



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
EAST NOISE BARRIER WALL
HIGHWAY 417
OTTAWA, ONTARIO
G.W.P. 4097-12-00**

GEOCRES Number: 31G5-266

Submitted
To
MMM Group Limited

March 25, 2015
File: 19-5161-177

TABLE OF CONTENTS

PART 1 FACTUAL INFORMATION

1	INTRODUCTION.....	1
2	SITE DESCRIPTION.....	1
3	SITE INVESTIGATION AND FIELD TESTING	2
4	LABORATORY TESTING	3
5	DESCRIPTION OF SUBSURFACE CONDITIONS.....	3
5.1	General.....	3
5.2	Station 16+120 to 16+255	3
5.3	Station 16+255 to 16+325	4
5.4	Station 16+325 to 16+425	4
5.5	Station 16+425 to 16+635	5
5.6	Bedrock.....	6
5.7	Groundwater Conditions.....	7
6	MISCELLANEOUS.....	8

PART 2 ENGINEERING DISCUSSION AND RECOMMENDATIONS

7	GENERAL	9
8	FOUNDATION DESIGN PARAMETERS.....	9
9	NOISE BARRIER WALL SUPPORTS.....	9
10	CAISSON INSTALLATION.....	10
11	CONSTRUCTION CONCERNS.....	10
12	CONSTRUCTION INSPECTION AND TESTING.....	10
13	CLOSURE.....	11

Appendices

Appendix A	Borehole Location Drawing
Appendix B	Record of Borehole Sheets
Appendix C	Laboratory Test Results
Appendix D	Historic Borehole Records
Appendix E	Soil Summary Table
Appendix F	Suggested Text for NSSP

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) at a proposed noise barrier wall site on Highway 417 in Ottawa, Ontario.

The purpose of this investigation was to obtain subsurface information at the site and, based on the data obtained, provide a comprehensive model of the subsurface conditions using borehole location plans, records of boreholes, laboratory test results, and a written description of the subsurface conditions.

Thurber was retained by the MMM Group Limited to carry out this foundation investigation under MTO Agreement Number 4012-E-0037.

2 SITE DESCRIPTION

The site of the proposed east noise barrier is on the north side of the Richmond Road southbound to Highway 417 westbound on-ramp from the west end of the existing OC Transpo bus terminal approximately 340 m west of Richmond Road westerly for approximately 515 metres (16+120 to 16+635, Highway 417 stationing). The ramp is constructed as a highly variable fill within the study area with the maximum fill height (reported to be as much as 8.3 meters in Borehole 97-8A) to either side of the structure over Holly Acres Road.

This site is located in a suburban area; currently only the transitway and bus terminal separate the Bayshore residential subdivision from Highway 417 to the south in the area of the proposed noise barrier. Local topography is generally flat with some low rolling hills.

The urban geology of the national capital area map released by the Geological Survey of Canada in 2008 (GSC Open File 5311, 2008) indicates that the soil conditions within the east noise barrier study area are offshore marine sediments primarily consisting of silt and clay overlying bedrock at depths ranging from 15 to 25 metres below ground surface.

Several relevant reports were available from the City of Ottawa and in the MTO Geocres Library concerning the project site. Borehole records from the following reports are included in Appendix D as supplementary information:

- Report to the City of Ottawa – Geotechnical Investigation, West Transitway Extension, Bayshore Station to East of Moodie Drive, Ottawa, Ontario, Golder Associates Ltd., Project 09-1121-0008, 2011
- Report to the City of Ottawa – Geotechnical Investigation, Proposed West Transitway Extension and South-West Ramp, West of Bayshore Station to West of Acres Road, Nepean, Ontario, Golder Associates Ltd., Project 971-2058, 1998
- MTO Report GEOCRE 31G05-145 – Hwy 417 W.B. Overpass Structure at Acres Road and Associated Ramps

It is noted that the locations of the boreholes provided in Golder Report 09-1121-0008 were not referenced to either coordinates or chainage and the locations of boreholes provided in Golder Report 971-2058 were referenced to historical transitway chainage that has since changed. The locations as provided on Drawing No. 1 in Appendix A should be considered as approximate for those boreholes.

It is also noted that the boreholes from GEOCRE 31G05-145 were drilled prior to the realignment of the on-ramp and the construction of the approach fill leading to and from the structure over Holly Acres Road.

3 SITE INVESTIGATION AND FIELD TESTING

This borehole investigation and field testing program was carried out on January 18, 2015. The program consisted of drilling and sampling 3 boreholes (numbered 15-1, 15-2 and 15-3) to a depth of 6.7 m (elevations 62.6 m to 63.3 m).

Prior to the start of drilling, the borehole locations were marked on a site plan drawing and utility clearances were obtained. The borehole locations and elevations were subsequently surveyed by Thurber Engineering.

A truck-mounted CME 75 drill was used to drill and sample the boreholes. Hollow stem augers were used to advance the boreholes through the overburden soil. Soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT). In-situ shear vane testing was carried out using an MTO N-vane.

Results of the field drilling and sampling are presented on the Record of Borehole sheets in Appendix B.

A member of Thurber's technical staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes, secured the recovered soil samples in labelled containers, and transported the samples to Thurber's laboratory for further examination and testing.

4 LABORATORY TESTING

All recovered soil samples were subjected to Visual Identification and to natural moisture content determination. Selected soil samples were subjected to grain size distribution analyses (sieve and hydrometer) and Atterberg limit testing. The results of this laboratory testing program are shown on the Record of Borehole sheets in Appendix B and on the Figures in Appendix C.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

5.1 General

Reference is made to the Record of Borehole sheets in Appendix B and Appendix D for details of the soil stratigraphy encountered in the boreholes. An overall description of the stratigraphy is given in the following paragraphs; however, the factual data presented in the record of boreholes governs any interpretation of the site conditions.

In general, the subsurface conditions encountered in the boreholes consisted of embankment fill overlying silty clay over sand over glacial till on bedrock.

As the wall is more than 0.5 km in length, the following descriptions of subsurface conditions have been broken into three different sections from west to east.

5.2 Station 16+120 to 16+255

The stratigraphy for this section of the noise barrier wall is based on Thurber Borehole 15-3 and historic Boreholes 7-11, 10-106, 10-107 and 10-108. It is noted that Borehole 7-11 was drilled prior to the re-alignment of the on-ramp.

An asphalt layer 150 mm thick was encountered at ground surface in Borehole 15-3 and was underlain by a 4.4 m thick layer of fill consisting of gravelly sand, some silt with a top surface elevation of 69.8 m. The moisture content of the samples tested ranged from 4% to 14%. Standard Penetration Test (SPT) 'N' values ranged from of 2 to 67 blows per 0.3 m of penetration indicating a loose to dense relative density although most of the fill was in a compact to dense state. It should be noted that the upper portion of the fill material was frozen at the time of drilling and the high blow counts recorded near the ground surface should not be considered typical of this fill material. Grain size distribution analyses carried out on two representative samples indicated 24% to 35% gravel, 43% to 57% sand, 19% to 22% silt and clay. Plots of the grain size distribution curves are provided in Figure C1 in Appendix C.

Fill was also observed in three of the historic boreholes and extended down from ground surface to elevation 65.5 m, 64.9 m and 65.3 m in Boreholes 10-108, 10-107 and 10-106. It was described as clayey silt to silty sand and gravel, and was generally compact. Construction debris (wood, concrete and rebar fragments) were observed in Borehole 10-108 and 10-107.

Beneath the fill material in Borehole 15-3, a deposit of sandy clay and silt with a top surface elevation of 65.5 m was encountered that extended below the termination depth of 6.7 m at elevation 63.3m. The SPT 'N' values ranged from 2 to 5 blows per 0.3 m of penetration within this deposit. In-situ shear vane testing found undrained shear strength values ranging from 71 kPa to 84 kPa indicating the clay to be in a stiff state. The moisture content of this material ranged from 25% to 49%. Grain size distribution analyses carried out on a representative sample indicated it consisted of 0% gravel, 23% sand, 42% silt and 35% clay sized particles. A plot of the grain size distribution curve is provided in Figure C2 in Appendix C. Atterberg Limit testing on one sample of the clay material yielded a Liquid Limit of 61% with a Plastic Limit of 22% indicating the material can be classified as a high plastic clay. Please see Figure C3 in Appendix C.

