

**FOUNDATION INVESTIGATION AND DESIGN REPORT
CULVERT REPLACEMENT AT MONDOR CREEK
SITE NO. 39E-229
HIGHWAY 11
COCHRANE DISTRICT, ONTARIO
G.W.P. No. 5169-10-00**

GEOCRES Number: 42H-53

Report to

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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 twin culverts on Highway 11 over Mondor Creek, located in the Township of Lamarche, Cochrane Area, Ontario.

The foundations terms of reference indicates that there is no record of any previous foundation investigation carried out at or near the subject culvert.

The purpose of this investigation was to obtain subsurface information at the twin culvert location 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.

Thurber was retained by URS Canada Inc. (URS) to carry out this foundation investigation under the MTO Assignment Number 5012-E-0033.

2 SITE DESCRIPTION

The culvert site is located on Highway 11, 4.2 km south of Highways 579/652 in the Township of Lamarche, Cochrane District, Ontario. This culvert allows Mondor Creek to flow, from west to east, under Highway 11.

The existing structure is a twin 3.7 m span by 2.7 m high by 39 m long steel plate pipe arch (SPPA) in 5.0 m of fill. The structure was constructed in 1976. It is understood that the structure is in poor condition with deterioration of several elements.

The grade of the existing Highway 11 in the vicinity of the twin culverts ranges between approximate Elevations 263.5 and 264.0 m. The embankment fill height at the culverts is up to approximately 5 m.

The site is located within the town limits of Cochrane with residential and commercial properties nearby. Naturally low-lying, swampy areas are present near the inlet and outlet of the culvert, with vegetation consisting of tall grass and shrubs with occasional trees. Local topography is of low relief

with no visible bedrock outcrops. Areas surrounding the properties are heavily forested. The property to the southwest of the twin culverts features remnants of a motel building. The area in the immediate vicinity of the culvert is undulating and generally sloping downwards from the highway grade to the creek. Rockfill is visible in the vicinities of the culvert inlet and outlet.

Based on published geological information, the general area of the project is covered by glacio-lacustrine sediments of clays and silts laid down by the Glacial Lake Barlow-Ojibway. These deposits are mostly varved clays, but massive clays are also present in some areas. Due to the different rates of seasonal deposition during various periods of glaciation, the lower zones of the deposits display much thicker varves than in the upper zones. Below the varved clays are glacial outwash deposits of silts, sands and gravel underlain by Early Precambrian metasedimentary rocks.

3 SITE INVESTIGATION AND FIELD TESTING

This borehole investigation and field testing program was carried out between October 10 and October 31, 2013. The program consisted of drilling and sampling 11 boreholes (numbered MC13-01 to MC13-11) to depths ranging from 8.2 to 34.7 m. Of these boreholes, two were located at the culvert inlet (MC13-10 and 13-11), two were located at the culvert outlet (MC13-01 and 13-02), three were located at the embankment crest (MC13-04, 13-08 and 13-09), two were located on the road for roadway protection (MC13-05 and 13-07) and two were located further away for the detour lane on the east side (MC13-03 and 13-06).

Prior to the start of drilling, the borehole locations were marked/staked in the field and utility clearances were obtained. The co-ordinates and elevations of the as-drilled boreholes were subsequently provided by Callon Dietz obtained from the DTM, based on borehole location sketches provided by Thurber. The approximate borehole locations are shown on a Borehole Locations and Soil Strata drawing included in Appendix C.

A truck-mounted drill rig was used to drill and sample the boreholes on the highway and the shoulder, and a track-mounted drill rig was used to drill and sample the culvert inlet and outlet boreholes. In addition, a portable tripod drill rig was used to advance boreholes at locations of difficult access beyond the highway. Hollow stem augers and/or NW casing were used to advance the boreholes until the target depth was reached. Soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT). Field vane shear testing using an MTO “N” size vane were carried out in soft to firm cohesive soils. A limited number of thin walled Shelby tube (73 mm inside diameter) samples were obtained at selected locations. Below the last sample, dynamic cone penetration tests (DCPT) were conducted until refusal was reached in all but Boreholes MC13-01, 13-03 and 13-06. Groundwater conditions in the open boreholes were observed throughout the drilling operations. The details of standpipe piezometer installations and borehole completion are summarized in Table 3.1.

Table 3.1
Borehole Completion and Standpipe Piezometer Installation Details

Borehole Number	Standpipe Piezometer Installations				Completion Details
	Tip Location (Depth/Elev.)	Screen Depth (m)	Screen Elevation (m)	Filter Stratum	
MC13-01	7.5 / 251.9	4.2 to 8.2	255.2 – 251.2	Silty Clay	Bentonite holeplug to surface
MC13-02	-	None Installed			Bentonite holeplug mixed with auger cuttings to surface
MC13-03	-	None Installed			Bentonite holeplug to 0.1 m, sand and gravel to surface
MC13-04	-	None Installed			Bentonite holeplug to 1.8 m and auger cuttings to surface
MC13-05	-	None Installed			Bentonite holeplug to 1.8 m and auger cuttings to surface
MC13-06	-	None Installed			Bentonite holeplug to 1.9 m and auger cuttings to surface
MC13-07	-	None Installed			Bentonite holeplug to 0.1 m, sand and gravel to surface
MC13-08	-	None Installed			Bentonite holeplug to 0.1 m, sand and gravel to surface
MC13-09	-	None Installed			Bentonite holeplug to surface
MC13-10	-	None Installed			Bentonite holeplug mixed with auger cuttings to surface
MC13-11	5.9 / 252.8	3.9 to 6.4	254.8 – 252.3	Silty Clay	Bentonite seal to 3.3 m, auger cuttings to 0.3 m, bentonite holeplug 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, 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 moisture content determination. Selected soil samples were subjected to grain size distribution analyses (sieve and hydrometer) and plasticity testing (Atterberg Limits). Two samples were selected from the Shelby tubes for laboratory consolidation (oedometer) testing. 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. A

sample of creek water was submitted to a qualified analytical laboratory for testing against selected corrosivity parameters.

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. A stratigraphic profile and selected cross-sections for this culvert site are presented on the Borehole Locations and Soil Strata Drawings in Appendix C 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 granular fill overlying an extensive deposit of silty clay with some clayey silt to silt interlayers. The silty clay underlies a thin veneer of topsoil or is exposed at ground surface beyond the highway. Groundwater levels are generally in the order of 0.3 to 3 m below original ground surface. More detailed descriptions of the individual stratum are presented below.

5.2 Topsoil

A layer of topsoil between 25 and 75 mm in thickness was encountered at ground surface in Boreholes MC13-01, 13-02, 13-09, and 13-10 located near the culvert inlet and outlet areas. 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 at ground surface in Boreholes MC13-03, 13-04, 13-05, 13-06, 13-07, and 13-08. This fill typically consists of brown sand and gravelly sand with some inferred cobbles, organic inclusions and rootlets at shallow depths. In Borehole MC13-05, a 1.2 m thick layer of silty clay fill underlies the upper gravelly sand fill with inclusions of wood fragments (with nails). Where encountered, the embankment fill was found extending to 2.0 to 4.5 m depths (base Elevations from 262.0 to 259.3 m).

SPT N-values measured in the cohesionless fill ranged from 11 blows per 0.3 m penetration to greater than 50 blows for less than 0.3 m penetration, but mostly between 24 and 60 blows per 0.3 m penetration indicating a typically compact to very dense state. The high 'N' values may be attributed to the presence of cobbles or boulders. Measured moisture contents of the recovered fill samples ranged between 2% and 30%, with most values ranging from 5% to 15%. Grain size analyses conducted on samples of the gravelly sand fill are presented on Figures B1 and B2 in Appendix B. These results are summarized in the following tables.

Soil Particles	%
<u>Gravelly Sand Fill</u>	
Gravel	22 to 36
Sand	53 to 65
Silt and Clay	6 to 13

5.4 Silty Clay

Silty clay was encountered in all eleven boreholes drilled at the site. This grey soil typically contained trace to some sand and trace gravel. Boreholes MC13-01, 13-02, 13-03, 13-04, 13-06, 13-08, 13-09, 13-10, and 13-11 terminated within the silty clay at depths of 7.0 to 23.5 m (base Elevations 255.2 to 240.0 m). Where the silty clay was fully penetrated in Boreholes MC13-05 and 13-07, the base of the silty clay was encountered at depths of 22.6 to 23.3 m (base Elevations 241.2 to 240.5 m).

The weathered crust of the silty clay deposit is approximately 1.5 to 4 m thick (base elevations between 254.5 and 260.3 m). It has a relatively stiff consistency and typically brown in colour. Within the crust, the SPT N-values typically ranged between 3 and 39 blows per 0.3 m penetration, with most values lying between 4 and 14 blows. In conjunction with measured field vane shear strengths ranging from 48 to greater than 98 kPa, the silty clay crust was found to have a typically stiff to firm consistency with occasional hard zones. Below the crust, the silty clay becomes grey with measured N-values ranging between 0 and 6 blows per 0.3 m penetration. In conjunction with measured field vane shear strengths ranging from 10 to 67 kPa, the lower portion of the silty clay was found to have a typically stiff to firm consistency with some very soft and occasional stiff zones.

Two laboratory consolidation (oedometer) tests were carried out on undisturbed specimens prepared from Shelby tube samples obtained in Boreholes MC13-04 and MC13-08. Inferred parameters from the tests are summarized in the following table.

Borehole and Sample Number	Existing Overburden Pressure, p'_o (kPa)	Pre-consolidation Pressure, p'_c (kPa)	Compression Index, C_c	Recompression Index, C_r	Initial Void Ratio, e_0	Over-consolidation Ratio, OCR
MC 13-04 TW1	150	150	0.28	0.030	0.67	1.0
MC 13-08 TW1	125	140	0.27	0.038	0.89	1.1

The coefficient of consolidation, C_v , value is estimated to be in the order of $0.0035 \text{ cm}^2/\text{s}$, or about $11 \text{ m}^2/\text{yr}$, within the range of stresses anticipated to be acting on the foundation soils.

The parameters obtained from these tests are considered representative of the lightly over-consolidated to normally consolidated portion of the silty clay deposit just below the weathered crust.

A specific gravity value of 2.75 and 2.73 were measured for the tested specimens from MC13-04 and 13-08, respectively. These values correspond to a unit weight of approximately 19 kN/m^3 .

Detailed results of these oedometer tests are included in Appendix B.

The measured water contents of samples recovered from these soils typically ranged from 20% to 60%. Occasional values of greater than 60% at shallow depths are attributed to the organic contents in the soil. Grain size analyses conducted on samples of the silty clay are presented on Figures B3 to B7, and Atterberg Limits test results are presented in Figures B10 to B12 in Appendix B. The results are summarized in the following tables.

Soil Particles	%
<u>Silty Clay</u>	
Gravel	0 to 12
Sand	0 to 16
Silt	18 – 75
Clay	16 - 73
Soil Property	%
Liquid Limit	34 to 62
Plasticity Index	16 to 38

The results of the Atterberg Limits tests indicate that the silty clay is typically of intermediate plasticity (CI) with occasional high plasticity (CH) zones.

5.5 Clayey Silt to Silt

Layers of clayey silt and silt were encountered beneath the silty clay in Boreholes MC13-05 and 13-07. These soils were grey in colour and contained trace clay and sand.

Both boreholes terminated within the clayey silt to silt at depths of 25.0 m (base Elevation 238.8 m). SPT N-values measured within the clayey silt varied between 10 and 12 blows per 0.3 m penetration indicating a stiff consistency. An N-value of 13 blows was measured within the silt indicating a compact state.

Measured water contents of samples recovered from these soils ranged from 18% to 35%. Grain size analyses conducted on samples of each of these soils are presented on Figures B8 and B9 in Appendix B. The results are summarized in the following table.

Soil Particles	%
<u>Clayey Silt</u>	
Gravel	0
Sand	0
Silt	87
Clay	13
<u>Silt</u>	
Gravel	0
Sand	0
Silt	90
Clay	10

Below the sampled depth of each of Boreholes MC13-02, 13-04, 13-05, 13-07, 13-08, 13-09, 13-10 and 13-11, a DCPT was carried out to practical refusal (100 blows per 0.3 m) at depths of 18.6 to 34.7 m (Elevations 240.1 to 229.1 m).

5.6 Groundwater Conditions

Free water was observed in most of the boreholes upon completion of drilling. Standpipe piezometers were installed in Boreholes MC13-01 and MC13-11 to permit longer term monitoring. Water levels observed in the open boreholes and those measured in the two installed standpipes are presented below.

Borehole	Date of Reading	Water Level Depth (m)	Water Level Elevation (m)
MC13-01	Nov. 1, 2013	0.3	259.1
	Nov. 7, 2013	0.3	259.1
MC13-02	Oct. 14, 2013	Dry	-
MC13-03	Oct. 30, 2013	0.2 m	263.5
MC13-04	Oct.15, 2013	11.0 m	252.8
MC13-05	Oct.10, 2013	10.0 m	253.8
MC13-06	Oct.11, 2013	5.6 m	258.4
MC13-07	Oct.28, 2013	2.8 m	261.0
MC13-08	Oct.31, 2013	0.2 m	263.6
MC13-09	Oct.12, 2013	-	-

MC13-10	Oct.12, 2013	Borehole caved to 0.6 m	
MC13-11	Nov.1, 2013	3.5	255.2
	Nov.7, 2013	3.4	255.3

Where surface water is present, the groundwater level should be assumed to coincide with the local surface or creek water level. Based on the observations and measurements above, the groundwater level adjacent to the creek is at approximate Elevation 259 m. The groundwater levels are expected to vary seasonally and are subject to severe weather events such as rainstorms.

6 MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. Callon Dietz provided the northing and easting coordinates and ground surface elevations using their local DTM based on borehole location sketches provided by Thurber.

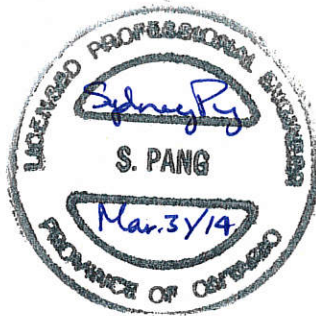
Downing Drilling of Hawkesbury, Ontario supplied and operated a truck-mounted drill rig, a track-mounted CME 55 drill rig, and a tri-pod rig to carry out the drilling, sampling and in-situ testing operations.

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

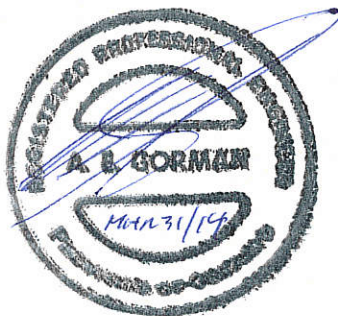
A sample of creek water was submitted to AGAT Laboratories in Mississauga, Ontario for testing against selected corrosivity parameters.

Overall project management was provided by Mr. Alastair Gorman, P.Eng. Direction of the field and laboratory program was provided by Dr. Sydney Pang, P.Eng. Interpretation of the field data and preparation of this report was completed by Ms. Katrina Young and Dr. Pang. The report was reviewed by Mr. Gorman and 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 provides foundation recommendations for the design of the replacement of the existing twin culverts at Mondor Creek on Highway 11, located 4.2 km south of Highways 579/652.

Based on the terms of reference, the existing structure is twin 3.7 m span by 2.7 m high by 39 m long Steel Plate Pipe Arch (SPPA) culverts. These twin culverts were constructed in 1976. It is understood that the structure is in poor condition with deterioration of several elements. The embankment at this location is up to 5 m in height.

The discussions and recommendations presented in this report are based on information provided by URS and on the factual data obtained during the course of this investigation.

An archived drawing shows the general topography of the subject area prior to construction of the culvert and the highway. A selected photograph of the culvert area is included in Appendix F for reference.

8 CULVERT FOUNDATIONS

8.1 General

Preliminary information from URS indicates that current project requirements involve replacement of the existing twin culverts with twin concrete box culverts along the same alignments. It is understood that embankment widening will be required on the east side to accommodate temporary traffic detour during construction. Physical dimensions of the proposed culverts obtained from a preliminary General Arrangement (GA) drawing and other design information provided by URS are presented in the following Table 8.1. Boreholes drilled at the culvert site are also identified in this table for reference.

Table 8.1 Physical Data of Proposed Replacement Culverts

Culvert #	Borehole Numbers	Approx. Invert Elevations (m)		Length (m)	Width (m)	Height (m)
		Inlet	Outlet			
C08	MC13-10 and 13-11 near inlet	257.4	257.0	≈ 39	3.68	3.2
	MC13-09 at toe of slope near inlet					
	MC13-04 and 13-08 through embankment adjacent to existing culvert					
	MC13-05 and 13-07 through embankment further south and north, respectively, of existing culvert					
	MC13-01 and 13-02 near outlet					
	MC13-03 and 13-06 some 100 m to the north and south, respectively, of the existing culvert					

Note: All dimensions are preliminary and subject to changes

8.2 Foundation Alternatives

This section presents discussions on available types of replacement culverts and foundation alternatives, and provides recommendations on a feasible and/or preferred foundation option.

