

**FOUNDATION INVESTIGATION AND DESIGN REPORT
CULVERT EXTENSIONS
ADDITION AND REPLACEMENT
HIGHWAY 11
SOUTH LIMIT OF TEMAGAMI, NORTHERLY 20.3 KM
NEW LISKEARD AREA
G.W.P. No. 715-92-00**

GEOCRES Number: 31M-78

Report to

MMM Group

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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 the locations of a number of culverts where new extensions and replacement of existing extensions are required along Highway 11 from the south limit of Temagami northerly 20.3 km.

A search of the Ministry of Transportation Ontario (MTO) GEOCRES Library did not reveal record of any previous foundation investigation carried out near the subject culverts.

The purpose of this investigation was to obtain subsurface information at the culvert locations and, based on the data obtained, to provide borehole location plans, stratigraphic profiles, records of boreholes, laboratory test results, and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained at each culvert location during the course of the present investigation.

Thurber was retained by the MMM Group to carry out this foundation investigation under the MTO Agreement Number 5006-E-0043.

2 SITE DESCRIPTION

The culvert sites are located within a 20 km section of Highway 11 northerly from the south limit of the Town of Temagami. The subject section of highway straddles the Townships of Strathy, Best and Gillies Limit.

All nine (9) existing culverts are of the concrete open frame type. Six (6) of the culverts have CSP extensions already installed. The grade of the existing Highway 11 in the vicinities of the culverts ranges between approximate Elevations 300 m and 344 m. The embankment fill heights at the culverts vary from approximately 3 m to 5 m.



The culvert sites are located in rural areas adjacent to swamps, creeks and other watercourses. There are frequent bedrock outcrops and moderate vegetation cover in the surrounding areas.

The terrain in the general vicinity of the site is rugged featuring steep escarpments and elevations ranging from 275 to 700 m at Ishpatina Ridge, which is the highest point in Ontario. The surface geology is typically results of the Wisconsin glaciation. Soil cover is relatively thin and the underlying bedrock is predominantly volcanic and metavolcanic rocks of the Precambrian Age. Valley bottoms are often infilled with glacial fluvial sands. Peat is also commonly found in depressions located between rock ridges and outcrops. The area has been known for its mining tradition involving cobalt and other precious ores.

3 SITE INVESTIGATION AND FIELD TESTING

This borehole investigation and field testing program was carried out between November 14, 2007 and May 29, 2008. In November and December, 2007, the program consisted of drilling and sampling 24 boreholes (numbered 07-01 to 07-24) to depths ranging from 0.2 m to 10.7 m (Elevations 292.2 m to 340.5 m). The boreholes were located either on the road shoulder or in the ditch adjacent to the culverts. A subsequent site visit was carried out by one of our engineers on May 29, 2008 to the culvert site near Station 12+305, Township of Strathly. Several hand auger probes and visual observations were conducted at the inlet and outlet areas of the existing culvert.

Prior to the start of drilling, the borehole locations were marked/staked in the field and utility clearances were obtained. The drilled boreholes were subsequently surveyed by the MMM Group.

A track mounted drill rig was used to drill and sample the boreholes. Hollow stem augers were used to advance the boreholes until practical refusal. Soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT). Five of the boreholes were further advanced through rock fill and/or bedrock using NQ size coring equipment in conjunction with NW casings. Groundwater conditions in the open boreholes were observed throughout the drilling operations. The details of piezometer installations and borehole completion are summarized in Table 3.1.

Table 3.1
Borehole Completion and Piezometer Installation Details

Borehole Number	Piezometer Installations			Completion Details
	Screen Depth (m)	Screen Elevation (m)	Sand Filter Stratum	
07-01	4.5 – 7.6	307.0 – 303.9	Silt and Sand	Sand to surface
07-02		None Installed		Sand to surface
07-03		None Installed		Bentonite to surface
07-04		None Installed		Auger cuttings to surface
07-05		None Installed		Auger cuttings to surface



Borehole Number	Piezometer Installations			Completion Details
	Screen Depth (m)	Screen Elevation (m)	Sand Filter Stratum	
07-06		None Installed		Auger cuttings to surface
07-07		None Installed		Auger cuttings to surface
07-08		None Installed		Auger cuttings to surface
07-09		None Installed		Auger cuttings to surface
07-10	0.1 – 1.7	314.2 – 312.6	Peat / Sand	Bentonite from top of screen to surface
07-11		None Installed		Bentonite and auger cuttings to surface
07-12		None Installed		Bentonite with auger cuttings to surface
07-13		None Installed		Auger cuttings to surface
07-14		None Installed		Bentonite to surface
07-15		None Installed		Bentonite to surface
07-16		None Installed		Bentonite to surface
07-17		None Installed		Bentonite to surface
07-18	1.1 – 3.3	307.2 – 305.0	Silty/Gravelly Sand	Bentonite to surface
07-19		None Installed		Backfilled with auger cuttings to surface
07-20	2.6	313.1 – 311.1	Bedrock	Bentonite to surface
07-21		None Installed		Auger cuttings to surface
07-22		None Installed		Bentonite to surface
07-23		None Installed		Bentonite and auger cuttings to surface
07-24	0.9 – 3.3	341.1 – 338.6	Sand & Gravel Fill / Bedrock	Bentonite to surface

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

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, stored the rock core samples in wooden boxes, 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 (VI) and to natural water content determination. Selected soil samples were subjected to grain size distribution analyses (sieve and hydrometer). Point load testing was carried out on selected rock cores for unconfined compressive strength correlation. The results of this laboratory testing program are shown on the Record of Borehole sheets in Appendix A and on the figures in Appendix B.



5 DESCRIPTION OF SUBSURFACE CONDITIONS

5.1 General

Reference is made to the Record of Borehole sheets in Appendix A for details of the soil stratigraphy encountered in the boreholes. Stratigraphic profiles for the nine (9) culvert extension locations are presented on the Borehole Locations and Soil Strata Drawings in Appendix D for illustrative purposes. 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 located on the highway shoulder consist of asphalt and/or granular fill overlying inferred or proven rock fill. Boreholes located in the side ditches encountered peat and/or road fill overlying native sand and silt deposits. The native soils are underlain by inferred or proven bedrock at some locations. More detailed descriptions of the individual stratum are presented below.

5.2 Asphalt and Topsoil

A layer of asphalt between 50 and 75 mm in thickness was encountered at ground surface in Boreholes 07-7, 07-9 and 07-16 drilled through the paved shoulder of the highway. Topsoil ranging from 100 to 375 mm in thickness was encountered in Boreholes 07-15, 07-18, 07-20, 07-21 and 07-24. The topsoil thickness may vary between and beyond the borehole locations, and the limited data is not suitable for estimating topsoil quantities.

5.3 Fill

Embankment fill was encountered below the asphalt or exposed at ground surface in all except Boreholes 07-1, 07-4, 07-5, 07-10, 07-12, 07-18, 07-20 and 07-21. This fill typically consists of brown sand, gravelly sand to sand and gravel. Where encountered, the fill was found extending to 0.8 m to 4.9 m depth (Elevations 292.2 to 343.0 m).

SPT N-values measured in the cohesionless fill typically ranged from 6 to greater than 100 blows per 0.3 m penetration indicating a loose to very dense state. The water contents of the recovered fill samples ranged between 2% and 22%. Grain size analyses conducted on samples of the fill are presented on Figures B1 to B4 in Appendix B. These results are summarized in the following tables.



Soil Particles	%
<u>Gravelly Sand Fill</u>	
Gravel	24 to 32
Sand	56 to 66
Silt and Clay	10 to 12
<u>Sand and Gravel Fill</u>	
Gravel	35 to 57
Sand	39 to 51
Silt and Clay	4 to 14
<u>Sand and Sandy Silt Fill</u>	
Gravel	1 to 12
Sand	25 to 76
Silt	12 to 70
Clay	0 to 4

5.4 Rock Fill

Rock fill mixed with gravelly sand and silt was encountered in Boreholes 07-15, 07-16, 07-19, 07-22, 07-23, and inferred upon auger refusal at the bottom of Boreholes 07-2, 07-3, 07-6, 07-7, 07-9, 07-11, 07-17 and 07-19. Where encountered, the rock fill underlies the surficial road fill. Where fully penetrated in Boreholes 07-15, 07-16, 07-22 and 07-23, the rock fill thickness ranged from 0.7 to 3.8 m, and the base of the rock fill was at 2.2 to 4.6 m depths (Elevations 306.9 to 340.0 m).

SPTs were attempted at selected intervals in order to detect the base of the rock fill and top of native soil. The N-values (blows per 0.3 m penetration) are shown on the Record of Boreholes sheets. However, N-values exceeding 100 blows for 0.3 m, or less, penetration generally reflect the fact that the sampling spoon was bouncing on larger rock fragments. Lower SPT values within the rock fill generally represent sampling of fines filling the spaces between larger fragments. In neither case is the SPT value a reflection of relative density of the rock fill in the conventional sense.

Gradation of the finer material sampled within the rock fill is not shown as it is not representative of the bulk grading of the embankment fill and might be misleading. Visual observations indicated that individual pieces within the rock fill are typically up to the order of 1 m in nominal dimension. However, it must also be anticipated that larger rock sizes exist in the embankment fill.



5.5 Peat

Peat was encountered in Boreholes 07-1, 07-4 and 07-10 at ground surface. The peat was fibrous, wet and had a dark brown to black colour. In these boreholes, the peat thickness ranged from 1.4 to 3.6 m and the base of the peat layers varied between Elevations 307.9 and 312.9 m. Measured water contents of peat samples ranged from 100% to over 600%.

SPT N-values measured in the peat were 2 blows per 0.3 m penetration indicating a very loose state.

5.6 Sand, Silty Sand, Silt

Layers of brown sand, silty sand, sandy silt to silt with variable amounts of gravel and occasional cobbles were encountered in Boreholes 07-1, 07-5, 07-10, 07-12, 07-14, 07-20 and 07-23, respectively. These deposits were found ranging between 0.2 and 4.3 m in thickness, with base elevations varying from 293.9 to 330.6 m.

SPT N-values measured within these deposits ranged between 12 blows per 0.3 m penetration to greater than 100 blows for less than 0.3 m penetration, indicating a compact to very dense state. The measured water contents of samples recovered from these soils typically ranged from 8% to 22%. Grain size analyses conducted on samples of the silty sand, sand and silt are presented on Figures B5, B6 and B7, respectively, in Appendix B. The results are summarized in the following table.

Soil Particles	%
<u>Sand to Silty Sand</u>	
Gravel	0 to 25
Sand	43 to 86
Silt and Clay	13 to 37
<u>Silt</u>	
Gravel	0
Sand	2
Silt	87
Clay	11

5.7 Gravelly Sand and Sand and Gravel Till

Deposits of brown to grey gravelly sand and sand and gravel with variable amounts of silt and clay were encountered in Boreholes 07-14, 07-15, 07-16, 07-18 and 07-21. These deposits were found ranging between 0.9 and 6.1 m in thickness, with base elevations at auger refusal varying from 292.2 to 340.5 m.



SPT N-values measured within these deposits ranged from 19 blows per 0.3 m penetration to greater than 100 blows for less than 0.3 m penetration, indicating a compact to very dense state. These high N-values measured in the sand and gravel till inferred the presence of cobbles and boulders. The measured water contents of samples recovered from these soils typically ranged from 8% to 18%. Grain size analyses conducted on samples of the gravelly sand to sand and gravel till are presented on Figure B8 in Appendix B. The results are summarized in the following table.

Soil Particles	%
Gravel	27 to 36
Sand	48 to 56
Silt and Clay	8 to 25

5.8 Silty Sand to Sand and Silt Till

Brown to grey silty sand, sandy silt to sand and silt till deposits were encountered in Boreholes 07-4, 07-8, 07-14 and 07-15. Where encountered, the tills ranged from 0.3 to 2.3 m in thickness with their bases at 1.3 m to 7.2 m depths (Elevations 295.4 m to 308.9 m).

SPT N-values measured within the till layers ranged from 15 blows per 0.3 m penetration to greater than 100 blows for less than 0.3 m penetration, indicating compact to very dense conditions. Some of the higher 'N'-values may be attributed to the presence of cobbles, boulders or rock fill. The water contents of the till samples were typically in the order of 10% to 17% except in Borehole 07-8 where a value of 73% was measured due to the presence of organics. Grain size analyses conducted on samples of the tills are presented in Figures B9 and B10 of Appendix B. These results are summarized in the following table.

Soil Particles	%
Gravel	9 to 18
Sand	43 to 50
Silt	28 to 40
Clay	8 to 9

5.9 Bedrock

The soils described above were found to be underlain by granite and tonalite (intrusive plutonic rock) bedrock of the Pre-Cambrian Canadian Shield. The bedrock was proven by coring in Boreholes 07-20, 07-22 and 07-24. Proven bedrock and auger refusal depths and elevations at these borehole locations are presented in the following table.



Borehole Number	Depth to Bedrock or Auger Refusal (m)	Top of Bedrock Elevation (m)
07-01	7.9	303.6
07-04	2.5	308.9
07-05	0.2	301.3
07-08	1.3	298.2
07-10	2.3	312.1
07-12	0.7	301.1
07-14	10.4	292.2
07-16	10.7	300.8
07-18	9.2	299.1
07-20	2.8*	312.9*
07-21	1.0	340.5
07-22	3.6*	340.0*
07-23	8.4	330.6
07-24	2.2*	339.8*

* Proven by coring

Visual observations and results of hand auger probes at the culvert site near Station 12+305, Township of Strathy, indicate that bedrock is exposed or located at not more than 0.4 m below the creek bed level at the west end of the existing culvert (near Boreholes 07-05, 07-06). No exposed bedrock was observed at the east end of the culvert (near Boreholes 07-07, 07-08).

The measured Total Core Recovery (TCR) was 100% in the three boreholes. The Rock Quality Designation (RQD) values varied from 73 to 94% indicating a fair to excellent rock quality. The Fracture Indices (FI) were typically between 0 and 6 per 0.3 m core run.

The estimated Unconfined Compressive Strength (UCS) for the cores ranged from 125 to 468 MPa indicating a very strong to extremely strong rock. These estimated rock strength values are based on point load tests that were conducted on selected rock cores recovered from the boreholes.

5.10 Groundwater Conditions

Free water was not observed in most of the boreholes upon completion of drilling, except for Borehole 07-14 where a water level at 4.0 m depth (Elevation 298.6 m) in the open borehole was recorded. A standpipe piezometer was installed in each of Boreholes 07-1, 07-10, 07-18, 07-20 and 07-24. Measured water levels in these piezometers are presented below.



Borehole (screen location)	Date of Reading	Water Level Depth (m)	Water Level Elevation (m)
07-1 (silty sand/silt)	December 13, 2007	3.6	307.9
	December 15, 2007	3.7	307.8
07-10 (peat/sand)	December 15, 2007	1.6	312.7
07-18 (silty sand/ gravelly sand)	November 28, 2007	2.9	305.4
	December 13, 2007	Found damaged	-
07-20 (silty sand/bedrock)	December 13, 2007	3.1	312.6
	December 15, 2007	3.3	312.4
07-24 (sand and gravel fill /bedrock)	December 13, 2007	Dry	-
	December 15, 2007	Dry	-

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

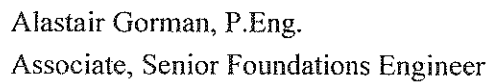
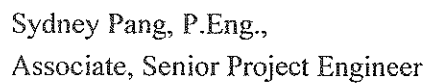
Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. The MMM Group surveyed the as-drilled locations, and provided the northing and easting coordinates and ground surface elevations.

Landcore Drilling of Chelmsford, Ontario supplied and operated a track-mounted CME 55 drill rig to carry out the drilling, sampling and in-situ testing operations.

The drilling and sampling operations in the field were supervised on a full time basis by Mr. Stephane Loranger and Ms. Eckie Siu of Thurber. Laboratory testing was carried out by Thurber in its MTO-approved laboratory.

Overall project management and direction of the field program was provided by Mr. Alastair Gorman, P.Eng. Interpretation of the field data and preparation of this report was completed by Dr. Sydney Pang, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.





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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 foundation recommendations for the design of extensions or replacement of extensions to nine (9) existing culverts along Highway 11 from the south limit of Temagami, northerly 20.3 km.

Based on the terms of reference, selected details of the culverts along the project alignment requiring foundation investigation and design are shown in Table 7.1 below. The culverts are numbered 1 to 9 for reporting purposes.

**Table 7.1
Selected Culvert Details**

Culvert #	General Location	Approx. Station* (Township)	Existing Type	Existing Size (mm)	Work Type and Comments
1	~1 km north of First Avenue, Town of Temagami	11+975 (Strathy)	Concrete Open Footing	910 x 910 (high)	Extension at both ends
2	Just south of CNR spur line	12+305 (Strathy)	Concrete Open Footing	2,440 x 1,830 (high)	Extension at both ends West – removal of 1.0m; addition of 6.2m East – removal 1.0m; addition of 5.2m
3	Just south of TCPL eastment	13+650 (Strathy)	Concrete Open Footing with CSP extension (east)	910 x 610 (high)	Extension replacement at east end
4	~400 m south of Andorra Road	18+957 (Strathy)	Concrete Open Footing with CSP extension (west)	910 x 910 (high)	Extension at east end
5	~300 m north of Red Squirrel Road	20+120 (Strathy)	Concrete Open Footing with CSP extension (west)	1,520 x 910 (high)	Extension replacement at west end
6	~350 m south of Granite Lake Bridge	11+818 (Best)	Concrete Open Footing	910 x 910 (high)	Extension at both ends



Culvert #	General Location	Approx. Station* (Township)	Existing Type	Existing Size (mm)	Work Type and Comments
7	South of Smooth Water Road	12+990 (Best)	Concrete Open Footing with CSP extension (east)	910 x 610 (high)	Extension replacement at east end
8	Just south of Three Sisters Road	14+565 (Gillies Limit)	Concrete Open Footing with CSP extension (west)	910 x 610 (high)	Extension replacement at west end
9	At pond just west of Highway 11	15+630 (Gillies Limit)	Concrete Open Footing with CSP extension (east)	1,270 x 760 (high)	Extension replacement at east end

Note: * Refers to Highway 11 centreline.

The discussions and recommendations presented in this report are based on our understanding of the project and on the factual data obtained during the course of this investigation.

Details of the nine subject culverts are described in the foundation engineering terms of reference. Plans and profiles for the original culvert construction were provided by the MMM Group. Selected photographs showing the existing conditions of the culvert extension areas are included in Appendix E for reference.

8 CULVERT FOUNDATIONS

8.1 General

The current project requirements involve new and replacement extensions at one or both ends of the existing culverts as outlined in Table 7.1. It is assumed that no detours will be required during construction and that all extensions can be accommodated within the existing highway platform. Physical dimensions of the existing culverts obtained from the plans and profiles provided by the MMM Group are presented in the following Table 8.1. Boreholes drilled at each culvert are also identified in this table for reference.

Table 8.1
Physical Dimensions of Culverts

Culvert #	Borehole Numbers	Existing Invert Elevations (m)		Length of Existing Culvert (m)
		Inlet	Outlet	
1	07-01,07-02,07-03,07-04	310.96	310.87	20.1
2	07-05,07-06,07-07,07-08 and hand probes	Not Available		21.3
3	07-9,07-10	313.97	313.94	21.6
4	07-11,07-12	301.66	301.45	24.7
5	07-13,07-14	298.09	297.94	28.3
6	07-15,07-16,07-17,07-18	308.09	307.97	21.6



Culvert #	Borehole Numbers	Existing Invert Elevations (m)		Length of Existing Culvert (m)
		Inlet	Outlet	
7	07-19,07-20	315.16	314.98	26.5
8	07-21,07-22	339.58	339.51	20.7
9	07-23,07-24	338.56	338.43	23.1

8.2 Foundation Alternatives

This section presents discussions on available types of culvert extension and foundation alternatives, and provides recommendations on feasible and/or preferred foundation option(s).

Several common culvert and foundation types are listed as follows:

- Concrete, open footing, culvert
- Concrete box (closed) culvert
- Corrugated Steel Pipe (CSP)

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

From Table 7.1, it is understood that all nine existing culverts are of the concrete open footing type, with existing CSP extensions on some of them. It is recommended that preference be given to using concrete open frame sections as new and replacement extensions. Engineered granular fill pads may be used at locations where it is required to raise the subgrade to the desired invert elevations or where higher geotechnical resistances are required.

For all new and replacement extensions, it is preferable to use precast concrete sections rather than cast-in-place construction since the former type can be installed more rapidly with less potential for disturbance of the founding soils during installation.

8.3 Foundation Design

The culvert extensions should be founded at the same level as the existing base of culverts in order to avoid undermining of the existing structures and to reduce disturbance of the foundation soils.

8.4 Concrete Open Footing Culvert Extensions

For concrete open footing culvert extensions, the footings should be founded at or below the elevations presented in Table 8.2 below.