The cohesive layer was observed in all of the historic boreholes and was described as silty clay to clayey silt. Only Borehole 7-11 fully penetrated this unit. In Borehole 7-11, the base was found at a depth of 4.6 m at elevation 61.3 m. A sand layer varying from loose to very dense was observed beneath the silty clay. The sand extended to a depth of 24.4 m or elevation 41.5 m. A thin layer of till was observed beneath the sand. Dolostone bedrock was found beneath the till at elevation 39.4 m.

5.3 Station 16+255 to 16+325

No subsurface stratigraphy has been included for this section of the noise barrier wall as it is assumed that the noise barrier wall supports will be incorporated structurally into the existing overpass of Holly Acres Road.

5.4 Station 16+325 to 16+425

The stratigraphy for this section of the noise barrier wall is based on historic boreholes 97-8A, 7-13, 09-C, 14-2 and 97-5. It is noted that the historic Boreholes 7-13 and 14-2 were drilled prior to re-alignment of the on-ramp.

A thin 80 mm to 90 mm lift of topsoil was noted at ground surface in Boreholes 7-13, 09-C and 97-5. Fill was observed in Boreholes 97-8A, 09-C, 14-2 and 97-5. The upper most portion of the fill in Borehole 97-8A was a loose sand some gravel which extended down to elevation 68.4 m and was underlain by a layer of compact sandy silt fill down to elevation 65.5 m. A very stiff to firm layer of silty clay fill was present beneath elevation 65.5 m in Borehole 97-8A and beneath

the topsoil in Boreholes 09-C and 97-5. The elevation of the underside of the silty clay fill ranged from 63.1 m to 67.4 m. Very loose to compact sand fill was observed beneath the silty clay fill. This layer included silt and clay pockets as well traces of organic matter, asphalt and gravel. It extended down to elevations ranging from 60.6 m to 64.0 m.

Underlying the fill, a native silty clay to clayey silt was observed in Boreholes 97-8A and 7-13 which extended to elevation 58.5 m in Borehole 7-13 and was not fully penetrated in Borehole 97-8A at borehole termination elevation of 59.1 m. Vane shear test results indicate values of 50 kPa to in-excess of 100 kPa. The moisture content is reported to range from 17% to 45%. Atterberg limit testing on two samples indicated one to be of high plasticity and the second of intermediate plasticity.

A thick deposit of sand was noted beneath the above noted soils. The sand extended to elevations ranging from 39.8 m to 41.7 m in Boreholes 7-13, 09-C and 14-2. The upper portions of the sand were loose to compact. The lower portion was compact to dense.

Beneath the sand layer, a thin strata of glacial till was observed in Boreholes 7-13 (1.6 m thick) and 14-2 (2.1 m thick). The till is described as a heterogeneous mixture of sand, gravel and boulders and was dense to very dense.

Dolostone bedrock was proven by coring in Boreholes 7-13, 09-C and 14-2 at elevations ranging from 39.1 m to 40.1 m.

5.5 Station 16+425 to 16+635

The stratigraphy for this section of the noise barrier wall is based on Thurber Boreholes 15-1 and 15-2 and historic Boreholes 7-9, 97-4, 97-2, 7-10, 97-1 and 10-101. It is noted that the historic Boreholes 7-9 and 7-10 were drilled prior to re-alignment of the on-ramp.

An asphalt layer 125 mm to 150 mm thick was encountered at the surface in Boreholes 15-1 and 15-2. It was underlain by a 2.9 m to 4.5 m thick layer of fill consisting of gravelly sand some silt to sand some silt some gravel with a top surface elevation ranging from 69.2 m to 69.8 m. The moisture content of the samples tested ranged from 2% to 17%. Standard Penetration Test (SPT) 'N' values ranged from 12 to 68 blows per 0.3 m of penetration indicating a compact to dense state. It should be noted that the upper portion of the fill material was frozen at the time of drilling and the high blow counts recorded near the ground surface should not be considered typical of this fill material. Grain size distribution analyses carried out on three representative samples indicated 11% to 26% gravel, 54% to 71% sand, 14% to 20% silt and clay. Plots of the grain size distribution curves are provided in Figure C1 in Appendix C. It is noted that a black layer was observed in both boreholes at approximate elevation 66.8 m which is thought to be a remnant of an old asphalt layer.

Fill was also observed in all but one (97-1) of the historic boreholes and extended down from ground surface to elevations ranging from 59.1 m to 65.4 m. It was described as a mixture of clayey silt, sand and gravel. Organic material and construction debris (wood and concrete fragments) were observed in Borehole 97-2 and 97-4. A buried asphalt layer was noted in Borehole 97-2 at elevation 66.7 m.

Beneath the fill material in Borehole 15-1 and 15-2, a deposit of clay and silt to sandy clay and silt with a top surface elevation ranging from 66.2 m to 65.4 m was encountered that extended below the termination depth of 6.7 m in both boreholes at elevations 62.6 m and 63.3 m respectively. The SPT 'N' values ranged from 2 to 14 blows per 0.3 m of penetration within this deposit. In-situ shear vane testing found undrained shear strength values ranging from 60 kPa to 84 kPa indicating the clay to be in a stiff state. The moisture content of this material ranged from 30% to 47%. Grain size distribution analyses carried out on two representative samples indicated 0% gravel, 2% to 28% sand, 41% to 44% silt and 31% to 54% clay. Plots of the grain size distribution curves are provided in Figure C2 in Appendix C. Atterberg Limit testing on two samples of the clay material yielded Liquid Limit values of 34% and 69% with Plastic Limits of 14% and 28%. Please see Figure C3 in Appendix C. The material from Borehole 15-1 can be classified as a high plastic clay while the material from Borehole 15-2 can be classified as a clay of low plasticity.

The cohesive layer was observed in three of the historic boreholes (7-10, 97-1 and 10-101) and was described as silty clay to clayey silt. Boreholes 7-10 and 97-1 fully penetrated this unit. The base was found to range in elevation from 60.2 m to 63.9 m. A silty sand to sand layer varying in consistency from loose to very dense was observed beneath the silty clay. The sand extended to the termination depth of 12.7 m elevation 53.2 m in Borehole 7-10.

5.6 Bedrock

Based on historic borehole records, the surface of the dolostone bedrock surface is relatively flat and at an elevation of approximately 40 m within the study area of the proposed noise barrier.

5.7 Groundwater Conditions

Groundwater observations were made at the time of drilling in all boreholes and, if present, the observed ground water depths are noted on the Record of Borehole sheets in Appendix B. The following table summarizes the groundwater observations:

Wall Section	Borehole	Groundwater Elevation (m)
16+120 to 16+255	7-11	63.0
16+325 to 16+425	7-13	62.8
	14-2	63.5 (cave)
16+425 to 16+635	97-4	65.3
	97-2	65.4
	97-1	61.3

Where surface water is present, the groundwater level should be assumed to coincide with the local surface water level. Local high water levels and the effects of heavy rainfalls must also be taken into consideration.

6 MISCELLANEOUS

Thurber obtained utility clearances prior to drilling. Thurber personnel surveyed the borehole ground surface elevations, and used measurements taken in the field to determine the northing and easting coordinates from existing CAD drawings. The locations of the historic boreholes as shown on Drawing 1 in Appendix A have been interpreted from past investigations and are approximate.

