



Terraprobe

*Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing*

**FOUNDATION INVESTIGATION AND DESIGN REPORT
JENKINS CREEK CULVERT REPLACEMENT
HIGHWAY 520, 0.9 KM WEST OF THE HIGHWAY 510 IN MAGNETAWAN
AGREEMENT NUMBER: 5012-E-0001
G.W.P. 5446-09-00, W.P. 5447-09-01, SITE 44-286/C
GEOCRETS No. 31E-325
MINISTRY OF TRANSPORTATION, ONTARIO
NORTHEASTERN REGION**

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from foundation investigations conducted at the Jenkins Creek Culvert site where culvert replacement is proposed. The Jenkins Creek Culvert was located on Highway 520, 0.9 km west of Highway 510 in Magnetawan, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide borehole location plans, records of boreholes, stratigraphic profiles, laboratory test results and descriptions of the subsurface conditions. Models of the subsurface conditions were developed from the data obtained.

Terraprobe Inc. ("Terraprobe") conducted the investigation as a sub-consultant to G. D. Jewell Engineering Inc. ("G. D. Jewell") under the Ministry of Transportation Ontario ("MTO") Northeastern Region Agreement Number 5012-E-0001.

For reporting purpose the investigated site is identified as:

- Jenkins Creek Culvert, MTO Site #44-286/C ("Jenkins site"), Highway 520, 0.9 km west of Highway 510 in Magnetawan, 4.0 x 31.0 m (diameter x length) corrugated steel pipe with approximately 2.5 m of cover.

2 SITE DESCRIPTION & PHYSIOGRAPHY

Jenkins Creek Culvert was located at about 0.9 km west of Highway 510 in the Municipality of Magnetawan, Ontario. Highway 520 crossed Jenkins Creek via the existing culvert. At this site Highway 520 was a two-lane highway with gravel shoulders carrying east and west bound traffic.

Jenkins Creek flows generally from north to south meandering gently within a well-defined flood plain. The terrain is generally flat and within the flood plain area vegetation consisted primarily of grass, shrubs and occasional small trees. Beyond the flood plain the area was vegetated with mature stands of deciduous and coniferous trees. Bedrock outcrops were observed in the vicinity of the site.

The study area is located in the Precambrian Laurentian peneplane in north-eastern Ontario. The topography is generally irregular. Recent deposits consist of peat, gravel, sand, clay and till soils. Soil cover on both sides of the creek is generally sparse and represented by sand/silt with cobbles and boulders. In the creek bed, gravel soils were also encountered. The mineral soil cover is typically less than 1 m and may vary greatly over short distances. Locally, the depth of soil cover may extend to depths of around 20 m in the area of the site.



The soil deposits are underlain by metasedimentary rocks of the Huronian Supergroup and gneisses of the Grenville Province and their intrusive equivalents. The areas have undergone considerable folding, intrusive activity, regional metamorphism and faulting. Bedrock predominantly comprises pink granitic gneiss and dark grey migmatite. The bedrock in the immediate vicinity of the site is at various depths ranging from surface to over 20 m. Bedrock outcrops were observed in many locations in the area of the site.

3 SITE INVESTIGATION AND FIELD TESTING

The field investigation at Jenkins Creek site was conducted on October 30 to November 9, 2012, and consisted of drilling and sampling a total of fifteen test holes comprising eight boreholes, JC1 to JC8, one auger probe, JC2-P and six dynamic cone penetration tests JC3-cone to JC8-cone. The test holes were advanced to depths from 1.1 to 15.7 m below the existing ground surface. Further details of the work plan are summarized in the Table 3.1. The locations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix C.

Table 3.1 – Test Hole Details

Test Hole No.		Purpose of the Borehole	Location	Depth (m)		
				SPT/Cone/ Auger	Rock coring	Total
Borehole	JC1	Foundation	Midpoint	11.8	3.9	15.7
	JC2	Roadway protection	Midpoint	11.6	3.2	14.8
	JC3	Foundation	In front of the north end of the existing culvert	3.2	3.8	7.0
	JC4	Cofferdam	Within/close to the proposed cofferdam location	2.9	3.7	6.6
	JC5	Cofferdam	Within/close to the proposed cofferdam location	5.9	3.5	9.4
	JC6	Cofferdam	Within/close to the proposed cofferdam location	1.1	3.7	4.8
	JC7	Foundation	In front of the south end of the existing culvert	3.7	3.1	6.8
	JC8	Cofferdam	Within/close to the proposed cofferdam location	3.1	3.4	6.5
Auger Probe	JC2-P	Roadway protection	Beside Borehole JC-2	1.4	-	1.4
Dynamic Cone Penetration Test	JC3-cone	Foundation	Beside Borehole JC-3	3.2	-	3.2
	JC4-cone	Cofferdam	Beside Borehole JC-4	2.9	-	3.3
	JC5-cone	Cofferdam	Beside Borehole JC-5	5.7	-	5.7
	JC6-cone	Cofferdam	Beside Borehole JC-6	1.1	-	1.1
	JC7-cone	Foundation	Beside Borehole JC-7	3.2	-	3.2
	JC8-cone	Cofferdam	Beside Borehole JC-8	3.0	-	3.0

Tulloch Geomatics Inc. ("Tulloch") established survey control points at the Jenkins site. Tulloch surveyed Boreholes JC3 to JC8 and provided geodetic elevations to Terraprobe. Terraprobe utilized the control points to survey the remaining test holes at the Jenkins site to establish ground surface elevations at the test hole locations.



Terraprobe marked the borehole locations on the site. Access to some of the borehole locations was difficult due to locally steep slopes and existing structures. These boreholes were therefore relocated to be as close as feasible to the staked out locations while allowing safe operation of the drill rig. Utility clearances were obtained by Terraprobe prior to the field drilling.

Samples of the overburden soils were obtained at selected intervals of depth using a split spoon sampler in conjunction with Standard Penetration Testing ("SPT") as specified in ASTM Method D1586. The in-situ undrained shear strength was measured in the softer cohesive soil using an MTO type field vane. Relatively undisturbed soil samples were also collected with thin-walled Shelby Tube samplers. Boreholes JC1 to JC 8 were also advanced into bedrock using NQ size diamond coring techniques.

