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2013.05.08 - 2013.05.08 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
150.8													
0.0	TOPSOIL: (50mm)												
	Silty CLAY , trace sand, occasional shale fragments Very Stiff Reddish Brown (FILL)		1	SS	22								0 6 58 36
150.0													
0.8	SHALE , highly weathered, thinly bedded, reddish brown		2	SS	50/ 0.150								
			3	SS	50/ 0.100								
	Start coring at 2.4m												
	Slightly weathered to fresh, thinly bedded, reddish brown, occasional limestone interbeds		1	RUN									RUN #1 TCR=100% SCR=92% RQD=75% UCS=8MPa (Average)
	Limestone interbeds (25mm to 75mm thick) at 2.7m, 2.9m, 3.1m, 3.4m, 3.6m Clay seam at 3.1m												
	Horizontal fractures at 2.5m, 2.9m, 3.0m, 3.1m, 3.2m, 3.3m, 3.4m, 3.5m, 3.9m		2	RUN									RUN #2 TCR=100% SCR=100% RQD=95% UCS=10MPa (Average)
	Limestone interbeds (25mm thick) at 4.1m, 4.7m, 4.8m, 5.1m, 5.3m												
	Horizontal fractures at 4.0m, 4.1m, 4.4m, 4.9m												
	Limestone interbeds (25mm thick) at 5.4m, 5.7m, 5.8m		3	RUN									RUN #3 TCR=100% SCR=100% RQD=100% UCS=18MPa (Average)
144.8													
5.9	END OF BOREHOLE AT 5.9m. BOREHOLE OPEN TO 5.9m AND WATER LEVEL AT 1.2m UPON COMPLETION OF CORING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.												

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RECORD OF BOREHOLE No 13-10

1 OF 1

METRIC

W.P. _____ LOCATION N 4 817 938.9 E 290 656.9 ORIGINATED BY GA
 HWY 403/QEW BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2013.05.09 - 2013.05.09 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)					
150.8								20	40	60	80	100					
0.0	TOPSOIL: (50mm)																
	Silty CLAY , occasional rootlets Stiff Reddish Brown (FILL)		1	SS	11												
149.8			2	SS	50/ 0.150												
0.9	SHALE , highly weathered, thinly bedded, reddish brown																
			3	SS	50/ 0.150												
	Start coring at 2.4m																
	Slightly weathered to fresh, thinly bedded, reddish brown, occasional limestone interbeds																
	Limestone interbeds (25mm thick) at 2.7m, 2.9m, 3.5m, 3.6m		1	RUN													
	Horizontal fractures at 2.5m, 2.6m, 2.7m, 2.8m, 3.0m, 3.3m, 3.4m, 3.6m																
	Limestone interbeds (25mm to 50mm thick) at 4.9m, 5.0m, 5.1m, 5.3m																
	Horizontal fractures at 4.0m, 4.3m, 4.4m, 4.8m, 5.1m		2	RUN													
145.3																	
5.5	END OF BOREHOLE AT 5.5m. BOREHOLE OPEN TO 5.5m AND WATER LEVEL AT 1.5m UPON COMPLETION OF CORING. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.																
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) May 30/13 4.9 145.9 Jun 26/13 5.5 145.3																

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+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 13-11