Table 8.2
Approximate Highest Footing Levels

Culvert #	East Extension		West Extension		Founding Stratum
	Founding Depth (m)	Founding Elevation (m)	Founding Depth (m)	Founding Elevation (m)	
1	0.5	310.9	0.5	311.0	Engineered Fill*
2	Below water	298.2	Below water	298.2	Bedrock
3	1.4	312.9	Not applicable		Eng. Fill / Sand
4	0.3	301.5	Not applicable		Silt
5	Not Applicable		4.9	297.7	Comp. Granular A
6	0.4	307.8	0.7	308.0	Silty Sand (E) / Fill (W)
7	0.7	315.0	Not applicable		Sand
8	Not applicable		2.0	339.5	Sand and Gravel / Bedrock
9	1.2	337.8	Not applicable		Fill / Rock Fill

* After peat and organics are removed.

It is recommended that the culverts be designed to resist external loadings including frost forces, lateral earth pressures, hydrostatic pressure, weight of embankment fill, traffic loadings and surcharge due to construction equipment.

Recommendations on subgrade preparation procedures including sub-excavation, backfilling, bedding and inspection are provided in Section 8.6.

8.4.1 Geotechnical Resistance

The geotechnical resistances for culvert footing design depend on the subsurface conditions in the area of the footprints of the culvert extension. Based on the results of the boreholes and assuming that the subgrade preparation procedures recommended in this report are followed, the recommended geotechnical resistances at or below the founding elevations for each of the open footing culvert locations are presented as follows:



Table 8.4.1
Recommended Founding Elevations
and Geotechnical Resistances

Culvert #	Assumed Founding Conditions for Design	Highest Founding Elevations (m)	Geotechnical Resistance	
			Factored ULS (kPa)	SLS (kPa)
1	Engineered Fill* (compact)	311.0 (west) 310.9 (east)	190	125
2	Bedrock (prepared surface)	298.2 (both)	225	150
3	Engineered Fill / Sand (compact to dense)	312.9 (east)	225	150
4	Silt (dense)	301.5 (east)	225	150
5	Engineered Granular A Pad (compact)	297.7 (west)	300	200
6	Gravelly Sand (compact)	307.9 (east)	225	150
	Fill (compact to very dense)	308.0 (west)	225	150
7	Sand (compact)	315.0 (east)	225	150
8	Sand and Gravel (Very Dense) / prepared bedrock	339.5 (west)	225	150
9	Fill / Rock Fill (Compact)	337.8 (east)	225	150

* After peat and organics are removed.

The above geotechnical resistances are based on a minimum footing width of 0.6 m, and are for vertical, concentric loads only. Effects of load inclination and eccentricity should be taken into account as illustrated in the CHBDC (2006) Clause 6.7.3 and Clause 6.7.4.

The geotechnical resistances at SLS quoted above correspond to 25 mm settlement for an individual culvert footing under the applied load. Further comments on settlements are presented in Sections 8.5 and 8.7 of this report.

Resistance to lateral forces/sliding resistance between precast concrete and the underlying undisturbed, typically compact native soils or existing fill should be evaluated in accordance with the CHBDC, 2006 assuming an ultimate coefficient of friction of 0.55.

For frost protection purposes, the culvert design should incorporate 2.1 m of earth cover, or its thermal equivalent, to the foundation base.



8.5 Settlements

Foundation settlements will occur primarily as a result of embankment fill loading in the vicinity of the new culvert sections. It is understood that new fill is to be placed adjacent to the culvert extensions to flatten the embankment slopes. Information on vertical and lateral extents of new fill is unavailable at the time of preparation of this report. Where the native sands and silts, or existing fill, are in a compact or dense state, any settlement should be immediate in nature and should essentially be completed by the end of construction. Post construction settlement should be considered negligible. There should be no foundation settlement where the extensions are placed on bedrock. Where peat exists, removal and replacement is recommended, provided embankment stability can be maintained, in order to limit settlement.

Concrete open footing culvert extensions may be designed with articulated joints in order to accommodate the anticipated settlements.

8.6 Subgrade Preparation

Some boreholes located near the culverts encountered peat or native soils with organic inclusions. The presence of alluvial and organic deposits should be expected in the vicinities of the swamps and watercourses. In order to minimize post construction total and differential settlements, it is recommended that once the excavation reaches the required elevation, all remaining topsoil, organics, alluvial deposits, loose and/or soft surficial native soils or otherwise disturbed materials should be removed. The exposed surface should then be inspected by qualified geotechnical personnel to confirm that the subgrade is uniform and competent to support the culvert extension.

At locations such as Culverts #1 and #3 where peat is present, reference should be made to Section 8.7 for recommendations on peat/organics removal and backfilling.

At locations above the water level, backfill to the sub-excavation for reinstating the founding elevation should consist of Granular A or B Type II material placed and compacted in accordance with SP 902S01. Mass concrete of the same grade as the footing concrete may be used as an alternative to compacted granular backfill. In submerged areas at the watercourses and swamps, or where surficial ponding water prohibits adequate compaction of new fill, it is recommended that materials that do not require compaction, such as OPSS 1004 clear crushed stone or rock fill (finer portion with maximum nominal dimension of 150 mm), be used as backfill to the sub-excavation.



8.7 Specific Foundation Design and Construction Recommendations

In addition to the foundation design recommendations presented above, the following presents foundation design and construction comments specific to each culvert location.

8.7.1 Culvert #1 (Strathy 11+975)

Based on Boreholes 07-01 and 07-04, the footprints of the extensions to Culvert #1 will likely be directly above 1.7 to 3.1 m of peat. Peat contains organics, has a high water content and is highly compressible.

The peat within the required area of construction must be removed in accordance with OPSD 203.020 and/or 203.030, where applicable, to expose the underlying native sands and silts. However, if rock fill or mineral soil/fill is encountered at the base of the existing embankment and protruding into the excavation limits dictated by OPSD 203.020 or 203.030, this material should be left in place and the excavation limits adjusted accordingly.

All peat must be stripped from below the footprint of the culvert extension. The anticipated base of the excavation required stripping of peat to Elevation 309.0 at the east and 307.9 at the west. The limits of excavation must extend for at least 1.0 m beyond the sides and outer end of the culvert extension when measured at the founding level.

The method of excavation and backfill to maintain stability of the existing embankment must remain the responsibility of the contractor. However, one possible method of excavation and backfilling is as follows:

- Commence excavation at the face of the existing embankment fill and excavate down the face of any buried fill or to the limits shown on the applicable OPSD; a trench box may be used as required during excavation.
- When excavation has reached the required depth, work out towards the end of the culvert extension
- As excavation proceeds away from the existing embankment, place fill at least up to the required founding level
- When excavation and backfill have been completed, trim the backfill to the required founding level and apply as much compactive effort to the fill as is feasible.

Since the fill will be placed to depth of 2 to 3 m and below water, it is important that the fill consists of material that will not require compaction in shallow lifts in order to support the culvert. Suitable materials include, though are not necessarily limited to 19 mm clear crushed stone or rock fill with a maximum particle size of 150 mm.



Settlement under the constructed culvert extension is expected to be less than 25 mm, provided that peat is removed as recommended above.

8.7.2 Culvert #2 (Strathy 12+305)

Based on the results of the field work, it appears that the lower portion of the culvert is submerged at both the inlet and outlet locations. Bedrock was found to be partially exposed on the banks of the flow channel, and present within 1 m below the surface water level where investigated. Since the existing culvert is of the concrete open footing type, it is recommended that preference be given to using the same type as extensions.

Two methods of construction were considered for this site, one of which requires careful consideration of the local hydrology and drainage. The alternatives are:

- Unwater the site and construct in the dry.
- Place sediment curtains around the site and construct under water.

Alternative 1

In this alternative, the contractor is required to unwater the site prior to constructing the culvert extensions. The method of unwatering the site should be designed by the contractor. One method that could be considered is building a sandbag cofferdam around the site and dewatering inside the cofferdam. Before this method could be implemented, it would be necessary for either:

- Studies to show that removing the culvert from service for the duration of construction is feasible from the point of view of the impact on drainage and the risk of increasing the water level on one side of the highway.
- There must be a feasible method of diverting the anticipated culvert flow through another culvert or by pumping to a downstream location.

If either of these conditions can be satisfied, the contractor can work in the dry and can proceed as follows:

- Strip the overburden to bedrock, but do not excavate below Elevation 298.0 without approval from the C.A.
- Backfill to the required founding level using Granular A if the site is dry enough to permit compaction or using 19 mm clear crushed stone if the site conditions are too wet to permit compaction.
- Construct the culvert extension (precast units are recommended)



The size and location of the cofferdam must take account of the potentially unstable nature of the founding soils under the influence of water percolating into the excavation.

Alternative 2

If it is not feasible to unwater the site and construct in the dry, site preparation must be carried out in a wet condition. Typically, work could proceed as follows:

- Place sediment curtains to contain disturbed soil
- Excavate to bedrock, but not below Elevation 298.0 without approval from the C.A.
- Place 19 mm clear crushed stone, compacting to the extent feasible
- Level off the crushed stone at the required founding level
- Construct the culvert extension using precast units.

The bedrock occurs close to the required founding level and is uneven. Regardless of the method of construction employed, it is possible that bedrock will be found to protrude into the excavation above the founding level and to obstruct culvert construction. In this case, it may be necessary to remove a quantity of bedrock and the contract documents must alert the contractor to this possibility and must contain provisional items to pay for rock excavation.

Settlement under the constructed culvert extension is expected to be less than 25 mm, provided that peat is removed as recommended above.

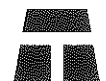
8.7.3 Culvert #3 (Strathy 13+650)

Based on Borehole 07-10, peat overlying native sand is present beneath the footprint of the new culvert extension. The footings of the new rigid frame extension should be founded on the dense sand underlying the peat or on engineered fill placed on the dense sand.

Excavation of the existing rockfill embankment will be required in order to expose the end of the concrete culvert. The back slope of the excavation in rockfill must not be steeper than 1H : 1V. Traffic should be maintained behind a line determined by projecting a plane upward from the base of excavation at an inclination of 1.25H : 1V.

Although not depicted in Borehole 07-10, it is possible that the surface water level within the swampy area is at or above the existing ground surface during construction. Accordingly, the Contractor should be equipped to carry out sub-excavation and backfilling underwater, where appropriate.

The peat within the required area of construction must be removed in accordance with OPSD 203.020 and/or 203.030, where applicable, to expose the underlying dense sand. However, if rock fill or mineral soil/fill is encountered at the base of the existing embankment and



protruding into the excavation limits dictated by OPSD 203.020 or 203.030, this material should be left in place and the excavation limits adjusted accordingly.

All peat must be stripped from below the footprint of the culvert extension. The anticipated base of the excavation to which peat stripping is required is Elevation 312.9.

Following stripping of the peat, 19 mm clear crushed stone must be placed up to the required founding level and must be compacted to the extent feasible.

Settlement under the constructed culvert extension is expected to be less than 25 mm, provided that peat is removed as recommended above.

8.7.4 Culvert #4 (Strathy 18+957)

Based on Borehole 07-12, dense silt overlying probable bedrock or rock fill is present beneath the footprint of the new culvert extension. The footings of the new rigid frame extension should be founded on the dense silt.

Excavation of the existing rock fill embankment will be required in order to expose the end of the concrete culvert. The back slope of the excavation in rock fill must not be steeper than 1H : 1V. Traffic should be maintained behind a line determined by projecting a plane upward from the base of excavation at an inclination of 1.25H : 1V.

Settlement under the constructed culvert extension is expected to be less than 25 mm.

8.7.5 Culvert #5 (Strathy 20+120)

Based on Boreholes 07-13 and 07-14 and site observations, the existing CSP extension is partially over-hanging the embankment slope. In order for the CSP to be replaced by a concrete rigid frame section, new engineered fill will have to be placed to support the culvert extension.

The following is recommended:

- Strip topsoil, peat, etc. from the culvert extension construction area
- Construct a pad of engineered fill composed of OPSS Granular “A” compacted to 100% of Standard proctor maximum dry density up to the required founding level
- At the founding level, the engineered fill should extend at least 1 m beyond the culvert
- The sides of the engineered fill pad should be sloped at no steeper than 1H : 1V and beyond that limit, additional fill must be placed to a slope not steeper than 2H : 1V

Settlement under the constructed culvert extension is expected to be less than 25 mm



Excavation of the existing embankment will be required in order to expose the end of the concrete culvert. The back slope of the excavation should be no steeper than 2H : 1V. If traffic cannot be maintained behind that slope, then slope protection must be used.

It is expected that construction at this site can be carried out in the dry provided surface precipitation and runoff from the highway are diverted away from the work areas.

8.7.6 Culvert #6 (Best 11+818)

Based on Boreholes 07-15 to 07-18, the existing culvert straddles cohesionless fill on the west side and native compact gravelly sand on the east side. The footings of the culvert extensions will be founded on compact sand and gravel fill / rock fill on the west side and native compact gravelly sand on the east side. Placement of new fill will induce settlement in the underlying soil/fill. This is expected not to exceed 25 mm and to mostly occur as construction is taking place.

It is expected that construction at this site can be carried out in the dry provided that surface precipitation and runoff from the highway are diverted away from the work areas.

8.7.7 Culvert #7 (Best 12+990)

Based on Borehole 07-20, the new culvert extension will be founded on compact to dense sand to silty sand overlying bedrock. If new fill is placed to widen/flatten the embankment, this will induce settlement in the underlying soil. The settlement is expected not to exceed 25 mm and to be essentially complete by the end of construction.

Excavation of the existing rock fill embankment will be required in order to expose the end of the concrete culvert. The back slope of the excavation in rock fill must not be steeper than 1H:1V. Traffic should be maintained behind a line determined by projecting a plane upward from the base of excavation at an inclination of 1.25H : 1V.

It is expected that construction at this site can be carried out in the dry provided the surface precipitation and runoff from the highway are diverted away from the work areas.

8.7.8 Culvert #8 (Gillies Limit 14+565)

Borehole 07-22, drilled through the embankment and close to the culvert encountered bedrock at a level above the culvert invert. Borehole 07-21 encountered auger refusal on possible bedrock above the culvert invert. However, due to access constraints, this latter borehole was drilled approximately 5 m north of the culvert. It may be assumed that the culvert will be founded on dense, native sand and gravel, although there remains a risk of bedrock encroaching into the construction envelop. In this case, it may be necessary to remove a quantity of bedrock and the contract documents must alert the contractor to this possibility and must contain provisional items to pay for rock excavation.



Excavation of the existing rock fill embankment will be required in order to expose the end of the concrete culvert. The back slope of the excavation in rock fill must not be steeper than 1H : 1V. Traffic should be maintained behind a line determined by projecting a plane upward from the base of excavation at an inclination of 1.25H : 1V.

It is expected that construction at this site can be carried out in the dry provided the surface precipitation and runoff from the highway are diverted away from the work areas.

8.7.9 Culvert #9 (Gillies Limit 15+630)

Based on Borehole 07-23, the new culvert extension will be founded over cohesionless fill/rock fill. If new fill will be placed to widen/flatten the road embankment, the foundation settlement associated with fill placement is expected to not exceed 25 mm and to be essentially complete by the end of construction.

The following procedure is recommended:

- Strip an area that extends at least 1.0 m beyond the culvert foundations down to 500 mm below the culvert founding level
- Chink any exposed rock fill
- Backfill to the founding level using 19 mm clear crushed stone

Excavation of the existing rock fill embankment will be required in order to expose the end of the concrete culvert. The back slope of the excavation in rock fill must not be steeper than 1H : 1V. Traffic should be maintained behind a line determined by projecting a plane upward from the base of excavation at an inclination of 1.25H : 1V.

It is expected that construction at this site can be carried out in the dry provided the surface precipitation and runoff from the highway are diverted away from the work areas.

9 CULVERT BACKFILL AND LATERAL EARTH PRESSURES

It is recommended that backfill to the culvert consists of free-draining, non-frost susceptible granular materials such as Granular A or B Type II conforming to the requirements of Special Provision No. 110F13, "Amendment to OPSS 1010, November 2003" dated March 2004. Reference should be made to the backfill arrangements stipulated in OPSD 803.01 as appropriate.

All fills should be placed in regular lifts and be compacted in accordance with SP 105S10 "Amendment to OPSS 501, February 1996", dated November 2004. The backfill should be placed and compacted in simultaneous lifts on both sides of a culvert, and the top of backfill elevation should be the same on both sides of the culvert at all times. Heavy compaction equipment must not be used adjacent to the walls and roofs of the culverts.



For rigid structures such as a concrete open frame culvert, it is recommended that at-rest horizontal earth pressures be used for design.

Earth pressures acting on the culvert walls may be assumed to impose a triangular distribution. For a fully drained backfill, the pressures should be computed in accordance with the CHBDC 2006 but are generally given by the expression:

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

where	p_h	=	horizontal pressure on the wall at depth h (kPa)
	K	=	earth pressure coefficient (see table below)
	γ	=	bulk unit weight of retained soil (see table below)
	h	=	depth below top of fill where pressure is computed (m)
	q	=	value of any surcharge (kPa)

Earth pressure coefficients for backfill to the retaining walls are dependent on the material used as backfill. Recommended unfactored values are shown in the following Table 9.1. Active pressures should be used for any wingwall or unrestrained wall.

Table 9.1
Earth Pressure Coefficients (K)

Wall Condition	Earth Pressure Coefficient (K)					
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ; \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I (modified) $\phi = 32^\circ; \gamma = 21.2 \text{ kN/m}^3$		Embankment Fill $\phi = 30^\circ; \gamma = 20.0 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active (Unrestrained Wall)	0.27	0.40	0.31	0.48	0.33	0.54
At rest (Restrained Wall)	0.43	0.62	0.47	0.70	0.50	0.76
Passive (Movement Towards Soil Mass)	3.7	-	3.3	-	3.0	-



In accordance with Clause 6.9.3 of the CHBDC, a compaction surcharge should be added. The magnitude should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 2.0 m for Granular B Type I, or at a depth of 1.7 m for Granular A or Granular B Type II.

The design of concrete culvert walls must incorporate measures such as weepholes and/or subdrains to permit drainage of the backfill, or alternatively the culvert walls should be designed to withstand the potential build-up of hydrostatic pressures behind the walls.

10 EMBANKMENT DESIGN AND CONSTRUCTION

It is understood that new fill may be placed adjacent to and over the culvert extensions in order to flatten the existing highway embankments, many of which are steeper than 2H : 1V. Embankment construction should be carried out in accordance with Special Provision No. 206S03 “Amendment to OPSS 206, December 1993” dated November 2006. The embankment material should consist of earth fill or Select Subgrade Material (SSM) in compliance with Special Provision No. 110F13, “Amendment to OPSS 1010, November 2003” March 2004. Rock fill may also be used for slope flattening purposes.

Provided that the earth fill or SSM is placed as recommended, it is anticipated that a slope inclination of 2H : 1V or flatter should remain stable. Rock fill will be stable at 1.25H : 1V or flatter. Consideration may be given to benching the existing earth slope surface as per OPSD 208.010 in order to enhance the keying in of the new fill.

In general, surface vegetation, peat, topsoil, organic deposits, disturbed material or otherwise loose/soft soils should be stripped from the culvert extension area and embankment footprint. Inspection and approval of the foundation surfaces by qualified geotechnical personnel is recommended.

11 EROSION CONTROL

Erosion protection should be provided at the culvert inlet and/or outlet areas where an extension is to be constructed. Design of the erosion protection measures must consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field.

Typically, rip-rap should be provided over all surfaces with which creek water is likely to be in contact. Treatment at the outlets should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with SP 572S01.

It is recommended that a clay seal or a concrete cut-off wall be used to minimize the potential for erosion near the inlet area. The clay seal should extend above the high water level and laterally for the



width of the granular material, and have a minimum thickness of 0.5 m. The material requirements should be in accordance with OPSS 1205.

12 EXCAVATION AND GROUNDWATER CONTROL

12.1 General

All excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the native sands and silts at these sites are classified as Type 3 soils above the water level and Type 4 soils below the water level. All existing fills and native soils below the water level are classified as Type 3 soils.

12.2 Foundations

Excavation and backfilling for culvert construction must be carried out in accordance with SP 902S01.

12.3 Excavations

Excavations for culvert extension construction will be carried out through the existing embankment fill including rock fill, peat and surficial native soils. At locations where there is space restriction or where a slope has to be retained, the excavations will need to be carried out in conjunction with a protection system.

The Special Provision No. 105S19 titled "Amendment to OPSS 539, November 2003, Construction Specification for Protection Systems" dated November 2006 will have to be included in the contract documents. It is recommended that Performance Level 2 as per Clause 539.04.02.01 (maximum horizontal displacement of 25 mm) be specified for these culvert extension sites.