In addition to the testing outlined above, Dynamic Cone Penetration Test (DCPT) was conducted at selected locations. This test consists of continuously driving into undisturbed ground a 50 mm diameter cone (60 vertex angle) attached to a drill rod, with a driving energy of 475 J per blow (63.5 kg hammer dropping freely a vertical distance of 0.76 m). The number of blows for each 300 mm of penetration is recorded and this provides an indication of the relative changes in the soil density/consistency with depth.

The ground water conditions in the open boreholes were observed throughout the drilling operations. One borehole JC1 was also instrumented with standpipe piezometer consisting of 25 mm diameter PVC pipe with a slotted screen enclosed in sand to permit longer term ground water level monitoring. The location and completion details of the piezometer are summarized in Table 3.2.

Table 3.2 – Piezometer Installation Details

Piezometer Location	Piezometer Details	
	Tip Depth/ Elevation (m)	Completion Details
JC1	11.6/274.9	Piezometer with 3.0 m slotted screen installed with filter sand to 7.6 m, bentonite seal from 7.6 m to 0.6 m and a concrete encased flush mount cover from 0.6 m to ground surface.

The remaining boreholes were abandoned in accordance with MOE Regulation 903.

Various drill rigs were used for the drilling, sampling and in-situ testing operations and the installation of piezometers. A track mounted drill rig was used to drill all of test holes at Jenkins site.

The drilling, sampling and coring operations were observed on a full time basis by a member of Terraprobe's technical staff who logged the boreholes and rock cores and prepared the recovered soil and rock samples for transport to Terraprobe's Brampton laboratory for further examination and testing.



4 LABORATORY TESTING

Soils were identified in the field in accordance with the MTO Soil Classification procedures. The recovered soil samples were transported to Terraprobe's Brampton laboratory where the field soil classifications were verified and water content determinations were completed. Selected samples were also subjected to a laboratory testing programme consisting of gradation analysis and Atterberg Limits tests. The results of this testing program are shown on the Record of Borehole sheets in Appendix A and on the various figures in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A. Details of the encountered soil and rock stratigraphy are also presented on the "Borehole Locations and Soil Strata" drawings in Appendix C. The stratigraphic boundaries shown have been inferred from non-continuous samples and observations of drilling resistance and typically represent a transition from one soil or rock type to another. These boundaries should not be interpreted to represent exact planes of geological change. The subsurface conditions are confirmed at the borehole locations only, and will vary between and beyond the locations investigated. The following discussion has been simplified in terms of the major stratigraphic units.

The subsurface stratigraphy encountered in Boreholes JC1 and JC2 drilled on the roadway generally comprised flexible pavement (asphaltic concrete and aggregate), sand fill and deposits of gravel, sand, sand and silt, and sandy silt. The overburden soils were underlain by metamorphic gneiss bedrock at depths of 11.8 and 11.6 m (Elev. 274.7 m) respectively.

Boreholes JC3 to JC8 drilled at the proposed cofferdam and the culvert inlet and outlet locations consisted of clayey silt fill, organic silt, sand fill, and deposits of sand, sand and silt, silt and silty sand. The overburden was underlain by metamorphic gneiss at depths of 1.1 to 5.9 m (Elev. 275.3 to 282.0 m).

The major soil strata encountered are described as below.

5.1 Flexible Pavement

A flexible pavement comprising of 50 to 130 mm thick asphaltic concrete underlain by a layer of aggregate in thicknesses of 190 and 270 mm was encountered in Boreholes JC1 and JC2. The granular fill extended to elevations of 286.3 and 285.8 m and was inferred to be in a compact state.

5.2 Topsoil

A surface topsoil layer about 80 to 190 mm thick was encountered in Boreholes JC3 to JC8. Topsoil thickness may vary between and beyond the boreholes.

5.3 Organic Silt

Organic silt was contacted at depths of about 0.2 to 1.5 m (Elev. 279.9 to 283.0 m) beneath the ground surface in Boreholes JC4, JC6 and underneath sand fill in Borehole JC7. The deposit had a thickness of about 0.9 to 2.7 m and extended to depths of 1.1 to 3.1 m (Elev. 277.9 to 282.0 m).



The organic silt was very soft to firm and had moisture contents ranging from about 24 to 138%, and typically above 60%.

5.4 Fill – Sand, Clayey Silt

Fill consisting of sand or clayey silt was encountered beneath the flexible pavement in Boreholes JC1 and JC2 and underneath the topsoil in Boreholes JC3 and JC7. The fill extended to depths of 1.5 to 6.6 m (Elev. 279.7 to 280.4 m) below the existing ground surface.

The grain size distribution plots of samples of the sand fill recovered from the boreholes are presented on Figure B1-1. These results show a grain size distribution consisting about of 3 to 22% gravel, 75 to 94% sand and 3% silt and clay size particles.

N-values in the range of 6 to 56 blows for 0.3 m were determined in the SPT test carried out in the fill, inferring a loose to very dense relative density or soft consistency. The water contents of the fill samples ranged from 4 to 40%.

5.5 Gravel

A deposit of gravel was encountered at a depth of 6.1 m (Elev. 280.4 m) in Borehole JC1 and extended to a depth of 7.6 m (Elev. 278.9 m) below ground surface.

A single N-value of 6 blows per 0.3m was determined in this deposit, indicating a loose relative density. The moisture content of one sample from this stratum was about 18%.

5.6 Sandy/Silty Soils

Cohesionless sandy/silty soils of various compositions (sandy silt, sand, sand and silt, and silt) were encountered below the gravel in Borehole JC1, underneath the sand fill in Boreholes JC2 and JC3, beneath the topsoil in Boreholes JC5 and JC8, and under the organic silt in Borehole JC7. The sandy/silty soil deposits were approximate 0.2 to 5.7 m in thickness and extended to bedrock at depths of 3.1 to 11.8 m (Elev. 274.7 to 281.0 m).

The results of grain size distribution analysis of samples recovered from these deposits are shown in Figure B1-2. These results show grain size distribution consisting of 0-10% gravel, 6-65% sand, 25-70% silt and 3-25% clay size particles. Atterberg Limits test carried out on one sample of the silt showed liquid limit and plastic limit of 21 and 18 per cent respectively as shown in Figure B1-3.

N-values determined in these deposits ranged from 4 to greater than 100 blows per 0.3 m indicating a loose to very dense relative density. The moisture contents of the sandy/silty samples ranged from 12 to 29%.