1 OF 1

METRIC

W.P. _____ LOCATION N 4 817 918.5 E 290 697.1 ORIGINATED BY GA
 HWY 403/QEW BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2013.05.10 - 2013.05.10 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
								20 40 60 80 100						
150.0														
0.0	TOPSOIL: (50mm)						150							
149.4	Silty CLAY , trace sand, occasional shale fragments		1	SS	8									0 5 61 34
0.7	Stiff Reddish Brown (FILL)													
	SHALE , highly weathered, reddish brown		2	SS	44		149							
			3	SS	50/ 0.150									
	Start coring at 2.4m						148							
	Slightly weathered, thinly bedded, reddish brown, occasional limestone interbeds													
	Limestone interbeds (25mm to 75mm) at 2.7m, 3.2m		1	RUN			147							RUN #1 TCR=100% SCR=95% RQD=57% UCS=6MPa (Average)
	Horizontal fractures at 2.6m, 2.7m, 2.9m, 3.1m, 3.2m, 3.3m, 3.4m, 3.5m, 3.6m, 3.7m, 3.8m													
	Limestone interbeds (25mm thick) at 3.9m, 4.6m, 4.7m, 4.9m, 5.1m, 5.3m, 5.4m						146							RUN #2 TCR=100% SCR=97% RQD=37% UCS=14MPa (Average)
	Horizontal fractures at 3.9m, 4.5m, 4.6m, 4.7m, 4.8m, 4.9m, 5.1m, 5.3m		2	RUN										
							145							
144.6														
5.5	END OF BOREHOLE AT 5.5m. BOREHOLE OPEN TO 5.1m AND WATER LEVEL AT 1.8m UPON COMPLETION OF CORING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.													

RECORD OF BOREHOLE No 13-12

1 OF 1

METRIC

W.P. _____ LOCATION N 4 817 926.6 E 290 748.1 ORIGINATED BY GA
 HWY 403/QEW BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2013.05.28 - 2013.05.28 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
								UNCONFINED							FIELD VANE				
								QUICK TRIAXIAL							LAB VANE				
149.1							20	40	60	80	100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L					
0.0	TOPSOIL: (125mm)																		
0.1	Silty CLAY , trace sand, occasional rootlets		1	SS	16												0 0 63 37		
	Very Stiff																		
148.2	Reddish Brown (FILL)		2	SS	50/														
0.8	SHALE , highly weathered, thinly bedded, reddish brown				0.150														
			3	SS	50/														
					0.100														
	Start coring at 3.1m																		
	Slightly weathered to fresh, thinly bedded, reddish brown, occasional limestone interbeds																		
	Soft zone (175mm) at 3.0m																		
	Limestone interbed (25mm) at 3.9m		1	RUN															
	Horizontal fractures at 3.2m, 3.3m, 3.4m, 3.7m, 3.8m, 4.2m																		
	Highly broken zone (75mm) at 3.9m																		
	Limestone interbed (25mm) at 3.6m, 3.7m, 4.1m, 4.2m, 4.5m, 4.6m, 5.1m, 5.2m, 6.0m																		
	Horizontal fractures at 4.7m, 5.1m, 5.7m, 5.9m		2	RUN															
143.0																			
6.1	END OF BOREHOLE AT 6.1m. BOREHOLE OPEN TO 6.1m AND WATER LEVEL AT 1.8m UPON COMPLETION OF CORING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																		

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RECORD OF BOREHOLE No 13-13

1 OF 1

METRIC

W.P. _____ LOCATION N 4 817 944.0 E 290 794.5 ORIGINATED BY GA
 HWY 403/QEW BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2013.05.28 - 2013.05.30 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
149.9														
0.0	TOPSOIL: (125mm)													
0.1	Silty CLAY , trace sand, occasional rootlets		1	SS	10									
	Stiff													
149.0	Reddish Brown/Brown (FILL)													
0.9	SHALE , highly weathered, thinly bedded, reddish brown		2	SS	48		149							
			3	SS	50/ 0.150		148							
	Start coring at 3.0m						147							
	Slightly weathered to fresh, thinly bedded, reddish brown, occasional limestone interbeds													
	Soft zone (225mm) at 3.0m													
	Limestone interbeds (25mm thick) at 3.5m, 3.6m, 4.2m, 4.3m		1	RUN			146							
	Horizontal fracture at 3.1m, 3.3m, 3.4m, 3.5m, 3.6m, 3.8m, 4.0m, 4.2m, 4.4m, 4.5m													
	Limestone interbeds (25mm thick) at 4.8m, 5.0m, 5.2m, 5.6m, 5.7m, 6.0m		2	RUN			145							
	Horizontal fracture at 5.0m, 5.2m, 5.4m													
143.8	Limestone interbed at 6.0m						144							
6.1	END OF BOREHOLE AT 6.1m. BOREHOLE OPEN TO 6.1m AND WATER LEVEL AT 3.3m UPON COMPLETION OF CORING. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.													
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) May 30/13 3.0 146.9 Jun 26/13 2.7 147.2													