Several common culvert types that may be considered for this site are listed as follows:

- Concrete box (closed) culvert
- Concrete, open footing, culvert
- Circular pipes (concrete, steel, HDPE)

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

The existing twin culverts are Steel Plate Pipe Arches (SPPA). Given the subsurface conditions and anticipated construction sequencing, we consider the box culvert to be the preferred replacement option from a foundation engineering standpoint. Precast sections can be installed rapidly with less potential for disturbance of the founding soils during installation. It is understood that the box culvert option with precast sections has been adopted by URS based on structural, hydraulic, foundation and constructability amongst other considerations. Design drawings show that precast twin concrete box culverts are to be used as replacements at this site. Based on this selection, recommendations on other feasible options are not further developed.

Concrete, open footing, culverts are not considered suitable as the shallow subgrade soils are incapable of providing the geotechnical resistances required to support strip footings of reasonable width. From a foundation engineering standpoint, concrete, steel and HDPE pipes

are also technically feasible alternatives, provided that other design issues including flow capacity, hydraulic properties and durability can also be satisfied.

The report herein focuses on providing foundation recommendations on the design and construction of box culverts and the associated wingwalls.

8.3 Foundation Design for Box Culverts

It is understood that the inverts of the replacement culverts are approximately the same as those of the existing culverts. Foundation design aspects for the replacement culverts include subgrade conditions, geotechnical resistances for the wingwalls, settlement of founding soils, lateral earth pressures, erosion control, protection system design and groundwater control, staged excavation, and stability of widening detour embankment.

8.3.1 Concrete Box Culverts

Since the replacement culverts will be constructed on the same alignments as the existing culverts, it is anticipated that the subgrade soils within the culvert footprints will not be subjected to any significant additional loading.

In order to provide a more uniform foundation subgrade condition, a 300 mm thick layer of bedding material conforming to OPSS 1010 Granular A requirements should be provided under the base of the box culverts as per OPSD 803.010. The bedding material should be placed on the approved subgrade as soon as practicable for protecting the subgrade from disturbance during construction following its inspection and approval. Construction equipment must not be allowed to travel on the bedding or the prepared subgrade.

Information from URS indicates that the underside of the Granular A pad is to be founded on firm silty clay. The founding elevation is at an approximate Elevation 256.5 m. The recommended geotechnical resistances for these founding elevations, under the existing culvert footprints, are as follows:

- Factored Geotechnical Resistance at ULS of 150 kPa
- Geotechnical Resistance at SLS (less than 25 mm settlement) of 100 kPa.

It is noted that the above values are associated with long term conditions where the subgrade soils have been pre-consolidated.

Resistance to lateral forces / sliding resistance between the concrete slab and the underlying Granular A should be calculated assuming an ultimate coefficient of friction of 0.4.

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.

Foundation design for any wingwalls associated with the box culverts are discussed in the following sub-section 8.3.2.

8.3.2 Retaining Walls

Retaining walls are required at all four quadrants of the new twin culverts. Consideration may be given to using Retained Soil Systems (RSS) walls or cantilevered concrete walls.

Borehole information indicates that the founding condition at the wall locations generally consist of the silty clay deposit with a stiff weathered crust at shallow depths grading into a firm consistency.

8.3.2.1 RSS Walls

The soil conditions encountered on site are generally suitable for the support of RSS walls. RSS walls should be specified as “Medium Performance” and “High Appearance”. The contract drawings should include information on the longitudinal alignment of the wall in plan, the top and base elevations of the wall in profile, cross-sectional space constraints and an NSSP for the RSS wall.

The performance of a RSS is dependent on, among other factors, the characteristics of its foundation. Failure to provide an adequate foundation may lead to settlement and distortion of the RSS and, in severe cases, to possible failure of the system. The foundation of the entire RSS mass must be considered, i.e. from the face of the wall to the furthest extent of the reinforcement.

To provide an acceptable foundation performance, the RSS mass should be founded as high as possible on the stiffer weathered crust of the silty clay. The highest recommended base level for the underside of the walls is at Elevation 256.5 m. An RSS wall founded at this level may be designed using a factored geotechnical resistance at ULS of 120 kPa and a geotechnical resistance at SLS of 90 kPa. The RSS may be founded on engineered fill resting on the silty clay subgrade. Engineered fill pads placed under the RSS mass must consist of OPSS Granular “A” compacted to 100% of its SPMDD at a moisture content within 2% of optimum. The engineered pad must be at least 500 mm beyond the limits of the RSS mass and levelling strip.

The geotechnical resistances provided above are for concentric, vertical loading. The effects of load inclination and eccentricity need to be taken into account according to the CHBDC (2010) Clauses 6.7.3 and 6.7.4.

The entire block of reinforced earth must be designed against various modes of failure including sliding and overturning. Sliding resistance along the base of the wall may be estimated using an ultimate friction coefficient of 0.55 for an engineered granular fill subgrade and 0.4 for a silty clay subgrade.

Topsoil, loose fill, and any soft/wet material must be stripped from the footprint of the RSS. The subgrade under the RSS foundation should be inspected and any soft spots sub-excavated and replaced with compacted granular materials prior to placing fill.

The proprietary RSS system must meet the Ministry's specifications for performance and appearance. The RSS supplier/designer may specify more stringent criteria or other requirements related to the particular design. The internal stability of the RSS wall should be analyzed by the supplier/designer of the proprietary product selected for this site.

Global stability of the RSS walls will be analyzed by Thurber once the detailed configurations of the walls are known. Preliminary analyses based on the schematic geometric configuration shown on the GA drawing indicate that RSS walls with an average retained height of 3.5 m are expected to satisfy global stability requirements.

8.3.2.2 Foundation Slabs

From a foundation standpoint, the retaining walls may be supported on foundation slabs founded on the stiff to firm silty clay. For a founding elevation of Elevation 256.5 m or lower, the recommended geotechnical resistances recommended above for the RSS walls may be used for design. Load inclination and eccentricity should also be taken into account as outlined above.

Resistance to lateral forces / sliding resistance between precast concrete and the underlying undisturbed, firm native silty clay should be evaluated in accordance with the CHBDC (2010) assuming an ultimate coefficient of friction of 0.35.

8.3.3 Settlements

It is understood that there is no grade raise at this site. The existing twin cell SPPA culverts are to be replaced with twin concrete box culvert along the same alignments. The opening sizes of the two culverts are approximately equal. Taking into consideration the proposed conceptual construction sequencing for this site, it is anticipated that rebound of the subgrade after removal of the existing culvert and the surrounding fill will be negligible. Due to the slightly heavier weight of the concrete box compared to the arch, the firm silty clay subgrade soils would be subjected to additional load resulting in some post construction consolidation settlements. The estimated post construction settlement is in the order of 5 to 10 mm within 10 years. Should the top of pavement profile need to be maintained at the culvert location, consideration may be given to resurfacing of the pavement at some point within five years after completion of construction.

8.3.4 Subgrade Preparation

After the excavation reaches the design founding elevation, any remaining fill, topsoil, creekbed deposits, disturbed soils and any deleterious materials within the culvert replacement footprint must be sub-excavated to undisturbed native firm silty clay at or below the desired

founding elevations. The exposed surface must be inspected to confirm that the subgrade is suitable and uniformly competent. Any soft areas should be sub-excavated and replaced with well compacted granular fill consisting of compacted OPSS 1010 Granular A or B Type II material. Mass concrete of the same grade as the footing concrete may be used as an alternative to compacted granular backfill below the design underside of the bedding.

This work must be carried out in accordance with OPSS 902 and construction must be carried out in the dry.

8.4 Construction Considerations

Staged open cutting will be employed to construct the replacement culverts at Mondor Creek. The highway embankment will be widened to the east in order to maintain one lane of traffic during culvert replacement.

Construction sequencing proposed by URS is shown on staging plans. The main features outlined in these plans are as follows:

- One lane of traffic will be maintained at all times during construction
- Cofferdams are required to be installed at the inlet and outlet areas as part of the creek flow and surface water diversions; creek flow will be maintained in at least one culvert at all times; pumping from sumps will be required
- Roadway protection will be required during all stages of construction
- Excavation and removal of the existing culvert, installation of the new culvert and backfilling will be carried out within the protection systems
- All works to be carried out in the dry.

Protection systems (temporary shoring) such as the use of interlocking steel sheetpiles will be required. Foundation recommendations for design of such a system are provided in a subsequent section of this report. Sump pumping will be required at all the sites to maintain reasonably dry excavations. Unwatering methods such as temporary diversion of creek and surface water using sandbag and/or sheetpile cofferdam may be required.

9 CULVERT BACKFILL AND LATERAL EARTH PRESSURES

It is recommended that backfill to the culvert and wingwalls consists of free-draining, non-frost susceptible granular materials such as Granular A or B Type II conforming to the requirements of OPSS 1010. Reference should be made to the backfill arrangements stipulated in OPSD 803.01 as appropriate. Excavated granular embankment fill may be considered for reuse (see section 12 below).

All fills must be placed in regular lifts and be compacted in accordance with OPSS 501. The backfill must 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 concrete box culverts, 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 2010 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)

If full drainage is not achievable, the culvert walls must be designed to withstand full hydrostatic pressure assuming a water level at least equal to the design creek water level.

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 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.

10 EMBANKMENT DESIGN AND CONSTRUCTION

The existing highway embankment is up to 5 m in height at the culverts. It is understood that there is no planned grade raise at this site.

Embankment reconstruction after culvert replacement should be carried out in accordance with OPSS 206. The embankment material should consist of either the excavated granular fill discussed above, or imported Granular A or B Type II material.

Provided that the granular material is placed as recommended, it is anticipated that the existing slope inclination of 3H : 1V, with slight steepening to 2H : 1V within the lower 3 m, should remain stable. Where applicable, benching of the existing earth slope surface should be carried out 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 areas around the culvert inlet and outlet, and within the embankment footprints. 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. Design of the erosion protection measures must consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field.

Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact which includes toe protection for the RSS walls. 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 OPSS 804.

A clay seal or a concrete cut-off wall should be used to minimize the potential for erosion or piping around the culvert. The clay seal must extend to the order of 0.3 m 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. A geosynthetic clay liner may be used as a clay seal.

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 embankment fill and native silty clays and clayey silts at this site are classified as Type 3 soils above the water level and Type 4 soils below the water level. Surficial alluvial deposits that are anticipated in the inlet and outlet areas are classified as Type 4 soils.

12.2 Foundations

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

Excavated gravelly sand to sand fill may be reused as backfill provided the following conditions are satisfied.

- There is sufficient space to stockpile on site and control the moisture content within acceptable limits for compaction
- Gradation and compaction characteristics are confirmed prior to reuse as backfill

12.3 Excavations

Excavations for culvert replacement will typically be carried out through the existing embankment fill and extended into the native silty clay and clayey silt deposits. The work will be carried out within a protection system.

Any protection system must be designed by licensed Professional Engineers experienced in such designs. OPSS 539 “Construction Specification for Protection Systems” 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 this culvert replacement site.

Particular attention must be paid to the design, installation and performance of roadway protection systems parallel to the culverts as it must support the unbalanced forces associated with the culvert being protected.

12.4 GROUNDWATER CONTROL

Groundwater perched within the embankment fill will seep into the excavations during culvert replacement. Surface runoff will also tend to accumulate in these excavations. The groundwater level is expected to be largely governed by the water level in the creek. As discussed in the previous section 8.4, a combination of the use of cofferdams at the inlet and outlet, creek water diversion, protection systems such as sheetpiled enclosures and pumping

from filtered sumps will be required to maintain dry excavations during the course of staged construction.

12 ROADWAY PROTECTION DESIGN

Roadway protection will be required during various stages of construction. The design of roadway protection is the responsibility of the Contractor. However, one option that is considered to be suitable for use at this site is steel interlocking sheetpile enclosures which are also anticipated to provide an effective groundwater cutoff. It is anticipated that the sheetpiles will need to be socketted into the very stiff to firm weathered crust of the native silty clay to develop the required toe resistance. It is anticipated that the shoring system may be stiffened by corner and cross bracings, where applicable.

An interlocking sheetpiled wall may be designed using the parameters given below:

$$\begin{aligned}\gamma &= 20 \text{ kN/m}^3 \\ \gamma_w &= 10 \text{ kN/m}^3 \\ K_a &= 0.33 \text{ (road embankment fill)} \\ &= 0.36 \text{ (silty clay)} \\ K_p &= 2.8 \text{ (silty clay)}\end{aligned}$$

Full hydrostatic pressure should be considered assuming a water level at least equal to the design creek water level.

The actual pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall, and these factors must be considered when designing the shoring system. Typically, a triangular earth pressure distribution similar to the one used for culvert lateral pressure design should be used for a cantilevered sheetpiled wall.

The designer of the roadway protection system must check whether the penetration depth is sufficiently deep to provide base fixity.

All shoring systems must be designed by a Professional Engineer experienced in such designs.

13 CONSTRUCTION CONCERNS

During construction, the Contract Administrator must employ experienced geotechnical staff to provide advice on construction activities related to foundation construction.

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 the culvert replacement. 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

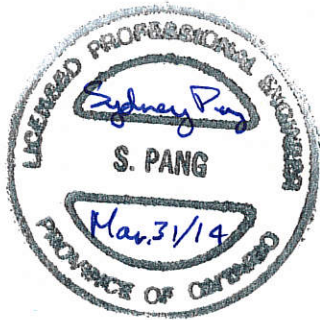
- Impact on the culvert being protected during construction must be addressed by an adequately designed and installed protection system
- removal of peat, organics, soft soils and alluvial deposits near creek channels and wetlands
- disturbance of the soil subgrade within the culvert and RSS foundation footprints; inspection and approval is required
- 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.

THURBER ENGINEERING LTD.



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Senior Foundations Engineer



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Appendix A

Record of Borehole Sheets

19-4406-9

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

EXPLANATION OF ROCK LOGGING TERMS




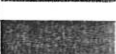

ROCK WEATHERING CLASSIFICATION

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

DISCONTINUITY SPACING

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

SYMBOLS

	CLAYSTONE
	SILTSTONE
	SANDSTONE
	COAL
	BEDROCK

STRENGTH CLASSIFICATION

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

TERMS

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

UNIFIED SOILS CLASSIFICATION

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

RECORD OF BOREHOLE No MC13-01

1 OF 1

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 434.7 E 302 604.2 ORIGINATED BY JG
 HWY 11 BOREHOLE TYPE Tripod COMPILED BY AN
 DATUM Geodetic DATE 2013.10.25 - 2013.10.25 CHECKED BY SKP

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	20 40 60	GR SA SI CL			
259.4														
0.0														
0.1	TOPSOIL: (75mm)													
	Silty CLAY some sand, some organics Firm Brown Moist		1	SS	4									
			2	SS	4									
			3	SS	7									
256.8														
2.6	Becoming soft Grey													
			4	SS	2									
			5	SS	2									
			6	SS	2									
			7	SS	3									
			8	SS	4									
251.2														
8.2	END OF BOREHOLE AT 8.23 m. Piezometer installation consists of 19 mm diameter Schedule 40 PVC pipe with a 1.52 m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov. 1/13 0.3 259.1 Nov. 7/13 0.3 259.1													

ONTMT4S 4069.GPJ 2012TEMPLATE(MTO).GDT 3/20/14

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

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No MC13-02

2 OF 3

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 416.0 E 302 604.2 ORIGINATED BY KMY
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2013.10.14 - 2013.10.14 CHECKED BY SKP

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				
	Continued From Previous Page DCPT continued						249							
							248							
							247							
							246							
							245							
							244							
							243							
							242							
							241							
							240							

Continued Next Page

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

RECORD OF BOREHOLE No MC13-02

3 OF 3

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 416.0 E 302 604.2 ORIGINATED BY KMY
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2013.10.14 - 2013.10.14 CHECKED BY SKP

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	WATER CONTENT (%)					
	Continued From Previous Page DCPT continued						239							
							238							
236.8 22.3	END OF BOREHOLE AND DCPT AT 22.3m. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH AUGER CUTTINGS AND BENTONITE HOLEPLUG TO SURFACE.						237							

RECORD OF BOREHOLE No MC13-03

1 OF 2

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 520.8 E 302 587.3 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2013.10.30 - 2013.10.30 CHECKED BY SKP

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							
263.7														
0.0	SAND, trace to some gravel Dense to Compact Brown Moist (FILL)		1	SS	31									36 54 10 (SI+CL)
			2	SS	41									
			3	SS	18									
			4	SS	11									
260.9														
2.8	Silty CLAY, some sand, trace gravel Soft to Very Soft Grey Wet		5	SS	2									
			1	TW	PH									
			6	SS	0									0 0 60 40
			7	SS	0									
			8	SS	0									
			9	SS	1									0 13 34 53

Continued Next Page

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

METRIC




SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)	GR SA SI CL		
	Continued From Previous Page												
253.3 10.4	Silty CLAY Very Sift Grey END OF BOREHOLE AT 10.4m. FREE WATER AT 0.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.1m, SAND AND GRAVEL TO SURFACE.						\$-5.0\$						

RECORD OF BOREHOLE No MC13-04

1 OF 4

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 434.5 E 302 587.7 ORIGINATED BY SLL
 HWY 11 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2013.10.15 - 2013.10.15 CHECKED BY SKP