5.7 Bedrock

Biotite gneiss bedrock was contacted below the overburden soils at the depths ranging from 1.1 to 11.8 m below the existing grade. The gneiss bedrock was proved by coring at all of the boreholes locations and the bedrock depth and elevations to the top of bedrock are summarized in Table 5.1.



Table 5.1 – Depth to Bedrock

Borehole Number	Depth to Bedrock (m)	Top of Bedrock Elevation (m)
JC1	11.8	274.7
JC2	11.6	274.7
JC3	3.2	276.8
JC4	2.9	277.9
JC5	5.9	275.3
JC6	1.1	282.0
JC7	3.7	277.8
JC8	3.1	281.0

The gneiss was light grey to pink, fine to medium grained, with close to moderate spaced flat to dipping cross joints. The bedrock was unweathered and massive to strongly foliated.

The gneiss bedrock exhibited high strength with biotite rich layers. Total core recovery in this bedrock ranged from 80 to 100% and the RQD values ranged from 0 to 100% however the RQD values were typically above 50%. Based on these results the rock quality is considered to be fair to good with occasional zones of very poor to poor quality rock.

5.8 Groundwater Level

A standpipe piezometer was installed in Borehole JC1 and the groundwater level readings were measured on separate visits made after the completion of drilling. The groundwater level records are presented in Table 5.2.

Table 5.2 – Groundwater Level Measurements

Borehole	Date	Water Levels	
		Depth (m)	Elevation (m)
JC1	November 25, 2012	5.8	280.7
	December 4, 2012	5.7	280.8

Based on General Arrangement Drawing provided by G. D. Jewell, the water level in Jenkins Creek was recorded at Elev. 280.14 m on November 1, 2012 indicating that the groundwater table existed just above the creek water level.

All groundwater observations at this site were short term and the levels are expected to fluctuate seasonally and with precipitation conditions. The ground water level may also be affected by the free water level in the creek.

5.9 Miscellaneous

The drilling, sampling and in-situ testing operations and the installation of piezometers were conducted with various drill rigs owned and operated by Walker Drilling Ltd. of Utopia, Ontario. A track mounted drill rig was used to drill all of test holes at Jenkins site. Traffic control was provided by Jackson Trademark Services Ltd. of Aurora, Ontario.



The boreholes were advanced using hollow-stem augers and casing and washboring methods. Rock cores were retrieved by NQ size diamond coring techniques.

Mr. Wen Zhu, E.I.T. carried out the field work and the laboratory testing was performed at Terraprobe's Brampton laboratory. The report was written by Mr. W. Lei, P. Eng. and Mr. J. G. Muckle, Senior Geotechnical Engineer. Mr. Michael Tanos, P. Eng., MTO Designated Principal Contact carried out an independent review of the report.



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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

6 GENERAL

This report presents interpretation of the geotechnical data in the factual report and provides geotechnical design recommendations for Jenkins Creek Culvert replacement (MTO Site # 44-286/C) on Highway 520, Northeastern Region, Ontario.

The existing Jenkins Creek Culvert ("Jenkins site") is located 0.9 km west of Highway 510 in Magnetawan, Township of Chapman, District of Huntsville. The existing culvert consists of a round corrugated steel pipe culvert measuring 31.0 m in length and 4.0 m in diameter that carries Highway 520 east bound and west bound traffic over Jenkins Creek. It is proposed to replace the existing culvert with a new single span structure in the same location as the existing structure. It is understood that a full road closure is planned. A detour may be constructed to maintain Highway 520 traffic during the construction of the new culvert. The design of the detour is outside of the scope of this assignment.

Three replacement options are under consideration for the new Jenkins Creek Culvert. The options include a precast concrete box culvert, a sheet pile/prestressed slab structure and precast concrete rigid frame supported on cast-in-place footings.

7 STRUCTURE FOUNDATIONS

7.1 Structure Foundations

The subsurface stratigraphy encountered in Boreholes JC1 and JC2 drilled on roadway generally comprised flexible pavement and sand fill overlying strata of gravel, and loose to compact sands and silts. Bedrock was encountered at a depth of about 11.7 m (Elev. 274.7 m). Ground water was measured in the standpipe piezometer installed in Borehole JC1 at a depth of about 5.7 m below the ground surface (Elev. 280.8 m) at the time of the investigation.

Some of the boreholes drilled on the upstream and downstream sides of the culvert penetrated a deposit of highly compressible organic silt to about elevation 278 m. Other boreholes penetrated strata of loose to compact sands and silts. Bedrock was encountered in boreholes drilled on the upstream side of the culvert at depths of about 2.9 to 5.9 m (Elev. 275.3 to 277.9 m). Boreholes drilled on the downstream side of the culvert encountered the bedrock surface at depths of 1.1 to 3.7 m (Elev. 277.8 to 282.0 m).



The existing CSP culvert has an invert elevation of about 278.5 m. The results of boreholes JC1 and JC2 suggest that the organic silt may have been excavated in the immediate area of the existing structure.

Three replacement options including sheet pile/prestressed slab structure, precast concrete rigid frame on cast-in-place footings and precast concrete box culvert, are being considered for the new culvert. Accordingly three foundation options including Driven Piles, Spread Footings and Granular A Pad have been considered for the culvert replacement.

The presence of the highly compressible organic silt, the relatively low bearing resistance of the sand and silt strata that underlie the site, and the high groundwater levels result in potentially difficult conditions that will impact the design of the culvert.

7.1.1 Granular A Pad

Based on arrangement drawings provided by G. D. Jewell, the founding level for a new precast concrete box culvert would be at about elevation 278.0 m. Loose to compact sandy silt, sand and silt, or sand were encountered in Boreholes JC1, JC2, JC3 and JC7 at and below elevation of 278.0 m.

It is understood that the flow of water through the existing culvert would be temporarily diverted away from the construction area and proper dewatering would be carried out. Therefore the construction will proceed in sufficiently dry conditions and Granular A pad can be used to support the new culvert. Depending on the effectiveness of the dewatering, consideration could be given to using clear crushed stone to support the new culvert rather than Granular A.

Typically a precast box culvert will be supported on a Granular A pad. Preparatory work may be needed in localized areas to remove weak and disturbed soils if encountered during the construction within the footprint of the new culvert, to enhance the stability and to ensure that settlement will be within an acceptable range. The Granular A pad will need to be thickened where required to replace the sub-excavated soil.