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RECORD OF BOREHOLE No 13-14

1 OF 1

METRIC

W.P. _____ LOCATION N 4 817 955.6 E 290 844.0 ORIGINATED BY GA
 HWY 403/QEW BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2013.05.23 - 2013.05.23 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
150.2							20	40	60	80	100					
0.0	ASPHALT: (150mm)															
0.2	CONCRETE: (300mm)															
149.7																
0.5	SAND and GRAVEL Brown (FILL)															
149.3																
0.9	SHALE, highly weathered, reddish brown		1	SS	28											
			2	SS	38											
	Moderately weathered		3	SS	74											
	Start coring at 3.0m															
	Slightly weathered to fresh, thinly bedded, reddish brown															
	Limestone interbeds (25mm) at 3.0m, 3.2m, 3.3m, 3.7m, 3.9m, 4.3m		1	RUN												
	Highly broken zones: 150mm at 3.0m 225mm at 3.6m															
	Horizontal fracture at 3.3m, 3.4m, 3.5m, 3.6m, 3.8m, 3.9m, 4.0m, 4.2m															
	Limestone interbeds (25mm) at 5.0m, 5.3m, 5.7m, 5.9m		2	RUN												
	Highly broken zones: 150mm at 4.8m 100mm at 6.0m															
	Horizontal fracture at 4.5m, 4.9m, 5.1m, 5.2m, 5.5m, 5.6m, 5.8m, 6.0m															
144.1																
6.1	END OF BOREHOLE AT 6.1m. BOREHOLE OPEN TO 6.1m AND WATER LEVEL AT 1.5m UPON COMPLETION OF CORING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.3m, CONCRETE TO 0.15m, THEN ASPHALT PATCH TO SURFACE.															

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+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 13-15

1 OF 1

METRIC

W.P. _____ LOCATION N 4 818 008.5 E 290 914.7 ORIGINATED BY LRB
 HWY 403/QEW BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2013.05.14 - 2013.05.14 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								20 40 60 80 100					
150.2													
0.8	TOPSOIL: (25mm)												
149.6	SAND and GRAVEL, some silt Compact Reddish Brown Moist (FILL)		1	SS	11								46 42 12 (SI+CL)
0.6	SHALE, highly weathered, reddish brown, occasional limestone interbeds		2	SS	72								
			3	SS	80/ 0.275								
	Start coring at 2.4m												
	Moderately to slightly weathered, thinly bedded		1	RUN									
	Highly broken from 2.4m to 2.6m												
	Clayey (50mm) at 2.4m												
	Limestone (75mm) at 2.8m and (50mm) at 2.9m Oxidation from 4.2m to 4.3m		2	RUN									
	Highly broken (150mm) at 3.0m and 4.2m												
	Limestone (25mm) at 4.0m, 4.3m and (100mm) at 3.4m												
	Limestone (25mm to 75mm) at 4.9m, 5.3m, 5.5m, 5.7m, 5.8m		3	RUN									
	Vertical fracture (50mm) at 5.3m and (125mm) at 5.6m												
144.3													
5.9	END OF BOREHOLE AT 5.9m. BOREHOLE BACKFILLED WITH BENTONITE TO SURFACE.												