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			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL		
								20	40	60	80	100	W _P	W	W _L							
263.8																						
0.0	Gravelly SAND Dense Brown Moist (FILL)		1	SS	39													36	54	10 (SI+CL)		
263.2																						
0.6	SAND , trace gravel and silt, occasional cobbles Dense to very Dense Brown Moist (FILL)		2	SS	47																	
				3	SS	60													28	63	9 (SI+CL)	
			4	SS	60																	
			5	SS	43																	
260.2																						
3.6	Silty CLAY , some sand, trace roots and rootlets, topsoil stained Stiff Grey Moist																					
			6	SS	14																	
				7	SS	10													0	5	27	68
			8	SS	2																	
256.9																						
6.9	Soft																					
				9	SS	3																
			10	SS	1																	

Continued Next Page

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

RECORD OF BOREHOLE No MC13-04

2 OF 4

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 434.5 E 302 587.7 ORIGINATED BY SLL
 HWY 11 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2013.10.15 - 2013.10.15 CHECKED BY SKP

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			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL
								20 40 60 80 100	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE			W _P W W _L							
Continued From Previous Page																			
250.5 13.3	Silty CLAY , some sand Soft Grey Moist						253	2.0 +										Field vane attempted, could not turn	
			11	SS	8											0 11 65 24			
								252										Field vane attempted, could not turn	
			1	TW	PH												0 16 42 42		
	Trace gravel							251											
	Firm							250	2.0 +										
			12	SS	4														Field vane attempted, could not turn
								249											
	Becoming wet							248											
			13	SS	2													0 0 38 62	
								247	4.0 +										
								246		5.0 +									
					245														
					244		4.0 +												

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MC13-04

3 OF 4

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 434.5 E 302 587.7 ORIGINATED BY SLL
 HWY 11 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2013.10.15 - 2013.10.15 CHECKED BY SKP

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			SHEAR STRENGTH kPa		W P W W L				GR SA SI CL
								20 40 60 80 100	20 40 60					
Continued From Previous Page									○ UNCONFINED + FIELD VANE					
	Silty CLAY , trace gravel Soft Grey Wet		16	SS	5		243	3.0 +					0 0 43 57	
	With clayey silt varves		17	SS	2		241							
240.3	End of sampling at 23.5m and start of DCPT at 24.1m						240	4.0 +						
23.5							239							
							238							
							237							
							236							
							235							
							234							

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MC13-04

4 OF 4

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 434.5 E 302 587.7 ORIGINATED BY SLL
 HWY 11 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2013.10.15 - 2013.10.15 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	W P	W	W L	WATER CONTENT (%)		
	Continued From Previous Page							20 40 60 80 100						
								20 40 60 80 100						
230.1								20 40 60 80 100						
33.7	END OF BOREHOLE AND DCPT AT 33.7m UPON REFUSAL ON PROBABLE BEDROCK OR BOULDER. BOREHOLE OPEN TO 18.4m AND WATER LEVEL AT 11.0m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.8m THEN CUTTINGS TO SURFACE.													

RECORD OF BOREHOLE No MC13-05

1 OF 4

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 393.2 E 302 587.8 ORIGINATED BY SLL
 HWY 11 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2013.10.10 - 2013.10.10 CHECKED BY SKP

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			SHEAR STRENGTH kPa				WATER CONTENT (%)					GR	SA	SI	CL
								20 40 60 80 100				20 40 60								
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
263.8																				
0.0	Gravelly SAND , trace to some silt Dense to Very Dense Brown Moist (FILL)		1	SS	37									○					26 63 11 (SI+CL)	
			2	SS	47									○						
			3	SS	59									○						
			4	SS	50									○					30 64 6 (SI+CL)	
260.8							263													
3.0	Wood fragments with 0.25m long nail inside spoon		5	SS	24															
260.5	Brown to Grey																			
3.3	Silty CLAY , with wood fragments Firm Brown Moist (FILL)		6	SS	6		260								○					
259.3																				
4.5	Silty CLAY , trace to some sand, topsoil stained Firm Brown to Grey Moist Some peat layers		7	SS	7		259									○				
			8	SS	3		258													
							257												0 9 28 63	
256.6																				
7.2	Soft																			
			9	SS	WH		256								○					
							255													
			10	SS	WH										○					
							254													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MC13-05

2 OF 4

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 393.2 E 302 587.8 ORIGINATED BY SLL
 HWY 11 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2013.10.10 - 2013.10.10 CHECKED BY SKP

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			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL
								20	40	60	80	100	W _P	W					
Continued From Previous Page								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE											
247.5 16.3	Silty CLAY , trace gravel Soft Grey Wet 																		

Continued Next Page

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

RECORD OF BOREHOLE No MC13-05

3 OF 4

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 393.2 E 302 587.8 ORIGINATED BY SLL
 HWY 11 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2013.10.10 - 2013.10.10 CHECKED BY SKP

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						
Continued From Previous Page								○ UNCONFINED + FIELD VANE						
								● QUICK TRIAXIAL × LAB VANE						
241.2	Silty CLAY Soft Grey Wet		17	SS	3		243							
22.6	Clayey SILT Stiff Grey Wet		18	SS	4		242							
								4.0 +						
			19	SS	10		241							
							240							
			20	SS	12									
238.8							239							0 0 87 13
25.0	End of sampling at 25.0m and start of DCPT at 25.6m						238							
							237							
							236							
							235							
							234							

Continued Next Page

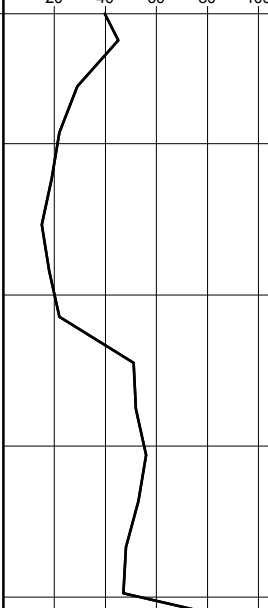
+³, ×³: Numbers refer to Sensitivity
 20
15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MC13-05

4 OF 4

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 393.2 E 302 587.8 ORIGINATED BY SLL
 HWY 11 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2013.10.10 - 2013.10.10 CHECKED BY SKP





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								WATER CONTENT (%)		
								○ UNCONFINED	+	FIELD VANE						● QUICK TRIAXIAL	×	LAB VANE
	Continued From Previous Page							20 40 60 80 100										
	DCPT continued																	
229.8								230										
34.0	END OF BOREHOLE AND DCPT AT 34.0m. BOREHOLE OPEN TO 17.8m AND WATER LEVEL AT 10.0m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.8m, THEN CUTTINGS TO SURFACE.																	

RECORD OF BOREHOLE No MC13-06

1 OF 1

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 321.2 E 302 588.1 ORIGINATED BY SLL
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2013.10.11 - 2013.10.11 CHECKED BY SKP

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						WATER CONTENT (%)							
								20 40 60 80 100						20 40 60							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						w _p w w _L							
264.0						264															
0.0	SAND , some gravel Dense Brown Moist (FILL)		1	SS	31																
263.3																					
0.7																					
	Gravelly SAND , some silt, occasional cobbles and boulders Dense Brown Moist (FILL)		2	SS	43																
			3	SS	50/ 0.075																
262.0																					
	Silty CLAY , topsoil stained, trace rootlets Hard to Very Stiff Dark Brown Moist Brown		4	SS	39																
260.3																					
	Firm Grey Wet																				
													</								






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RECORD OF BOREHOLE No MC13-07

1 OF 4

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 446.9 E 302 579.6 ORIGINATED BY SLL
 HWY 11 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2013.10.17 - 2013.10.28 CHECKED BY SKP

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			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL							
								20 40 60 80 100				w _p w w _L														
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE																		
263.8																										
0.0	Gravelly SAND Dense Brown Moist (FILL) Occasional cobbles		1	SS	49		263							○		31	57	12 (SI+CL)								
																			○							
					2			SS	50/ 0.075												○					
					3			SS	38												○					
					4			SS	46												○					
260.9								261																22	65	13 (SI+CL)
2.9	Silty CLAY , some sand Very Stiff Brown Moist		5	SS	27																					
260.1																										
3.7	Firm Becoming grey Wet		6	SS	7				260																	
					7	SS	3																			
					8	SS	1																			
					9	SS	PH																			
255.1																										
8.7	Soft		1	TW	PH																					
							254																			

Continued Next Page

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

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No MC13-07

3 OF 4

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 446.9 E 302 579.6 ORIGINATED BY SLL
 HWY 11 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2013.10.17 - 2013.10.28 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
	Continued From Previous Page							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				
	Silty CLAY Stiff Grey Wet		16	SS	2		243	3.0				
			17	SS	3		242					
								3.0				
	Wet						241					
240.5			18	SS	4							0 0 90 10
23.3	SILT , trace sand, trace clay Loose to Compact Grey Wet						240					
			19	SS	13		239					
238.8												
25.0	End of sampling at 25.0m and start of DCPT						238					
							237					
							236					
							235					
							234					

Continued Next Page

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

RECORD OF BOREHOLE No MC13-07

4 OF 4

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 446.9 E 302 579.6 ORIGINATED BY SLL
 HWY 11 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2013.10.17 - 2013.10.28 CHECKED BY SKP

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	20 40 60	W _p W W _L				
	Continued From Previous Page DCPT continued						233 232 231 230	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
229.1														
34.7	END OF BOREHOLE AND DCPT AT 34.7m UPON REFUSAL. FREE WATER AT 2.8m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.1m, SAND AND GRAVEL TO SURFACE.													

RECORD OF BOREHOLE No MC13-08

1 OF 4

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 415.2 E 302 579.6 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2013.10.31 - 2013.10.31 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL
								20 40 60 80 100				w P w w L							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE											
263.8																			
0.0	SAND , trace gravel Compact to Dense Brown Wet (FILL) Occasional cobbles <																		

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MC13-08

2 OF 4

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 415.2 E 302 579.6 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2013.10.31 - 2013.10.31 CHECKED BY SKP

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			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL	
								20 40 60 80 100	○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × LAB VANE	W _P W W _L									
	Continued From Previous Page																			
	Silty CLAY Very Soft to Soft Grey Wet																			
			10	SS	1		253	6.0 +									3	12 44 41		
			11	SS	3		252	8.0 +												
							251													
								5.0 +												
			2	TW	PH		250													
							249	5.0 +												
							248	8.0 +												
							247										0	10 32 58		
			13	SS	1															
								6.0 +												
							246													
			14	SS	1		245													
244.9																				
18.9	End of sampling and start of DCPT at 18.9m																			
							244													

Continued Next Page

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

RECORD OF BOREHOLE No MC13-08

3 OF 4

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 415.2 E 302 579.6 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2013.10.31 - 2013.10.31 CHECKED BY SKP

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	WATER CONTENT (%)					
	Continued From Previous Page DCPT continued							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	20 40 60					
234.6							243							
29.2	END OF BOREHOLE AT 29.2m UPON REFUSAL. FREE WATER AT 0.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH						235							

Continued Next Page

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

RECORD OF BOREHOLE No MC13-08

4 OF 4

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 415.2 E 302 579.6 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2013.10.31 - 2013.10.31 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					W _p W W _L 20 40 60					
	Continued From Previous Page BENTONITE HOLEPLUG TO 0.1m, SAND AND GRAVEL TO SURFACE.																

ONTMT4S 4069.GPJ 2012TEMPLATE(MTO).GDT 3/20/14

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No MC13-09

2 OF 3

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 441.6 E 302 565.3 ORIGINATED BY KMY
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2013.10.12 - 2013.10.12 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)				GR	SA	SI	CL	
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE								
	Continued From Previous Page																		
	Silty CLAY , trace gravel, occasional cobbles		9	SS	1														
	Firm																		
	Grey																		
	Wet																		
												</							

Continued Next Page

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

METRIC

[illegible]

RECORD OF BOREHOLE No MC13-10

1 OF 3

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 434.0 E 302 560.3 ORIGINATED BY KMY
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2013.10.12 - 2013.10.12 CHECKED BY SKP

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						
SHEAR STRENGTH kPa								WATER CONTENT (%)							
							○ UNCONFINED + FIELD VANE								
							● QUICK TRIAXIAL × LAB VANE								
259.8	<div>TOPSOIL: (25mm) Light Brown</div> <div>Silty CLAY, trace sand Stiff to firm Brown Moist to Wet</div> <div>Becoming grey Wet</div>		1	SS	6										
			2	SS	8										
					3	SS	3								
					4	SS	2								
					5	SS	1								
			6	SS	3										
252.2	End of sampling at 7.6m and start of DCPT														
7.6															

Continued Next Page

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

RECORD OF BOREHOLE No MC13-10

2 OF 3

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 434.0 E 302 560.3 ORIGINATED BY KMY
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2013.10.12 - 2013.10.12 CHECKED BY SKP

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	WATER CONTENT (%)					
	Continued From Previous Page DCPT continued							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	20 40 60					
249														
248														
247														
246														
245														
244														
243														
242														
241														
240														

Continued Next Page

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

RECORD OF BOREHOLE No MC13-10

3 OF 3

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 434.0 E 302 560.3 ORIGINATED BY KMY
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2013.10.12 - 2013.10.12 CHECKED BY SKP

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	WATER CONTENT (%)					
	Continued From Previous Page DCPT continued							20 40 60 80 100						
238.2							239							
21.6	END OF BOREHOLE AT 21.6m. BOREHOLE CAVED TO 0.6m, BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.													

RECORD OF BOREHOLE No MC13-11

1 OF 2

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 419.9 E 302 560.0 ORIGINATED BY KMY
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2013.10.14 - 2013.10.15 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × LAB VANE	W _P	W	W _L		
								20 40 60 80 100	20 40 60 80 100					
258.7														
0.0	Silty CLAY , with rootlets Firm to Stiff Dark Brown Moist		1	SS	6									
	Light Brown to Grey		2	SS	5									
	Some organics		3	SS	6									
	Firm Grey Moist to Wet		4	SS	3									
			5	SS	2									
			6	SS	4									
251.7	End of sampling at 7.0m and start of DCPT													
7.0														

Continued Next Page

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

RECORD OF BOREHOLE No MC13-11

2 OF 2

METRIC

GWP# 5169-10-00 LOCATION Mondor Creek N 5 431 419.9 E 302 560.0 ORIGINATED BY KMY
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2013.10.14 - 2013.10.15 CHECKED BY SKP

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	20 40 60	W _p W W _L				
	Continued From Previous Page DCPT continued													
248														
247														
246														
245														
244														
243														
242														
241														
240.1 18.6	END OF BOREHOLE AT 18.6m. Piezometer installation consists of 19 mm diameter Schedule 40 PVC pipe with a 1.52 m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov. 1/13 3.5 255.2 Nov. 7/13 3.4 255.3													

ONTMT4S 4069.GPJ 2012TEMPLATE(MTO).GDT 3/20/14

Appendix B

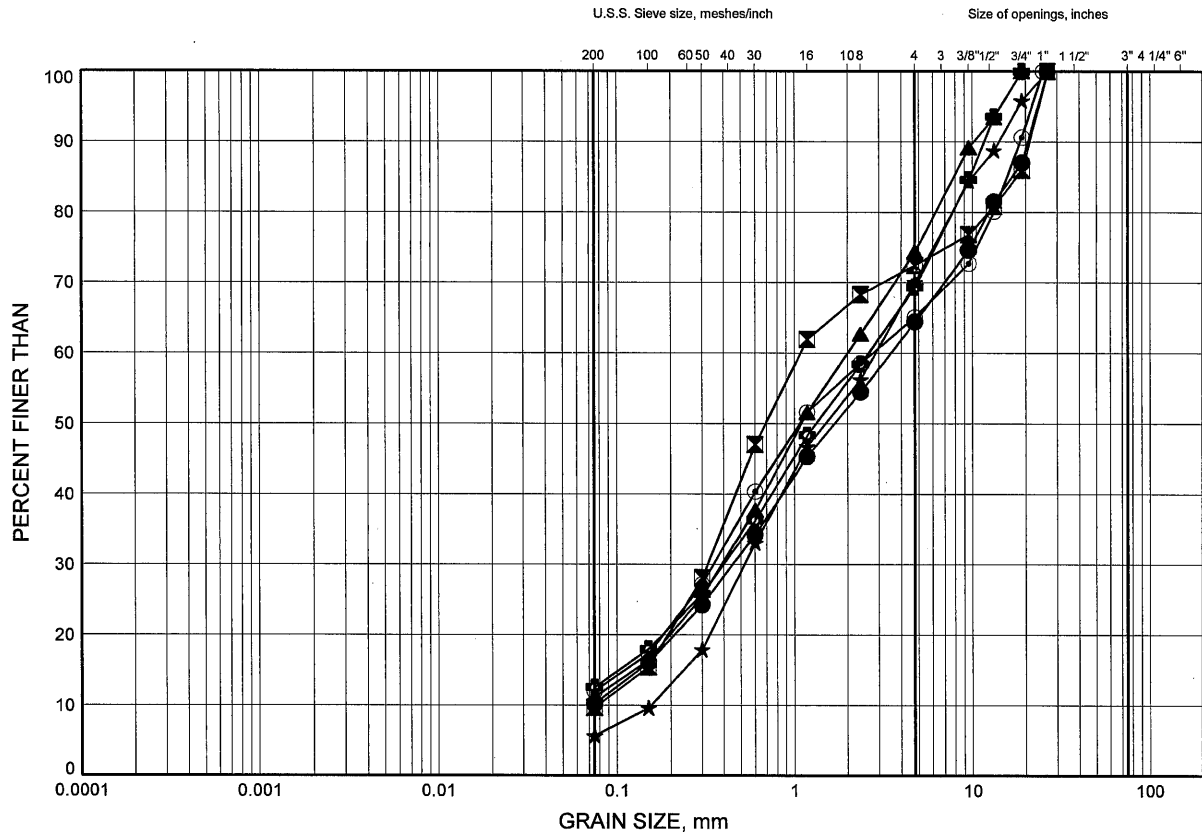
Laboratory Test Results

Hwys 11, 583, 652 Culverts - Foundations

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)
●	MC13-04	0.30	263.50
⊠	MC13-04	1.83	261.97
▲	MC13-05	0.30	263.50
★	MC13-05	2.59	261.21
⊙	MC13-06	1.07	262.93
⊕	MC13-07	0.30	263.50