The specifications with respect to placement water content, lift thicknesses and degree of compaction must be consistently achieved to ensure that the engineered fill (i.e. the Granular A pad) will perform satisfactorily. The Granular A must be placed in lifts of 300 mm thickness (or less), with each lift uniformly compacted to 95% Standard Proctor Maximum Dry Density ("SPMDD"). Confirmatory inspection and testing of the engineered fill must be carried out on a full-time basis by the geotechnical engineer.

The upper 300 mm of the Granular A pad must be compacted to 100% SPMDD. The Granular A pad must have a minimum nominal thickness of 500 mm. A suitable non-woven geotextile is to be placed between the Granular A pad (or the clear crushed stone) and subgrade soils to prevent fine particles from migrating into the granular material and to help stabilize the base of the excavation. Adequate control of the groundwater is essential to the effectiveness of this type of construction. The underlying soil strata are fine grained and highly susceptible to disturbance. For this reason vibratory compaction equipment should only be used with great caution.



Closed box cell culverts and wing walls to be supported on the Granular A pad constructed as outlined above, may be designed using a factored geotechnical resistance at Ultimate Limit States (ULS) of 225 kPa and a geotechnical reaction of 150 kPa at Serviceability Limit States (Type II). In the case of pre-cast units, it may be necessary to place a 100 mm thick leveling course of uncompacted Granular A base or fine aggregate beneath the culvert sections.

Prior to placing the levelling course, the founding subgrade must be cleaned of all deleterious materials as well as any standing water. The founding subgrade must be inspected and approved by the geotechnical engineer prior to proceeding with further construction work. If construction proceeds during freezing weather conditions, adequate temporary frost protection for the founding subgrade must be provided. At the both ends of the new culvert, the founding subgrade of the culvert should be provided with a minimum of 2.0 m of earth cover or equivalent thermal protection.

The sliding resistance of mass concrete on the subgrade surfaces may be computed based on ultimate coefficients of friction of 0.7 for a Granular A pad.

Passive earth pressure resistance is generally not considered as a resisting force against sliding for conventional structure design because a structure must deflect significantly to develop the full passive resistance.

7.1.2 Spread Footings

If the option of precast concrete rigid frame is selected, then cast-in-place spread footings will be required to support the new culvert. The new culvert will be approximately located at the same location as the existing one.

Based on the preliminary culvert design provided by G. D. Jewell, the founding depth would be at about elevation 278.0 m. The subsurface conditions encountered in the four Boreholes JC1, JC2, JC3 and JC7 at and below the proposed founding level generally consisted of loose to compact sands and silts that are highly susceptible to disturbance. The relatively low bearing resistance of soil at and below the founding level would result in a large footing width for the precast rigid frame, with the potential for significant total and differential settlements. Alternatively, the structure could be supported on driven piles.

Based on the above and from a foundation engineering perspective, the alternative of a concrete rigid frame on cast-in-place footing at the site has not been recommended.

7.1.3 Driven Sheet Piles

If the sheet pile/prestressed slab design alternative is selected, the sheet piles are likely to be driven to practical refusal on gneiss bedrock at a depth of about 12 m (Elev. 274.7 m). The overlying fill and the native soil deposits may contain cobbles and boulders and the piles may encounter these obstacles during driving. Based on the General Arrangement provided by G.D. Jewell, the top portion of sheet piles (elev. 279.0 to 284.0 m) will be required to resist lateral earth pressure from the embankment fill. Sheet piles can be driven to effective refusal on bedrock.



7.1.4 Recommended Foundation Alternative

From a foundation engineering perspective, the precast concrete box culvert supported on a Granular A pad is the preferred option for the Jenkins Creek Culvert replacement.

7.2 Frost Cover

The frost penetration for the culvert site is 2.0 m. Therefore, all footings should have at least 2.0 m of earth cover or equivalent synthetic insulation for frost protection.

A 125 mm thick Dow Styrofoam insulation or equivalent can be placed underneath the culverts for frost protection. The installation details for the insulation should be developed in consultation with the manufacturer.

8 EXCAVATION

All excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the soils at Jenkins site may be classified as Type 3 soils above the water table and Type 4 soils below the water table. Excavations in the Type 3 soils may be sloped at 1H:1V and excavations in Type 4 soils may be sloped at 3H:1V or flatter.

Where workers must enter excavations extending deeper than 1.2 m, the trench walls must be suitably sloped and/or braced in accordance with the Occupational Health and Safety Act and Regulations for Construction Projects.

Surface drainage should be designed to direct flow of surface water away from the excavations. Excavation to several meters below the water table will be required to construct the culverts and it is possible that the sand fill contains large pieces of rock. Excavations should be undertaken in accordance with OPSS 902.

9 GROUNDWATER CONTROL

At the Jenkins site, the groundwater levels were measured in the standpipe piezometer installed in Borehole JC1 at depths of 5.8 m (Elev. 280.7 m) and 5.7 m (Elev. 280.8 m) below the ground surface on November 25 and December 4, 2012 respectively. The excavations will extend several meters below the measured water levels and excess hydrostatic pressure exists in the underlying sandy layer.

It is understood that the flow of water through the existing culvert would be temporarily diverted away from the construction area so that construction will proceed in sufficiently dry conditions as per OPSD 221.010, OPSD 221.020 or OPSD 221.030 as appropriate. An interceptor trench on the existing embankment is also recommended to prevent surface water from entering the excavation.

It is expected that excavation to about elevation 278 m would be required at the Jenkins site. The excavation will penetrate the sand fill and native sandy soils (gravel, sandy silt, sand and silt) and the excavation invert would be about 2.8 m below the measured ground water level of 280.8 m. The creek water would be diverted away through a temporary bypass pipe culvert. Ground water seepage into the excavation should however be expected from the permeable sandy soil layers. Effective dewatering is anticipated to be required at the site.



The design of the dewatering system should be the responsibility of the Contractor. If excavations are extended into the sandy layer, it is recommended that the groundwater level be temporarily lowered to 1.0 m below the elevation of the deepest excavation. The contract documents should contain a NSSP alerting the contractor that in view of the non-cohesive nature of the soil and high groundwater table proper dewatering scheme would be required for excavation and construction in dry conditions. The suggested wording for this NSSP is included in Appendix E.

A Permit To Take Water (PTTW) is required for any water taking if the volume exceeds 50,000 L/day. A PTTW for groundwater control will most likely be required for the site where the excavations are below the water table and are made within the high permeability sandy/silty soils. The rate and volume required for dewatering will be dependent on the construction methods and staging chosen by the contractor.