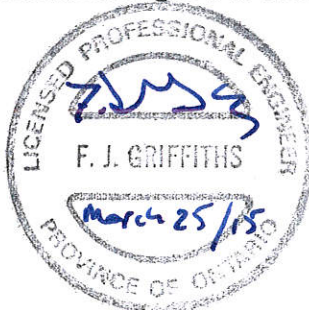
George Downing Estate Drilling of Hawkesbury, Ontario, supplied and operated a truck mounted CME 75 drill rig. Beacon Lite of Ottawa, Ontario, supplied the traffic control equipment and personnel required for a full ramp closure. The drilling and sampling operations in the field were supervised on a full time basis by Ms. Gabrielle Marcotte, P.Eng. of Thurber. Laboratory testing was carried out by Thurber in its MTO-approved laboratory in Ottawa, Ontario.

Overall project management and direction of the field program was provided by Mr. Kenton Power, P.Eng. Interpretation of the field data and preparation of this report was completed by Mr. Christopher Murray, E.I.T. and Dr. Fred Griffiths, 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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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

This report presents interpretation of the geotechnical data in the factual report and presents recommendations for the design of the foundations of the east noise barrier wall proposed for the north side of the Richmond Road southbound to Highway 417 westbound on-ramp from the existing Bayshore transit station westerly for approximately 515 metres. The location of the noise barrier is to be on the north shoulder of the on-ramp.

8 FOUNDATION DESIGN PARAMETERS

Design of the foundation for the noise barriers should be carried out based on the current version of the Canadian Highway Bridge Code, CAN/CSA S6.

Standard Special Provision (SSP) number 799F01 entitled Construction Specification for the Installation of a Noise Barrier, should be included in the tender documents for this noise barrier.

Typical soil parameters of the existing soils are given in the Soil Summary Table presented in Appendix E of this report.

The on-ramp is constructed as a fill. In the absence of detailed cross-sections and drainage data, the design groundwater level may be assumed to be 1.0 m above the base of the fill.

Frost penetration depth for Ottawa is 1.8 m in accordance with OPSD 3090.101.

9 NOISE BARRIER WALL SUPPORTS

It is anticipated that the proposed noise barrier wall will be supported on conventional augered caissons (i.e. drilled shafts).

In order to take into account frost action and surficial disturbance, the ultimate lateral passive resistance of a caisson within the upper 1.8 m below final grade should be neglected in the foundation design. It is recommended that all surficial weak soils, including topsoil and organics, be neglected in determining lateral resistance. The slope of the highway embankments in front of a caisson will result in reduced

lateral passive resistance that must be taken into account during design in accordance with SSP 799F01 clause 7.03.01.

Where an undrained shear strength, S_u , is provided for a cohesive soil (silty clay to clay), the ultimate lateral passive resistance should be calculated in conjunction with the total soil unit weight. When designing for portions of the caissons below the groundwater in cohesionless soils (sands and silts) and fills, the submerged soil unit weight, γ' , should be used. The required depth of the drilled shaft will be governed by lateral loads, including wind loads. The length of the caisson should also be sufficient to counteract frost jacking (upward) forces.

An equivalent caisson width equal to 3 times the caisson diameter may be assumed for lateral resistance calculations. Appropriate load and resistance factors should be applied for caisson design.

10 CAISSON INSTALLATION

Caisson installation should generally be carried out in accordance with OPSS 903.

Caisson installation equipment must be able to dislodge, handle and remove construction debris, cobbles, asphalt layers, boulders, rock fragments, and to penetrate other obstructions within the fill, where encountered. The contract documents should contain an NSSP alerting the contract bidders to the specific aspects relating to construction for augered caisson foundations at this site.

Groundwater levels are at variable depth below existing ground surface. Soil sloughing and water seepage may occur in unsupported holes especially at depths below the groundwater level. Temporary liners should be available to support the caisson sidewalls and provide seepage cut-off where required.

Suggested wordings for an NSSP to cover the above aspects are provided in Appendix F.

11 CONSTRUCTION CONCERNS

Concerns during caisson construction mainly involve drilling through, handling and removal of construction debris, cobbles or boulders, soil sloughing and water seepage from caisson sidewalls. Recommendations on how to address these issues have been outlined in the previous section.

12 CONSTRUCTION INSPECTION AND TESTING

Caisson construction should be monitored by qualified geotechnical personnel (as per OPSS 903) to verify the soil conditions and to confirm that those conditions are consistent with the design assumptions in this report.

13 CLOSURE

Preparation of this foundation design report was carried out by Mr. Christopher Murray, E.I.T.. The report was reviewed by Dr. Fred Griffiths and Dr. P.K. Chatterji, P.Eng.

Thurber Engineering Ltd.



Christopher Murray, M.A.Sc., E.I.T.
Geotechnical Engineer in Training



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Review Principal, Designated MTO Contact

Appendix A

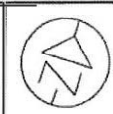
Borehole Location Drawing

19-5161-177

MINISTRY OF TRANSPORTATION, ONTARIO

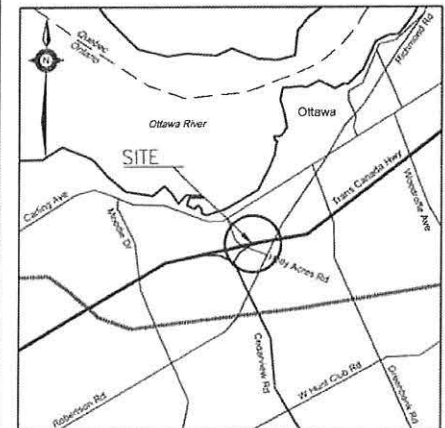
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No 4097-12-00



HIGHWAY 417
PROPOSED
NOISE BARRIER WALL
BOREHOLE LOCATIONS

SHEET



KEYPLAN
LEGEND

- Borehole (Current Investigation)
- ◐ Borehole (Previous Investigation)
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60' Cone, 475J/blow)
- PH Pressure, Hydraulic
- W Water Level
- HA Head Artesian Water
- PZ Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
15-1	69.3	5 023 044.3	358 864.4
15-2	70.0	5 023 023.7	358 785.9
15-3	70.0	5 022 909.8	358 452.1
7-9	65.7	5 022 987.5	358 702.7
7-10	65.9	5 022 993.6	358 750.5
7-11	65.9	5 022 934.1	358 505.7
7-13	66.1	5 022 959.8	358 599.9
14-2	65.6	5 022 981.1	358 656.4

-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. 31G5-266

NO	ELEVATION	NORTHING	EASTING
APPROXIMATE LOCATIONS			
97-1	66.0	5 023 046.0	358 773.1
97-2	69.2	5 023 011.1	358 726.0
97-4	69.6	5 022 998.1	358 686.7
97-5	69.2	5 022 988.7	358 654.7
97-8A	70.7	5 022 966.6	358 601.8
09-C	68.4	5 022 989.0	358 628.6
10-101	66.7	5 023 076.2	358 815.1
10-106	70.1	5 022 931.8	358 507.2
10-107	69.4	5 022 918.4	358 463.3
10-108	68.9	5 022 899.1	358 400.6

40 0 40 80m
SCALE 1:2000



DATE	BY	DESCRIPTION
DESIGN	CM	CHK PC CODE
DRAWN	MFA	CHK CM SITE
STRUC	DMC	DATE MAR 2015

FILENAME: P:\Projects\1915161\177 Hwy 417 Noise Barriers\Drawings\177-BoreholePlan(CST).dwg
PLOT DATE: 3/24/2015 9:17 AM

Appendix B

Record of Borehole Sheets

19-5161-177

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

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


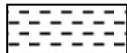



 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (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

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

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Very thinly bedded	20 to 60mm				
Laminated	6 to 20mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Thinly Laminated	Less than 6mm				
<u>TERMS</u>		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
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.				