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 13-16

1 OF 1

METRIC

W.P. _____ LOCATION N 4 818 032.0 E 290 946.7 ORIGINATED BY LRB
 HWY 403/QEW BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2013.05.14 - 2013.05.14 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
149.9							20	40	60	80	100	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	
0.0	TOPSOIL: (25mm)											W P	W	W L	
149.4	Silty CLAY, trace sand, trace rootlets		1	SS	12								○		
0.5	Stiff Brown (FILL)														
	SHALE, highly weathered, reddish brown		2	SS	57								○		
	Occasional limestone interbeds		3	SS	84/ 0.275								○		
	Start coring at 2.4m														
	Highly weathered to slightly weathered, thinly bedded Clayey from 2.4m to 2.6m		1	RUN											
	Limestone (50mm) at 2.6m and 3.0m														
	Highly fractured from 2.7m to 3.0m														
	Limestone (25mm) at 3.6m, 3.8m, 3.9m, 4.6m		2	RUN											
	Horizontal fracture every 25mm to 75mm through out the run														
	Highly fractured (25mm to 50mm) at 3.4m, 3.6m														
	Limestone (25mm) at 5.3m, 5.6m, 5.7m and (75mm) at 5.0m, 5.8m		3	RUN											
	Horizontal fracture approx. every 100mm through out the run														
144.0															
5.9	END OF BOREHOLE AT 5.9m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.														
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) May 30/13 2.8 147.1 Jun 26/13 2.8 147.1														

ONTMT4S 1184.GPJ 2012TEMPLATE(MTO).GDT 8/1/13

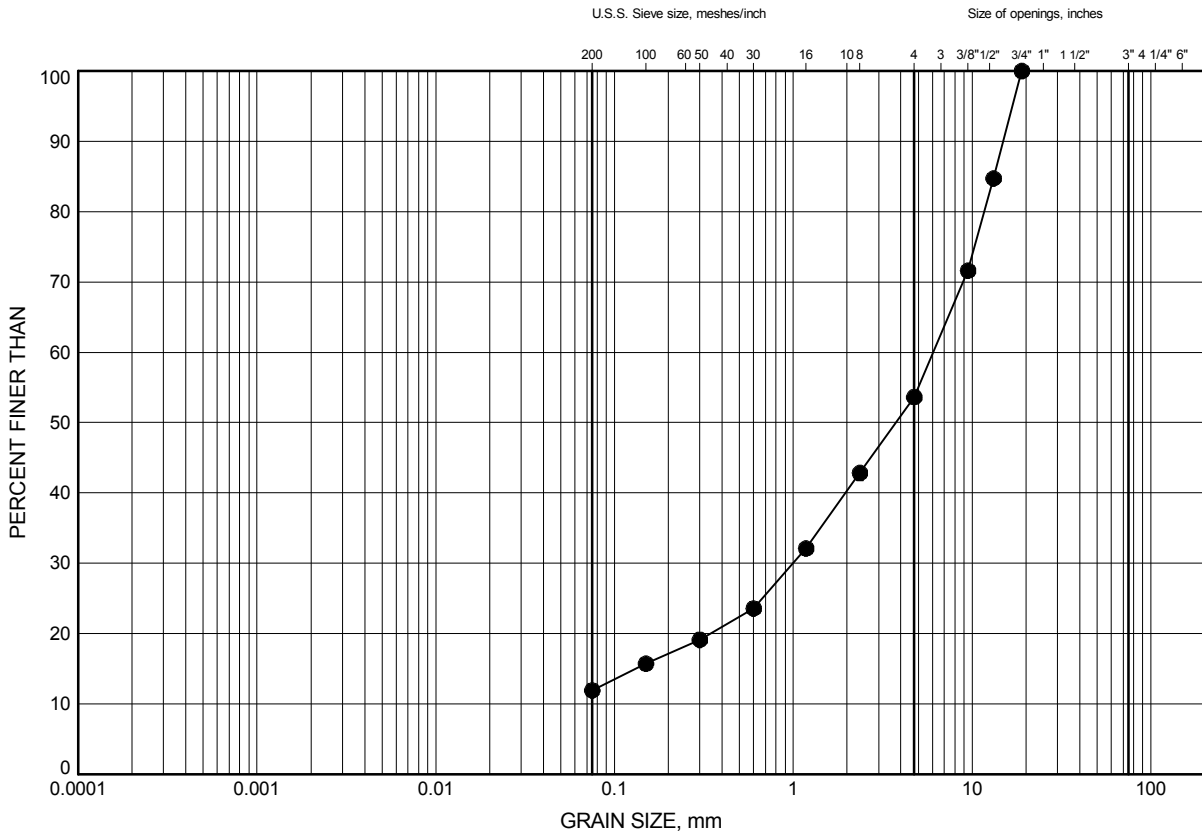
Appendix B

Laboratory Test Results

QEW and Hwy 403
GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND & GRAVEL FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	13-15	0.30	149.89

Date July 2013
W.P.