Protection systems may be required to retain the embankment fill and/or the existing culvert at some locations. As discussed previously, installation of shoring elements through rock fill will encounter varying degrees of difficulties depending on the rock fill gradation characteristics. Specialized drilling equipment will be required to penetrate the rock fill in order to socket the shoring elements to the required depth. Any protection system should be designed by licensed Professional Engineers experienced in such designs.

12.4 Groundwater Control

Groundwater perched within the embankment fill will seep into the excavations during culvert construction. Surface runoff will also tend to accumulate in these excavations. Beyond the toe of the embankment, the groundwater level varies between locations but is expected to be governed by the water level in the watercourses (creeks/streams/swamps). The Contractor



must make provisions to control any water seepage, surface runoff and ponding by measures including the use of sump pumps to maintain dry excavations during the course of construction. At Culvert #2 where unwatering is impractical in open water, the Contractor should be prepared to carry out the construction underwater. Temporary surface water diversion may be possible at some locations.

13 CONSTRUCTION CONCERNS

During construction, the Contract Administrator should employ experienced geotechnical staff to observe construction activities related to foundation construction, and to inspect and approve the culvert subgrade.

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

- Impact of excavation on the existing pavement surface

Daily visual inspection of the pavement surface must be carried out in the vicinity of each culvert under construction. If cracks form in the pavement or settlement is observed to occur, these matters must immediately be brought to the attention of the C.A. for determining as to whether remedial action is required.

- Occurrence of bedrock within the culvert construction envelop

Many of the sites are underlain by bedrock which characteristically has an uneven surface. It is possible that, in the course of construction, it will become necessary to remove small quantities of bedrock. The contract documents must alert bidders to this possibility and the contract must contain provisional items to cover payment of rock excavation.

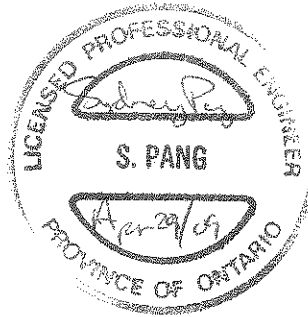
- removal of peat, organics, soft soils and alluvial deposits near creek and stream channels,
- disturbance of the soil subgrade within the culvert foundation footprints,
- confirmation that the culvert backfills and approach fills are adequately placed and compacted to specifications.

It is recommended that provision(s) be included in the contract requiring the QVE to confirm that the above issues are adequately addressed. Should there be any doubts about issues such as depth of sub-excavation, these provisions should require the QVE to alert the CA.



14 CLOSURE

Preparation of this foundation design report was carried out by Dr. Sydney Pang, P.Eng. The report was reviewed by Mr. Alastair Gorman, P.Eng. and Dr. P.K. Chatterji, P.Eng.



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Associate, Senior Foundations Engineer



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Principal, Designated MTO Contact



Appendix A

Record of Borehole Sheets



METRIC

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	WATER CONTENT (%)
								SHEAR STRENGTH kPa										
311.5								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE										
								40 80 120 160 200						20 40 60				

DEPTH (m)	SOIL DESCRIPTION	UNIT	SS	CL	LI	WATER LEVEL (m)	REMARKS
0.0	PEAT, fibrous Very Loose Dark Brown to Black Wet	1	AS				
307.9		2	SS	2			
		3	SS	2			
		4	SS	2			
		5	SS	2			
306.8	Silty SAND, trace organics Very Loose Brown Moist to Wet	6	SS	12			
		7	SS	17			
303.6	SILT, some clay, trace sand Compact Grey Moist						
7.9	END OF BOREHOLE AT 7.9m UPON AUGER REFUSAL. Piezometer installation consists of 19mm diameter schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2007.12.13 3.6 307.9 2007.12.15 3.7 307.8						

ONTMT4S 6110.GPJ 4/28/09


+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 07-02

1 OF 1

METRIC

G.W.P. 715-92-00 LOCATION N 5 215 746.1 E 396 532.1, Stralhy (Sta. 11+975) ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SLL
 DATUM Geodetic DATE 2007.12.12 - 2007.12.12 CHECKED BY MEF

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							WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE							w _p w w _L		
315.0							20 40 60 80 100										
0.0	SAND, some gravel, some silt Compact to Loose Brown Moist (FILL)		1	AS											Augers grinding a 0.4 to 0.5m. 13 75 12 (SI+CL) Augers grinding a 1.7 to 1.8m.		
			2	SS	14												
			3	SS	6												
312.8																	
2.1	END OF BOREHOLE AT 2.1m UPON AUGER REFUSAL ON PROBABLE ROCKFILL. BOREHOLE BACKFILLED WITH SAND TO SURFACE.																

+³, X³: Numbers refer to
Sensitivity

20
15
10
5
0
5
10
15
20
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-03

1 OF 1

METRIC

G.W.P. 715-92-00 LOCATION N 5 215 738.7 E 396 541.3, Strathy (Sta. 11+975) ORIGINATED BY ES
HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SLL
DATUM Geodetic DATE 2007.12.12 - 2007.12.12 CHECKED BY MEF



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 γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
314.9														
0.0	Gravelly SAND, some silt Dense Brown Moist (FILL)		1	AS										
			2	SS	42									26 63 11 (SI+CL)
			3	SS	32									
312.6														
2.3	END OF BOREHOLE AT 2.3m UPON AUGER REFUSAL ON PROBABLE ROCKFILL. BOREHOLE BACKFILLED WITH BENTONITE AND AUGER CUTTINGS TO SURFACE.													Augers grinding at 2.1 to 2.3m.

RECORD OF BOREHOLE No 07-04

1 OF 1

METRIC

G.W.P. 715-92-00 LOCATION N 5 215 740.7 E 396 550.0, Strathy (Sta. 11+975) ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SLL
 DATUM Geodetic DATE 2007.12.15 - 2007.12.15 CHECKED BY MEF

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	
311.4							20	40	60	80	100			
0.0	PEAT, fibrous, trace to some sand, some rootlets Very Loose Dark Brown to Black Wet		1	AS									475	
			2	SS	2									
			3	SS	2								107	
309.2														
2.2	SAND and SILT, trace gravel, trace clay Very Dense Grey Moist (TILL)		4	SS	50/ .100									9 43 40 8
308.9														
2.5	END OF BOREHOLE AT 2.5m UPON AUGER REFUSAL ON PROBABLE BEDROCK OR ROCKFILL. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO SURFACE.													

RECORD OF BOREHOLE No 07-05

1 OF 1

METRIC

G.W.P. 715-92-00 LOCATION N 5 216 063.8 E 396 510.8, Strathly (Sta. 12+305) ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SLL
 DATUM Geodetic DATE 2007.12.15 - 2007.12.15 CHECKED BY MEF

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 γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
301.5							20 40 60 80 100						
0.0	SAND, occasional gravel		1	SS	50/		0 20 40 60 80 100						
0.2	Very Dense Brown Moist				.025		0 20 40 60 80 100						
	END OF BOREHOLE AT 0.2m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO SURFACE.					301							

RECORD OF BOREHOLE No 07-06

1 OF 1

METRIC

G.W.P. 715-92-00 LOCATION N 5 216 064.7 E 396 516.6, Strathby (Sta. 12+305) ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SLL
 DATUM Geodetic DATE 2007.12.11 - 2007.12.11 CHECKED BY MEF

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						
303.5								20 40 60 80 100						
0.0	Gravelly SAND, some silt Dense Brown Moist (FILL) Augers grinding at 0.7 to 0.9m		1	AS			303							
				2	SS	31								
301.9	Augers grinding at 1.4 to 1.5m													
1.6	END OF BOREHOLE AT 1.6m UPON AUGER REFUSAL ON PROBABLE ROCKFILL. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO SURFACE.													

+³ ×³: Numbers refer to
Sensitivity

20
15 10 5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-07

1 OF 1

METRIC

G.W.P. 715-92-00 LOCATION N 5 216 065.0 E 396 525.6, Strathy (Sta. 12+305) ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SLL
 DATUM Geodetic DATE 2007.12.11 - 2007.12.11 CHECKED BY MEF



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 γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
303.6	ASPHALT: (50mm)		1	AS													
302.8	SAND and GRAVEL Brown Moist (FILL)																
0.8	END OF BOREHOLE AT 0.8m UPON AUGER REFUSAL ON PROBABLE ROCKFILL. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO SURFACE.																

RECORD OF BOREHOLE No 07-08

1 OF 1

METRIC

G.W.P. 715-92-00 LOCATION N 5 216 066.7 E 396 535.8, Strathy (Sta. 12+305) ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SLL
 DATUM Geodetic DATE 2007.12.15 - 2007.12.15 CHECKED BY MEF

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						
299.5								20 40 60 80 100						
0.0	SAND, trace to some gravel, trace rootlets, some organics Brown Moist (FILL)		1	AS			299	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE						
298.7								40 80 120 160 200						
0.8	Sandy SILT, trace gravel, trace rootlets Very Dense Dark Brown Moist (TILL)		2	SS	.50									Augers grinding at 0.8 to 1.2m.
298.2					.075									
1.3	END OF BOREHOLE AT 1.3m UPON AUGER REFUSAL. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO SURFACE.													

RECORD OF BOREHOLE No 07-09

1 OF 1

METRIC

G.W.P. 715-92-00 LOCATION N 5 217 410.3 E 396 468.6, Strathy (Sta. 13+650) ORIGINATED BY ES
HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SLL
DATUM Geodetic DATE 2007.12.11 - 2007.12.11 CHECKED BY MEF

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 γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
317.7 0.0 0.1	ASPHALT: (75mm) Gravelly SAND, some silt Dense to Very Dense Brown Dry (FILL)		1	AS													
			2	SS	34											32 56 12 (SI+CL)	
315.9 1.8	END OF BOREHOLE AT 1.8m UPON AUGER REFUSAL ON PROBABLE ROCKFILL. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO SURFACE.		3	SS	50/												

RECORD OF BOREHOLE No 07-10

1 OF 1

METRIC

G.W.P. 715-92-00 LOCATION N 5 217 418.7 E 396 482.8, Strathy (Sta. 13+650) ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SLL
 DATUM Geodetic DATE 2007.12.13 - 2007.12.13 CHECKED BY MEF

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						
314.3								20 40 60 80 100						
0.0	PEAT, fibrous Very Loose Dark Brown to Black Wet						314							
312.9			1	SS	2								211	
1.4	SAND, trace gravel, trace silt, trace rootlets Dense Mottled Brown and Grey Wet		2	SS	35									
312.1														
2.3	END OF BOREHOLE AT 2.3m UPON AUGER REFUSAL ON PROBABLE BEDROCK. Piezometer installation consists of 19mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2007.12.15 1.6 312.7													

+³, X³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-11

1 OF 1

METRIC

G.W.P. 715-92-00 LOCATION N 5 222 051.0 E 397 770.9, Strathy (Sta. 18+957) ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SLL
 DATUM Geodetic DATE 2007.11.30 - 2007.11.30 CHECKED BY MEF

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							PLASTIC LIMIT w _p NATURAL MOISTURE CONTENT w LIQUID LIMIT w _L						
306.1							20	40	60	80	100										
0.0	Gravelly SAND , some silt Very Dense Brown Moist (FILL)		1	AS																	
			2	SS	105																
			3	SS	70/ 275																
303.9																					
2.2	END OF BOREHOLE AT 2.2m UPON AUGER REFUSAL ON PROBABLE ROCKFILL. BOREHOLE BACKFILLED WITH BENTONITE AND AUGER CUTTINGS TO SURFACE.																				

+³, x³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-12

1 OF 1

METRIC

G.W.P. 715-92-00 LOCATION N 5 222 045.8 E 397 781.3, Strathy (Sta. 18+957) ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SLL
 DATUM Geodetic DATE 2007.12.14 - 2007.12.14 CHECKED BY MEF

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 γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
301.8																	
0.0	SILT, trace to some sand, occasional gravel Dense Brown Moist		1	SS	40												
301.1																	
0.7	END OF BOREHOLE AT 0.7m UPON AUGER REFUSAL ON PROBABLE BEDROCK OR ROCKFILL. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO SURFACE.																
							301										

RECORD OF BOREHOLE No 07-13

1 OF 1

METRIC

G.W.P. 715-92-00 LOCATION N 5 223 082.1 E 398 289.3, Strathy (Sta. 20+120) ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SLL
 DATUM Geodetic DATE 2007.12.14 - 2007.12.14 CHECKED BY MEF

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 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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 40 80 120 160 200					WATER CONTENT (%)						
293.5																	
0.0	SAND and GRAVEL, trace rootlets Compact Brown Moist (FILL)		1	AS													
			2	SS	24												
292.2																	
1.4	END OF BOREHOLE AT 1.4m UPON AUGER REFUSAL ON PROBABLE BEDROCK OR ROCKFILL. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO SURFACE.																

+³, ×³: Numbers refer to
Sensitivity

20
15 10 5
(%) STRAIN AT FAILURE

METRIC

+³, X³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 07-14

2 OF 2

METRIC

G.W.P. 715-92-00 LOCATION N 5 223 066.0 E 398 300.1, Strathy (Sta. 20+120) ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SLL
 DATUM Geodetic DATE 2007.12.10 - 2007.12.10 CHECKED BY MEF

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			20 40 60 80 100	W P W W L	20 40 60				
292.2	Gravelly SAND, some silt Very Dense Grey Wet													
10.4	Continued From Previous Page END OF BOREHOLE AT 10.4m UPON AUGER REFUSAL ON PROBABLE BEDROCK. WATER LEVEL AT 4.0m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE TO SURFACE.					292								

METRIC

[illegible]

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-15

2 OF 2

METRIC

G.W.P. 715-92-00 LOCATION N 5 224 759.1 E 400 453.8, Best (Sta. 11+818) ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers / NQ Coring COMPILED BY SLL
 DATUM Geodetic DATE 2007.11.20 - 2007.11.20 CHECKED BY MEF

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			20	40	60	80	100					
	Continued From Previous Page																
298.0	SAND and GRAVEL, some silt Very Dense Grey Wet (TILL)		10	SS	50												
10.7	END OF BOREHOLE AT 10.7m. BOREHOLE BACKFILLED WITH BENTONITE AND AUGER CUTTINGS TO SURFACE.				.075												

RECORD OF BOREHOLE No 07-16

1 OF 2

METRIC

G.W.P. 715-92-00 LOCATION N 5 224 751.9 E 400 461.3, Best (Sta. 11+818) ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers / NQ Coring COMPILED BY SLL
 DATUM Geodetic DATE 2007.11.26 - 2007.11.26 CHECKED BY MEF

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					
311.4							20 40 60 80 100						
0.0	ASPHALT: (75mm)												
0.1	SAND and GRAVEL Brown Moist (FILL)		1	AS									
310.7													
0.8	ROCKFILL, mixed with gravelly sand, some silt Compact to Very Dense Brown Moist (FILL)		2	SS	23								
			3	SS	50/ .100								
	Loose		4	SS	8								
306.8													
4.6	Gravelly SAND, some silt and clay Very Dense Grey Moist		5	SS	78								
			6	SS	65								
			7	SS	50/ .100								
302.2													
9.2	SAND and GRAVEL, some silt and clay Very Dense Grey Moist: (TILL)		8	SS	50/ .125								

27 50 23
Auger Refusal at
1.8m, switched to
NQ Coring to
3.2m.

27 59 14
(SI+CL)

Auger Refusal at
7.7m, switched to
NQ Coring to
9.1m.

37 38 25
(SI+CL)

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-16

2 OF 2

METRIC

G.W.P. 715-92-00 LOCATION N 5 224 751.9 E 400 461.3, Best (Sta. 11+818) ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers / NQ Coring COMPILED BY SLL
 DATUM Geodetic DATE 2007.11.26 - 2007.11.26 CHECKED BY MEF

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 γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
	Continued From Previous Page																
300.8	SAND and GRAVEL, some silt and clay Very Dense Grey Moist (TILL)						301										
10.7	END OF BOREHOLE AT 10.7m UPON AUGER REFUSAL ON PROBABLE BEDROCK OR BOULDER. BOREHOLE BACKFILLED WITH BENTONITE TO SURFACE.																

+³, x³: Numbers refer to
Sensitivity

20
15
10
5
0
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-17

1 OF 1

METRIC

G.W.P. 715-92-00 LOCATION N 5 224 737.8 E 400 460.2, Best (Sta. 11+818) ORIGINATED BY ES
HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SLL
DATUM Geodetic DATE 2007.11.28 - 2007.11.28 CHECKED BY MEF

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						
311.9								20 40 60 80 100						
								O UNCONFINED + FIELD VANE						
								● QUICK TRIAXIAL X LAB VANE						
								WATER CONTENT (%)						
								PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT						
								w _p w w _L						
0.0	SAND and GRAVEL, some silt Compact to Dense Brown Moist (FILL)		1	AS			312							38 48 14 (SI+CL)
			2	SS	23		311							
			3	SS	36		310							
309.5														
2.4	END OF BOREHOLE AT 2.4m UPON AUGER REFUSAL ON PROBABLE ROCKFILL. BOREHOLE BACKFILLED WITH BENTONITE TO SURFACE.													

+³, x³: Numbers refer to
Sensitivity

20
15 10 5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-18

1 OF 2

METRIC

G.W.P. 715-92-00 LOCATION N 5 224 731.9 E 400 467.1, Best (Sta. 11+818) ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SLL
 DATUM Geodetic DATE 2007.11.28 - 2007.11.28 CHECKED BY MEF

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					WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	w _p w w _L						
308.3							20 40 60 80 100								
0.0	TOPSOIL: (375mm), some clay, trace sand, occasional black staining		1	AS											
307.9	Black														
0.4	Wet														
	Gravelly SAND, some silt														
	Compact to Very Dense		2	SS	29										
	Grey														
	Moist														
			3	SS	19										
			4	SS	28										
			5	SS	21										
			6	SS	50/ .125										
			7	SS	50/ .025										
299.1															
9.2	END OF BOREHOLE AT 9.2m UPON REFUSAL ON PROBABLE BEDROCK OR BOULDER. Piezometer installation consists of a 19mm diameter schedule 40 PVC pipe														

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-18

2 OF 2

METRIC

G.W.P. 715-92-00 LOCATION N 5 224 731.9 E 400 467.1, Best (Sta. 11+818) ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SLL
 DATUM Geodetic DATE 2007.11.28 - 2007.11.28 CHECKED BY MEF

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 γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	40 80 120 160 200					
Continued From Previous Page														
	with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2007.11.28 2.9 305.4 2007.12.13 Piezometer Damaged													

METRIC

[illegible]

ONTMT4S 6110.GPJ 4/28/09

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 07-20

1 OF 1

METRIC

G.W.P. 715-92-00 LOCATION N 5 225 851.3 E 400 738.6, Best (Sta. 12+990) ORIGINATED BY TG
 HWY 11 BOREHOLE TYPE Hollow Stem Augers / NQ Coring COMPILED BY SLL
 DATUM Geodetic DATE 2007.11.17 - 2007.11.18 CHECKED BY MEF

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						
							WATER CONTENT (%)							
							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT							
							w _p w w _L							
							20 40 60 80 100							
							40 80 120 160 200							
							20 40 60							
315.7														
0.0														
0.1	TOPSOIL: (100mm), trace rootlets Black Wet		1	AS									0 87 13 (SI+CL)	
	SAND, some silt Compact Brown Wet		2	SS	29									
314.4														
1.4	Silty SAND, trace to some gravel, trace clay Compact to Very Dense Brown Wet		3	SS	22									
			4	SS	67								12 51 30 7	
312.9														
2.8	GRANITE BEDROCK Very Strong		5	SS	507								Auger Refusal at 2.8m, switched to NQ Coring. TCR=100%, SCR=100%, RQD=90%, UCS=219MPa Range UCS = 198 to 245MPa	
					.050									
			1	RUN										
311.1														
4.6	END OF BOREHOLE AT 4.6m. Piezometer installation consists of 30mm PVC schedule 40 PVC pipe with a 1.52m slotted screen. DATE DEPTH (m) ELEV. (m) 2007.12.13 3.1 312.6 2007.12.15 3.3 312.4													

+³, X³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-21

1 OF 1

METRIC

G.W.P. 715-92-00 LOCATION N 5 230 944.3 E 400 828.3, Gillies Limit (Sta. 14+565) ORIGINATED BY SLL, TG
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SLL
 DATUM Geodetic DATE 2007.11.16 - 2007.11.17 CHECKED BY MEF

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 γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
341.5																	
0.0																	
0.1	TOPSOIL: (100mm), trace rootlets Black Wet		1	AS													
340.5	SAND and GRAVEL, trace silt and rootlets Very Dense Dark Brown		1	SS	50/											37 55 8	
1.0	Moist END OF BOREHOLE AT 1.0m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO SURFACE.				.125											(SI+CL)	

RECORD OF BOREHOLE No 07-22

1 OF 1

METRIC

G.W.P. 715-92-00 LOCATION N 5 230 936.1 E 400 838.2, Gillies Limit (Sta. 14+565) ORIGINATED BY SLL, TG
 HWY 11 BOREHOLE TYPE Hollow Stem Augers / NQ Coring COMPILED BY SLL
 DATUM Geodetic DATE 2007.11.16 - 2007.11.18 CHECKED BY MEF

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						
343.7							20	40	60	80	100			
0.0	SAND and GRAVEL, trace silt Brown Moist (FILL)		1	AS										35 58 7 (SI+CL) Auger Refusal at 0.7m, switched to NQ Coring.
343.0														
0.7	ROCKFILL Very Dense Brown (FILL)													
			2	SS	50/ .050									
			3	SS	50/ .025									
340.0														
3.6	TONALITE BEDROCK Very Strong to Extremely Strong		1	RUN										RUN 1# TCR=100%, SCR=100%, RQD=73%, UCS=304MPa Range UCS = 140 to 468MPa

RECORD OF BOREHOLE No 07-23

1 OF 1

METRIC

G.W.P. 715-92-00 LOCATION N 5 231 946.8 E 400 702.4, Gillies Limit (Sta. 15+630) ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SLL
 DATUM Geodetic DATE 2007.11.14 - 2007.11.15 CHECKED BY MEF

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		
339.0														
0.0	SAND and GRAVEL, trace silt Brown Moist (FILL)		1	AS			339							47 47 6 (SI+CL)
337.8							338							
1.2	ROCKFILL, some gravel, some sand Compact to Very Dense Brown Moist (FILL)		1	SS	10		337							
	Obstruction at 3.2 to 3.8m		2	SS	50/ .100		336							
335.2							335							
3.8	Silty CLAY, with inferred cobbles and boulders Hard Grey Moist		3	SS	75		334							
333.5							333							
5.5	SAND, some silt, trace inferred cobbles Dense to compact Grey Wet		4	SS	46		332							
							331							
330.6														
8.4	END OF BOREHOLE AT 8.4m UPON AUGER REFUSAL ON PROBABLE BEDROCK OR BOULDER. BOREHOLE BACKFILLED WITH BENTONITE AND AUGER CUTTINGS TO SURFACE.													