Any accumulation of water from the base of the excavation should be removed prior to culvert installation or compacting granular fill. Culvert installation or compacting engineered fill must be done in the dry.

10 BEDDING

All disturbed, loosened or softened soils and deleterious material must be removed from the base of the excavation before bedding material is placed. It is anticipated that the final grades and geometries of the existing embankment of the Jenkins site will be kept unchanged. It is recommended that the fill material in these areas consist of OPSS Granular A material.

Bedding material should consist of OPSS Granular A material. Additional bedding requirements that may be imposed by the supplier must also be followed.

11 CAMBER

Flexible culverts on compressible soils, especially under high embankments, should be longitudinally cambered to counteract the effects of differential settlement, and so avoid ponding inside the culvert.

The existing road embankments have been in place for many years and no grade changes or embankment widening is proposed. On this basis differential settlement of a flexible culvert is expected to be relatively minor and cambering would not be warranted.

12 BACKFILLING

Backfill around the culvert should be carried out as per OPSD 803.010 (concrete culvert), or OPSD 802.010 (Flexible Pipe) and the backfill should consist of free-draining, non-frost susceptible granular materials in accordance with OPSS 1010. The excavated material comprising the sand fill at the site can be used for backfilling purposes provided it is free of organics and other deleterious material. This material will also require moisture conditioning prior to its placement. All granular fill (meeting OPSS 1010 specifications) should be placed in loose lifts not exceeding 200 mm thick and be compacted to at least 95% of its SPMDD.



For fills below the ground water level or immediately below the roadway, it is recommended that Granular A material be used. Where necessary, proper tapering should be provided as shown in OPSD 803.031. The design should also incorporate a subdrain.

Heavy compaction equipment should not be used adjacent to the walls and roof of the culvert. The height of the backfill to the culvert walls should be maintained equal on both sides of the structure during all stages of backfill placement. Compaction equipment to be used adjacent to retaining structures should be restricted in accordance with Special Provision 105S10. Backfilling operations should be undertaken in accordance with OPSS 902.

13 EARTH PRESSURE

Earth pressures acting on the structure should be computed in accordance with Clause 6.9 of the CHBDC but generally are given by the expression:

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

P_h = horizontal pressure on the wall (kPa)

K = earth pressure coefficient (see Table 13.1)

γ = unit weight of retained soil (see Table 13.1)

h = depth below top of fill where pressure is computed (m)

q = value of any surcharge (kPa)

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 1.7 m for Granular B Type I or at a depth of 2.0 m for Granular A or Granular B Type II.

Earth pressure coefficients for backfill to the headwall and wingwall are dependent on the material used as backfill. Typical values are given in Table 13.1.

Table 13.1 – Earth Pressure Coefficients

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 $\phi = 32^\circ; \gamma = 21.2 \text{ kN/m}^3$		Rock Fill $\phi = 42^\circ; \gamma = 19.0 \text{ kN/m}^3$	
	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*	0.20	0.28*
At rest (Restrained Wall)	0.43	-	0.47	-	0.33	-
Passive (Movement Towards Soil Mass)	3.70	-	3.30	-	5.0	-

* For wing walls.



The factors in the table above are “ultimate” values and require certain movements for the respective conditions to be mobilized. The values to use in design can be estimated from Figure C6.16 in the Commentary to the CHBDC, 2006.

14 ROADWAY PROTECTION

Should roadway protection be considered for the culvert construction, a road protection system or a temporary shoring system should be constructed in accordance with the Occupational Health and Safety Act of Ontario (OHSA). The shape of the soil pressure distribution diagram behind a shoring system depends upon the type of soil to be encountered and the amount of movement that can be permitted. The shoring system can be restrained, fixed or flexible. The sequence of work may also alter the shape of the pressure diagram during the various construction phases.

Earth pressure computations must also take into account the ground water level. Above the ground water level, earth pressure is computed using the bulk unit weight of the retained soil. Below the ground water level, the earth pressures are computed using the submerged unit weight of the soil. A hydrostatic pressure is also applied if the retained soil is not fully drained.

Flexible shoring should be designed on the basis of the active earth pressure coefficient (K_a). Where limited shoring movement (less than performance Level 1) is required the design should be based on the at rest earth pressure coefficient (K_o). For “kick out” design the lateral resistance should be computed on the basis of the passive earth pressure coefficient (K_p).

Decisions regarding shoring methods and sequencing are the responsibility of the Contractor. Shoring should be designed by a licensed Professional Engineer experienced in shoring design. Temporary shoring can be designed for a Performance Level 2, 25 mm maximum horizontal displacement.

At Jenkins site the boreholes JC1 and JC2 were drilled through the existing roadway embankment, in which the sand fill overlaying gravel and sandy or silty soils was encountered. The recommended unfactored values of the parameters for use in the design of structures subject to unbalanced earth pressures are given in Table 14.1. In addition an equivalent surcharge load should be included to account for the traffic loading.

Table 14.1 - Earth Pressure Coefficients

Soil	ϕ (deg)	γ (kN/m ³)	K_a	K_o	K_p
Sand Fill	25	19	0.36	0.53	2.77
Gravel	35	20	0.27	0.43	3.70
Sandy Silt, Sand, Sand And Silt	28	19	0.36	0.53	2.77

15 STAGED CONSTRUCTION

It is understood that a road closure is considered for culvert construction at Jenkins site.



Based on the information provided by G. D. Jewell, the road widening is not required during the construction. Otherwise the widening area may overload the weak/soft subgrade soils, resulting in excessive settlement and slumping.

16 APPROACH EMBANKMENTS

At the Jenkins site, road closure would be carried out for the culvert construction. The final grade and geometry of the embankment at the site would be kept the same as the existing embankment.

16.1 Stability

The local and global stability of the embankment fill will depend on the slope geometry and also to a large degree on the material used to construct the embankment. The existing embankment side slopes at the Jenkins site have performed satisfactorily for many years. Therefore, the same geometry of the embankments will have a high probability of providing stable performance and the risk will be low.

The specifications with respect to placement water content, lift thicknesses and degree of compaction must be consistently achieved to ensure that the embankments will perform satisfactorily.