RECORD OF BOREHOLE No 15-1

1 OF 1

METRIC

GWP# 4097-12-00 LOCATION 417 Noise Barrier Wall N 5 023 044.3 E 358 864.4 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Hollow Stem Auger COMPILED BY CM
 DATUM Geodetic DATE 2015.01.18 - 2015.01.18 CHECKED BY KP

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 (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W _P	W	W _L			GR	SA	SI	CL
								SHEAR STRENGTH kPa					WATER CONTENT (%)								
69.3																					
0.0	Asphalt (125 mm)																				
0.1	Gravelly Sand, some Silt Grey Wet (Frozen) (FILL)		1	SS	100/		69										26	54	20 (SI+CL)		
68.4			2	GS	100mm																
0.8	Sand, some Silt, Some Gravel Brown to Grey Dry (FILL)		3	SS	61																
							68														
			4	SS	19													11	71	18 (SI+CL)	
	-Thin black layer		5	SS	27		67														
66.2																					
3.0	Clay (CH) and Silt Very Stiff to Stiff Grey Dry		6	SS	13		66														
			7	SS	14		65											0	2	44	54
			8	SS	4		64														
			9	SS	2																
							63														
62.6																					
6.7	End of Borehole at 6.7 m Borehole Dry on Completion																				

ONTMT4S 19-5161-177 - EAST BARRIER.GPJ 2012TEMPLATE(MTO).GDT 25/3/15

RECORD OF BOREHOLE No 15-2

1 OF 1

METRIC

GWP# 4097-12-00 LOCATION 417 Noise Barrier Wall N 5 023 023.7 E 358 785.9 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Hollow Stem Auger COMPILED BY CM
 DATUM Geodetic DATE 2015.01.18 - 2015.01.18 CHECKED BY KP

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						
70.0														
0.0	Asphalt (150 mm)													
0.2	Gravelly Sand, some Silt Grey Dry (Top Frozen) (FILL)		1	GS										25 61 14 (SI+CL)
69.2														
0.8	Sand, some Silt, some Gravel Brown Moist (FILL)		2	SS	68		69							
			3	GS	15		68							
			4	SS	14									
67.2														
2.8	Sand and Asphalt Black (FILL)						67							
66.7			5	SS	12									
3.3	Silty Sand Brown Moist to Wet (FILL)													
			6	SS	21		66							
65.4														
4.7	Sandy Clay (CL) and Silt Very Stiff to Stiff Grey Moist		7	SS	9		65							
			8	SS	10									
							64							
			9	SS	4									0 28 41 31
63.3														
6.7	End of Borehole at 6.7 m Borehole Dry on Completion													




ONTMT4S 19-5161-177 - EAST BARRIER.GPJ 2012TEMPLATE(MTO).GDT 25/3/15

RECORD OF BOREHOLE No 15-3

1 OF 1

METRIC

GWP# 4097-12-00 LOCATION 417 Noise Barrier Wall N 5 022 909.8 E 358 452.1 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Hollow Stem Auger COMPILED BY CM
 DATUM Geodetic DATE 2015.01.18 - 2015.01.18 CHECKED BY KP

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					W P W W L							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)							
70.0								20	40	60	80	100								
0.0	Asphalt (150 mm)						70													
0.2	Gravelly Sand, some Silt Brown Dry (Top Frozen) (FILL)		1	GS															35 43 22 (SI+CL)	
			2	SS	67															
68.5																				
1.5	Gravelly Sand, some Silt Brown Dry to Wet (FILL)		3	SS	31															
			4	SS	15															
			5	SS	2															
			6	SS	51													24 57 19 (SI+CL)		
65.5																				
4.6	Sandy Clay (CH) and Silt Very Stiff to Stiff Grey Moist -Silt seams		7	SS	5													0 23 42 35		
			8	SS	2															
63.3																				
6.7	End of Borehole at 6.7 m Borehole Dry on Completion																			

ONTMT4S 19-5161-177 - EAST BARRIER.GPJ 2012TEMPLATE(MTO).GDT 25/3/15

+³, ×³: Numbers refer to Sensitivity 20
15 10 5 0 (%) STRAIN AT FAILURE

Appendix C

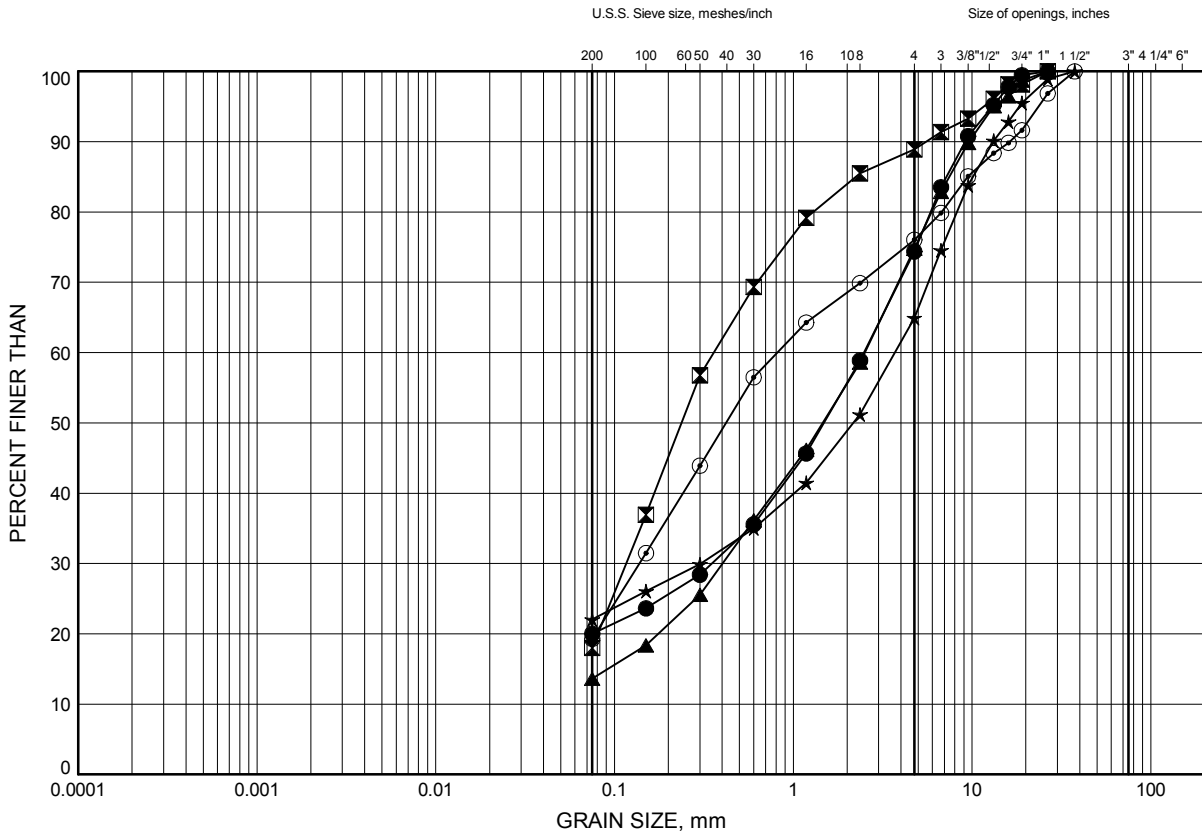
Laboratory Test Results

19-5161-177

417 Noise Barrier Wall GRAIN SIZE DISTRIBUTION

FIGURE C1

FILL: Gravelly Sand some Silt to Sand some Silt some Gravel



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-1	0.38	68.88
⊠	15-1	1.83	67.43
▲	15-2	0.30	69.73
★	15-3	0.30	69.74
⊙	15-3	4.11	65.93