ONTMT4S 6110.GPJ 4/28/09

+³, X³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-24

1 OF 1

METRIC

G.W.P. 715-92-00 LOCATION N 5 231 943.4 E 400 691.2, Gillies Limit (Sta. 15+630) ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers / NQ Coring COMPILED BY SLL
 DATUM Geodetic DATE 2007.11.16 - 2007.11.16 CHECKED BY MEF

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 γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	40 80 120 160 200					
342.0	TOPSOIL: (375mm) Black Wet													
341.6														
0.4	SAND and GRAVEL, trace silt Dense to Very Dense Dark Brown Moist to Wet (FILL)		1	SS	30									
339.8			2	SS	65									
2.2	TONALITE BEDROCK Very Strong to Extremely Strong		1	RUN										
338.6														
3.3	END OF BOREHOLE AT 3.3m. Piezometer installation consists of a 19mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2007.12.13 Dry - 2007.12.15 Dry -													

Appendix B

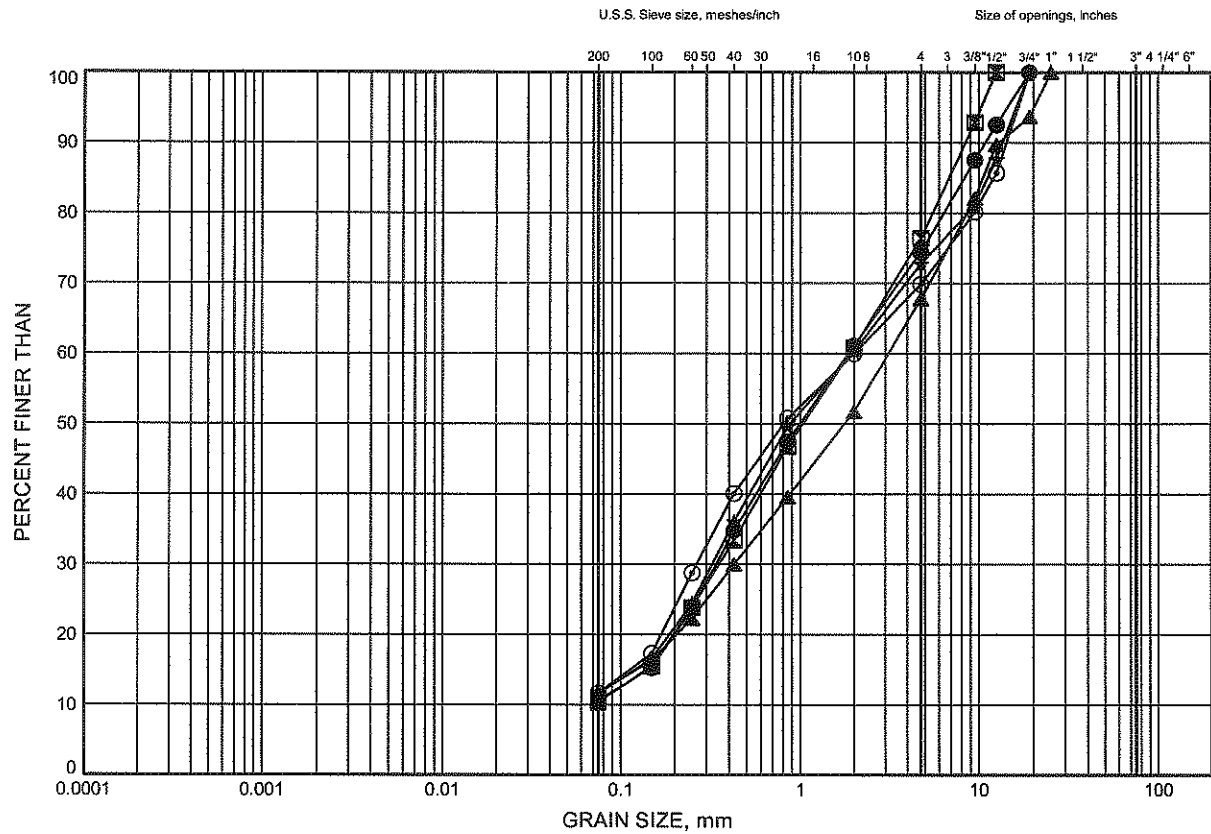
Laboratory Test Results



Hwy 11 - Temagami GRAIN SIZE DISTRIBUTION

FIGURE B1

GRAVELLY SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	07-03	1.07	313.87
■	07-06	1.07	302.42
▲	07-09	1.07	316.64
★	07-11	1.74	304.36
⊙	07-14	1.83	300.73

GRAIN SIZE DISTRIBUTION - THURBER 6110.GPJ 4/28/09

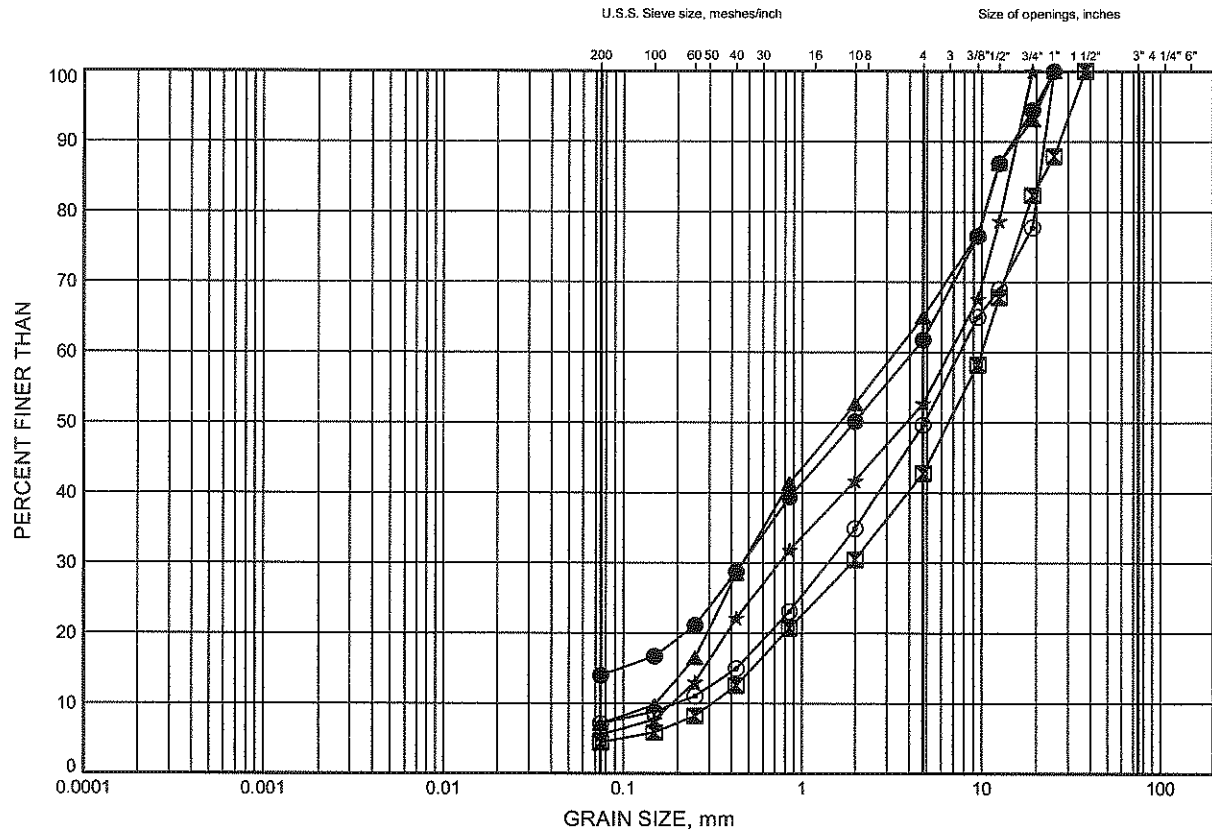
W.P.# 715-92-00
Prepared By AN
Checked By SKP



Hwy 11 - Temagami GRAIN SIZE DISTRIBUTION

FIGURE B2

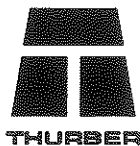
SAND AND GRAVEL FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	07-17	0.30	311.63
⊠	07-19	0.46	318.43
▲	07-22	0.46	343.21
★	07-23	0.27	338.73
⊙	07-24	1.83	340.13

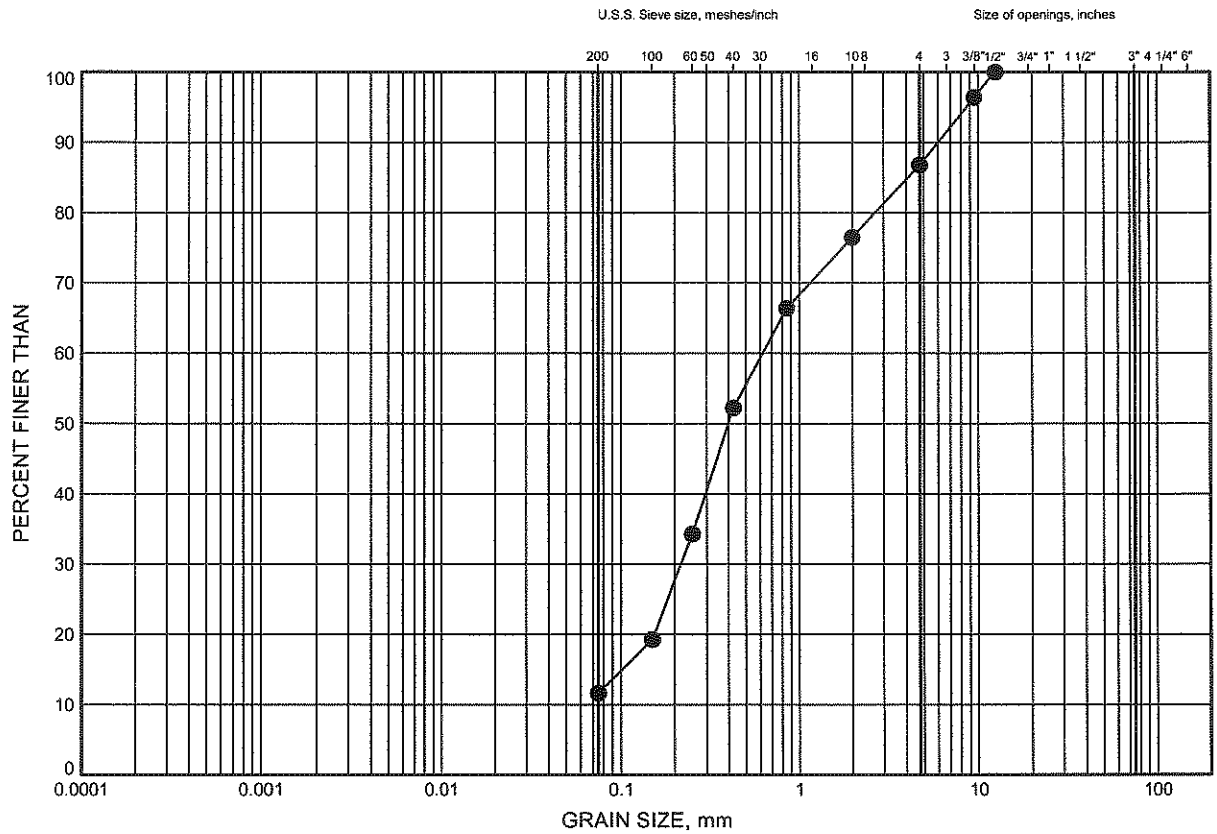


W.P.# 715-92-00
Prepared By AN
Checked By SKP

Hwy 11 - Temagami
GRAIN SIZE DISTRIBUTION

FIGURE B3

SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	07-02	1.07	313.89



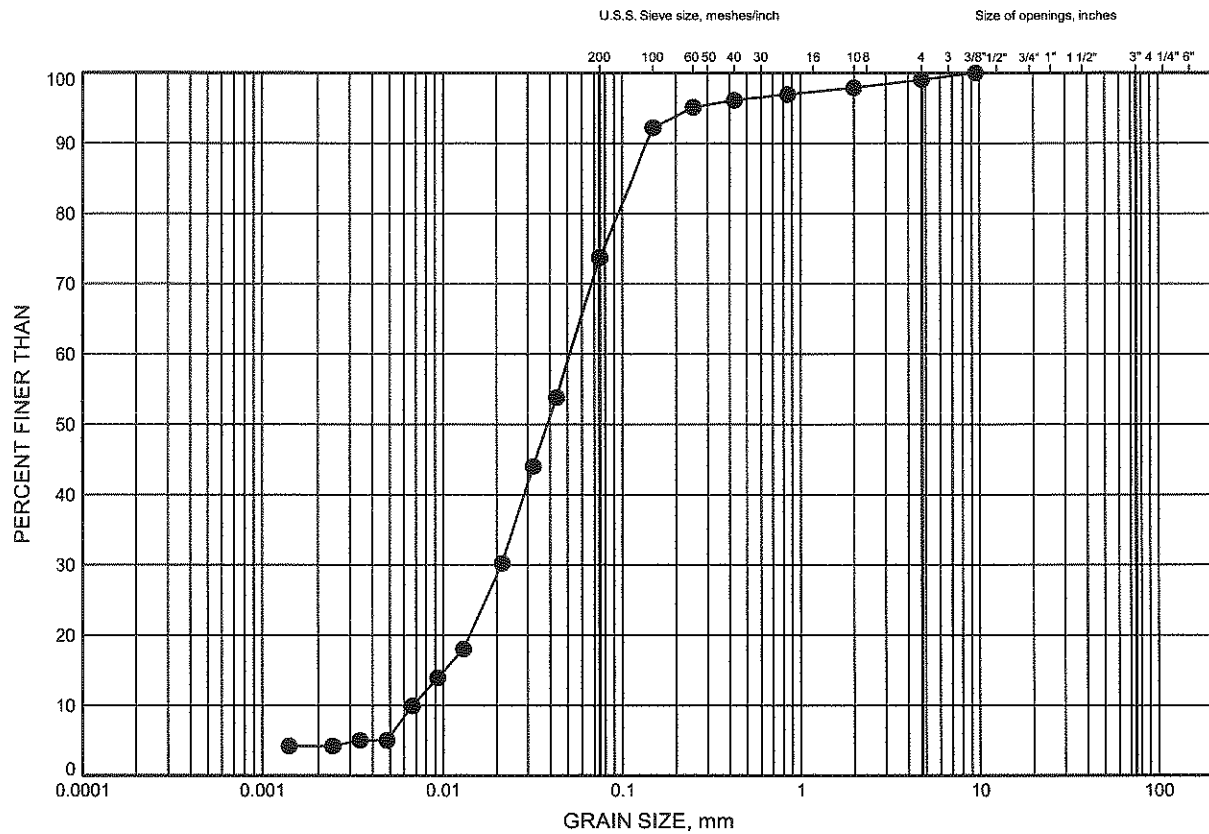
GRAIN SIZE DISTRIBUTION - THURBER 6110.GPJ 4/28/09

W.P.# 715-92-00
Prepared By AN
Checked By SKP

Hwy 11 - Temagami GRAIN SIZE DISTRIBUTION

FIGURE B4

SANDY SILT FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	07-15	2.40	306.32

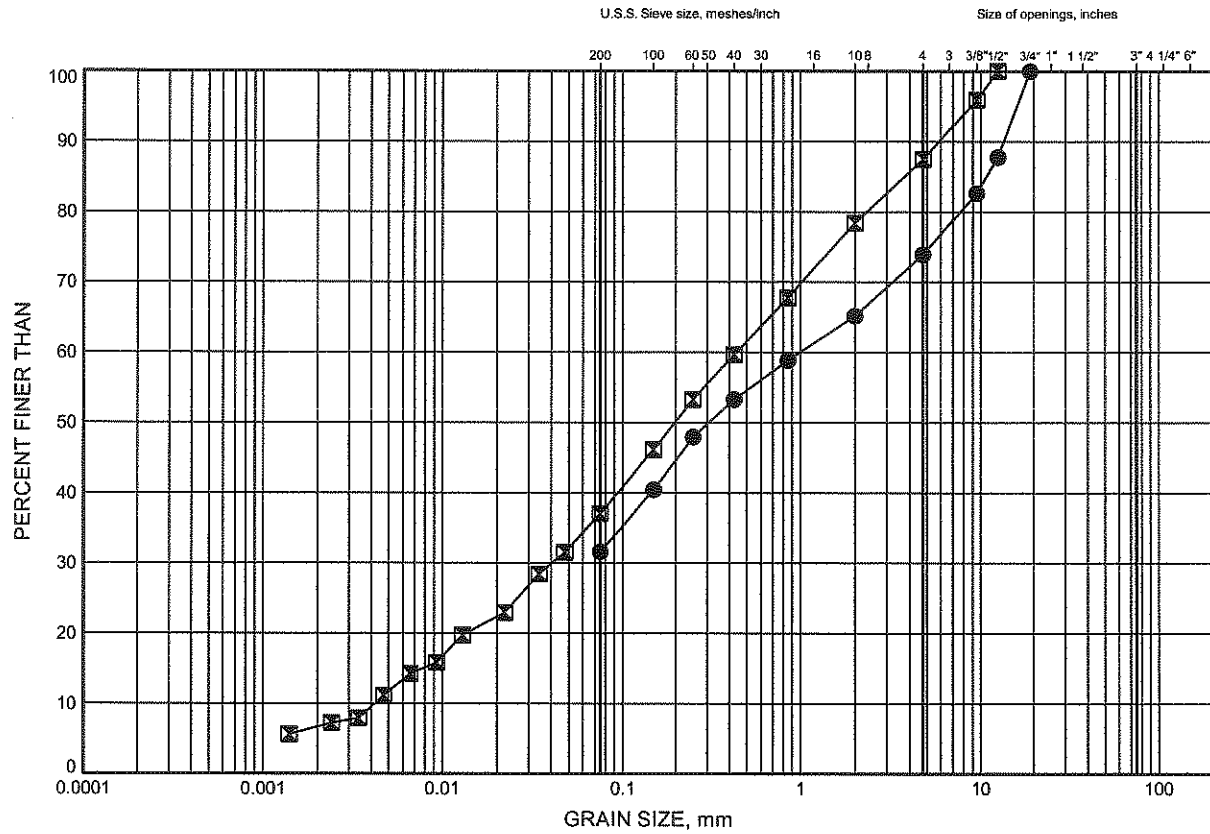


W.P.# 715-92-00
Prepared By AN
Checked By SKP

Hwy 11 - Temagami GRAIN SIZE DISTRIBUTION

FIGURE B5

SILTY SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	07-18	1.07	307.24
■	07-20	2.46	313.27