16.2 Settlement

The majority of soils underlain at the Jenkins site are sandy soils, a significant proportion of settlement is expected to be immediate and essentially complete by the end of construction, and the post-construction settlements are expected to be minimal (less than 25 mm).

It has been assumed that the deleterious materials if encountered would be removed in preparation for the new culvert and that the new embankment fill would be benched into the existing embankment.

17 EMBANKMENT CONSTRUCTION

To preserve continuity of drainage of the existing roadway embankment, Granular B material has been recommended for the embankment fill. Embankment construction should be in accordance with OPSS 501 and OPSS 206. Benching between existing fill and new fill should be established by benching in accordance with OPSD 208.010.

Proper erosion control measures should be implemented both during construction and permanently. Temporary erosion and sediment control must be provided in accordance with OPSS 577 and embankment slopes must be reinstated with permanent erosion protection in accordance with OPSS 511.

It is also imperative that the construction include provisions for preventing the flow of surface water down the face of the unprotected slopes. Surface water must be directed to protected outfalls/outlets designed to drain away from the embankment.



18 EROSION PROTECTION

Erosion protection should be provided at the culvert inlet and outlet (including the slopes and sides).

18.1 Clay Seal

At the inlet and outlet areas erosion protection could consist of a clay seal. The purpose of the clay seal is to ensure that water flow is channelled through the culvert and does not seep through the backfill around and underneath the structure. It should be ensured that the clay seal extends to cover all the granular backfill materials to prevent seepage. The clay seal should therefore be continuous around the culvert and have a minimum compacted thickness of 0.6 m and should extend at least 1 m above the high water level or the top of granular backfill. The clay seal should be protected by a layer of rip-rap. The material used for the clay seal should conform to the requirements stipulated in OPSS 1205.

18.2 Cut-off and Head Walls

Alternatively, concrete cut-off and head walls can be constructed to protect the granular backfill and prevent seepage around the culvert.

Concrete cut-off walls and head walls can also be used to protect the granular fill around the culvert outlet against erosion and scour. In this case, however, filtered erosion protection such as rip-rap should be provided along the channel and the sides beyond the concrete cut-off and head walls at the outlet. The rip-rap layer should cover all surfaces on the embankment slopes with which creek water is likely to be in contact. The rip-rap treatment at the inlet and outlet of the culverts should conform to OPSD 810.010, OPSD 810.020, OPSS 511 and SP511S01.

The above recommendations are suggestions only. The design of erosion protection schemes for the stream bed in the inlet and outlet areas will depend on hydrologic, hydraulic and/or other concerns. We recommend that a qualified geomorphologist be consulted to design the specifics of the channel, culvert outlet and inlet (i.e. thickness and extent of protection) and scour depth. Footings must also be placed below the scour depth.

19 COFFERDAM

Cofferdams are temporary enclosures to keep out water and soil so as to permit dewatering and construction of the permanent structure in the dry.

At Jenkins site, the Jenkins Creek has comparatively a small amount of flow, and an earth cofferdam may be feasible. The loads such as hydrostatic pressure, wave forces, current forces must be considered for the design of the cofferdam. The contractor has responsibility for the design of the cofferdam.

20 CONSTRUCTION CONCERNS

During construction, the Contract Administrator should employ experienced geotechnical staff to observe construction activities related to the foundation construction.

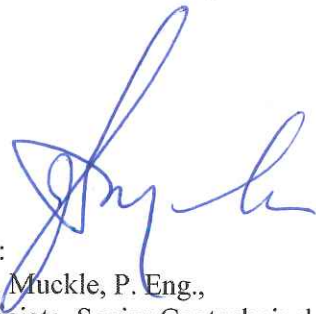


Potential construction concerns include, but are not necessarily limited to:

- The potential for encountering soft/weak soils at the founding grade that would necessitate sub-excavation and replacement with engineered fill;
- The susceptibility of the subgrade soil to disturbance from construction activity and the requirement to remove and replace disturbed soil that is not required in the design;
- The potential for erosion and undermining of exposed soil due to seepage of groundwater or creek water from underneath cofferdam;
- The potential for damage during construction resulting from increased run-off from storm events; and
- Shallow bedrock would be encountered at the location of the proposed bypass pipe at Jenkins site.



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TABLE

TERRAPROBE INC.



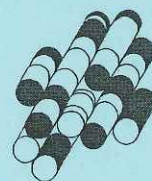
TABLE 1

DOCUMENT	TITLE
OPSS 206	Construction Specification for Grading
OPSS 501	Construction Specification for Compacting
OPSS 511	Construction Specification for Rip-Rap, Rock Protection and Granular Sheeting
OPSS 517	Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation
OPSS 539	Construction Specification for Temporary Protection Systems
OPSS 571	Construction Specification for Sodding
OPSS 572	Construction Specification for Seed and Cover
OPSS 577	Construction Specification for Temporary Erosion and Sediment Control Measures
OPSS 902	Construction Specification for Excavation & Backfilling of Structures
OPSS 1010	Material Specifications for Aggregates - Base, Subbase, Select Subgrade, and Backfill Material
OPSS 1205	Material Specification for Clay Seal
OPSD 208.010	Benching of Earth Slopes
OPSD 221.010	Temporary Water Passage System, Culvert in Watercourse
OPSD 221.020	Temporary Water Passage System, Pumping and Piping
OPSD 221.030	Temporary Water Passage System, Temporary Channel or Culvert Outside Watercourse
OPSD 802.010	Flexible Pile Embedment and Backfill, Earth Excavation
OPSD 803.010	Backfill and Cover for Concrete Culverts
OPSD 803.031	Frost Treatment-Pipe Culverts, Frost Penetration Line between Top of Pipe and Bedding Grade
OPSD 810.010	Rip-Rap Treatment for Sewer and Culvert Outlets
OPSD 810.020	Rip-Rap Treatment for Ditch Inlets
SP105S10	Amendment to OPSS 501, February 1996
SP110S13	Amendment to OPSS 1010
SP112S06	Amendment to OPSS 1205
SP511S01	Placement of Rip Rap, Rock Protection and Gravel Sheeting
NSSP	Non Standard Special Provision for Ground Water Control



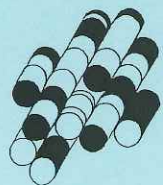
APPENDICES

TERRAPROBE INC.