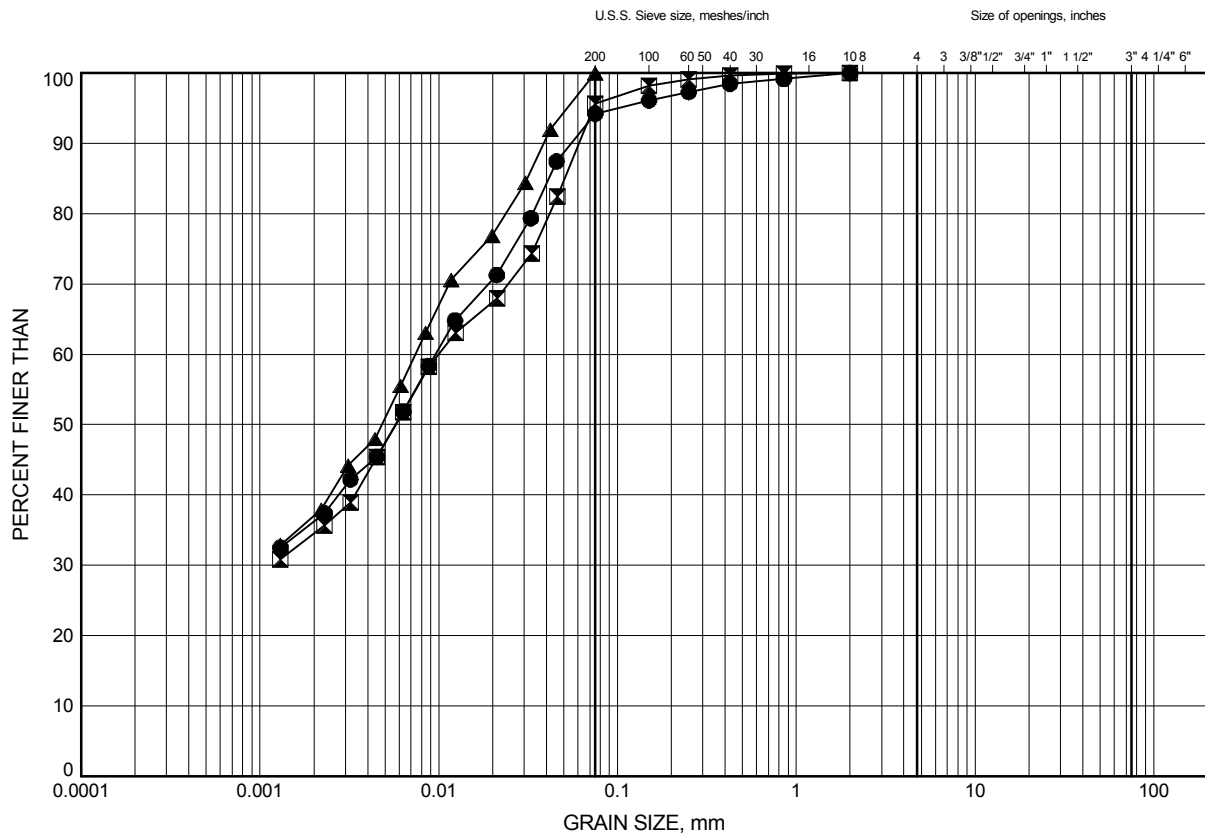


Prep'd AN
Chkd. LPG

QEW and Hwy 403
GRAIN SIZE DISTRIBUTION

FIGURE B2

Silty CLAY FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	13-09	0.30	150.46
⊠	13-11	0.30	149.74
▲	13-12	0.38	148.68

Date July 2013
W.P.