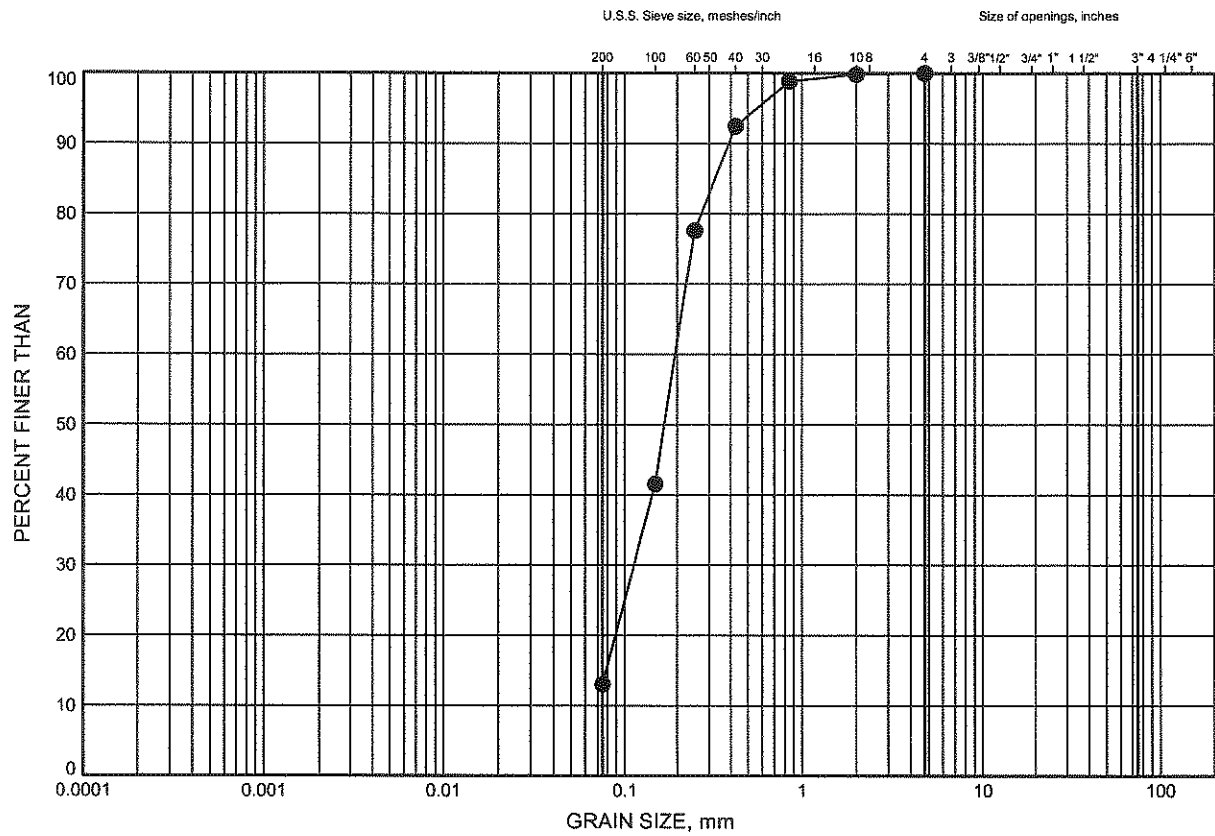


W.P.# 715-92-00
Prepared By AN
Checked By SKP

Hwy 11 - Temagami GRAIN SIZE DISTRIBUTION

FIGURE B6

SAND



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

LEGEND

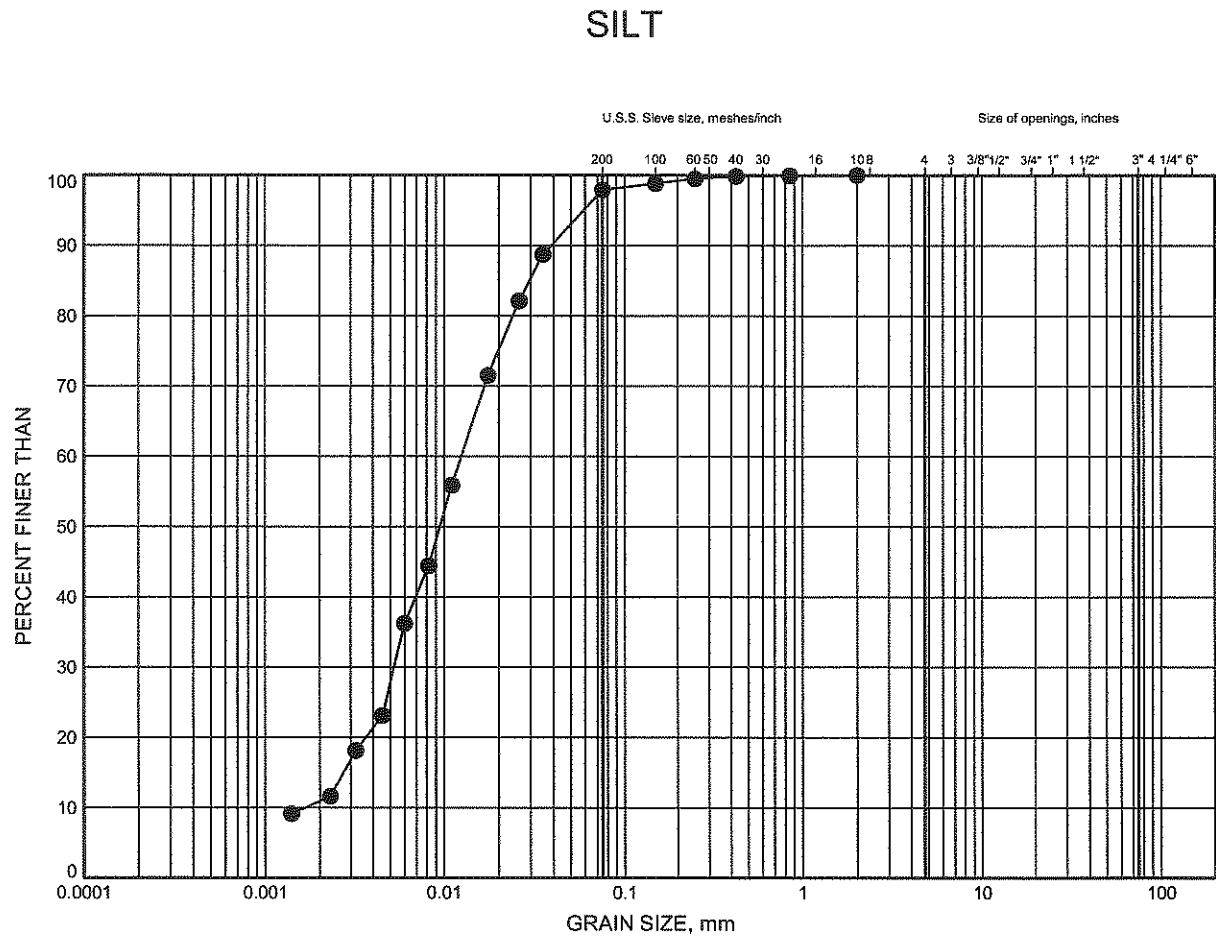
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	07-20	0.46	315.28



W.P.# 715-92-00
Prepared By AN
Checked By SKP

Hwy 11 - Temagami GRAIN SIZE DISTRIBUTION

FIGURE B7



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	07-01	4.88	306.60

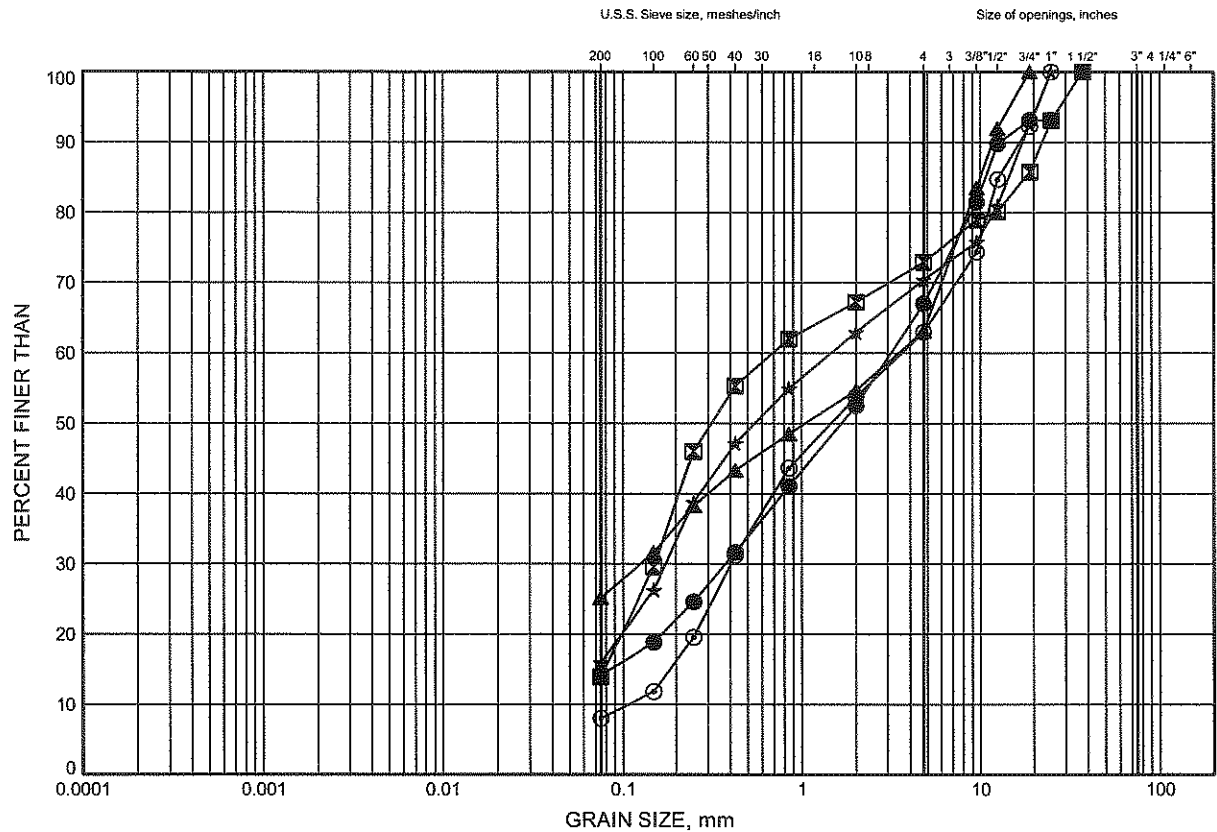


W.P.# 715-92-00
Prepared By AN
Checked By SKP

Hwy 11 - Temagami GRAIN SIZE DISTRIBUTION

FIGURE B8

GRAVELLY SAND AND SAND AND GRAVEL TILL



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

LEGEND

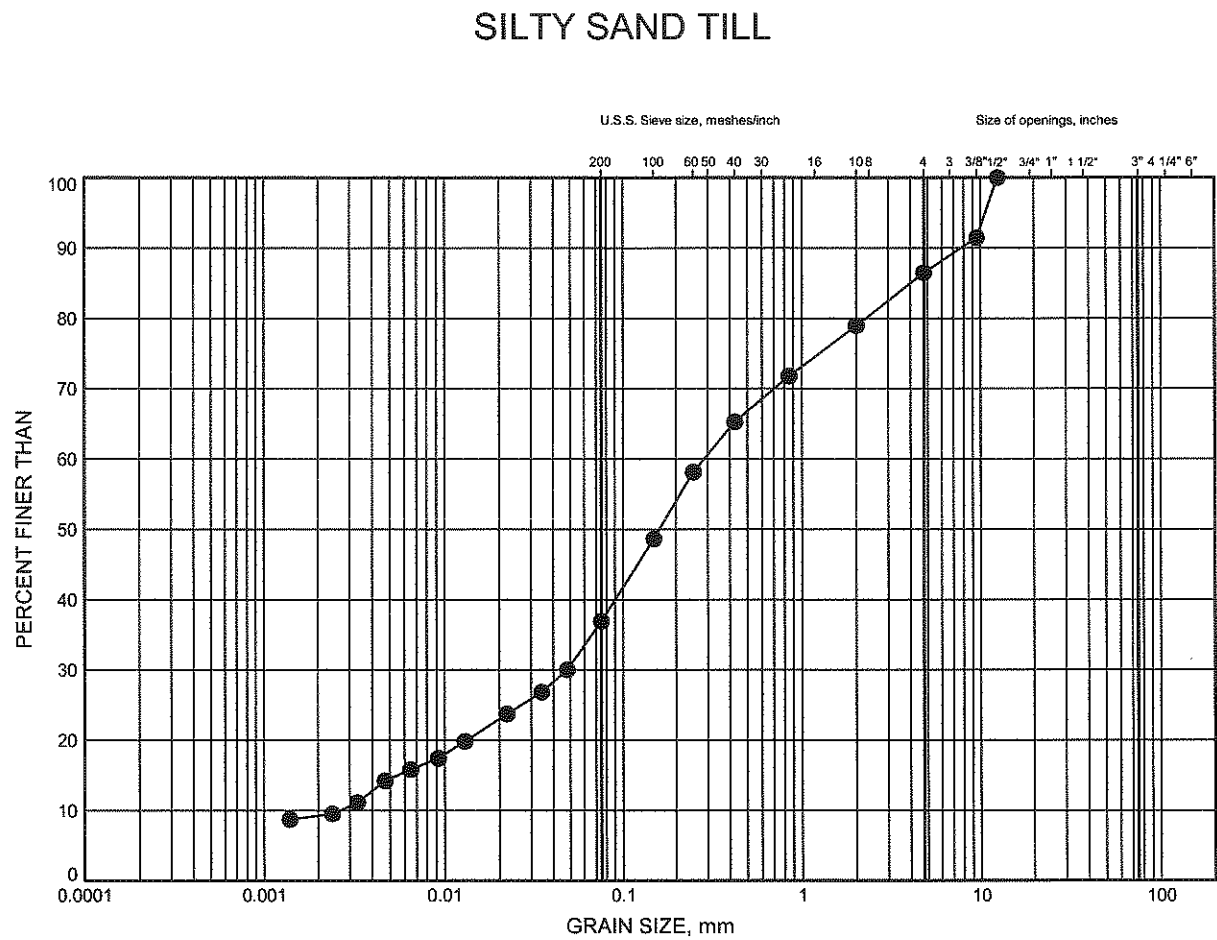
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	07-14	9.41	293.14
■	07-16	6.40	305.02
▲	07-16	9.21	302.21
★	07-18	3.35	304.95
⊙	07-21	0.90	340.61



W.P.# 715-92-00
Prepared By AN
Checked By SKP

Hwy 11 - Temagami
GRAIN SIZE DISTRIBUTION

FIGURE B9



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	07-15	4.70	304.02



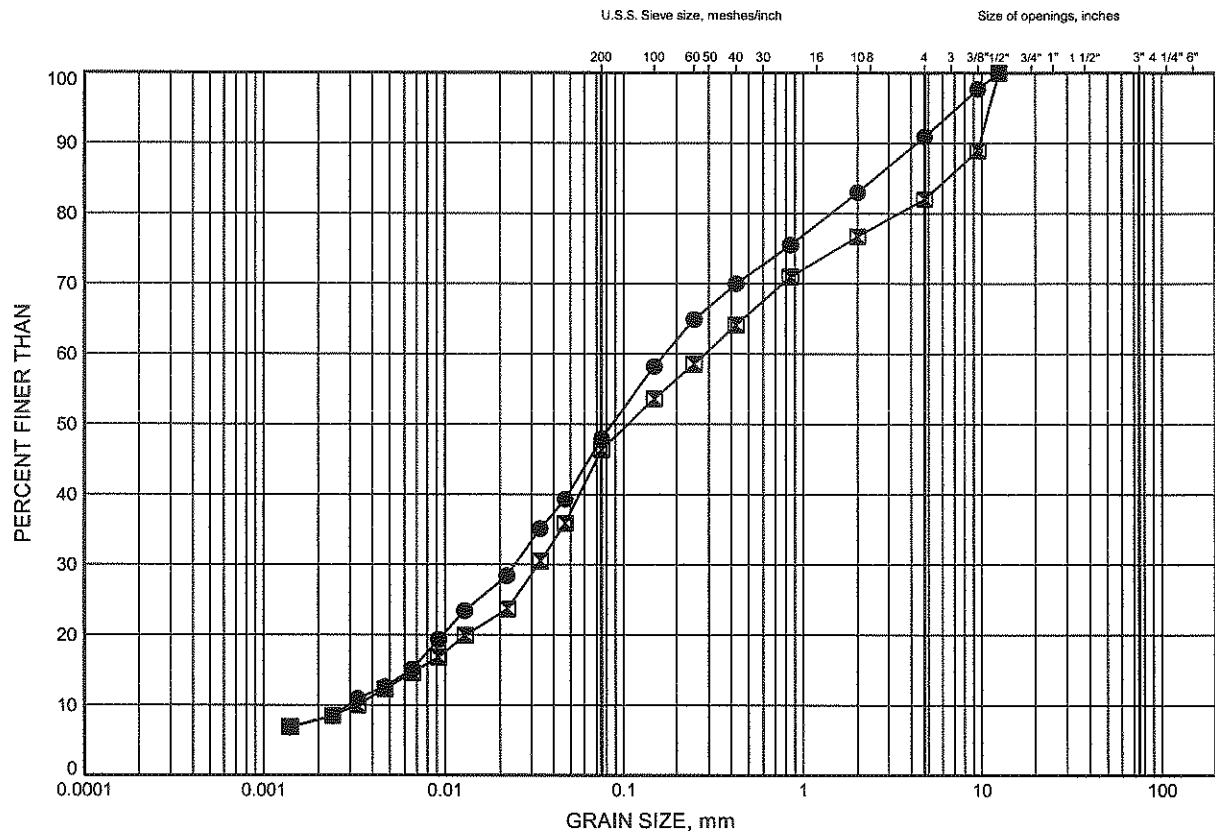
GRAIN SIZE DISTRIBUTION - THURBER 6110.GPJ 4/28/09

W.P.# 715-92-00
Prepared By AN
Checked By SKP

Hwy 11 - Temagami GRAIN SIZE DISTRIBUTION

FIGURE B10

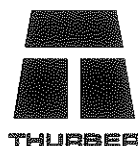
SAND AND SILT TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	07-04	2.41	308.99
◻	07-14	4.88	297.68



W.P.# 715-92-00
Prepared By AN
Checked By SKP

Appendix C

Foundation Alternatives Comparisons

19-5161-10



COMPARISON OF ALTERNATIVE CULVERT TYPES

Location	Concrete Open Footing Culvert	Concrete Rigid Box Culvert	Corrugated Steel Pipe Culvert
Extension to existing culverts	<p>Advantages:</p> <ul style="list-style-type: none"> i. Completely compatible to existing culvert types. ii. Relatively expedient installation if precast units are used. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. May require less sub-excavation than open footing culvert. ii. Relatively expedient installation if precast units are used. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. Can tolerate larger foundation settlements than concrete culverts. ii. Lower cost than concrete culverts.
	<p>Disadvantages:</p> <ul style="list-style-type: none"> i. May require deeper sub-excavation for footing construction 	<p>Disadvantages:</p> <ul style="list-style-type: none"> i. Not completely compatible to existing culvert types. ii. May require compacted granular pad on subgrade. iii. May create environmental issues such as those involving spawning fish species. 	<p>Disadvantages:</p> <ul style="list-style-type: none"> i. May only be used as temporary extensions since the main purpose of this project is to install permanent extensions compatible to existing culverts. ii. Not as durable as concrete culverts.