Date November 2013
WP# 5169-10-00



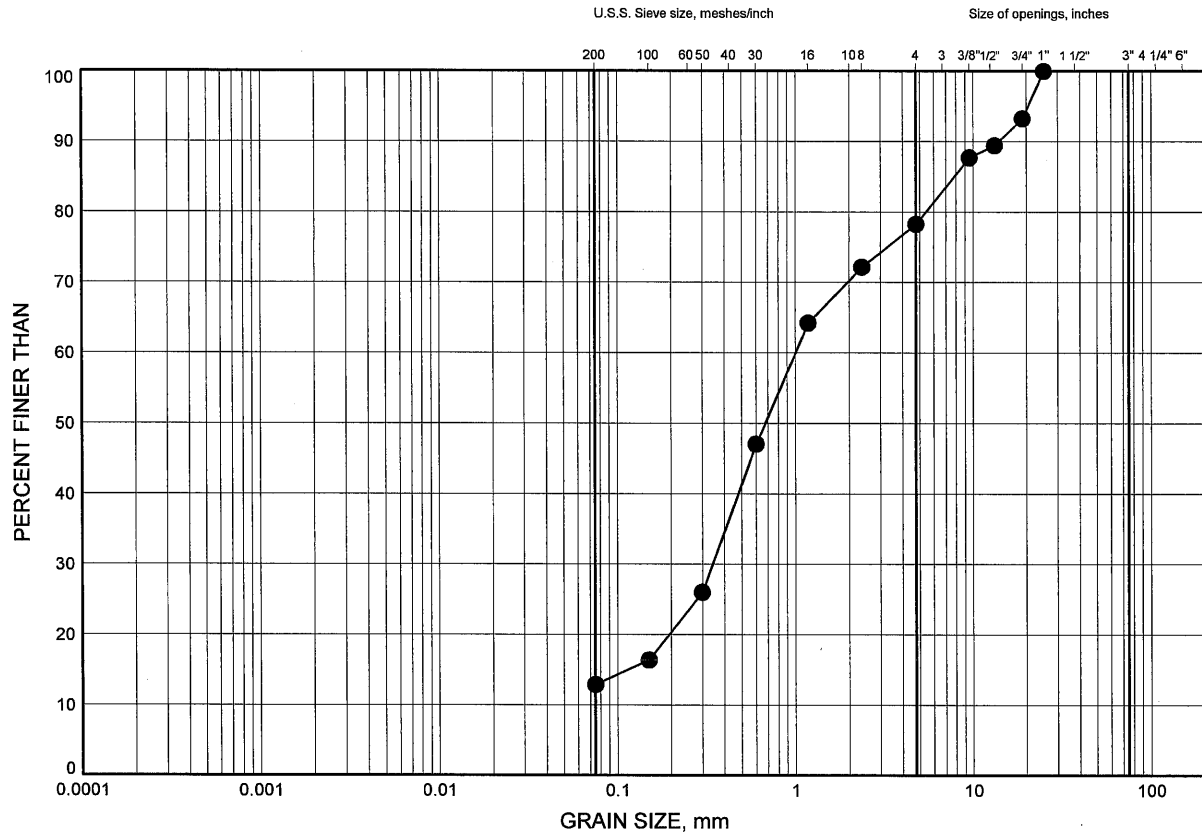
Prep'd AN
Chkd. SKP

Hwys 11, 583, 652 Culverts - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B2

GRAVELLY SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MC13-07	2.59	261.21

Date November 2013
 WP# 5169-10-00



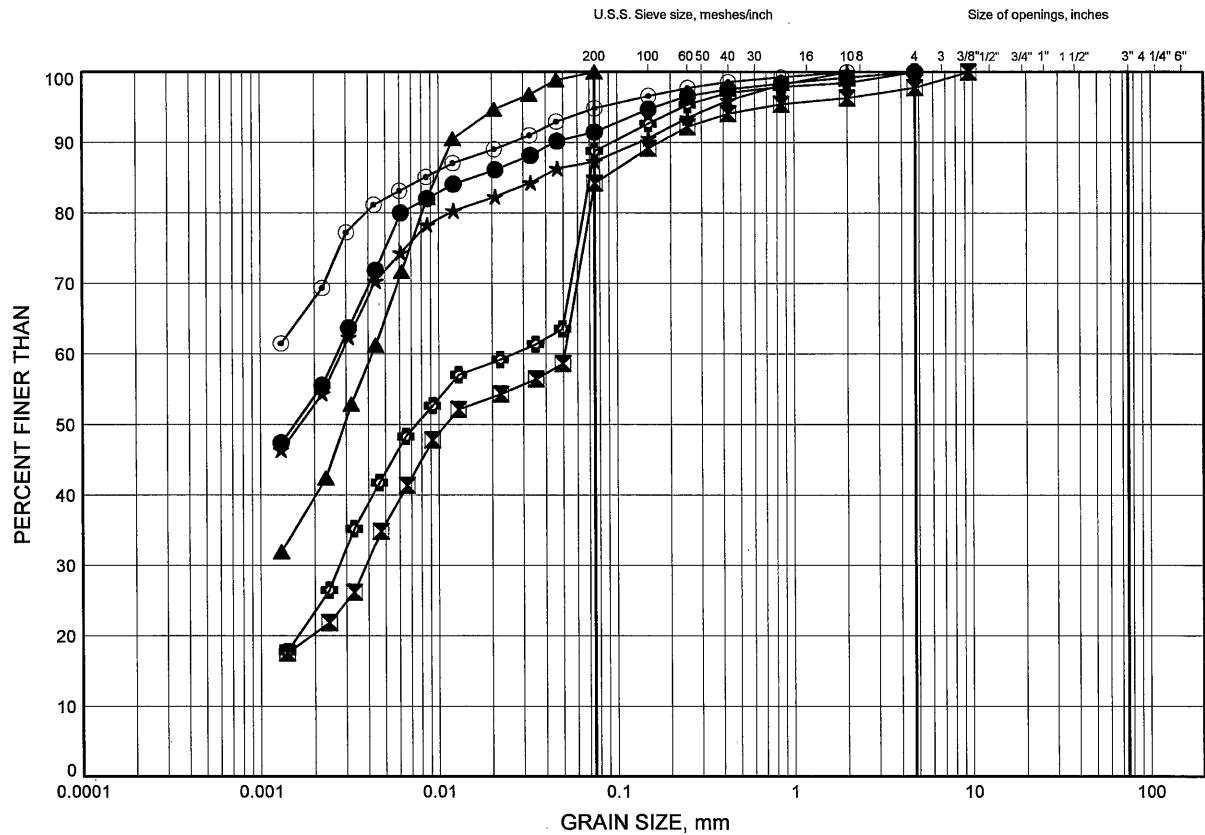
Prep'd AN
 Chkd. SKP

Hwys 11, 583, 652 Culverts - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B3

SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MC13-02	1.07	258.03
⊠	MC13-02	6.40	252.70
▲	MC13-03	4.88	258.82
★	MC13-03	9.45	254.25
⊙	MC13-04	4.88	258.92
⊕	MC13-04	10.97	252.83

Date November 2013

WP# 5169-10-00



Prep'd AN

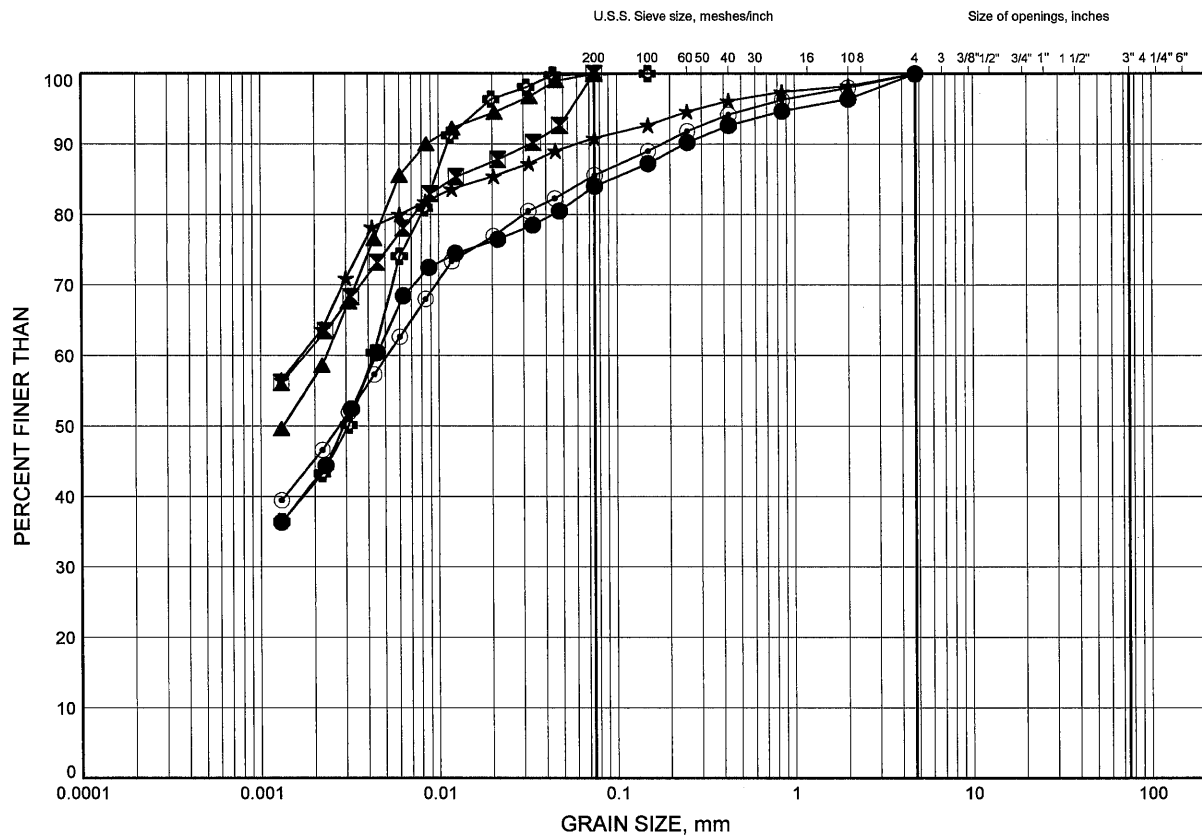
Chkd. SKP

Hwys 11, 583, 652 Culverts - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B4

SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MC13-04	12.40	251.40
⊠	MC13-04	15.54	248.26
▲	MC13-04	20.12	243.68
★	MC13-05	6.40	257.40
⊙	MC13-05	12.50	251.30
⊕	MC13-06	3.35	260.65

GRAIN SIZE DISTRIBUTION - THURBER 4069.GPJ 11/29/13

Date November 2013
WP# 5169-10-00



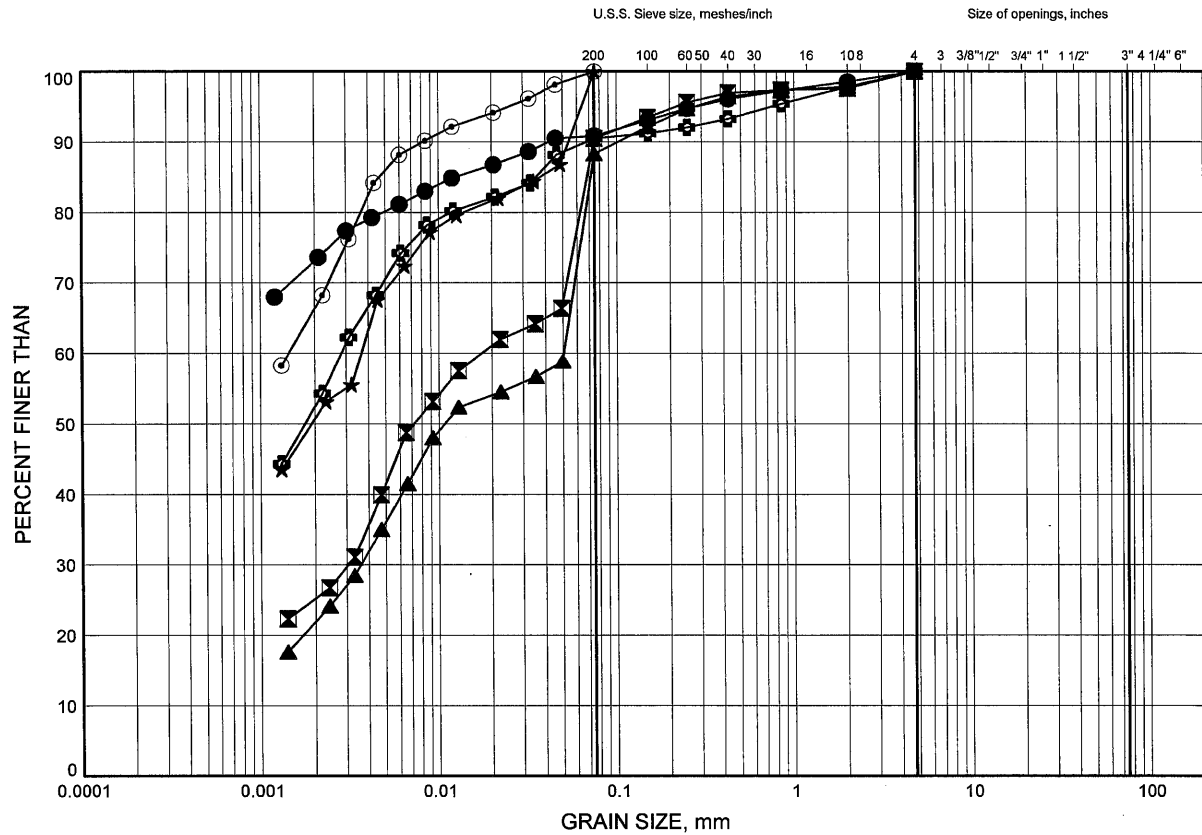
Prep'd AN
Chkd. SKP

Hwys 11, 583, 652 Culverts - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B5

SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MC13-06	6.40	257.60
⊠	MC13-07	6.40	257.40
▲	MC13-07	10.97	252.83
★	MC13-07	17.07	246.73
⊙	MC13-07	18.59	245.21
⊕	MC13-08	4.11	259.69

Date December 2013
Project 5169-10-00



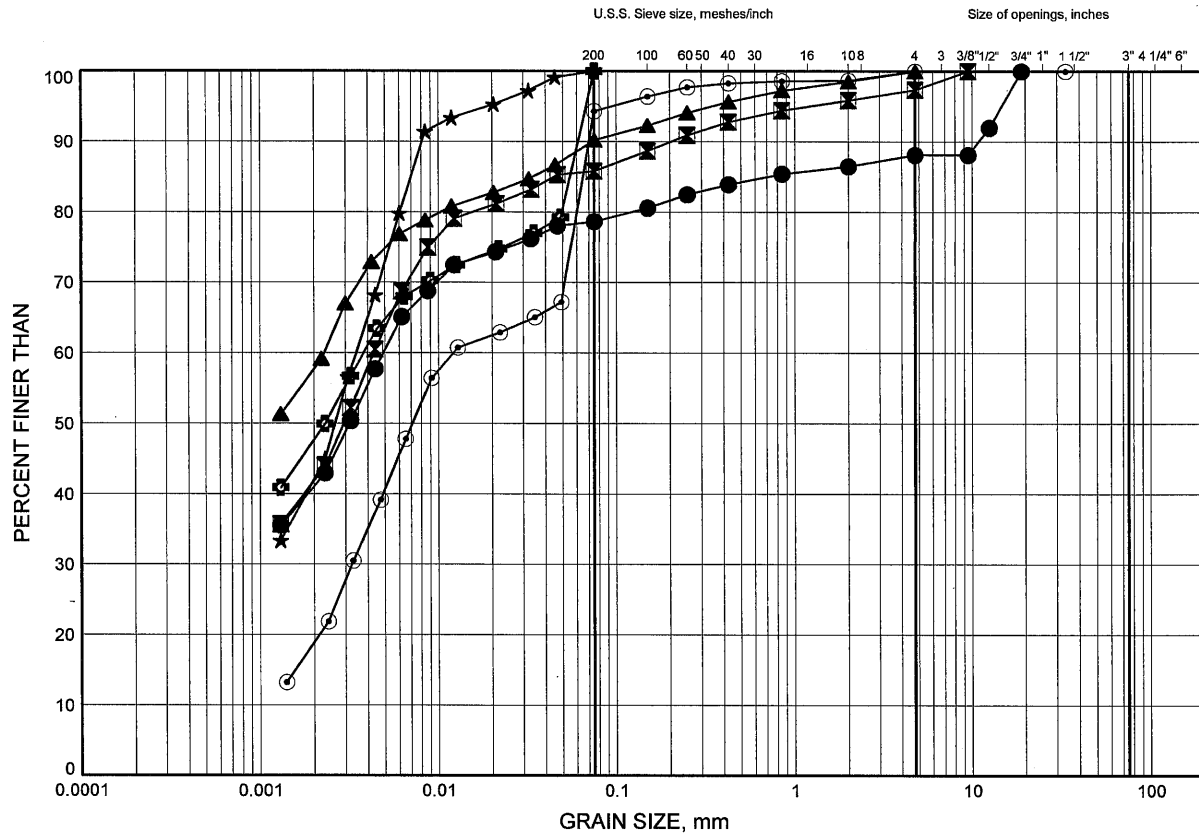
Prep'd AN
Chkd. SKP

Hwys 11, 583, 652 Culverts - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B6

SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MC13-08	9.45	254.35
⊠	MC13-08	10.97	252.83
▲	MC13-08	17.07	246.73
★	MC13-09	1.07	259.63
⊙	MC13-09	5.49	255.21
⊕	MC13-09	13.11	247.59

Date November 2013
WP# 5169-10-00



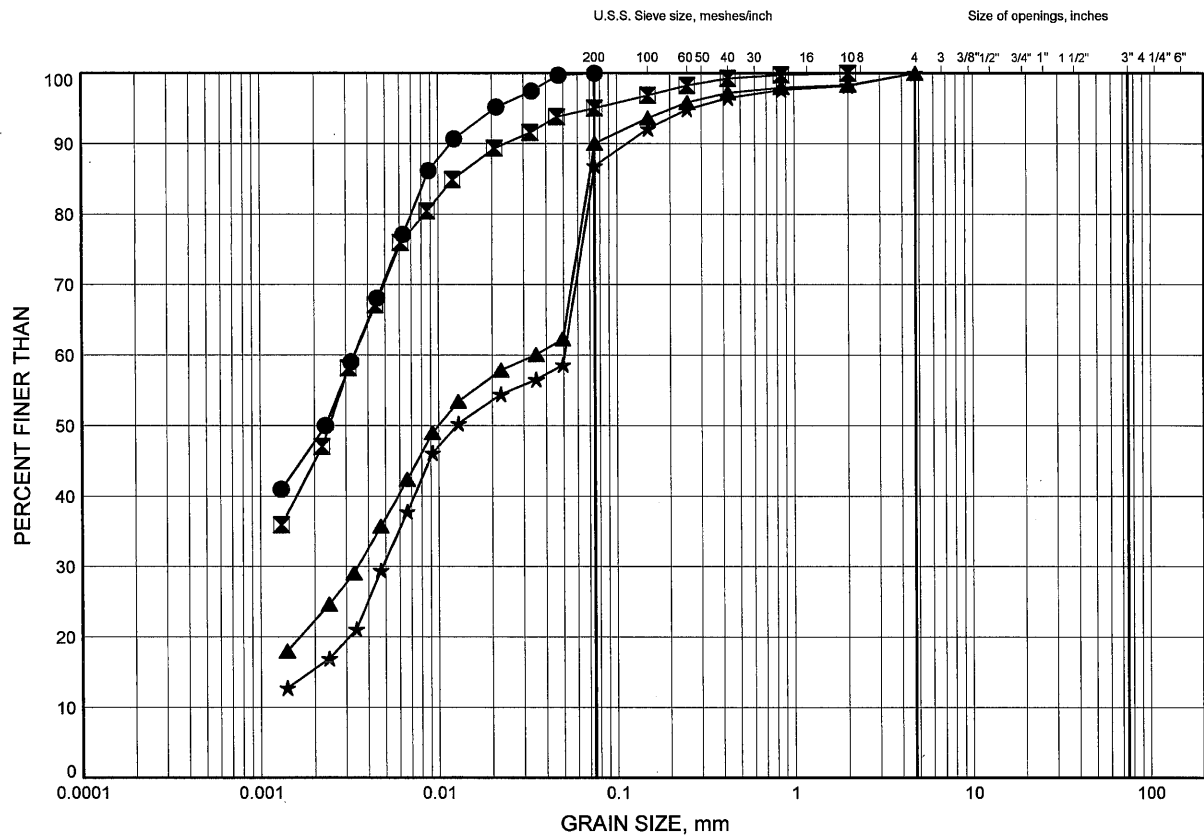
Prep'd AN
Chkd. SKP

Hwys 11, 583, 652 Culverts - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B7

SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MC13-09	18.59	242.11
⊠	MC13-10	1.07	258.73
▲	MC13-10	4.11	255.69
★	MC13-11	6.40	252.30

Date November 2013
WP# 5169-10-00



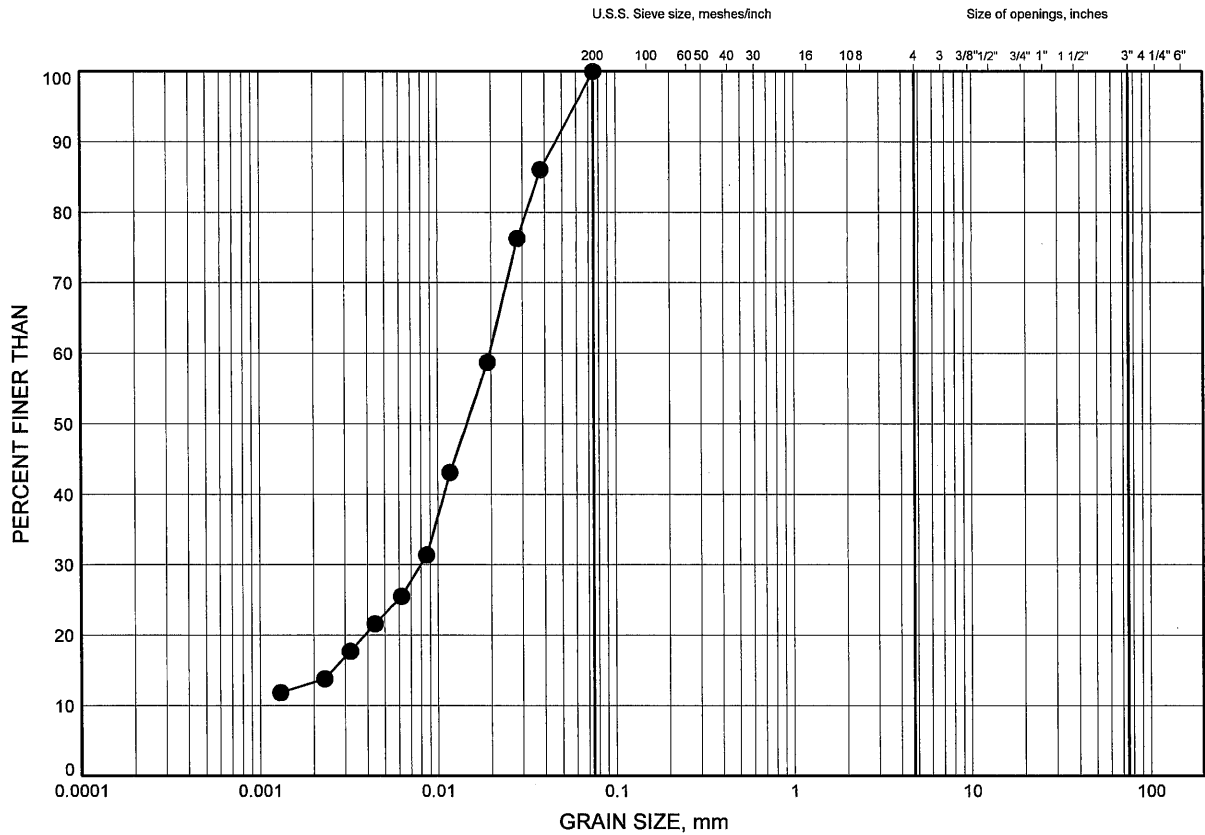
Prep'd AN
Chkd. SKP

Hwys 11, 583, 652 Culverts - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B8

CLAYEY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MC13-05	24.69	239.11

Date November 2013
 WP# 5169-10-00

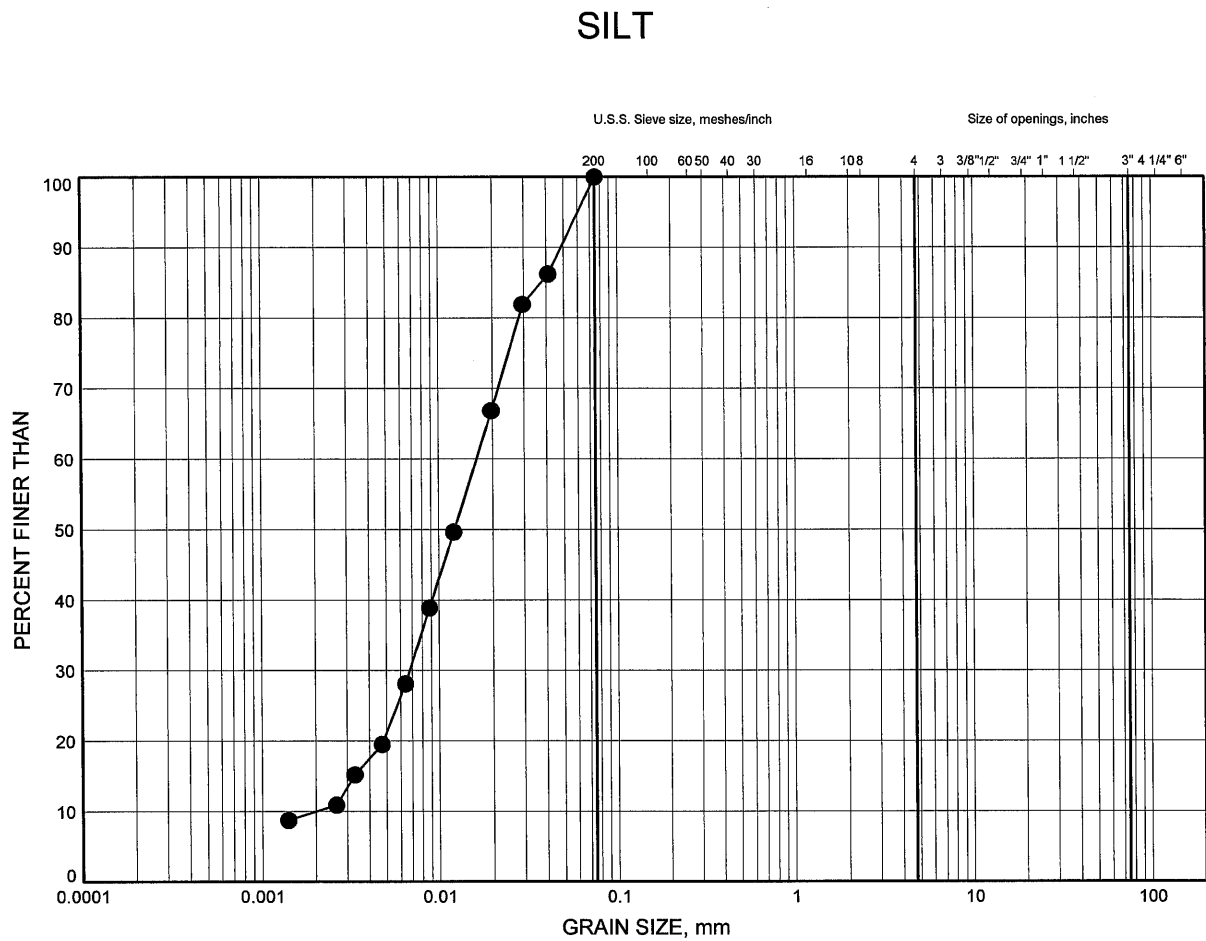


Prep'd AN
 Chkd. SKP

Hwys 11, 583, 652 Culverts - Foundations

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)
●	MC13-07	23.16	240.64

GRAIN SIZE DISTRIBUTION - THURBER 4069.GPJ 11/29/13

Date November 2013
 WP# 5169-10-00

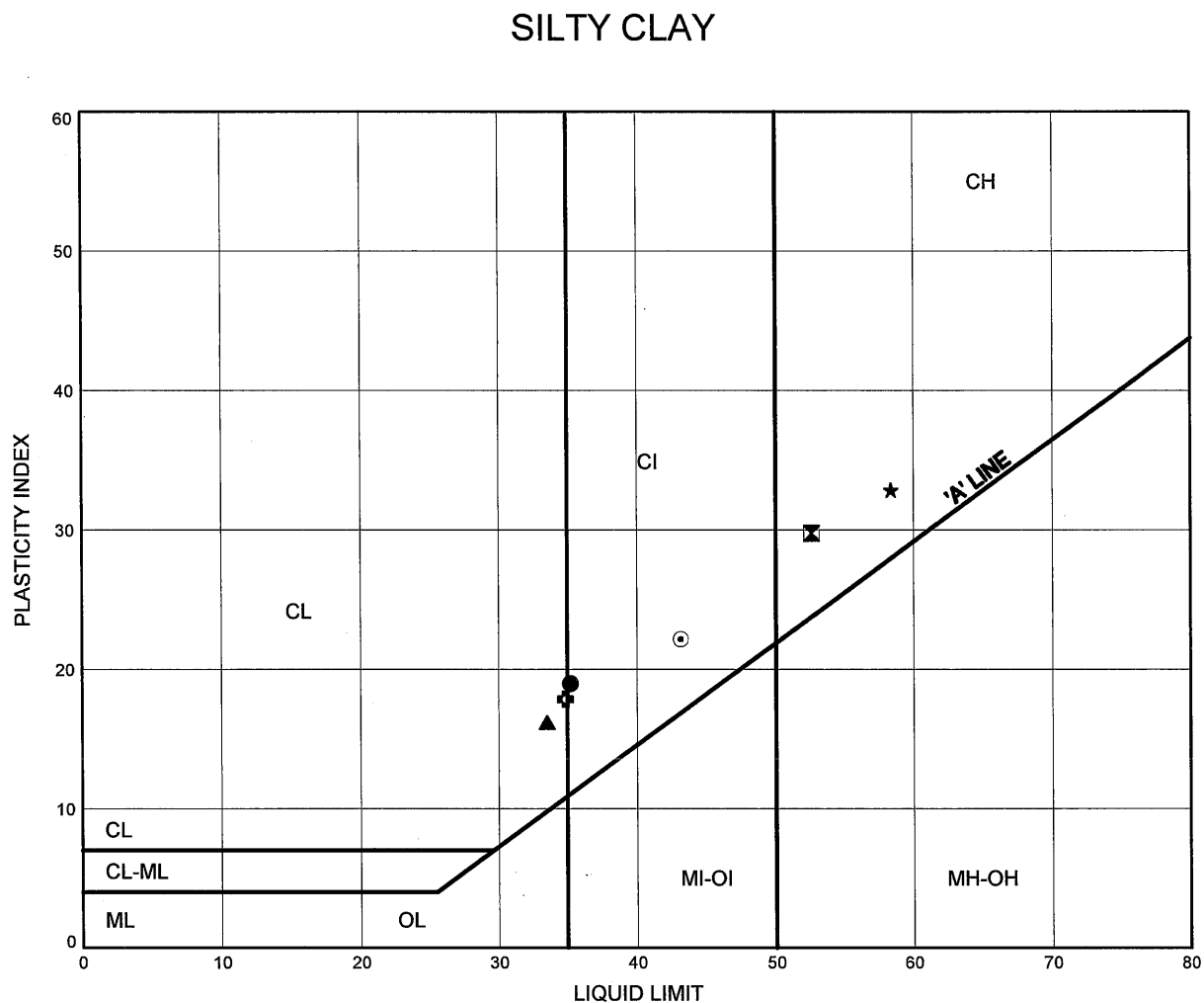


Prep'd AN
 Chkd. SKP

Hwys 11, 583, 652 Culverts - Foundations

ATTERBERG LIMITS TEST RESULTS

FIGURE B10



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MC13-02	6.40	252.70
⊠	MC13-04	4.88	258.92
▲	MC13-04	10.97	252.83
★	MC13-04	15.54	248.26
⊙	MC13-05	6.40	257.40
⊕	MC13-05	12.50	251.30