APPENDIX A

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LIMITATIONS AND RISK

Procedures

The soil conditions were confirmed at the borehole locations only and conditions may vary between and beyond the boreholes. The boundaries between the various strata as shown on the logs are based on non-continuous sampling. These boundaries represent an inferred transition between the various strata, rather than a precise plane of stratigraphic change.

This investigation has been carried out using investigation techniques and engineering analysis methods consistent with those ordinarily exercised by Terraprobe and other engineering practitioners, working under similar conditions and subject to the time, financial and physical constraints applicable to this project. The discussions and recommendations that have been presented are based on the factual data obtained.

It must be recognized that there are special risks whenever engineering or related disciplines are applied to identify subsurface conditions. Even a comprehensive sampling and testing programme implemented in accordance with the most stringent level of care may fail to detect certain conditions. Terraprobe has assumed for the purposes of providing design parameters and advice, that the conditions that exist between sampling points are similar to those found at the sample locations. The conditions that Terraprobe has interpreted to exist between sampling points can differ from those that actually exist.

It may not be possible to drill a sufficient number of boreholes or sample and report them in a way that would provide all the subsurface information that could affect construction costs, techniques, equipment and scheduling. Contractors bidding on or undertaking work on the project should be directed to draw their own conclusions as to how the subsurface conditions may affect them, based on their own investigations and their own interpretations of the factual investigation results, cognizant of the risks implicit in the subsurface investigation activities.

Changes In Site And Scope

It must be recognized that the passage of time, natural occurrences, and direct or indirect human intervention at or near the site have the potential to alter subsurface conditions. Groundwater levels are particularly susceptible to seasonal fluctuations.

The design advice is based on the factual data obtained from this investigation made at the site by Terraprobe and are intended for use by the owner and its retained designers in the design phase of the project. If there are changes to the project scope and development features, or there is any additional information relevant to the interpretations made of the subsurface information, the geotechnical design parameters and comments relating to constructibility issues and quality control may not be relevant or complete for the revised project. Terraprobe should be retained to review the implications of such changes with respect to the contents of this report.

This report was prepared for the express use of the Ministry of Transportation, its retained design consultants and G. D. Jewell Engineering Inc. It is not for use by others. This report is copyright of Terraprobe Inc. and no part of this report may be reproduced by any means, in any form, without the prior written permission of Terraprobe Inc. The Ministry of Transportation, its retained design consultants and G. D. Jewell Engineering Inc. are authorized users.

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED, AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	>200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	>3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

STRESS AND STRAIN

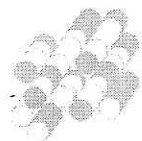
u_p	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

n_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_a	1	RATE OF SECONDARY CONSOLIDATION
C_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_c	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	- °	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	- °	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_x	1	SENSITIVITY = c_u / τ_c

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m ³	UNIT WEIGHT OF WATER	S_v	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ³ /s	RATE OF DISCHARGE
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $(w_L - w_p)$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $(w - w_p)/I_p$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	I_c	1	CONSISTENCY INDEX = $(w_L - w)/I_p$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m ²	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						



RECOVERY

- TCR** Total Core Recovery is the total length of core pieces, irrespective of their individual lengths obtained in a core run, and expressed as a percentage of the length of that core run.
- SCR** Solid Core Recovery is the total length of sound full-diameter core pieces obtained in a core run, expressed as a percentage of the length of that core run
- RQD** Rock Quality Designation pertains to the sum of those pieces of sound core which are 10 cm or greater in length obtained in a core run, expressed as a percentage of the length of that core run.

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
QUALITY	very poor	poor	fair	good	excellent

JOINT CHARACTERISTICS

Joint Spacing (adapted from Bieniawski 1989, ISRM 1981)

Classification	Spacing
very close	< 60 mm
close	60 – 200 mm
moderately close	0.2 to 0.6 m
wide	0.6 to 2 m
very wide	> 2 m

Natural Fracture Frequency (per 0.3 m)

Refers to the number of natural fractures (joints, faults, etc.) which are present per 0.3m. Ignores mechanical or drill-induced breaks, and closed discontinuities (e.g. bedding planes).

Orientation

Orientation	Angle from horiz.
horizontal/flat	0 - 20°
dipping	20 - 50°
vertical	50 - 90°

Joint Filling

Description	Approx. Φ^*
tight, hard, non-softening	25 - 35
oxidation, surface staining only	25 - 30
slightly altered, clay-free	25 - 30
sandy particles, clay-free	2 - 25
sandy and silty, minor clay	1 - 24
non-softening clays	6 - 12
swelling clay fillings	n/a

Joint Aperture

Classification	Aperture
closed / tight	< 0.5 mm
gapped	0.5 to 10 mm
open	> 10 mm

Planarity

- Planar
- Undulating
- Stepped
- Irregular
- Discontinuous

Roughness

- Very rough
- Rough
- Smooth
- Slickensided
- Polished

Coating	Description
clean	no filling
veneer	< 1 mm filling
coating / infill	> 1 mm filling

GENERAL

Degree of Weathering (after MTO, RR229 Evaluation of Shales for Construction Projects)

Zone	Degree	Description
Z1	unweathered	shale, regular jointing
Z2	partially weathered	angular blocks of unweathered shale, no matrix, with chemically weathered but intact shale
Z3		soil-like matrix with frequent angular shale fragments < 25mm diameter
Z4a		soil-like matrix with occasional shale fragments < 3mm diameter
Z4b	fully weathered	soil-like matrix only

Strength classification (after Marinos and Hoek, 2001)

Grade	Term	UCS (MPa)	Field Estimate (Description)
R6	extremely strong	> 250	can only be chipped by geological hammer
R5	very strong	100 - 250	requires many blows from geological hammer
R4	strong	50 - 100	requires more than one blow from geological hammer
R3	medium strong	25 - 50	can't be scraped, breaks under one blow from geological hammer
R2	weak	5 - 25	can be peeled / scraped with knife with difficulty
R1	very weak	1 - 5	easily scraped / peeled, crumbles under firm blow of geo. hammer
R0	extremely weak	< 1	indented by thumbnail

Bedding Thickness (Quarterly Journal of Engineering Geology, Vol 3, 1970)

Very thickly bedded	> 2 m	Medium bedded	200 – 600mm	Very thinly bedded	20 – 60mm	Thinly Laminated
Thickly bedded	0.6 – 2m	Thinly bedded	60 – 200mm	Laminated	6 – 20mm	< 6mm