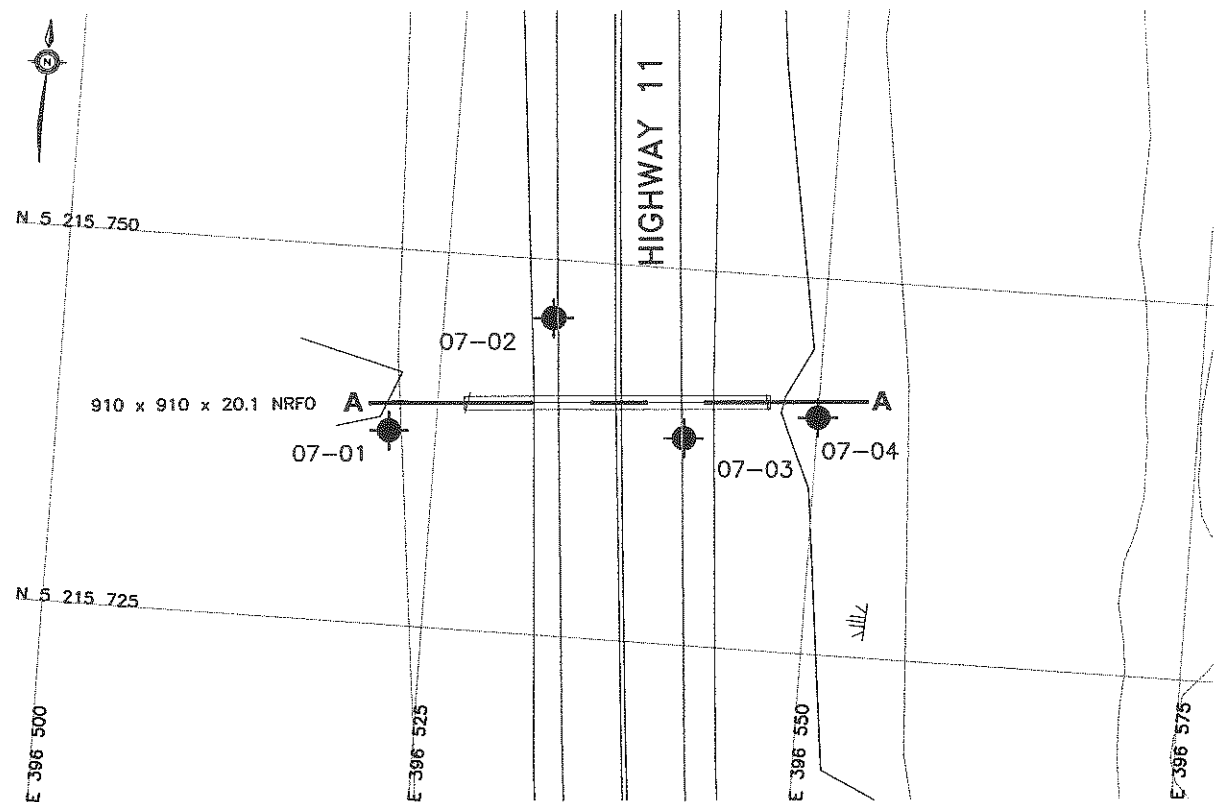


Appendix D

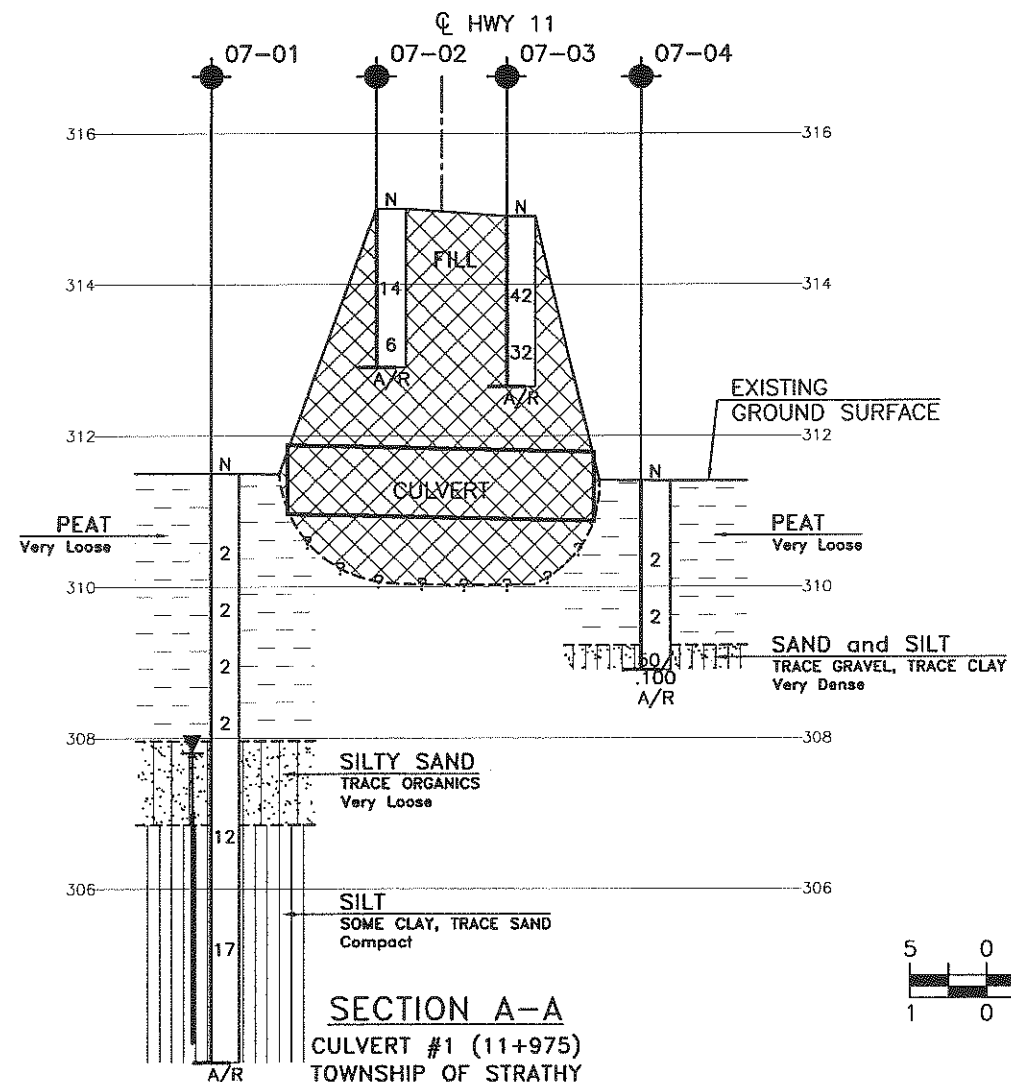
Borehole Locations and Soil Strata Drawings

19-5161-10

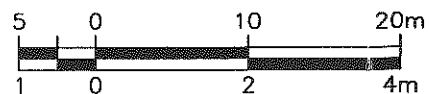




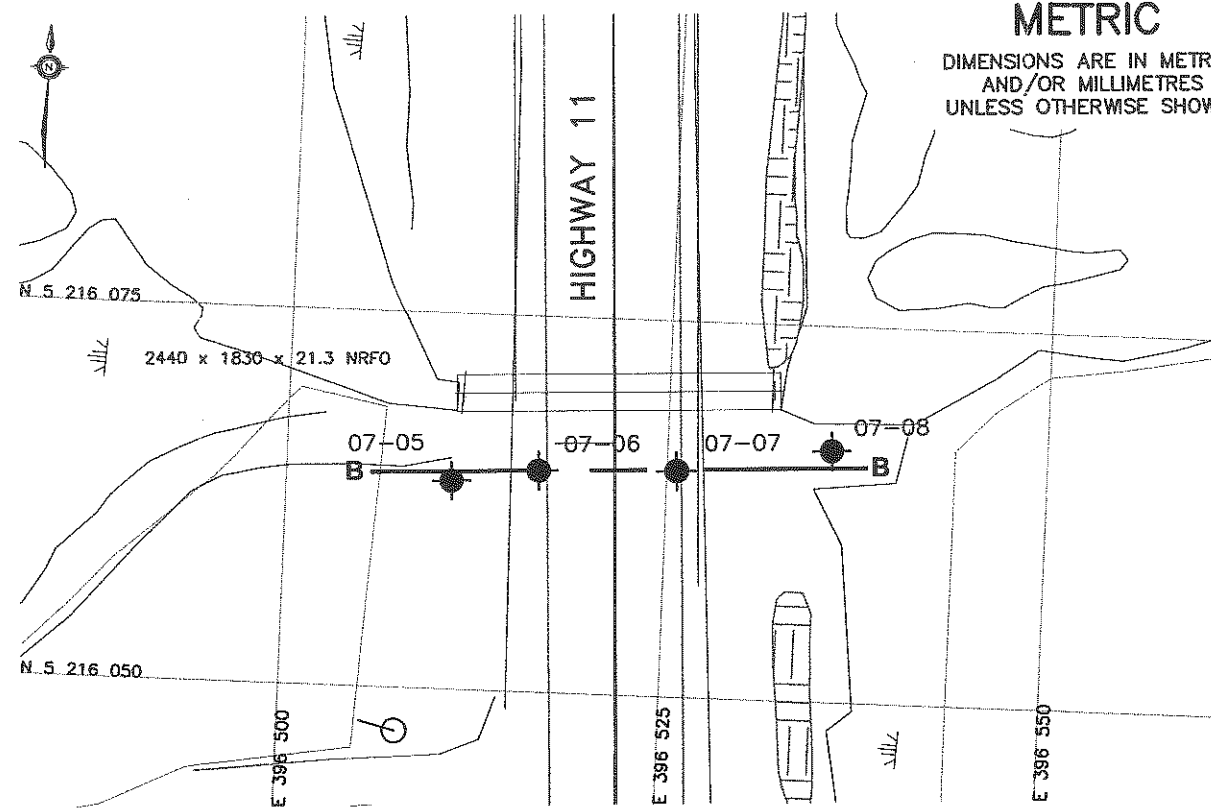
PLAN



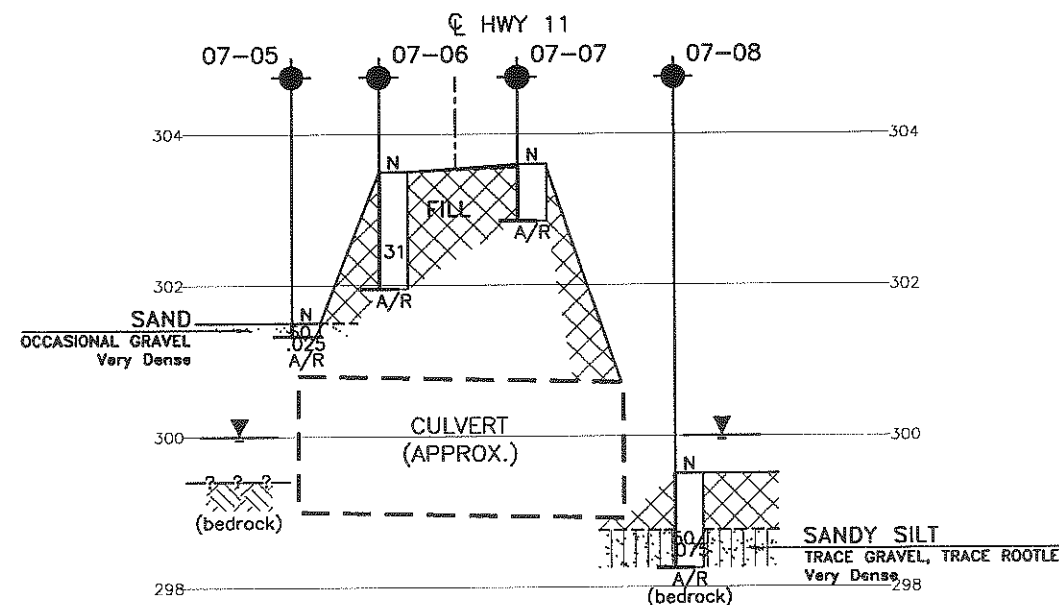
SECTION A-A
CULVERT #1 (11+975)
TOWNSHIP OF STRATHY



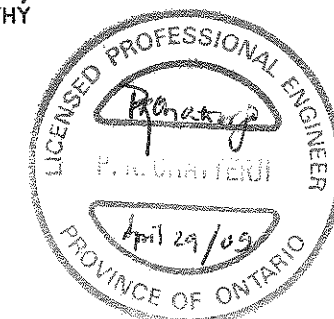
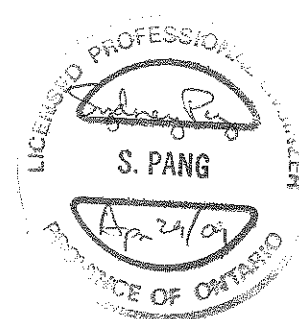
HOR
VER



PLAN



SECTION B-B
CULVERT #2 (12+305)
TOWNSHIP OF STRATHY



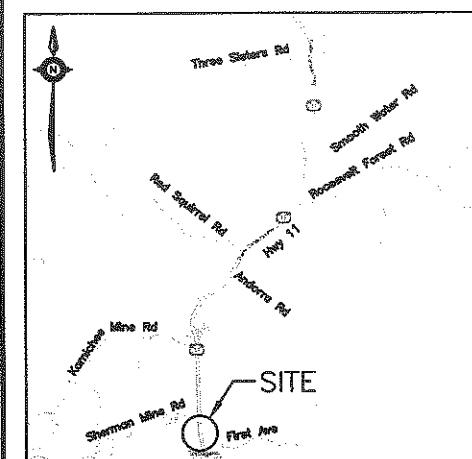
DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No 715-92-00

HWY 11 CULVERT EXTENSION
TEMAGAMI TO LATCHFORD
CULVERTS 1 & 2
BOREHOLE LOCATIONS AND SOIL STRATA



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

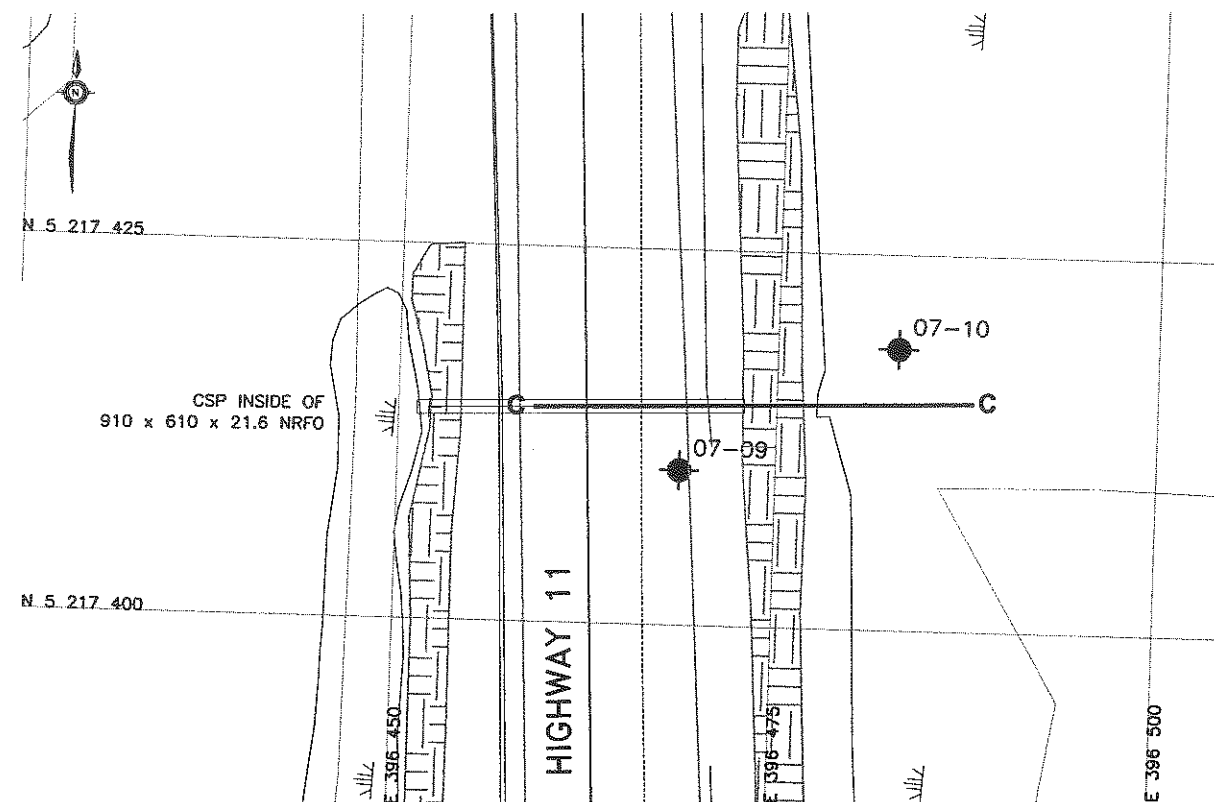
NO	ELEVATION	NORTHING	EASTING
07-01	311.5	5 215 737.9	396 521.9
07-02	315.0	5 215 746.1	396 532.1
07-03	314.9	5 215 738.7	396 541.3
07-04	311.4	5 215 740.7	396 550.0
07-05	301.5	5 216 063.8	396 510.8
07-06	303.5	5 216 064.7	396 516.6
07-07	303.6	5 216 065.0	396 525.6
07-08	299.5	5 216 066.7	396 535.8

NOTES

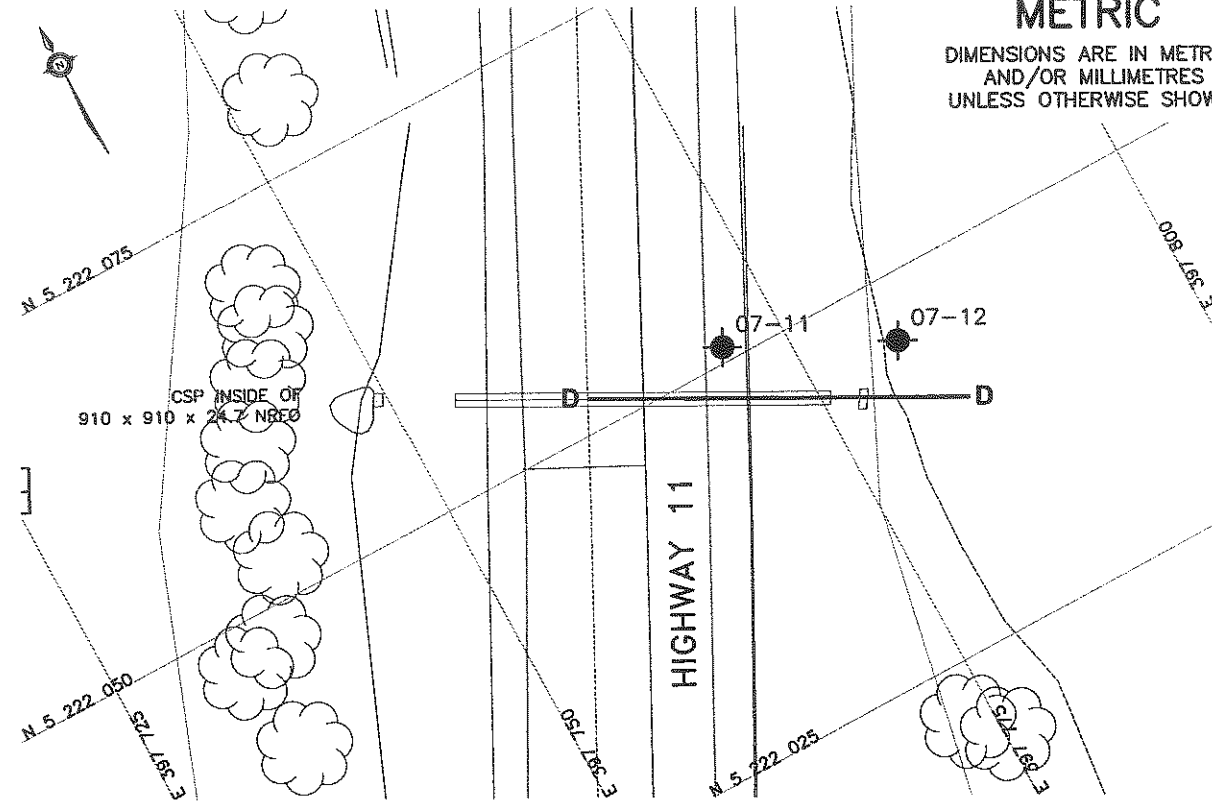
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 31M-78

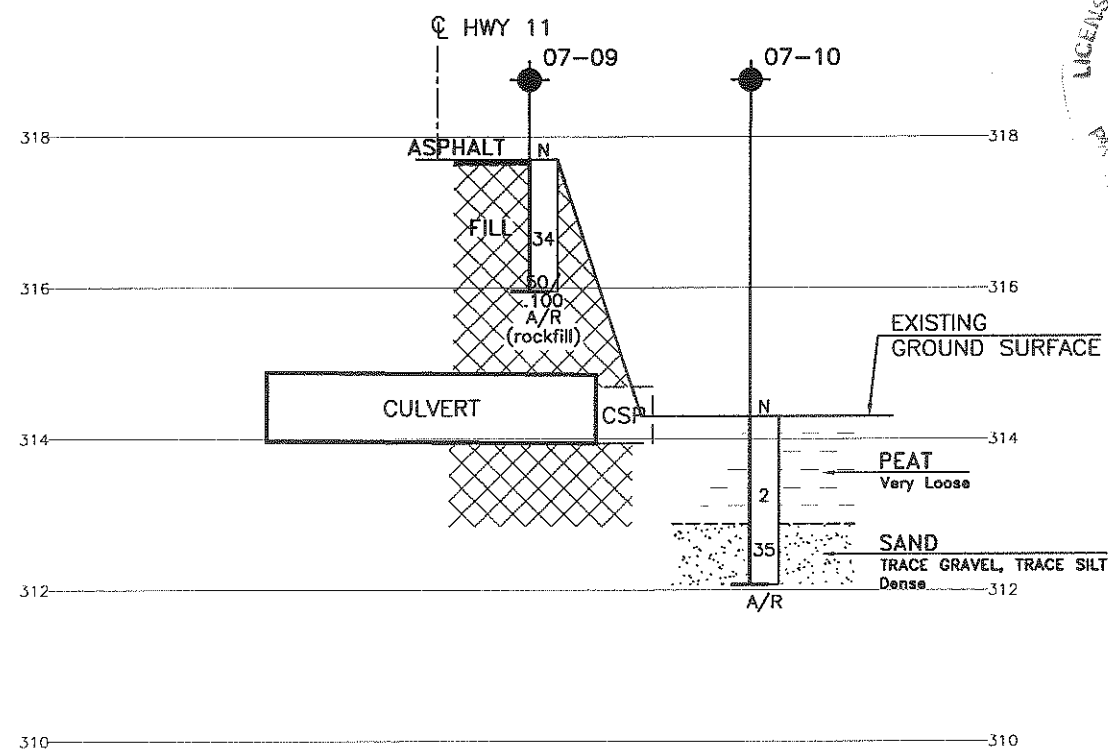
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DRAWN	MFA	CHK	SKP
CODE	LOAD	DATE	APR. 2009
STRUCT	DWG		