Date November 2013

WP# 5169-10-00



Prep'd AN

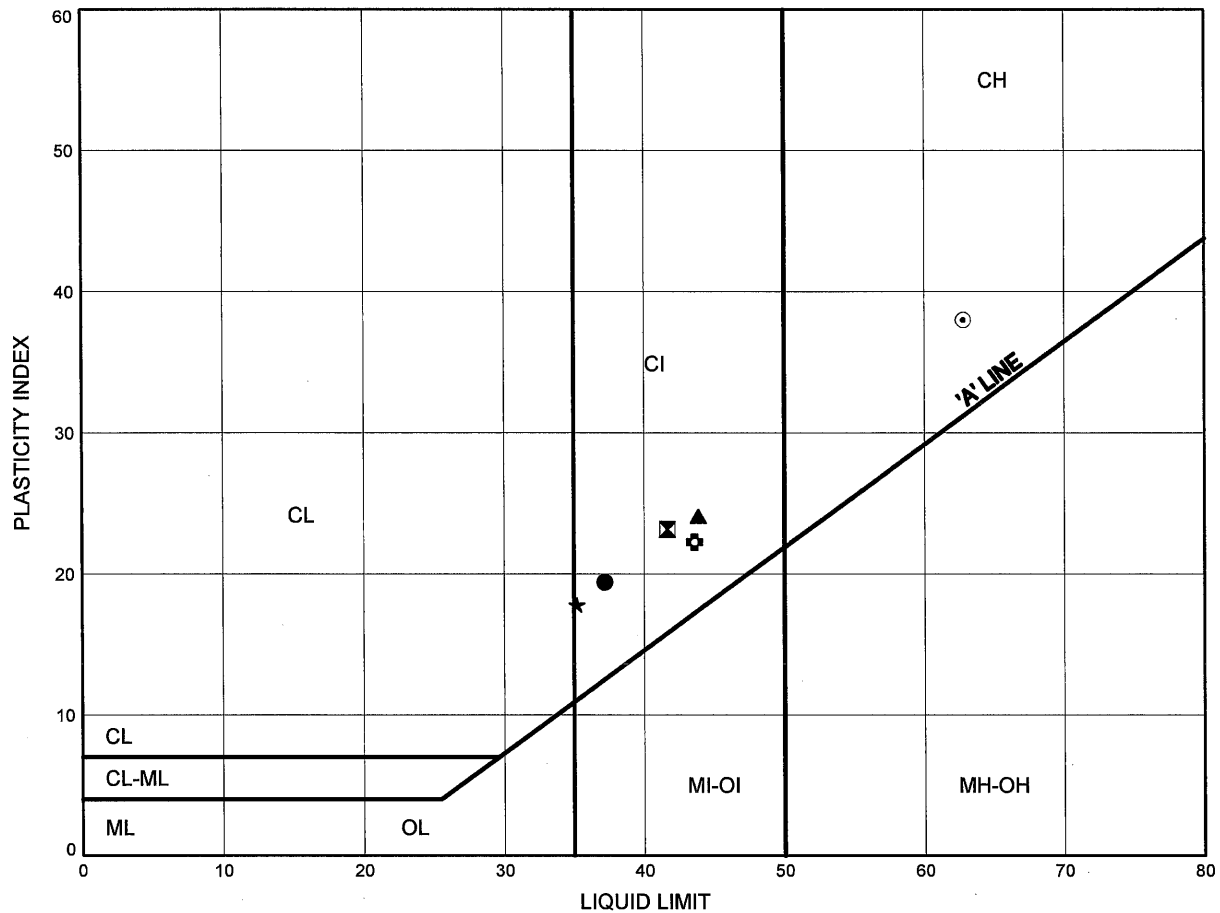
Chkd. SKP

Hwys 11, 583, 652 Culverts - Foundations

ATTERBERG LIMITS TEST RESULTS

FIGURE B11

SILTY CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MC13-06	3.35	260.65
⊠	MC13-06	6.40	257.60
▲	MC13-07	6.40	257.40
★	MC13-07	10.97	252.83
⊙	MC13-07	17.07	246.73
⊕	MC13-07	18.59	245.21

Date November 2013

WP# 5169-10-00



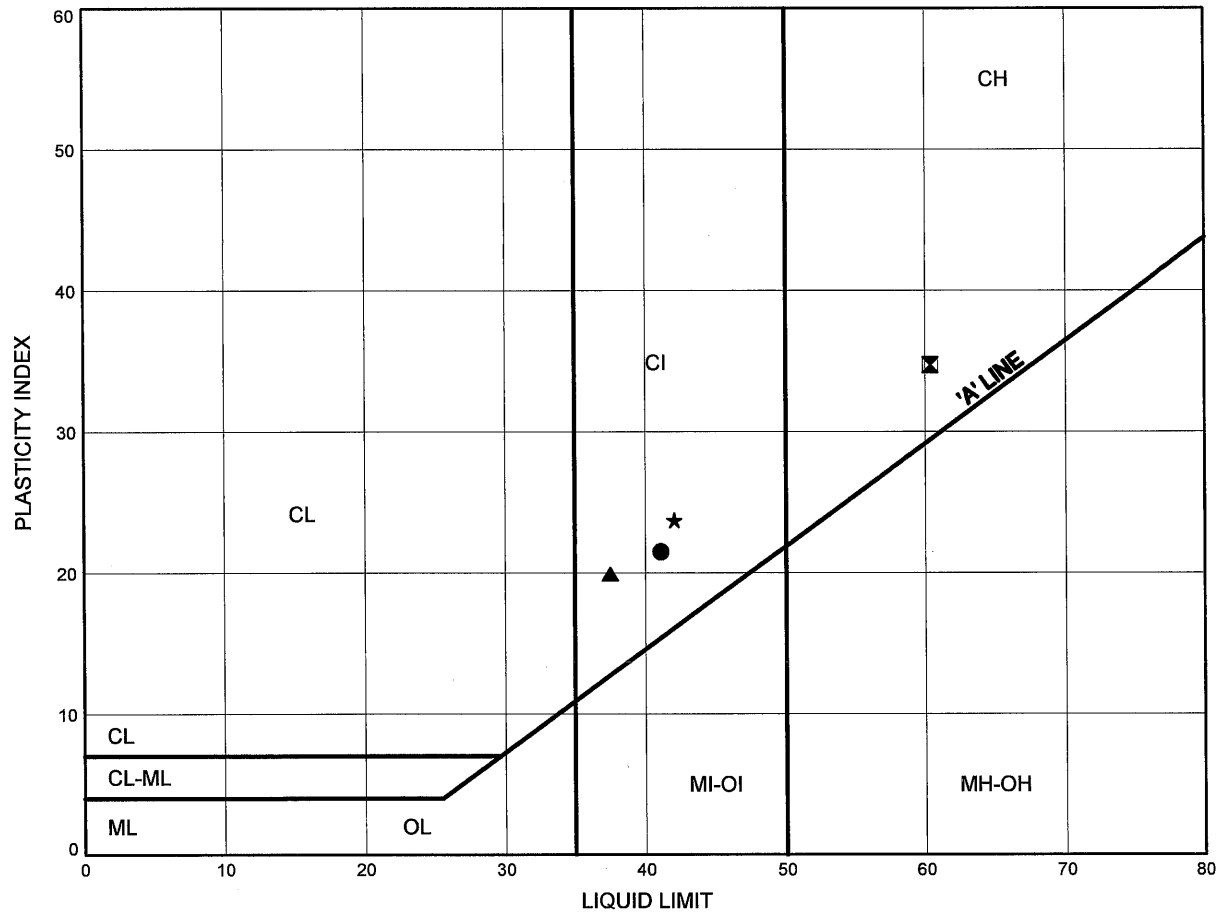
Prep'd AN

Chkd. SKP

Hwys 11, 583, 652 Culverts - Foundations
ATTERBERG LIMITS TEST RESULTS

FIGURE B12

SILTY CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MC13-09	5.49	255.21
⊠	MC13-09	13.11	247.59
▲	MC13-10	4.11	255.69
★	MC13-11	1.83	256.87

Date November 2013

WP# 5169-10-00



Prep'd AN

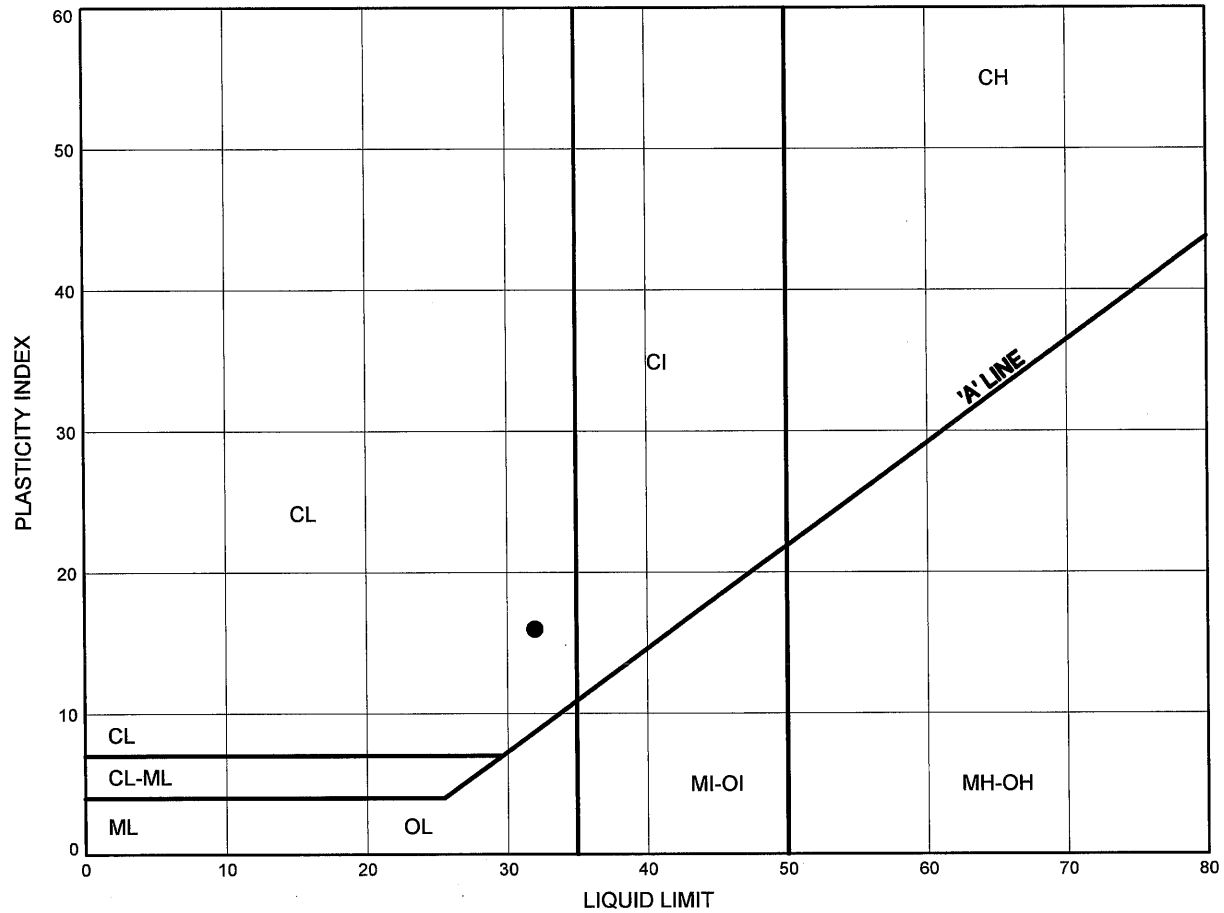
Chkd. SKP

Hwys 11, 583, 652 Culverts - Foundations

ATTERBERG LIMITS TEST RESULTS

FIGURE B13

CLAYEY SILT



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MC13-11	6.40	252.30

Date November 2013
 WP# 5169-10-00



Prep'd AN
 Chkd. SKP

Consolidation Test Report

CLIENT: URS Canada Inc.

FILE NUMBER: 19-4406-9

PROJECT: Mondor Creek

REPORT DATE: 7-Apr-14

TEST DATES: November 18, 2013 - November 29, 2013

SAMPLE: MC13-04-TW1 (40' - 41' 4")
Silty Clay, grey, contains 16% sand, 42% silt and 42% clay, PL=16%, LL=32%

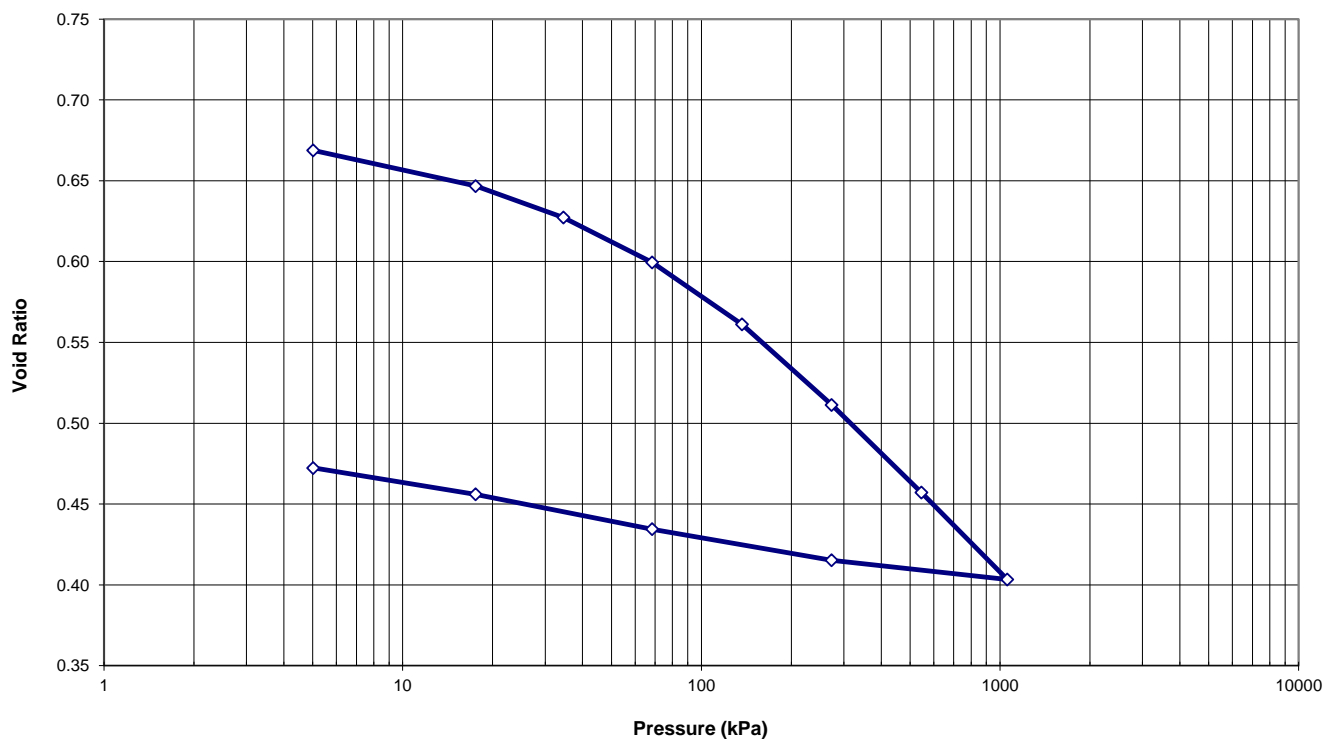
PROCEDURE: Test carried out in accordance with Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D 2435-04, method A (constant load increment duration of 24 hrs)

	<u>Start of Test</u>	<u>End of Test</u>
Wet Dens. (kg/m ³)	2063.8	2214.6
Dry Dens. (kg/m ³)	1636.8	1868.7
Moisture Cont. (%)	26.1	18.5
Void Ratio	0.681	0.473

Note: A Specific Gravity of 2.75 was measured for the void ratio and saturation calculations.

Void Ratio vs. Pressure

Project #: 19-4406-9
Client: URS Canada Inc.
Project Name: Mondor Creek
Sample: MC13-04-TW1 (40' - 41' 4")



Consolidation Test Report

Mondor Creek

19-4406-9

MC13-04-TW1 (40' - 41' 4")

TRIMMING: The Specimen was manually trimmed to the size of consolidation ring, then mounted in a fixed ring consolidometer.

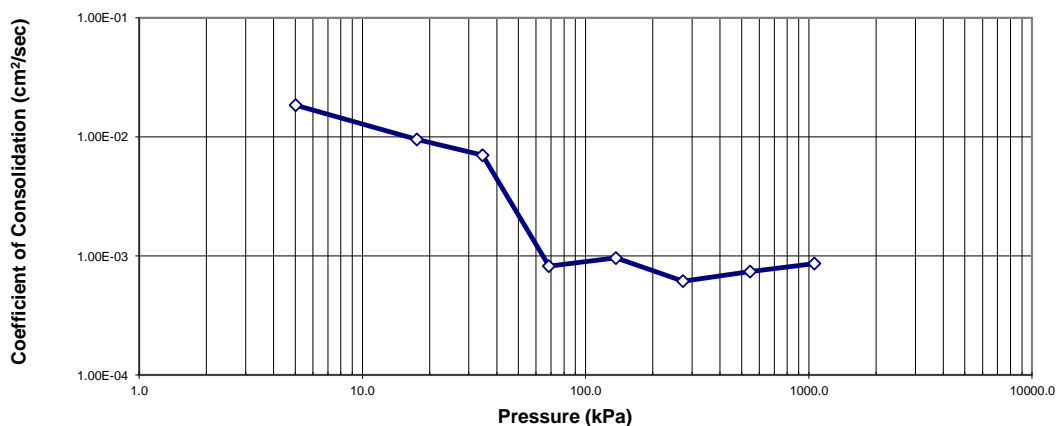
LOADING: A seating load of 5 kPa was applied and the consolidometer was flooded with distilled water. Sample was monitored to ensure no swelling effect occurred before the start of the test. Subsequent loads were applied after 100% primary consolidation was reached.