Date January 2015

GWP# 4097-12-00



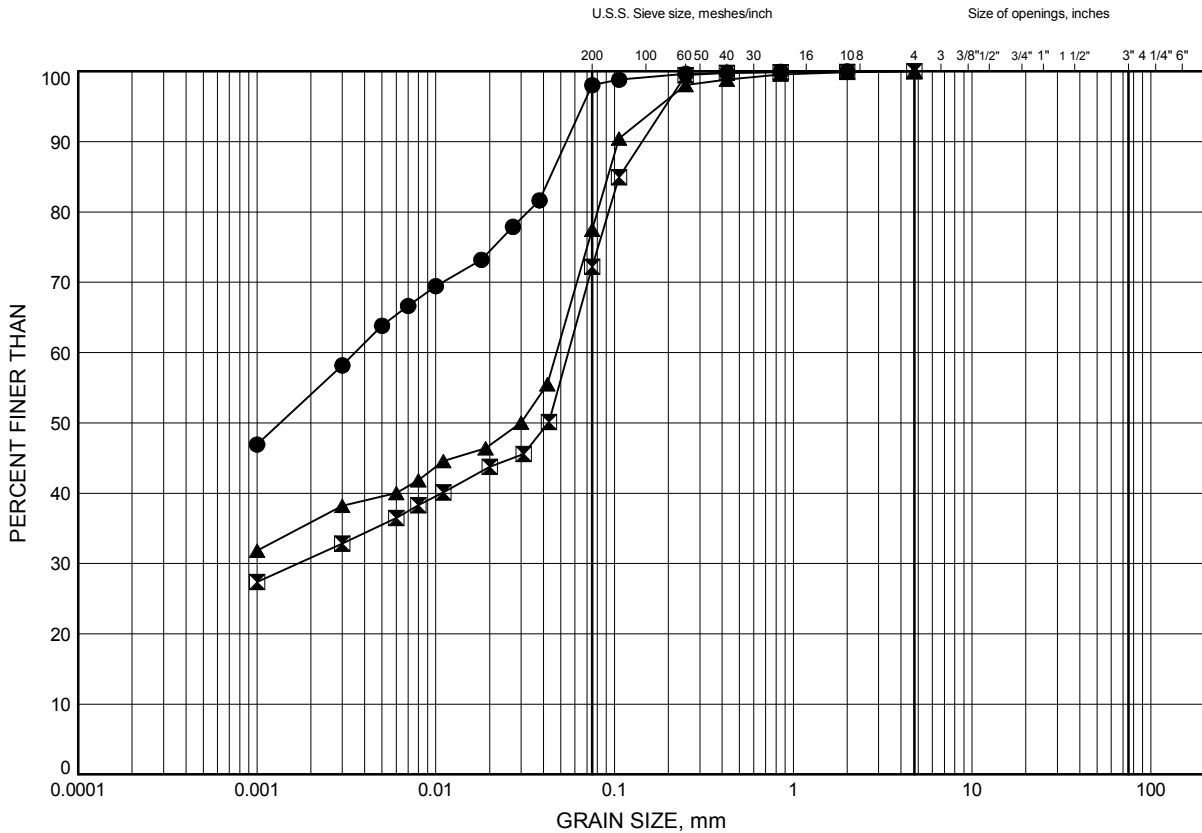
Prep'd CM

Chkd. KP

417 Noise Barrier Wall GRAIN SIZE DISTRIBUTION

FIGURE C2

Clay and Silt to Sandy Clay and Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-1	4.11	65.15
⊠	15-2	6.40	63.63
▲	15-3	4.88	65.16

Date January 2015

GWP# 4097-12-00

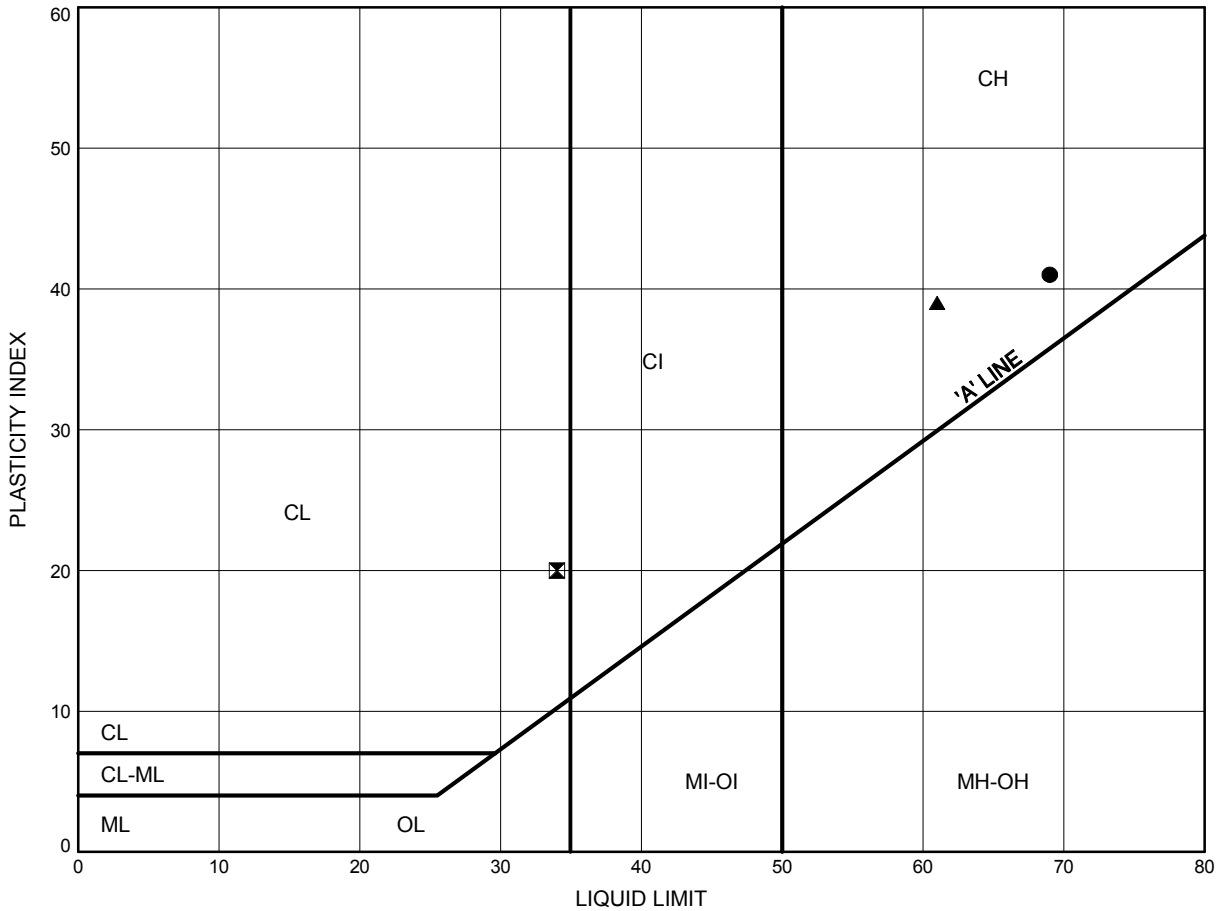


Prep'd CM

Chkd. KP

417 Noise Barrier Wall ATTERBERG LIMITS TEST RESULTS

FIGURE C3



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-1	4.11	65.15
⊠	15-2	6.40	63.63
▲	15-3	4.88	65.16

Date January 2015

GWP# 4097-12-00



Prep'd CM

Chkd. KP

Appendix D

Historic Borehole Records

19-5161-177

RECORD OF BOREHOLE No 7-9

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 765.3; E 358 681.4 ORIGINATED BY TS
DIST 9 HWY 416/417 BOREHOLE TYPE Hollow Stem Auger, Washbore & Cone Test COMPILED BY TS
DATUM Geodetic DATE 88 07 22 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60	W _p	W	W _L		
65.7	Ground Surface													GR SA SI CL
0.0	Mixt. of Clayey Silt Sand and Gravel Grey					*								
63.7	Very Stiff		1	SS	17		64							3 49 30 18
2.0	Sand Some Gravel Brown Compact (Fill)		2	SS	10		62							
			3	SS	10		60							28 64 (8)
59.1			4	SS	14		58							
6.6	Sand Trace Silt Grey		5	SS	9		56							0 98 (2)
	Loose		6	SS	7		54							
	Compact to Dense		7	SS	45		52							0 96 (4)
			8	SS	20		50							
50.0			9	SS	15		48							
15.7	End of Borehole						46							
							44							
							42							
							40							
38.6														
27.1	End of Cone Test													
	* Water Level not Established													

+3, x5: Numbers refer to 20
Sensitivity 15 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7-10