Prep'd AN
Chkd. LPG

Appendix C

Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

Spread Footing on Bedrock	Spread Footing on Engineered Fill	Steel H-Piles Driven to Shale Bedrock
<p><i>Advantages:</i></p> <ul style="list-style-type: none"> i. Economical to install. ii. Higher geotechnical resistance than footing on native soil. 	<p><i>Advantages:</i></p> <ul style="list-style-type: none"> i. Economical to install ii. Accommodates perched abutment. 	<p><i>Advantages:</i></p> <ul style="list-style-type: none"> i. High geotechnical resistance available by driving piles to bedrock. ii. Comparatively short abutment possible iii. Permits integral abutment design.
<p><i>Disadvantages:</i></p> <ul style="list-style-type: none"> i. Dewatering may be required depending on depth of excavation ii. Ineffective for resistance to uplift. 	<p><i>Disadvantages:</i></p> <ul style="list-style-type: none"> i. Dewatering may be required depending on depth of excavation ii. Lower geotechnical resistance than spread footing on bedrock iii. Ineffective for resistance to uplift. 	<p><i>Disadvantages:</i></p> <ul style="list-style-type: none"> i. Higher unit cost compared to footings.
RECOMMENDED FOR PIERS	RECOMMENDED FOR ABUTMENTS	FEASIBLE FOR ABUTMENTS

Appendix D

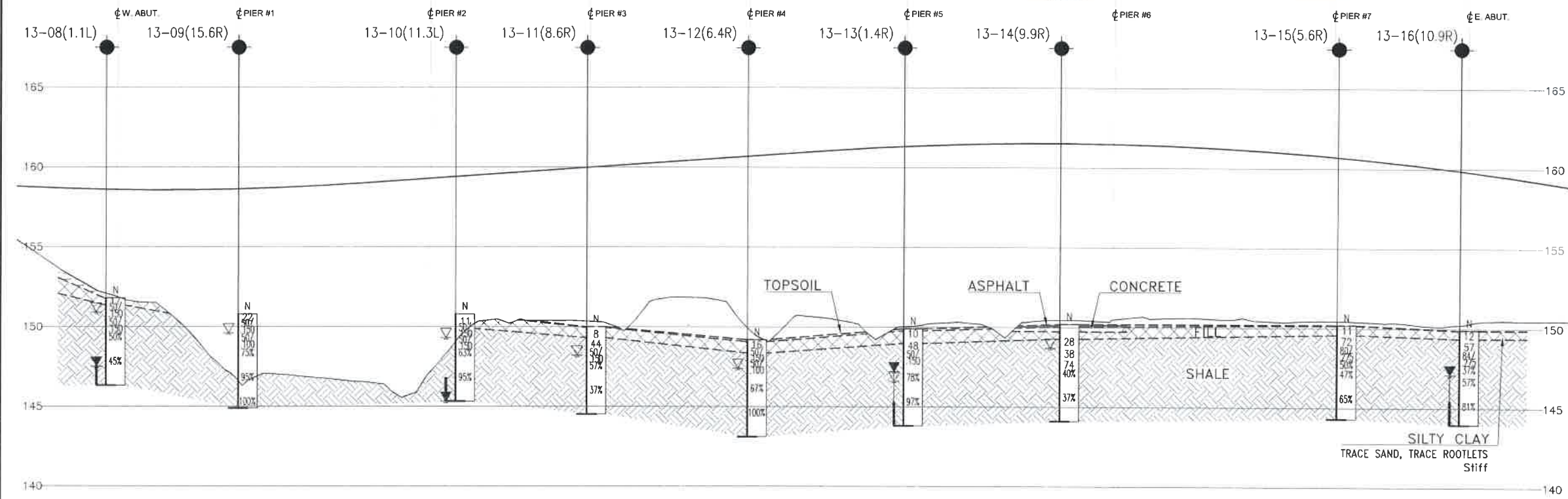
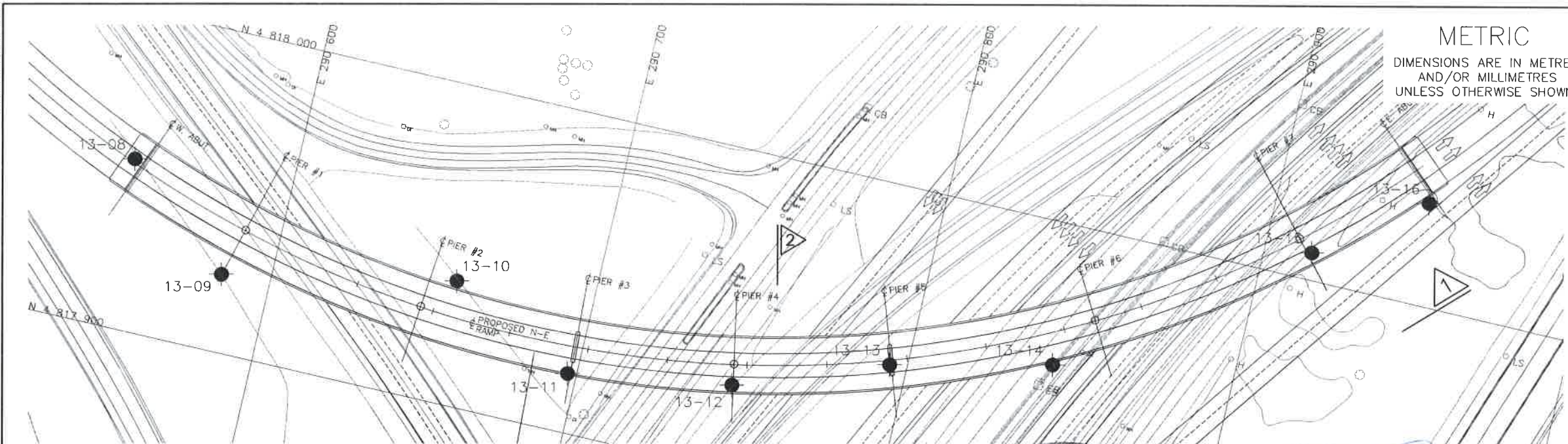
Site Photographs