CALCULATIONS: Coefficients of Consolidation were calculated by the square root time method.

Pressure (kPa)	Corr. H. (mm)	Avg. H. (mm)	d_{90} (mm)	t_{90} (min)	C_v (cm ² /s)	Void Ratio	m_v (m ² /kN)	k (cm/s)
0.0	20.000					0.681		
5.0	19.854	19.927	-0.115	0.757	1.85E-02	0.669	1.45E-03	2.64E-06
17.6	19.593	19.724	-0.116	1.440	9.55E-03	0.647	1.05E-03	9.82E-07
34.5	19.360	19.477	-0.067	1.904	7.04E-03	0.627	7.01E-04	4.84E-07
68.5	19.030	19.195	-0.173	15.840	8.22E-04	0.599	5.02E-04	4.05E-08
136.9	18.574	18.802	-0.240	12.960	9.64E-04	0.561	3.51E-04	3.31E-08
273.2	17.982	18.278	-0.370	19.184	6.15E-04	0.511	2.34E-04	1.41E-08
545.5	17.336	17.659	-0.410	14.900	7.40E-04	0.457	1.32E-04	9.57E-09
1057.7	16.696	17.016	-0.397	11.834	8.65E-04	0.403	7.21E-05	6.11E-09
273.2	16.839	16.768				0.415		
68.5	17.067	16.953				0.434		
17.6	17.324	17.196				0.456		
5.0	17.518	17.421				0.472		

Coefficient of Consolidation vs. Pressure

Project #: 19-4406-9
Client: URS Canada Inc.
Project Name: Mondor Creek
Sample: MC13-04-TW1 (40' - 41' 4")



Notes: C_v and k calculated using t_{90} values

TEST DONE BY:
REVIEWED BY:



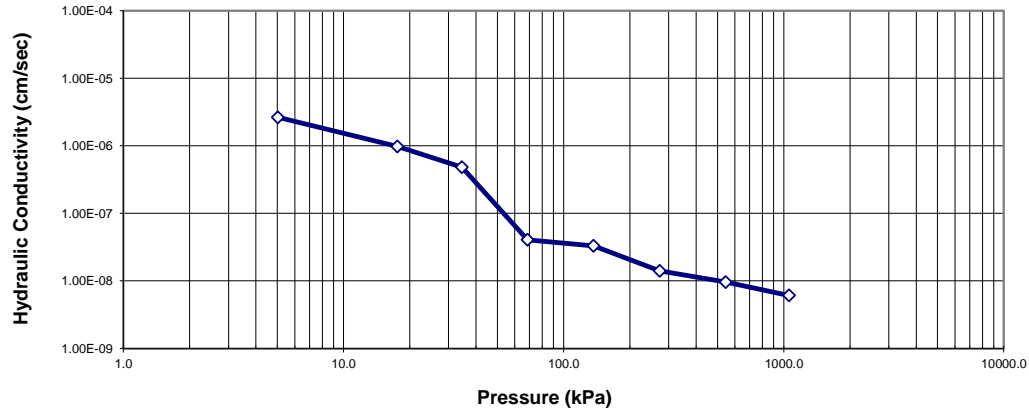
Consolidation Test Report

Mondor Creek
19-4406-9

MC13-04-TW1 (40' - 41' 4")

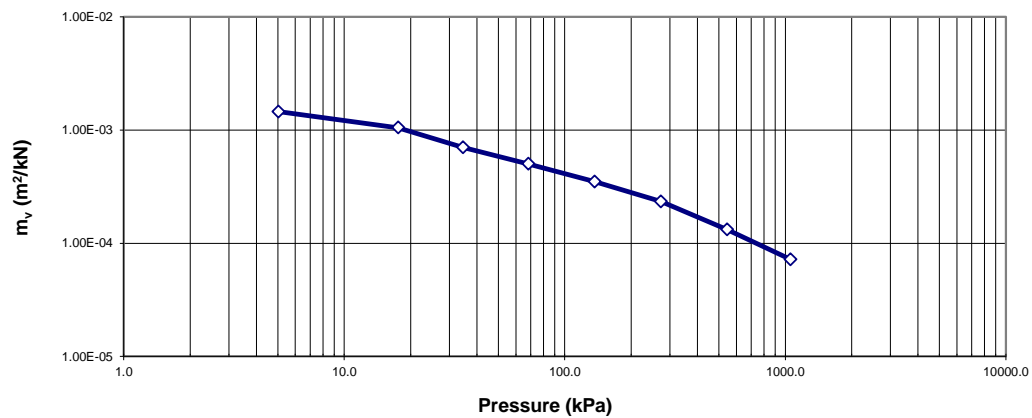
Hydraulic Conductivity vs. Pressure

Project #: 19-4406-9
Client: URS Canada Inc.
Project Name: Mondor Creek
Sample: MC13-04-TW1 (40' - 41' 4")



m_v vs. Pressure

Project #: 19-4406-9
Client: URS Canada Inc.
Project Name: Mondor Creek
Sample: MC13-04-TW1 (40' - 41' 4")



Consolidation Test Report

CLIENT: URS Canada Inc.

FILE NUMBER: 19-4406-9

PROJECT: Mondor Creek

REPORT DATE: 7-Apr-14

TEST DATES: November 18, 2013 - November 29, 2013

SAMPLE: MC13-08-TW1 (30' - 32')
Silty Clay, grey, contains 12% gravel, 9% sand, 38% silt and 41% clay, PL=18%, LL=36%

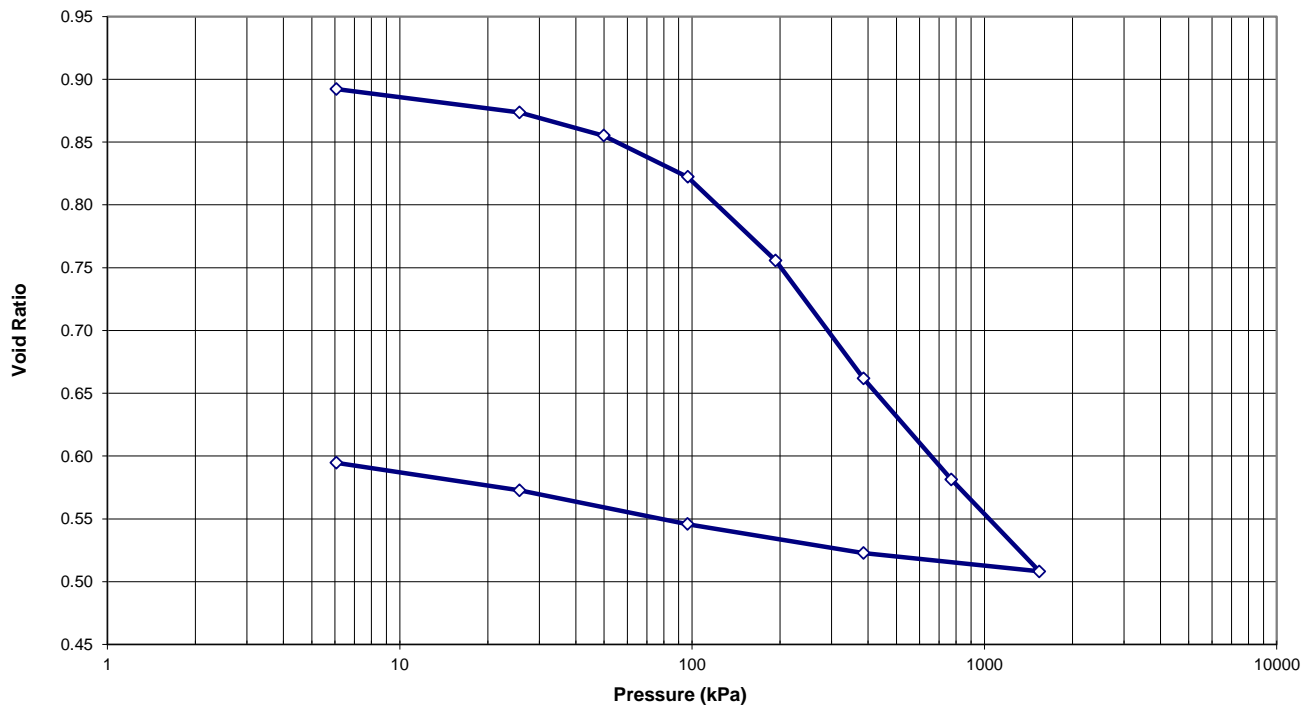
PROCEDURE: Test carried out in accordance with Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D 2435-04, method B

	<u>Start of Test</u>	<u>End of Test</u>
Wet Dens. (kg/m ³)	1923.4	2098.4
Dry Dens. (kg/m ³)	1439.3	1712.0
Moisture Cont. (%)	33.6	22.6
Void Ratio	0.897	0.595

Note: A Specific Gravity of 2.73 was measured for the void ratio and saturation calculations.

Void Ratio vs. Pressure

Project #: 19-4406-9
Client: URS Canada Inc.
Project Name: Mondor Creek
Sample: MC13-08-TW1 (30' - 32')



Consolidation Test Report

Mondor Creek
19-4406-9

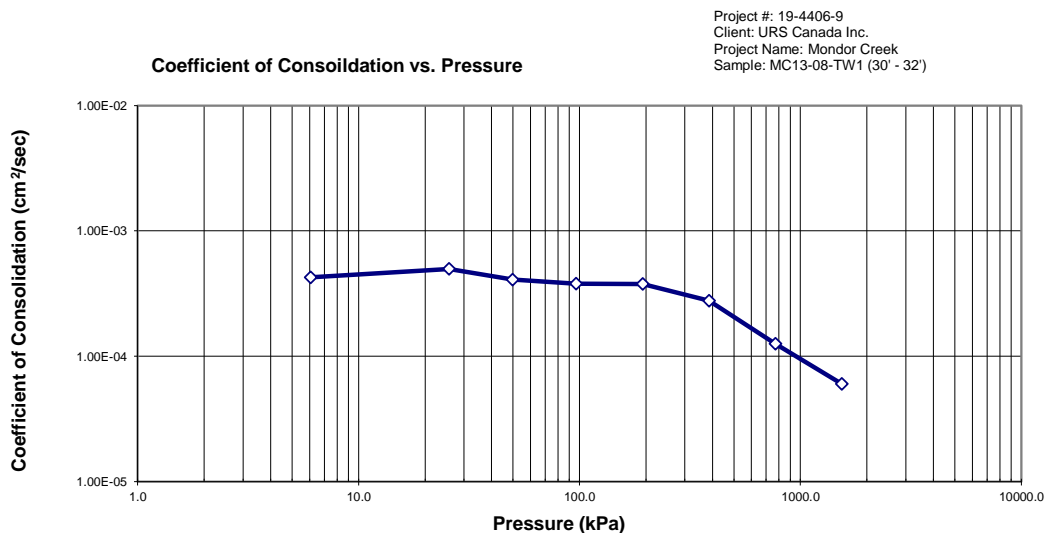
MC13-08-TW1 (30' - 32')

TRIMMING: The Specimen was manually trimmed to the size of consolidation ring, then mounted in a fixed ring consolidometer.

LOADING: A seating load of 6.1 kPa was applied and the consolidometer was flooded with distilled water. Sample was monitored to ensure no swelling effect occurred before the start of the test. Subsequent loads were applied after 100% primary consolidation was reached.

CALCULATIONS: Coefficients of Consolidation were calculated by the square root time method.

Pressure (kPa)	Corr. H. (mm)	Avg. H. (mm)	d_{90} (mm)	t_{90} (min)	c_v (cm ² /s)	Void Ratio	m_v (m ² /kN)	k (cm/s)
0.0	25.500					0.897		
6.1	25.434	25.467	-0.090	0.46	5.03E-02	0.892	4.26E-04	2.10E-06
25.7	25.186	25.310	-0.311	1.32	1.71E-02	0.874	4.98E-04	8.35E-07
49.9	24.937	25.062	-0.105	3.61	6.15E-03	0.855	4.09E-04	2.46E-07
96.6	24.495	24.716	-0.174	3.96	5.45E-03	0.822	3.79E-04	2.03E-07
193.2	23.601	24.048	-0.450	15.84	1.29E-03	0.756	3.78E-04	4.78E-08
385.7	22.339	22.970	-0.880	33.64	5.54E-04	0.662	2.78E-04	1.51E-08
770.7	21.258	21.799	-0.730	20.98	8.00E-04	0.581	1.26E-04	9.87E-09
1540.7	20.274	20.766	-0.620	13.18	1.16E-03	0.508	6.01E-05	6.82E-09
385.7	20.470	20.372				0.523		
96.6	20.780	20.625				0.546		
25.7	21.141	20.961				0.573		
6.1	21.438	21.290				0.595		

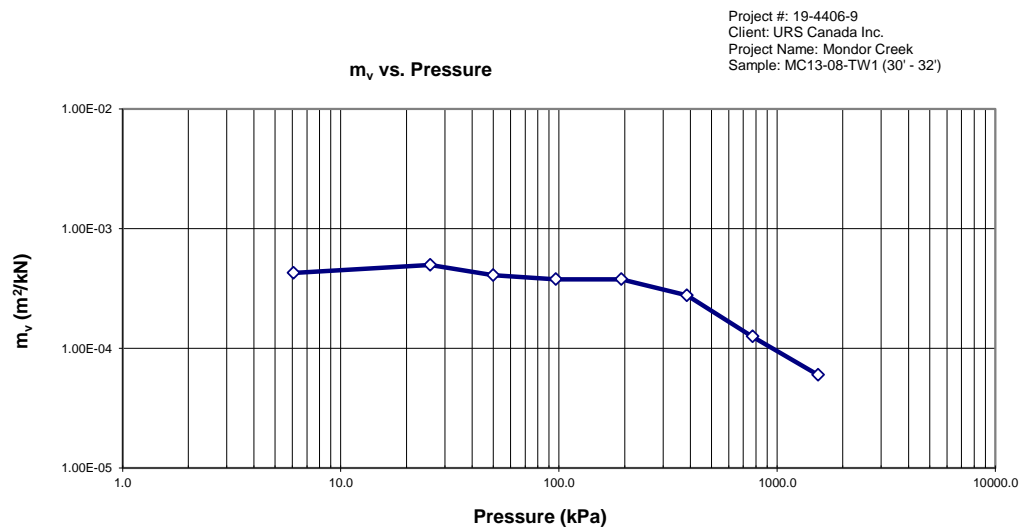
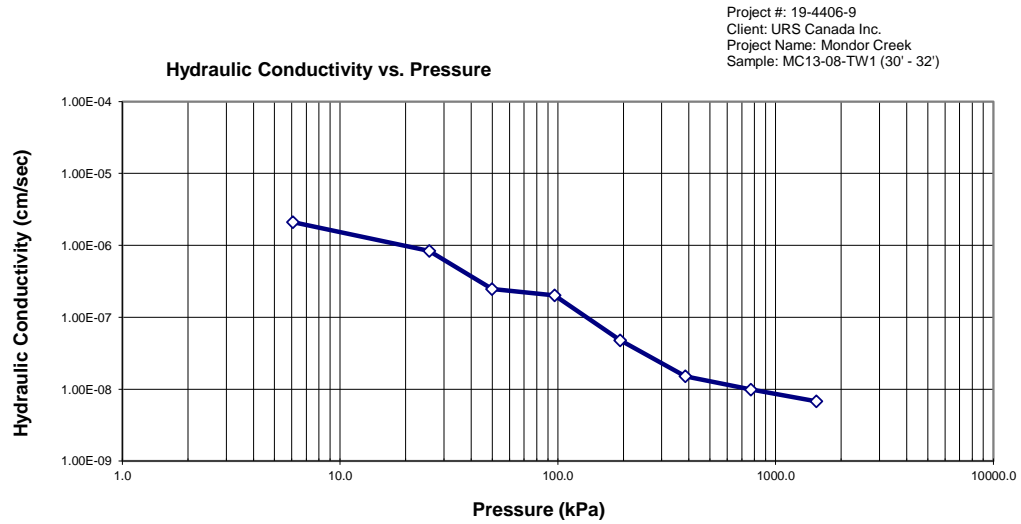