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 771.4; E 358 729.2 ORIGINATED BY TS
 DIST 9 HWY 416/417 BOREHOLE TYPE Hollow Stem Auger, Washbore & Cone Test COMPILED BY TS
 DATUM Geodetic DATE 88 07 22 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
65.9	Ground Surface										
0.0	Sand, Tr. Gravel					*					
65.0	Brown, Compact (Fill)										
0.9	Clayey Silt, Tr. Sand										
63.9	Brown, Stiff		1	SS	10		64				0 32 41 27
2.0	Sand		2	SS	15		62				5 66 17 12
	Trace of Silt										
	Trace of Gravel		3	SS	60		60				28 61 (11)
	Occ. Gravelly Zones		4	SS	38		58				7 83 (10)
	Compact to		5	SS	30		56				1 91 (8)
	Very Dense		6	SS	30		54				
			7	SS	40						
53.2			8	SS	31						
12.7	End of Borehole										
	* Water Level not Established										

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7-11

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 711.9; E 358 484.4 ORIGINATED BY TS
DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger, B-Casing, Washbore, Rock Core & Cone Test COMPILED BY TS
DATUM Geodetic DATE 88 07 18 CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	20 40 60 80 100					
65.9	Ground Surface												
0.0	Silty Caly Grey Firm to Stiff		1	SS	8							19.9	0 4 48 48
			2	SS	3								
63.0			3	TW	PH							17.9	0 5 51 44
2.9	Clayey Silt with interbedded Silty Sand		4	SS	3								0 11 53 36
61.3	Soft		5	SS	2								
4.6			6	SS	2								0 42 37 21
			7	SS	6								
	Sand		8	SS	4								
	Trace of Silt		9	SS	6								2 76 (22)
	Trace of Gravel		10	SS	22								
			11	SS	85								0 90 (10)
	Loose to Compact		12	SS	50								
	Dense to V. Dense		13	SS	36								0 93 (7)
41.5			14	RC	REC	94%							ROD = 0
24.4	Het. Mixt. of Sand, Gravel, Boulders (Glacial Till)		15	RC	REC	28%							RQD = 0
39.4			16	RC	REC	38%							RQD = 11%
26.5	Bedrock Silty Dolostone		17	RC	REC	90%							RQD = 63%
37.2													
28.7	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity 15 20 5 (%) STRAIN AT FAILURE 10

RECORD OF BOREHOLE No 7-13

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 737.6; E 358 578.6 ORIGINATED BY TS
DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger, B-Casing, Washbore, Rock Core, & Cone Test COMPILED BY TS
DATUM Geodetic DATE 88 07 20 -21 CHECKED BY

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			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
66.1	Ground Surface											
0.0	Topsoil		1	SS	5		66				17.4	0 12 43 45
	Silty Clay to Clay		2	TW	PH		64					0 5 55 40
	Firm to Stiff											
63.0			3	TW	PH		62					
3.1	Clayey Silt with interbedded Silty Sand		4	SS	2		60					
	Soft to Firm		5	SS	2		58					
58.5			6	SS	60/7	7cm	56					
7.6	Sand		7	SS	13		54					3 80 (17)
	Trace of Silt						52					
	Trace of Gravel						50					
	Occ. Gravel Zones		8	SS	20		48					
	Compact						46					
			9	SS	27		44					
			10	SS	14		42					
			11	SS	26		40					
41.7			12	SS	93							
24.4	Het. Mixt. of Sand, Gravel & Boulders (Glacial Till)		13	RC	REC 72%							RQD = 40%
40.1	Bedrock		14	RC	REC 100%							RQD = 100%
26.0	Silty Dolostone											
38.6												
27.5	End of Borehole											

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 14-2

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 758.9; E 358 645.1 ORIGINATED BY TS
DIST 9 HWY 416/417 BOREHOLE TYPE Cone Test, H-S Auger, B-Casing, Washbore COMPILED BY TS
DATUM Geodetic DATE 88 07 22-23 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	PLASTIC LIMIT Wp	NATURAL MOISTURE CONTENT W	LIQUID LIMIT Wl	
65.6	Ground Surface							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	WATER CONTENT (%) 20 40 60			GR SA SI CL
0.0	Mixture of Clayey Silt, Sand and Gravel (Fill) Brown Compact		1	SS	18		64					2 72 19 7
			2	SS	15		62					6 70 20 4
60.6			3	SS	21		60					5 88 (7)
5.0			4	SS	5		58					4 90 (6)
			5	SS	12		56					1 90 (9)
			6	SS	23		54					1 90 (9)
			7	SS	25		52					0 91 (9)
			8	SS	19		50					
			9	SS	30		48					
			10	SS	55		46					
			11	SS	38		44					13 78 (9)
			12	SS	33		42					
			13	SS	32		40					
			14	SS	36		38					
			15	SS	97							
41.2			16	SS	54							
24.4	Het. Mixture of Sand, Gravel and Boulders (Glacial Till)		17	RC	REC	100%						RQD = 41%
39.1	Bedrock		18	RC	REC	95%						RQD = 64%
26.5	Dolostone											
37.9	Unweathered											
27.7	End of Borehole											
	* Water Level Not Established Hole caved in at 2.1 m depth											

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

PROJECT: 971-2058

RECORD OF BOREHOLE 97-1

SHEET 1 OF 1

LOCATION: STA. 6+395, 4.2m LI.

BORING DATE: July 23, 1997

DATUM: Geodetic

SAMPLER HAMMER, 63.6kg, DROP, 760mm

PENETRATION TEST HAMMER, 63.6kg, DROP, 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER TYPE	BLOWS/0.3m	SHEAR STRENGTH		WATER CONTENT, PERCENT			
							Cu, kPa	nat. V. + rem. V. -	o. ● u. ○			Wp
		Ground Surface		88.01								
		Dark brown silty clay TOPSOIL		0.00								
				0.15								
1	Power Auger 200mm Diam (Hollow Stem)	Very stiff to stiff grey brown SILTY CLAY, occasional sand seam (Weathered Crust)			1	50 9						
2				2	50 2							
3		Stiff grey SILTY CLAY, some silty sand seams and layers			3	50 WH						
4			4	50 WH								
5												
6	Loose grey SILTY fine SAND, scattered trace gravel			5	50 7							
7			6	50 5								
		End of Hole		58.69 7.32								
8												
9												
10												

Bentonite Seal

Native Backfill

Standpipe

Caved Material

W.L. in Standpipe at Elev. 61.07m
Sept. 24, 1997

W.L. in Standpipe at Elev. 61.31m
Mar. 11, 1998

Bentonite
SealNative
Backfill

Standpipe

Caved
MaterialW.L. in
Standpipe at
Elev. 61.07m
Sept. 24, 1997W.L. in
Standpipe at
Elev. 61.31m
Mar. 11, 1998

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: D.J.S

CHECKED:

PROJECT: 871-2058

RECORD OF BOREHOLE 97-2

SHEET 1 OF 1

LOCATION: STA. 6+331, 12.5m RL

BORING DATE: July 23, 1997

DATUM: Geodetic

SAMPLER: HAMMER, 63.6kg, DROP: 760mm

PENETRATION TEST HAMMER, 63.6kg, DROP: 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT					
								Cu, kPa	nat.V. + rem.V. -	q - u -		Wp	W			W	
								20	40	60	80	20	40	60	80		
0	Power Auger 200mm Diam (Hollow Stem)	Ground Surface		89.17													
		Dark grey silty clay TOPSOIL		0.00													
				0.09													
1		Loose brown silty sand, some gravel and clay (FILL)			1	50 DO	7										MH
2		Probably Asphaltic Concrete			2	50 DO	4										
		Probably grey Crushed Stone			3	50 DO	1										
		Light brown fine SAND															
3		Compact brown fine to coarse sand, trace gravel (FILL)															MH
		Very stiff brown and dark brown silty clay, trace organic matter (FILL)															
5	Compact dark brown silty sand, some gravel, trace wood (FILL)																
	Dark brown clayey silt TOPSOIL																
	Loose dark brown SILTY SAND, trace organic matter																
6	Compact brown fine to coarse SAND, trace to some gravel																
7																	
		End of Hole		7.16													
8																	
9																	
10																	