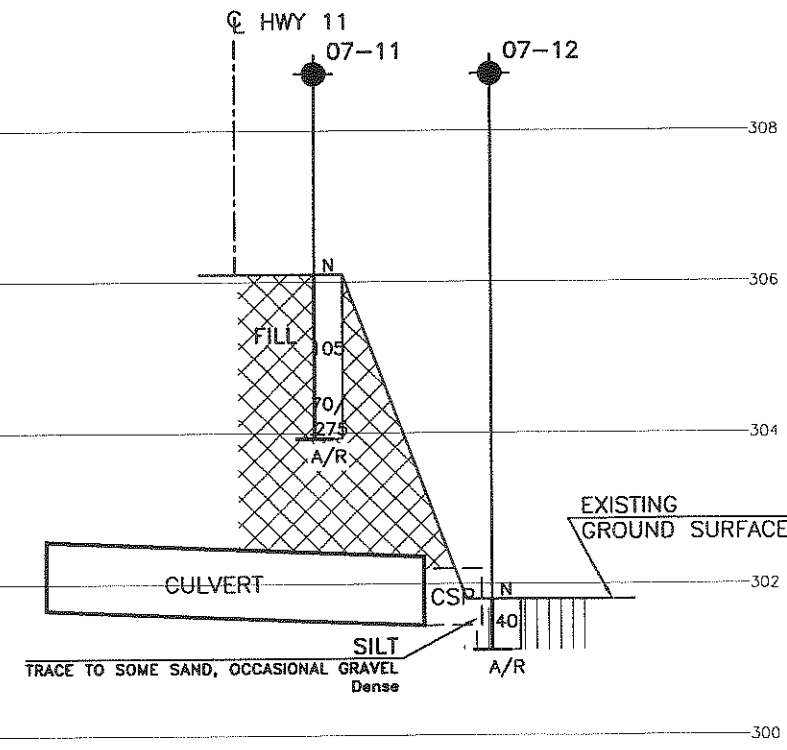
PLAN



PLAN



SECTION C-C
CULVERT #3 (13+650)
TOWNSHIP OF STRATHY



SECTION D-D
CULVERT #4 (18+957)
TOWNSHIP OF STRATHY



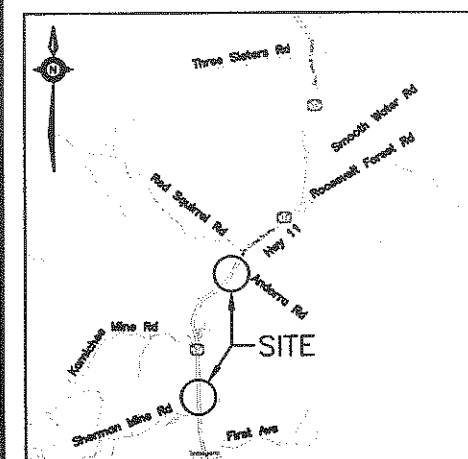
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CONT No
GWP No 715-92-00

HWY 11 CULVERT EXTENSION
TEMAGAMI TO LATCHFORD
CULVERTS 3 & 4
BOREHOLE LOCATIONS AND SOIL STRATA








SHEET



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
07-09	317.7	5 217 410.3	396 468.6
07-10	314.3	5 217 418.7	396 482.8
07-11	306.1	5 222 051.0	397 770.9
07-12	301.8	5 222 045.8	397 781.3

-NOTES-

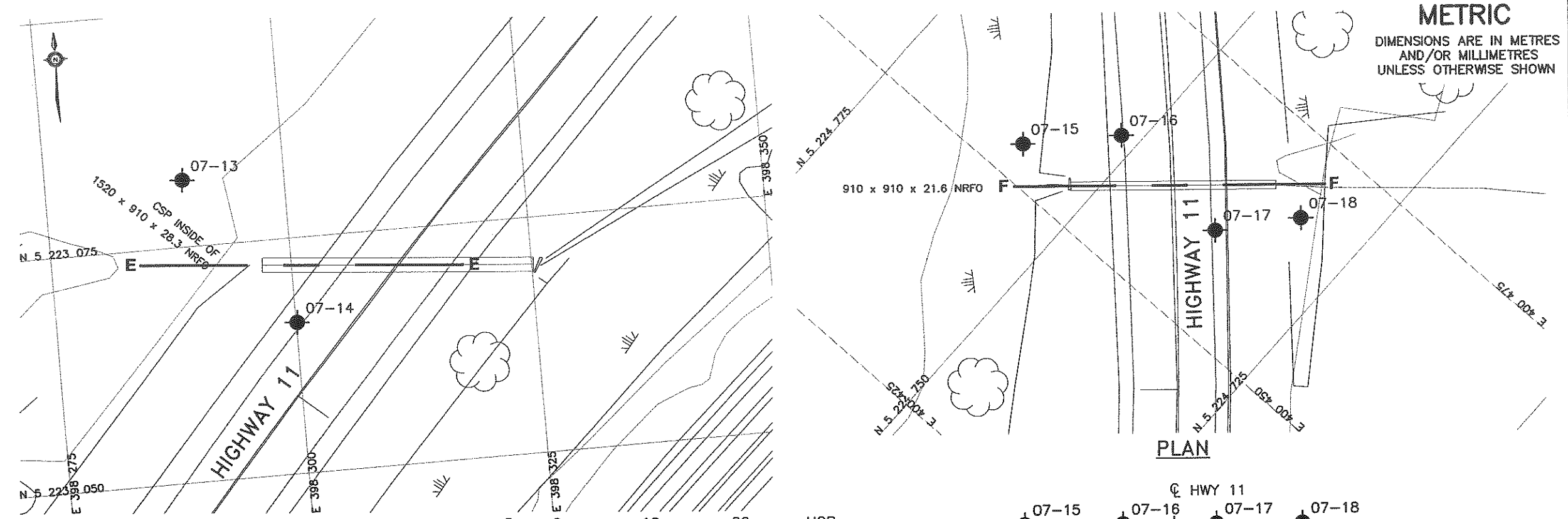
- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 31M-78

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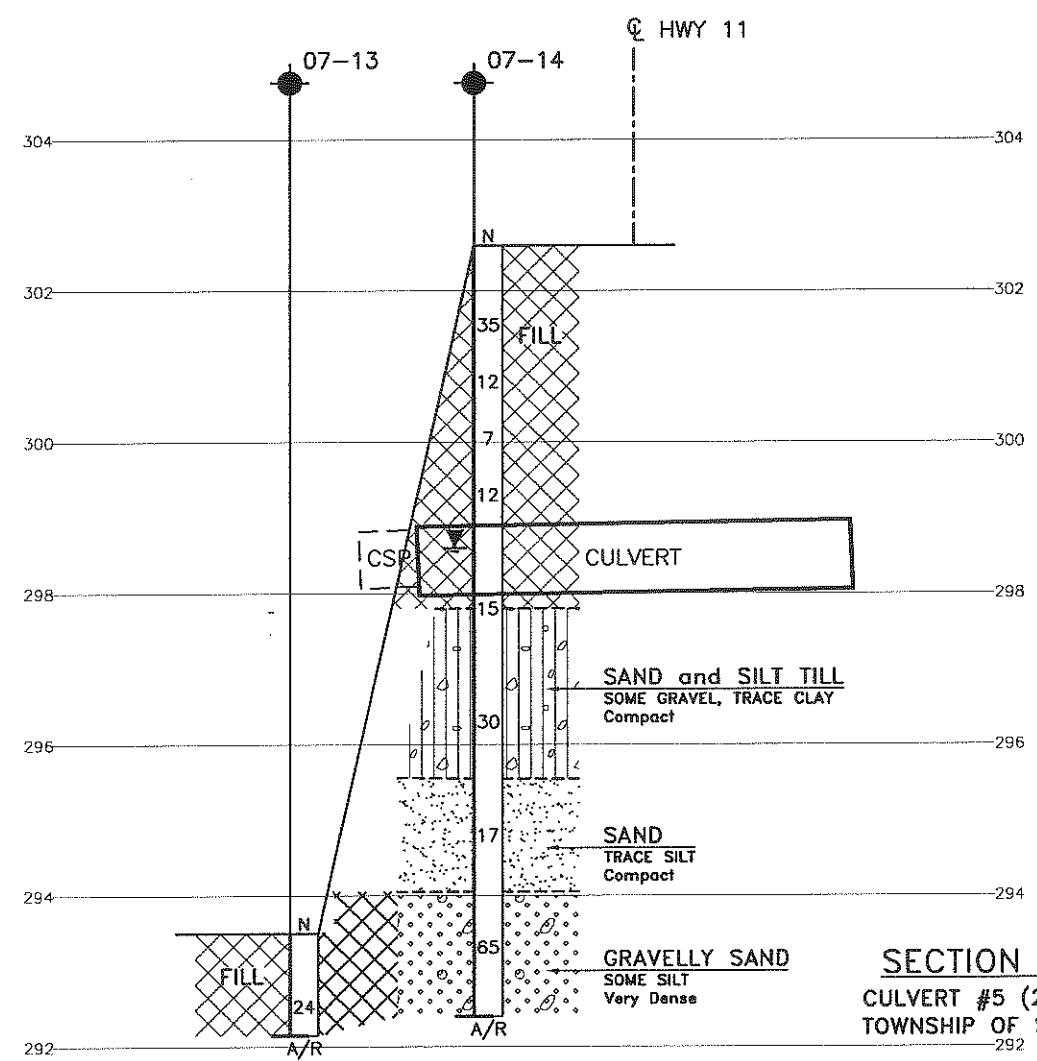
PLATE 1

MINISTRY OF TRANSPORTATION, ONTARIO
PR-0-707 BR-05
PLAN SCALE 1:1

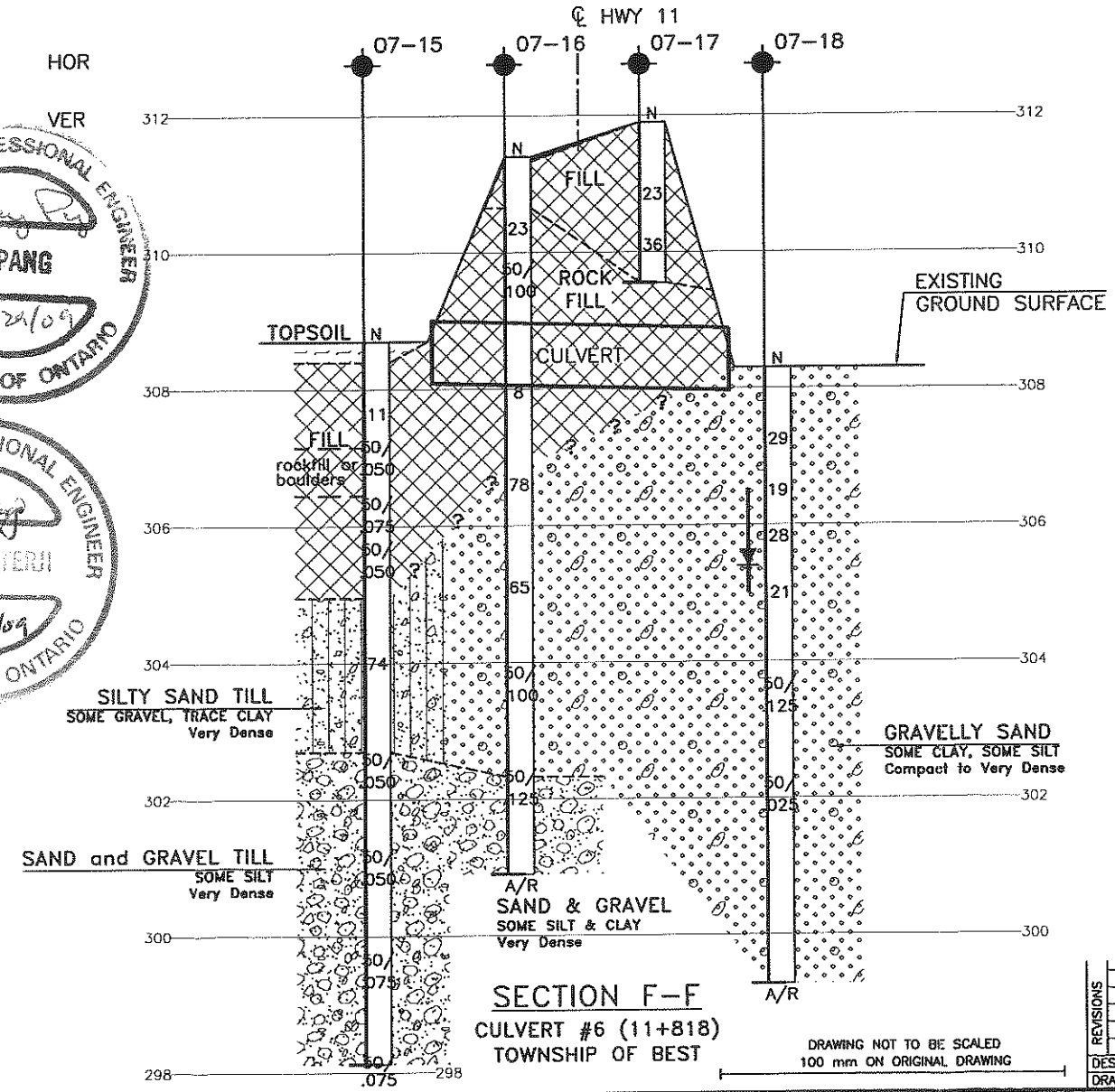


PLAN

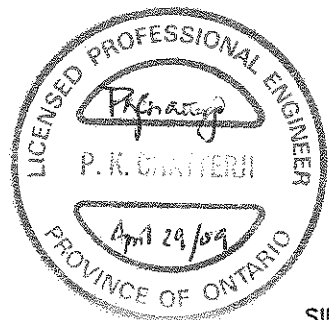
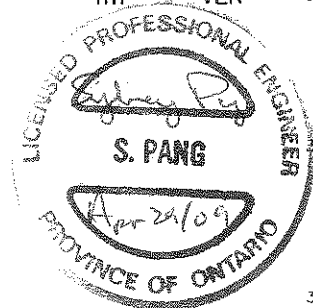
PLAN



SECTION E-E
CULVERT #5 (20+120)
TOWNSHIP OF STRATHLY



SECTION F-F
CULVERT #6 (11+818)
TOWNSHIP OF BEST



CONT No
GWP No 715-92-00

HWY 11 CULVERT EXTENSION
TEMAGAMI TO LATCHFORD
CULVERTS 5 & 6
BOREHOLE LOCATIONS AND SOIL STRATA

MMM GROUP

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
07-13	293.5	5 223 082.1	398 289.3
07-14	302.6	5 223 066.0	398 300.1
07-15	308.7	5 224 759.1	400 453.8
07-16	311.4	5 224 751.9	400 461.3
07-17	311.9	5 224 737.8	400 460.2
07-18	308.3	5 224 731.9	400 467.1