Notes: c_v and k calculated using t_{90} values

Consolidation Test Report

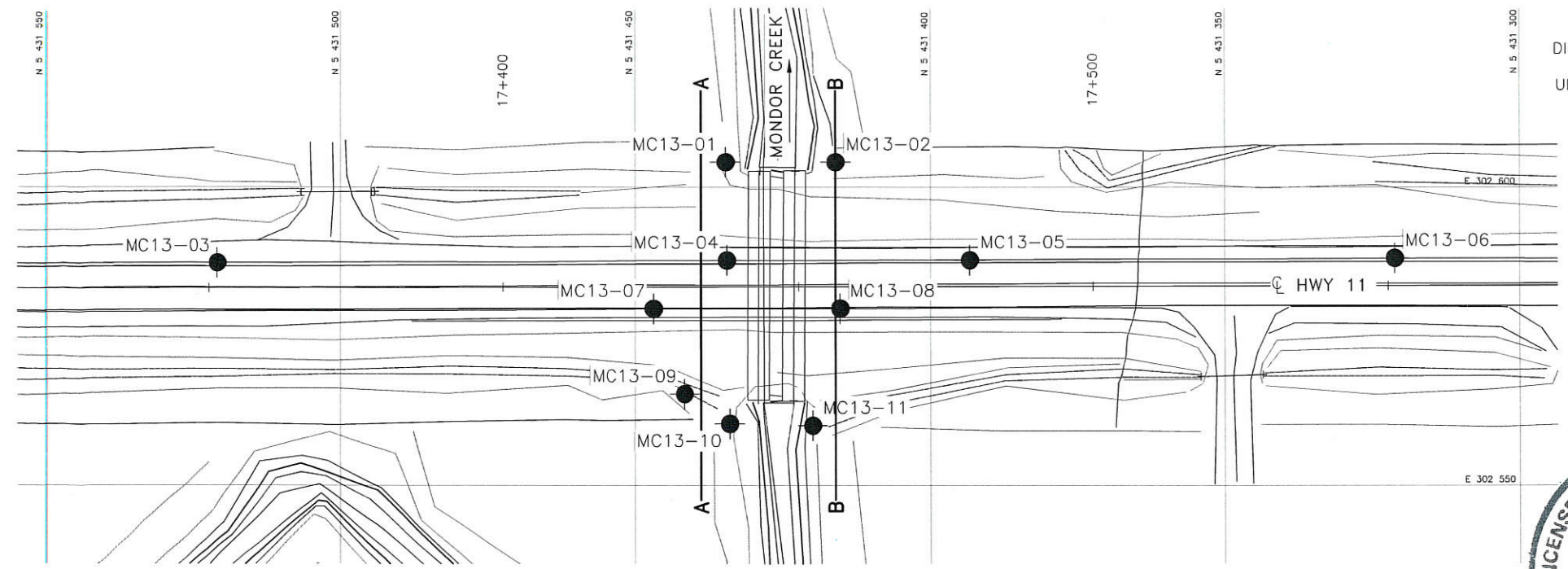
Mondor Creek
19-4406-9

MC13-08-TW1 (30' - 32')

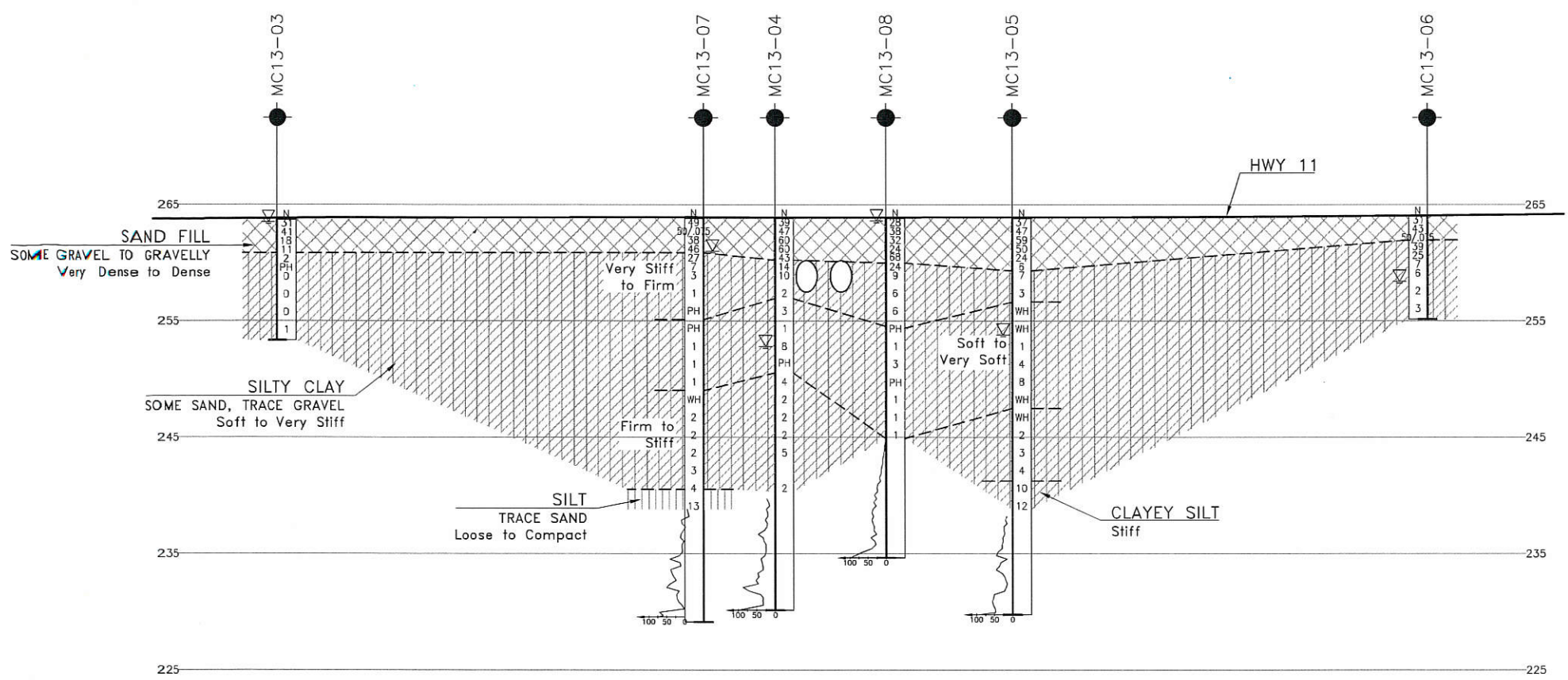


Appendix C

Borehole Locations and Soil Strata Drawings

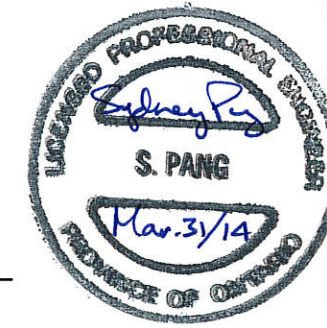
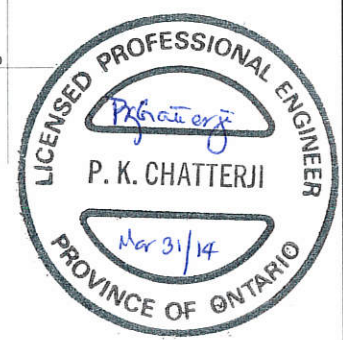


PLAN
SCALE 1:1000



PROFILE ALONG HWY 11
H 1:1000
V 1:500

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

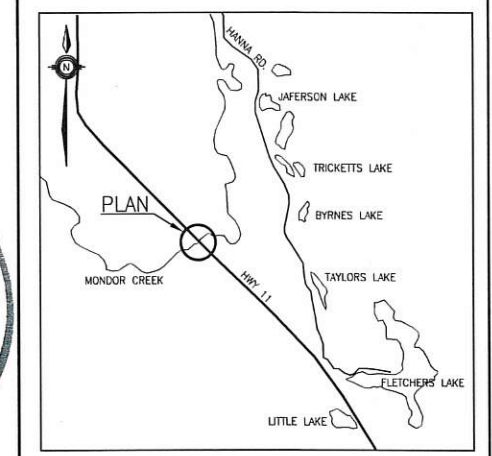


CONT No
GWP No 5169-10-00

HIGHWAY 11
MONDOR CREEK
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

URS

SHEET
S-02



KEYPLAN
LEGEND

- Borehole
- Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60' Cone, 475J/blow)
- WH Weight, Hammer
- PH Pressure, Hydraulic
- W Water Level
- HA Head Artesian Water
- P Piezometer
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
MC13-01	259.4	5 431 434.7	302 604.2
MC13-02	259.1	5 431 416.0	302 604.2
MC13-03	263.7	5 431 520.8	302 587.3
MC13-04	263.8	5 431 434.5	302 587.7
MC13-05	263.8	5 431 393.2	302 587.8
MC13-06	264.0	5 431 321.2	302 588.1
MC13-07	263.8	5 431 446.9	302 579.6
MC13-08	263.8	5 431 415.2	302 579.6
MC13-09	260.7	5 431 441.6	302 565.3
MC13-10	259.8	5 431 434.0	302 560.3
MC13-11	258.7	5 431 419.9	302 560.0

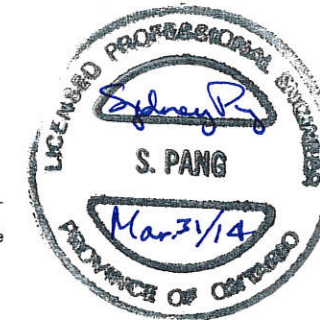
-NOTES-

- 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. 42H-53

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	SKP	CHK	SKP
DRAWN	AN	CHK	AEG
LOAD	DATE	STRUCT	DWG 2

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



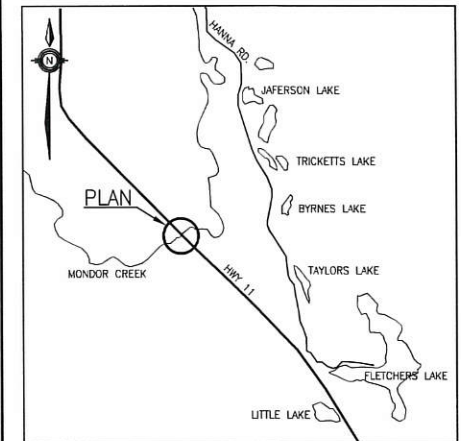
CONT No
GWP No 5169-10-00

HIGHWAY 11
MONDOR CREEK
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
S-03

URS

THURBER ENGINEERING LTD.



KEYPLAN
LEGEND

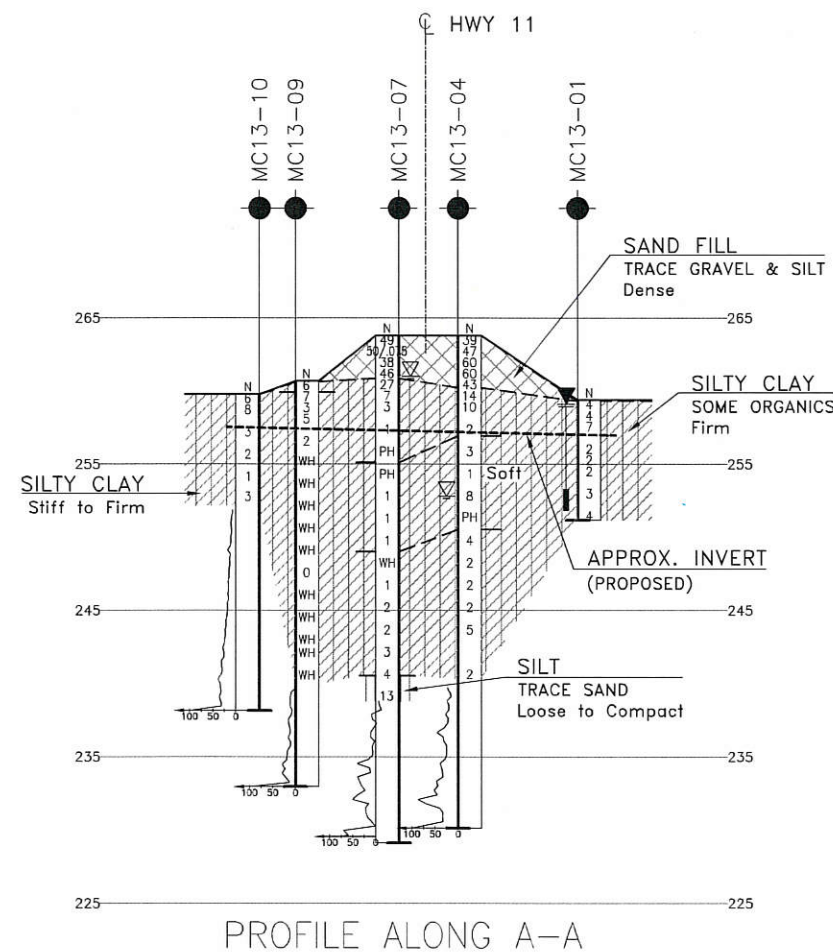
●	Borehole
⊙	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
WH	Weight, Hammer
PH	Pressure, Hydraulic
∇	Water Level
⊕	Head Artesian Water
⊕	Piezometer
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
MC13-01	259.4	5 431 434.7	302 604.2
MC13-02	259.1	5 431 416.0	302 604.2
MC13-03	263.7	5 431 520.8	302 587.3
MC13-04	263.8	5 431 434.5	302 587.7
MC13-05	263.8	5 431 393.2	302 587.8
MC13-06	264.0	5 431 321.2	302 588.1
MC13-07	263.8	5 431 446.9	302 579.6
MC13-08	263.8	5 431 415.2	302 579.6
MC13-09	260.7	5 431 441.6	302 565.3
MC13-10	259.8	5 431 434.0	302 560.3
MC13-11	258.7	5 431 419.9	302 560.0

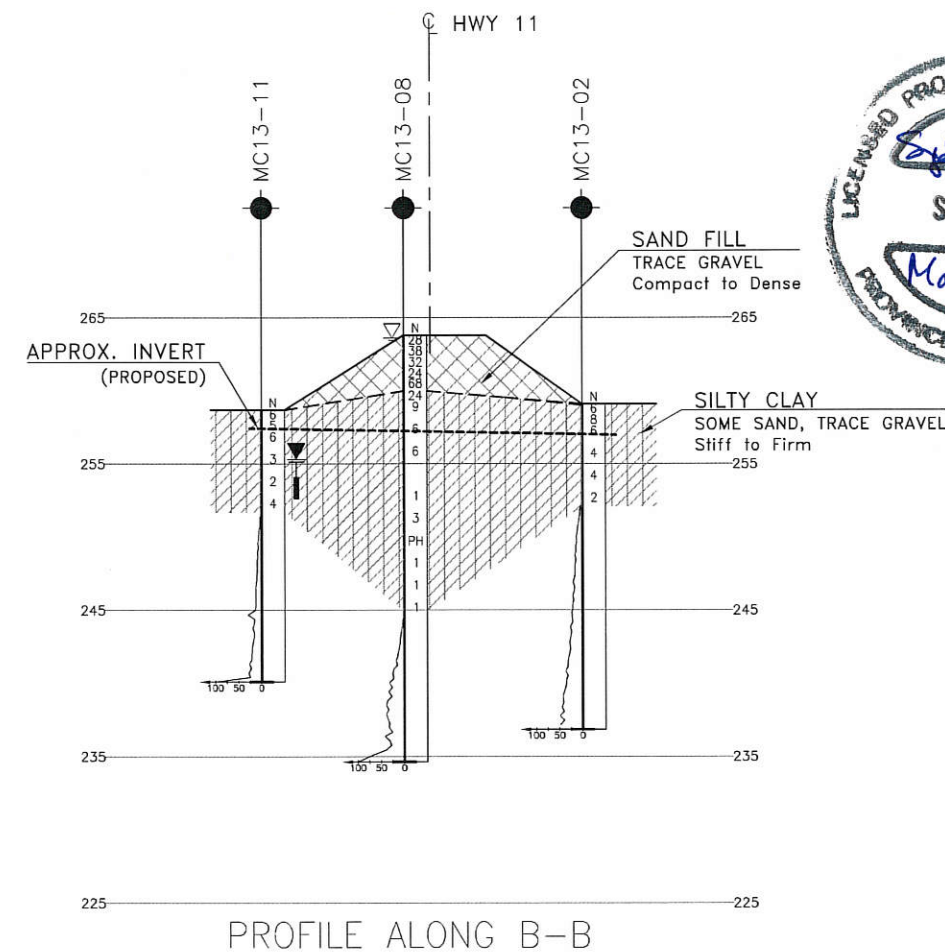
-NOTES-

- 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. 42H-53



PROFILE ALONG A-A



PROFILE ALONG B-B



H 1:1000

V 1:500

DATE	BY	DESCRIPTION
DESIGN	SKP	CHK SKP
DRAWN	AN	CHK AEG
LOAD	CODE	DATE
STRUCT	DWG	3

Appendix D

Foundation Alternatives Comparisons

COMPARISON OF ALTERNATIVE CULVERT TYPES

Proposed Works	Concrete Box (Closed) Culvert	Concrete Open Footing Culvert	Circular Pipe (concrete, steel, HDPE) Culvert
Culvert Replacement	<p>Advantages:</p> <ul style="list-style-type: none"> i. Relatively rapid installation and less disturbance to subgrade soils if precast units are used. ii. Less requirement for soil geotechnical resistances as loading is spread over a larger width. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Require dry sub-excavation for granular pad construction. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. Relatively rapid installation if precast units are used. ii. May have less environmental issues such as those involving spawning fish species. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Requires higher soil geotechnical resistances to support strip footings. ii. May require deeper sub-excavation for strip footing construction. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. May be installed using trenchless methods. ii. Steel and HDPE pipes may be more cost effective than concrete box and open footing culverts. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Steel and HDPE may not be as durable as concrete.

Appendix E

List of OPS Specifications

1. List of OPSS Documents Relevant this Project

- OPSS 206
- OPSS 209
- OPSS 404
- OPSS 422
- OPSS 501
- OPSS 517
- OPSS 518
- OPSS 539
- OPSS 804
- OPSS 902
- OPSS 1010
- OPSS 1205
- OPSD 803.01
- OPSD 810.01

Appendix F

Selected Photograph of Culvert Location



Photo 1: Mondor Creek Culvert Inlet