W.L. in
Open Hole at
Elev. 65.42m
on completion
of drilling

W.L. in
Open Hole at
Elev. 65.42m
on completion
of drilling

DATA INPUT: 0:27-2-013-JT

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: D.J.S

CHECKED:

PROJECT: 971-2058

RECORD OF BOREHOLE 97-4

SHEET 1 OF 1

LOCATION: STA: 6+296, 15.3m RL

BORING DATE: July 23, 1997

DATUM: Geodetic

SAMPLER: HAMMER, 63.6kg; DROP, 760mm

PENETRATION TEST HAMMER: 63.6kg; DROP, 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT					
				DEPTH (m)				Cu, kPa	nat. V - + rem. V - 0	0 - 0 U - 0	Wp	W	Wt				
0	Power Auger 200mm Diam (Hollow Stem)	Ground Surface		69.64											MH		
		Dark grey silty clay TOPSOIL		0.00													
				0.18													
1					1	SO	11										
2		Very loose to compact brown silty sand, some gravel and clay, trace concrete (FILL)			2	SO	3										
3					3	SO	2										
4					4	SO	2										
5					5	SO	23										
		Loose to compact brown fine to medium sand (FILL)		65.68 3.96													
				64.82 4.72													
6		Compact brown and dark grey sandy silt, some gravel and clay (FILL)		64.31 5.33													
		Dark brown sandy silt, trace roots TOPSOIL		64.09													
		Brown SILTY SAND, trace gravel		5.55													
7		End of Hole		5.64													
8																	
9																	
10																	

W.L. in
Open Hole at
Elev. 65.25m
on completion
of drilling

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: D.J.S

CHECKED:

W.L. in
Open Hole at
Elev. 85.25m
on completion
of drilling

PROJECT: 971-2058

RECORD OF BOREHOLE 97-5

SHEET 1 OF 1

LOCATION: STA. 8+275, 18.5m RL

BORING DATE: July 22, 1997

DATUM: Geodetic

SAMPLER HAMMER, 63.6kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.6kg; DROP, 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT					
								Cu, kPa	nat.V - + rem.V - ⊕	○ - ● U - ○		Wp	W			Wi	
0	Power Auger 200mm Diam (Hollow Stem)	Ground Surface		69.19													
		Dark brown silty clay TOPSOIL		0.00 0.09													
1		Very stiff grey brown silty clay, trace sand and gravel (FILL)		1	SO	8											
2				2	SO	3											
3			Very loose to compact brown silty sand, some gravel and clay (FILL)		3	SO	1										
4				4	SO	2											
5				5	SO	3											
6				6	SO	14											
			End of Hole		64.01 5.18												
7																	
8																	
9																	
10																	

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: D.J.S

CHECKED: B

DATA INPUT: 0:97.5-038.drf

PROJECT: 971-2058

RECORD OF BOREHOLE 97-8A

SHEET 1 OF 2

LOCATION: STA: 9+906, 31.7m RL

BORING DATE: July 22, 1997

DATUM: Geodetic

SAMPLER HAMMER: 63.6kg; DROP: 760mm

PENETRATION TEST HAMMER: 63.6kg; DROP: 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, K, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER TYPE	BLOWS/0.3m	SHEAR STRENGTH		WATER CONTENT, PERCENT			
							Cu, kPa	nat.V - + rem.V - @ 20 40 60 80	Q - ● U - ○ 20 40 60 80			Wp — W — Wt
0	Power Auger 200mm Diam (Hollow Stem)	Ground Surface		70.89								
		Grey brown SILTY CLAY		0.03								
				0.18								
1		Loose brown fine to coarse sand, some gravel, occasional cobble (FILL)										
2					1	50 DO	6					
				88.38 2.33								
3		Compact dark brown and brown sandy silt, some gravel, trace organic matter, occasional cobble (FILL)			2	50 DO	14					
4												
5				85.51 5.18		3	50 DO	15				
					4	50 DO	8					
6	Very stiff to firm grey brown silty clay, occasional sand seam and pocket (FILL)			5	50 DO	2						
7				6	50 DO	WM			○			
			83.07 7.82									
8	Loose brown fine sand, occasional sandy silt lump (FILL)			7	50 DO	4			○			
			82.40 8.29									
9	Firm to stiff grey SILTY CLAY, occasional fine sand seam with fine to coarse sand seams below 11.13m depth			8	50 DO	PM			○			
				9	50 DO	PM			○			
10		CONTINUED ON NEXT PAGE										

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: D.J.S

CHECKED: *P*

DATA INPUT: 0:978A-058.d/S/L

PROJECT: 971-2058

RECORD OF BOREHOLE 97-8A

SHEET 2 OF 2

LOCATION: STA. 9+906, 31.7m RL

BORING DATE: July 22, 1997

DATUM: Geodetic

SAMPLER HAMMER, 63.6kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.6kg; DROP, 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, K, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH		WATER CONTENT, PERCENT					
								Cu, kPa	rem. V -	nat. V -	Wp	W	WI		
10	Power Auger 200mm Diam (Hollow Stem)	CONTINUED FROM PREVIOUS PAGE													
11		Firm to stiff grey SILTY CLAY, occasional fine sand seam with fine to coarse sand seams below 11.13m depth			10	50 DO	WH								
12		End of Hole		59.11 11.58											
13															
14															
15															
16															
17															
18															
19															
20															

DATA INPUT: Q:978A-Q38.d/S/L

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: D.J.S

CHECKED:

PROJECT: 09-1121-0008-3000

RECORD OF BOREHOLE: 09-C

SHEET 1 OF 3

LOCATION: See Site Plan

BORING DATE: Dec. 4-8, 2009

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m										
								SHEAR STRENGTH Cu, kPa		nat V. + Q - ● rem V. ⊕ U - ○		WATER CONTENT PERCENT					
								20	40	60	80	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴			10 ⁻³
								20	40	60	80	20	40	60	80		
0		GROUND SURFACE		68.35													
	Power Auger 200mm Diam. (Hollow Stem)	Topsoil (FILL)		0.00													
		Grey brown silty clay, some sand, trace gravel, organic matter, and asphalt, with brown silty sand layers (FILL)		0.08													
1					1	50 DO	6										
						2	50 DO	5									
2																	
						3	50 DO	3									
3			Very loose brown silty sand, trace to some gravel and clay (FILL)		65.61												
					2.74												
						4	50 DO	2									
4			Grey brown silty clay, some sand, trace to some gravel and organic matter (FILL)		64.69												
					3.66												
		Compact grey brown to brown silty sand, some clay, trace gravel, organic matter, and asphalt (FILL)		64.08													
				4.27													
5					6	50 DO	10										
					7	50 DO	13										
6		Loose brown sand, trace gravel and silt (FILL)		62.56													
				5.79													
					8	50 DO	6										
7		Loose to compact grey brown fine to coarse SAND, trace gravel, and silt		61.64													
				6.71													
					9	50 DO	9										
8																	
					10	50 DO	9										
					11	50 DO	14										
9		Loose to compact grey brown fine to medium SAND, trace gravel		59.36													
				8.99													
					12	50 DO	10										
10					13	50 DO	18										
		CONTINUED NEXT PAGE															

DEPTH SCALE

1 : 50



LOGGED: R.I.

CHECKED: T.M.S.