-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. 31M-78

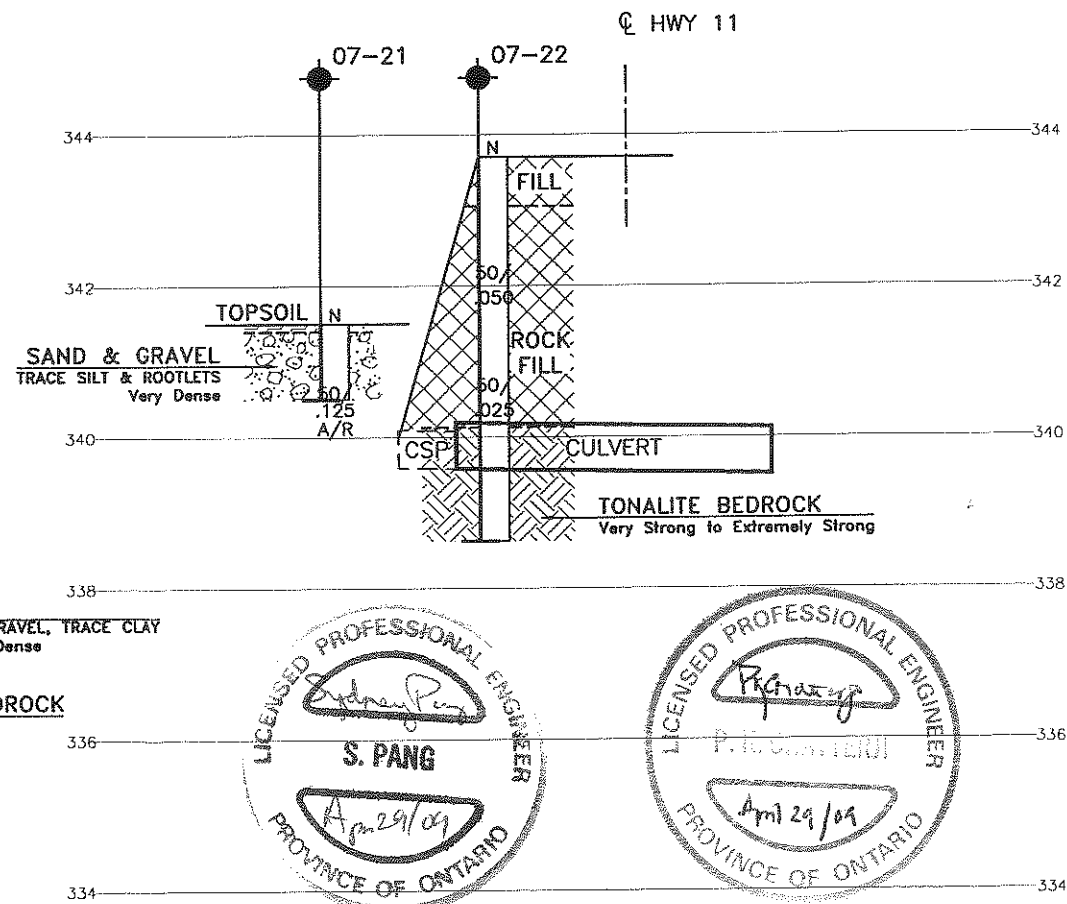
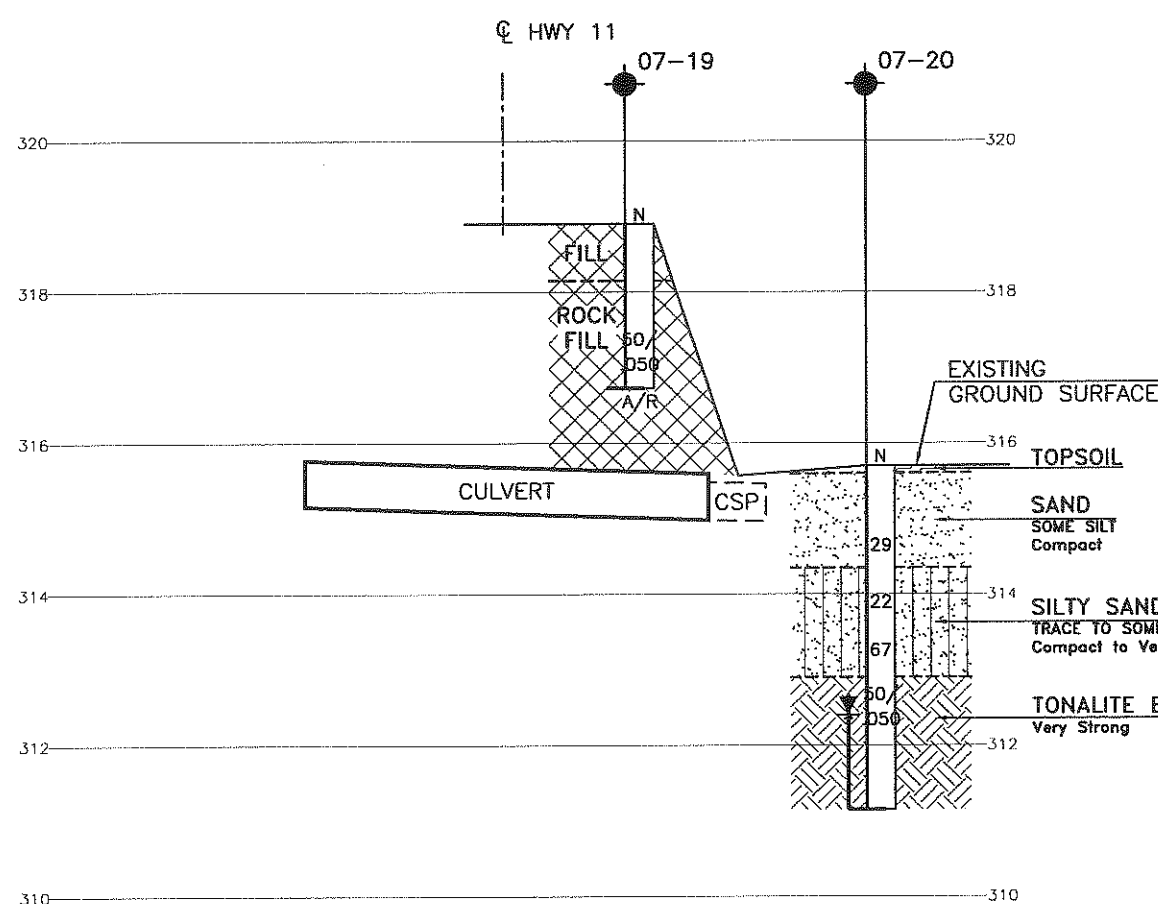
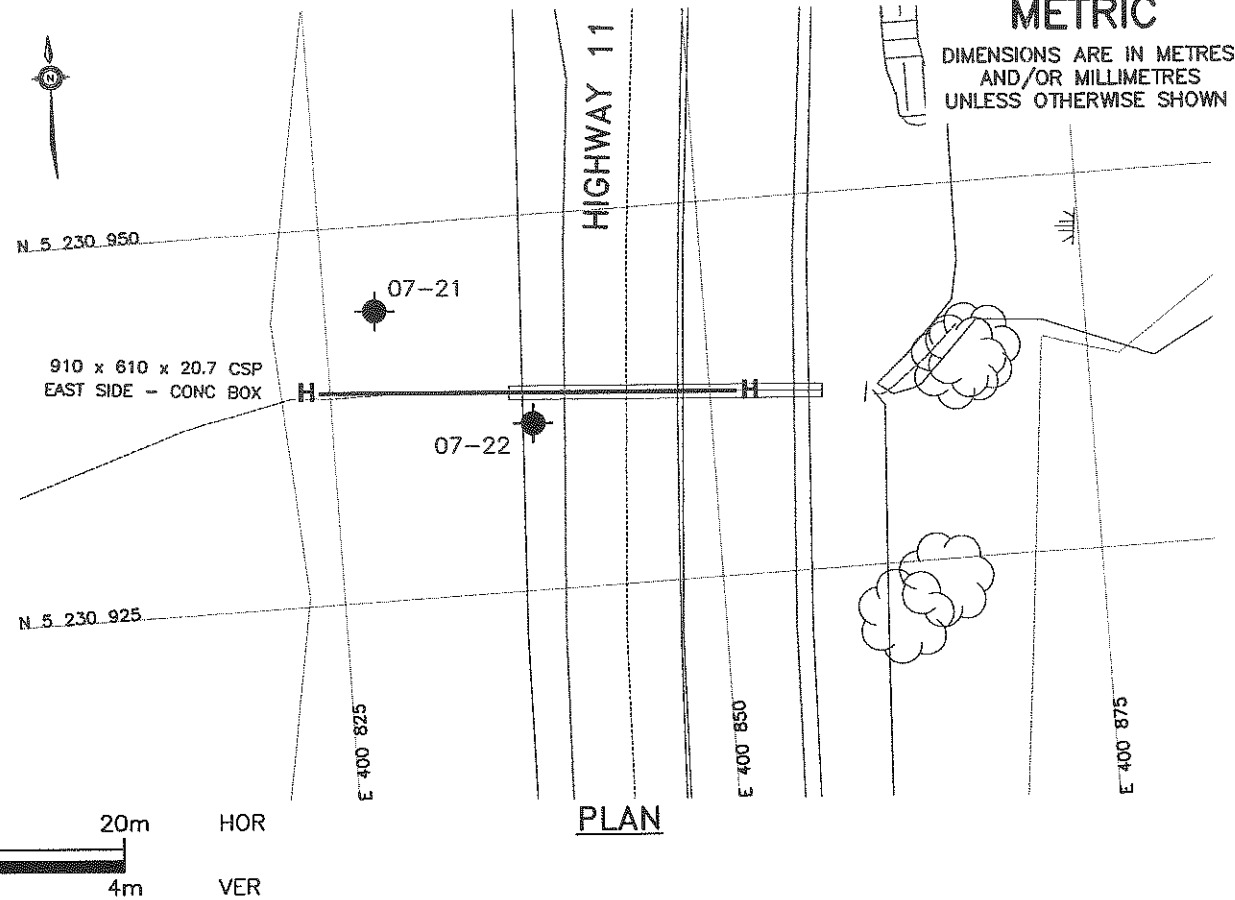
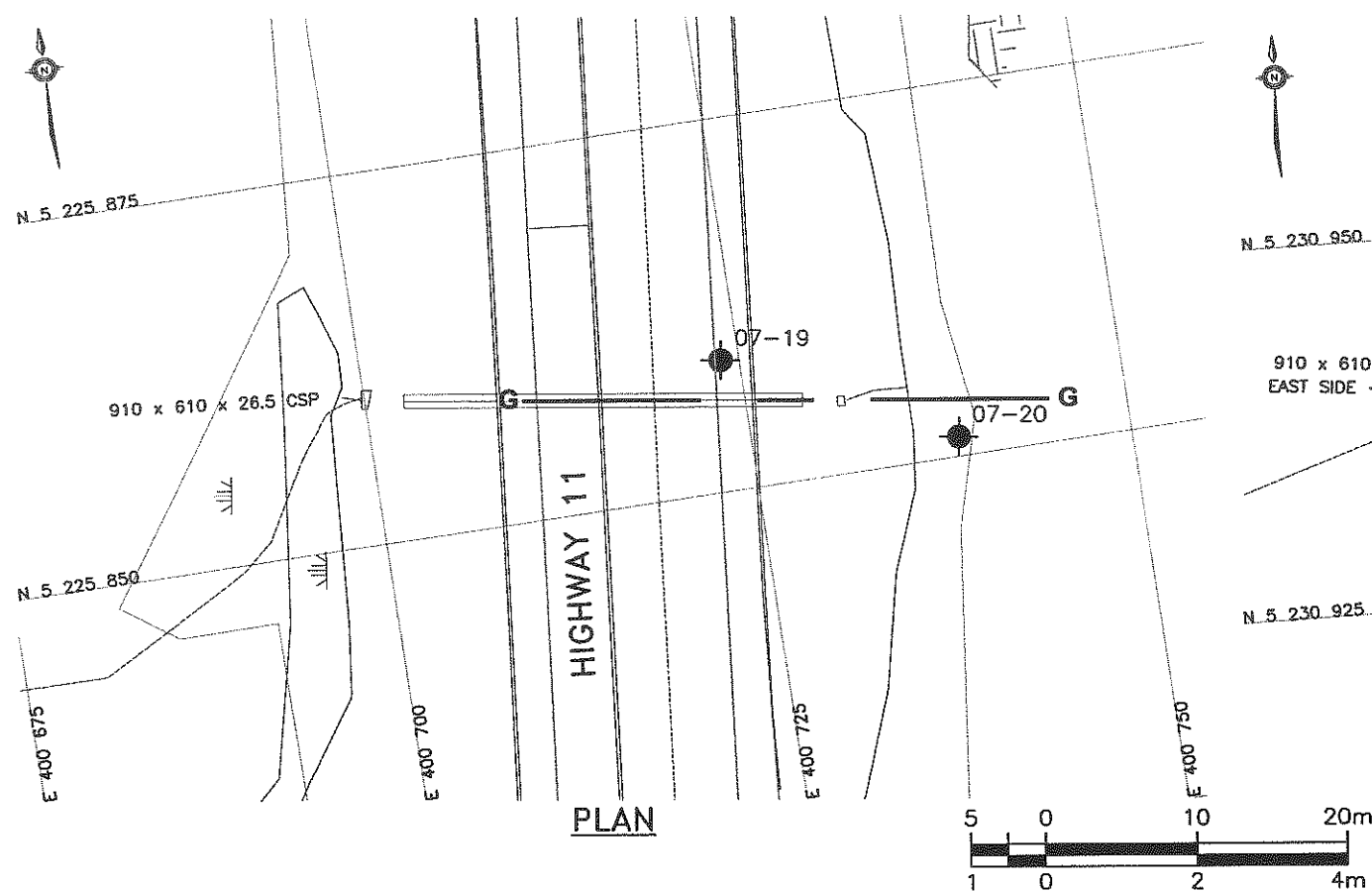
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100 mm ON ORIGINAL DRAWING

FILENAME
PL01DATE:

PLAN SCALE 1:1
SECTION SCALE 1:1
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SECTION G-G
CULVERT #7 (12+990)
TOWNSHIP OF BEST

SECTION H-H
CULVERT #8 (14+565)
TOWNSHIP OF GILLIES LIMIT

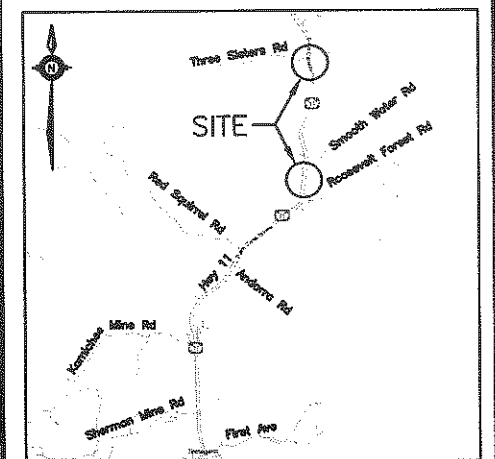
DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

CONT No
GWP No 715-92-00

HWY 11 CULVERT EXTENSION
TEMAGAMI TO LATCHFORD
CULVERTS 7 & 8
BOREHOLE LOCATIONS AND SOIL STRATA

MMM GROUP

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS



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

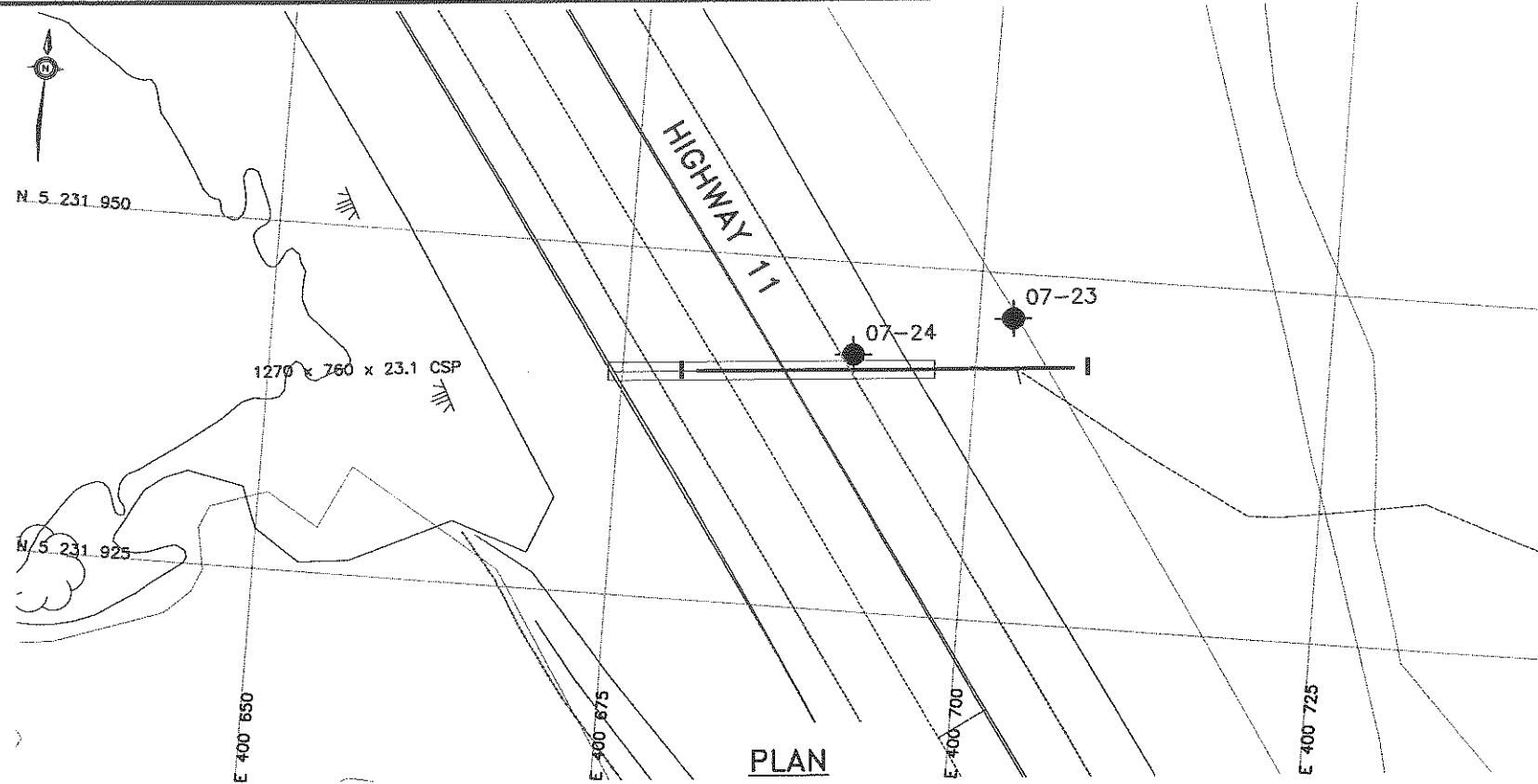
NO	ELEVATION	NORTHING	EASTING
07-19	318.9	5 225 858.8	400 723.8
07-20	315.7	5 225 851.3	400 738.6
07-21	341.5	5 230 944.3	400 828.3
07-22	343.7	5 230 936.1	400 838.2

NOTES

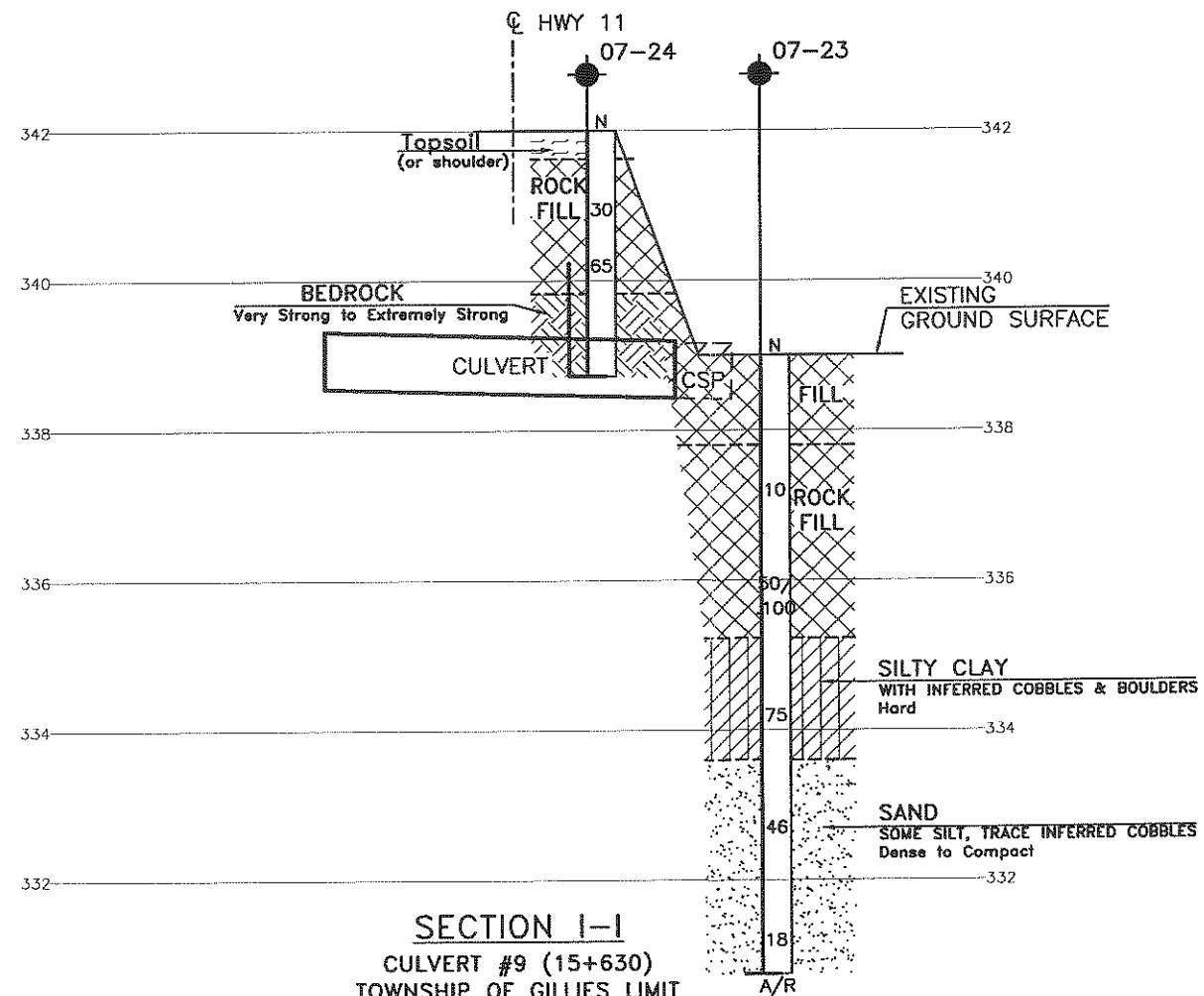
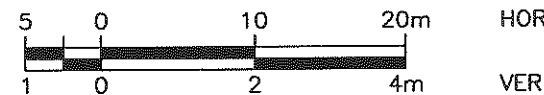
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 31M-78

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	SKP	CHK	PKC
DRAWN	MFA	CHK	SKP
DATE	APR. 2009		
STRUCT	DWG		



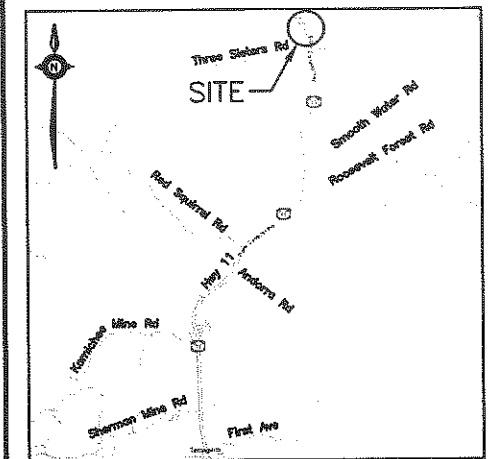
PLAN



SECTION 1-1
CULVERT #9 (15+630)
TOWNSHIP OF GILLIES LIMIT






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

CONT No GWP No 715-92-00
HWY 11 CULVERT EXTENSION TEMAGAMI TO LATCHFORD CULVERT 9 BOREHOLE LOCATIONS AND SOIL STRATA



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
07-23	339.0	5 231 946.8	400 702.4
07-24	342.0	5 231 943.4	400 691.2

-NOTES-

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

GEOCRES No. 31M-78

[illegible]

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

Appendix E

Selected Photographs of Culvert Extension Locations





Plate 1 Culvert #1 – East (Sta. 11+975 Township of Strathy)



Plate 2 Culvert #1 West (Sta. 11+975 Township of Strathy)



Plate 3 Culvert #2 – East (Sta. 12+305 Township of Strathy)



Plate 4 Culvert #2 – West (Sta. 12+305 Township of Strathy)



Plate 5 Culvert #3 – East (Sta. 13+650 Township of Strathy)



Plate 6 Culvert #5 – West (Sta. 20+120 Township of Strathy)



Plate 7 Culvert #6 – East (Sta. 11+818 Township of Best)



Plate 8 Culvert #6 – West (Sta. 11+818 Township of Best)



Plate 9 Culvert #7 – East (Sta. 12+990 Township of Best)



Plate 10 Culvert #8 – West (Sta. 14+565 Township of Gillies Limit)



Plate 11 Culvert #9 – East (Sta. 15+630 Township of Gillies Limit)