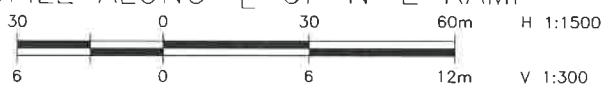
Photograph 1: Looking north from Upper Middle Road at the location where the new HWY403-QEW N-E ramp will cross over EB Highway 403.

Appendix E

Borehole Locations and Soil Strata Drawing



PROFILE ALONG ϕ OF N-E RAMP



DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

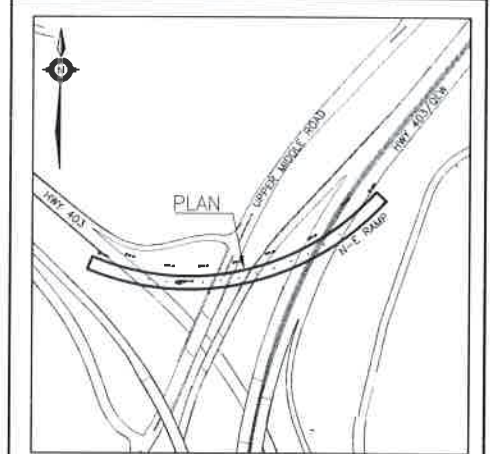
CONT No
WP No

HWY 403/Q.E.W.
N-E RAMP

BOREHOLE LOCATIONS AND SOIL STRATA

MRC **MCCORMICK RANKIN**
A member of **MMM GROUP**

THURBER ENGINEERING LTD.



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
13-08	151.8	4 817 953.6	290 550.0
13-09	150.8	4 817 924.3	290 584.6
13-10	150.8	4 817 938.9	290 656.9
13-11	150.0	4 817 918.5	290 697.1
13-12	149.1	4 817 926.6	290 748.1
13-13	149.9	4 817 944.0	290 794.5
13-14	150.2	4 817 955.6	290 844.0
13-15	150.2	4 818 008.5	290 914.7
13-16	149.9	4 818 032.0	290 946.7

-NOTES-

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

GEOCRES No. 30M5-294

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	LPG	CHK AEG	CODE
DRAWN	MFA	CHK LPG	SITE
LOAD			
STRUCT			
DWG			