MIS-BHS 001 0911210008.GPJ GAL-MIS.GDT 06/28/13 JUL/PLG

PROJECT: 09-1121-0008-3000

RECORD OF BOREHOLE: 09-C

SHEET 3 OF 3

LOCATION: See Site Plan

BORING DATE: Dec. 4-8, 2009

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	RESISTANCE, BLOWS/0.3m				k, cm/s					
								SHEAR STRENGTH Cu, kPa		nat V. + Q - ● rem V. ⊕ U - ○		WATER CONTENT PERCENT					
												Wp — W — WI					
							20	40	60	80		10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³		
							20	40	60	80		20	40	60	80		
20	Rotary Drill NQ Casing	--- CONTINUED FROM PREVIOUS PAGE ---				23	41										
		Dense to very dense fine to medium SAND, trace silt															
21						24	50 DO	>50									
22																	
23						25	50 DO	74									
24	Rotary Drill NQ Core					26	50 DO	34									
25																	
26		Dense grey fine to coarse SAND, some gravel, trace silt, with cobbles and boulders			42.38 25.97												
27	Rotary Drill NQ Core					27	50 DO	32									
28																	
29		Fresh grey DOLOMITIC LIMESTONE BEDROCK			39.79 28.56 39.59 28.76	C1	NQ RC	DD									
		End of Borehole															
30																	

DEPTH SCALE

1 : 50



LOGGED: R.I.

CHECKED: T.M.S.

MIS-BHS 001 0911210008.GPJ GAL-MIS.GDT 06/28/13 JLL/PLG

PROJECT: 09-1121-0008

RECORD OF BOREHOLE: 10-101

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Jan. 31, 2011

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	20 40 60 80				10 ⁻⁶ 10 ⁻⁵ 10 ⁻⁴ 10 ⁻³					
								SHEAR STRENGTH				WATER CONTENT PERCENT					
								Cu, kPa				nat V. + Q - rem V. ⊕ U - ●					
								20	40	60	80	20	40	60	80		
0	Power Auger 200mm Diam. (Hollow Stem)	GROUND SURFACE		66.66													
		ASPHALTIC CONCRETE		0.00													
		Grey crushed stone (BASE)		0.12	1	GRAB											
		Grey crushed stone (SUBBASE)		66.22													
		Grey crushed stone (SUBBASE)		0.44													
1																	
		Very stiff grey brown SILTY CLAY (Weathered Crust)		65.41													
				1.25	2	GRAB											
		End of Borehole		65.16													
				1.50													
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

LOGGED: P.H.

CHECKED: T.M.S.

DEPTH SCALE

1 : 50



MIS-BHS 001 0911210008.GPJ GAL-MIS.GDT 06/28/13 JLL/PLG

PROJECT: 09-1121-0008

RECORD OF BOREHOLE: 10-107

SHEET 1 OF 1





LOCATION: See Site Plan

BORING DATE: Feb. 09, 2011

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	RESISTANCE, BLOWS/0.3m				k, cm/s							
								SHEAR STRENGTH Cu, kPa		nat V. + rem V. ⊕		Q - U - ⊙		WATER CONTENT PERCENT					
								20	40	60	80	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³				
0		GROUND SURFACE		69.36															
	Power Auger 200mm Diam. (Hollow Stem)	Grey crushed stone (FILL)		0.00															
		Compact to dense grey brown silty sand and gravel, with numerous pieces of concrete and rebar fragments (FILL)		68.87															
				0.49															
1				1	50 DO	25													
		2	50 DO	34															
2																			
3																			
		3	50 DO	49															
4			Dense brown sand, some gravel and silt (FILL)		65.70														
					3.66														
		4	50 DO	50															
5		Very stiff grey brown SILTY CLAY, with silty sand seams (Weathered Crust)		64.88															
				4.48															
6																			
7																			

DEPTH SCALE

1 : 50



LOGGED: P.H.

CHECKED: T.M.S.

MIS-BHS 001 0911210008.GPJ GAL-MIS.GDT 06/28/13 JLL/PLG

PROJECT: 09-1121-0008

RECORD OF BOREHOLE: 10-108

SHEET 1 OF 1



LOCATION: See Site Plan

BORING DATE: Feb. 07, 2011

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	RESISTANCE, BLOWS/0.3m				k, cm/s					
								SHEAR STRENGTH Cu, kPa		nat V. + Q - ● rem V. ⊕ U - ○		WATER CONTENT PERCENT					
								20	40	60	80	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴			10 ⁻³
								20	40	60	80	20	40	60	80		
0		GROUND SURFACE		68.89													
	Power Auger 200mm Diam. (Hollow Stem)	Grey brown clayey silt to sandy silt, trace organics, wood, gravel, and concrete fragments (FILL)		68.89													
				0.00	1	GRAB	-										
1					2	50 DO	11							○		MH	
					3	50 DO	7										
2																	
					4	50 DO	9							○		MH	
3																	
				5	50 DO	>50											
		Very stiff to stiff grey brown SILTY CLAY (Weathered Crust)		65.54													
				65.54													
				3.35	6	50 DO	7					— ○ —					
4																	
					7	50 DO	3					○					
5																	
							⊕			+							
							⊕		+								
6		Firm to stiff grey SILTY CLAY		63.10													
				5.79													
		End of Borehole		62.79				⊕		+							
				6.10													
7																	
8																	
9																	
10																	

DEPTH SCALE

1 : 50



LOGGED: P.H.

CHECKED: T.M.S.

MIS-BHS 001 0911210008.GPJ GAL-MIS.GDT 06/28/13 JUL/PLG

Appendix E

Soil Summary Table

19-5161-177

Soil Summary Table

Location	Boreholes	Soil Layer	Geodetic Elevation (m)	Typical Soil Parameters		
				Unit Weight (kN/m ³)	Friction Angle ϕ (°)	Undrained Shear Strength S_u (kPa)
16+120 to 16+635	-	Future Granular Fill *	Variable	20	32	-
16+120 to 16+255	10-108, 15-3, 10-107, 7-11, 10-106	Fill: Gravelly Sand some Silt to Clayey Silt	Above 65.5	19	30	-
		Silty Clay to Sandy Clay and Silt, stiff	65.5 to 61.0	17	-	70
		Sand trace Silt trace Gravel, Compact	Below 61.0	19	30	-
16+325 to 16+425	97-8A, 7-13, 09-C, 14-2, 97-5	Fill: loose sand some gravel and cobbles	Above 68.5	19	30	-
		Fill: silty clay some sand, stiff to very stiff	68.5 to 65.5	18	-	70
		Fill: silty sand to sand, very loose to compact	65.5 to 62.0	19	30	-
		Silty Clay, firm to stiff	62.0 to 60.0	18	-	50
		Sand trace Silt trace Gravel, Loose to Compact	Below 60.0	19	30	-
16+425 to 16+635	7-9, 97-4, 97-2, 7-10, 15-2, 97-1, 10-101, 15-1	Fill: Silty Sand to Gravelly Sand	Above 66.0	19	30	-
		Clay and Silt to Sandy Clay and Silt, firm to stiff	66.0 to 62.0	17	-	60
		Sand trace Silt trace Gravel, Compact	Below 62.0	19	30	-

Note: In the absence of local surface water the design groundwater level should be assumed to be 1.0 m above the base of fill.

* Granular Fill to meet or exceed requirements of OPSS Granular B Type I

Appendix F

Suggested Text for NSSP

Suggested Text for NSSP on:

“Augered Caisson Construction for Noise Barrier Wall”

The Contractor is advised that variable types of subsurface materials may be encountered along the alignment of the noise barrier wall. Construction rubble, debris, cobbles and boulders amongst other obstructions may be present within the fill through which the caissons will be installed. For additional information regarding subsurface conditions, the Contractor is referred to the Foundation Investigation Report.

For bidding purposes, the Contractor shall assume the following:

1. The subsurface conditions at an augered caisson location are the same as those encountered in the borehole closest to the subject caisson location.
2. There is evidence that construction debris, asphalt layers, cobbles, boulders and rock fragments are present within the embankment fills. Caisson installation equipment must be able to dislodge, handle, remove or otherwise penetrate these obstructions and hard layers.
3. Water seepage and/or soil sloughing into the caisson hole will occur from existing fill and cohesionless soils at some locations. The cohesionless soils would be susceptible to disturbance under conditions of unbalanced hydrostatic head. Temporary liners must be available on site, or be made available on very short notice, to support the caisson sidewalls and provide seepage cut-off where required.

The Contractor is responsible for constructing the noise barrier wall foundations without disturbing the material at the sides or bases of the foundations.