Bedrock Graphic Legend



Inferred bedrock



Shale



Limestone

RECORD OF BOREHOLE No JC1

1 of 2

METRIC

G.W.P. 5446-09-00

LOCATION

Coords: E:292904.19 N:5058920.35

ORIGINATED BY WZ

DIST HWY 520

BOREHOLE TYPE

HOLLOW STEM AUGERS / WASH BORING , NQ ROCK CORING

COMPILED BY KC

DATUM GEODETIC

DATE _____

2012-11-7 - 2012-11-8

CHECKED BY HA

[illegible]

Continued Next Page

+³, X³: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

Nov. 7, 2012
Nov. 8, 2012

library: mto-qint.qlb report: mto-terraprobe soil path: \\pdclserver1-project files\1-geotechnical\2012\11-12-2100 - 2199\11-12-2130\qint\jenkins\11-12-2130 bh logs (new temp).gpj

RECORD OF BOREHOLE No JC1

2 of 2

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:292904.19 N:5058920.35 ORIGINATED BY WZ
DIST HWY 520 BOREHOLE TYPE HOLLOW STEM AUGERS / WASH BORING, NQ ROCK CORING COMPILED BY KC
DATUM GEODETIC DATE 2012-11-7 - 2012-11-8 CHECKED BY HA

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			SPT 'N' VALUE	SHEAR STRENGTH (kPa)					w _p	w			w _L
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE X LAB VANE				WATER CONTENT (%)				
						20	40	60	80	100							
	(continued)															GR SA SI C	
275.8	SANDY SILT, trace clay, loose to compact, grey, wet (continued)															...at 10.8m, spoon refusal	
10.7	SAND, some gravel, very dense, brown, wet		12	SS	179 / 250mm												
274.7																	
11.8	Coring started at 11.8m. Refer to Core Log JC1 for complete details.		1	RUN	NQ												
			2	RUN	NQ												
			3	RUN	NQ												
			4	RUN	NQ												
270.8																	

END OF BOREHOLE

Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
November 25, 2012	5.8	280.7
December 4, 2012	5.7	280.8

RECORD OF ROCK CORE No JC1

1 of 1

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:292904.19 N:5058920.35 ORIGINATED BY WZ
DIST HWY 520 BOREHOLE TYPE HOLLOW STEM AUGERS / WASH BORING, NQ ROCK CORING COMPILED BY KC
DATUM GEODETIC DATE 2012-11-7 - 2012-11-8 CHECKED BY HA

Depth (m)	Graphic Log	GENERAL DESCRIPTION	RUC Elev Depth	Recovery	Elevation (m)	Weathering Zones	UCS (MPa)		Natural Fractures		Laboratory Testing	Comments	Elevation (m)
							Estimated Strength		Frequency	Spacing			
		Rock coring started at 11.8m below grade	274.7m										
12		Gneiss, light grey, thinly bedded, very strong; joints are dipping; biotite to quartzofeldspathic, unweathered, massive to strongly foliated / gneissic	11.8m R1	TCR = 100% SCR = 80% RQD = 27%	274							— 12.2-12.3m: localized rubble zones	274
13			12.2m R2	TCR = 85% SCR = 85% RQD = 85%	273							— 12.6-12.7m: localized rubble zones	273
14			272.8m 13.7m R3	TCR = 97% SCR = 97% RQD = 97%	272							— 13.2-13.8m: slightly fractured	272
15			271.3m 15.2m R4	TCR = 85% SCR = 85% RQD = 85%	271								271

END OF BOREHOLE

Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.

RECORD OF BOREHOLE No JC2

1 of 2

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:292917.54 N:5058922.68 ORIGINATED BY WZ
DIST HWY 520 BOREHOLE TYPE HOLLOW STEM AUGERS / WASH BORING, NQ ROCK CORING COMPILED BY KC
DATUM GEODETIC DATE 2012-11-9 CHECKED BY HA

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE			SHEAR STRENGTH (kPa)										WATER CONTENT (%)		
								20	40	60	80	100						10	20	30
286.2	GROUND SURFACE																			
285.8 0.4	130mm ASPHALTIC CONCRETE		1	SS	10															
	270mm AGGREGATE																			
	FILL, sand, trace gravel, trace silt and clay; very loose to very dense, brown, moist to wet ...at 2.3m, some gravel		2	SS	31															
			3	SS	9															
			4	SS	51															
			5	SS	16															
	6	SS	56																	
279.7 6.6	SAND AND SILT, trace gravel, trace clay, loose to compact, dark grey / grey, wet		7A	SS	3															
			7B																	
			8	SS	14															

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

library: library - mto gnt.gdb report: mto-terraprobe soil path: \\pdcserver11-project files\\11-geotechnical\\2012\\11-12-2100 - 2199\\11-12-2130\\gnt\\jenkins\\11-12-2130 bh logs (new temp).gpi

RECORD OF BOREHOLE No JC2

2 of 2

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:292917.54 N:5058922.68 ORIGINATED BY WZ
DIST HWY 520 BOREHOLE TYPE HOLLOW STEM AUGERS / WASH BORING , NQ ROCK CORING COMPILED BY KC
DATUM GEODETIC DATE 2012-11-9 CHECKED BY HA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			SPT 'N' VALUE	SHEAR STRENGTH (kPa)						WATER CONTENT (%)				
								20 40 60 80 100										
								○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE X LAB VANE										
	(continued)																	
	SAND AND SILT, trace gravel, trace clay, loose to compact, dark grey / grey, wet (continued)												...at 10.1m, auger grinding					
	...at 10.8m, No sample recovered. Possible Sand and Silt.		10	SS	14								attempt with sand trap at 10.7m, no recovered sample					
274.7																		
11.6	Coring started at 11.6m. Refer to Core Log JC2 for complete details.		1	RUN									...at 11.6m, auger refusal and spoon bouncing					
			2	RUN														
			3	RUN														
			4	RUN														
271.4																		
14.8																		

END OF BOREHOLE

Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.

Library: library - mto gint.glb report: mto-terraprobe soil path: \\pdcserver11-project files\11-geotechnical\2012\11-12-2100 - 2109\11-12-2100\gint\terraprobe\11-12-2130 bh logs (new temp).gpl

RECORD OF ROCK CORE No JC2

1 of 1

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:292917.54 N:5058922.68 ORIGINATED BY WZ
DIST HWY 520 BOREHOLE TYPE HOLLOW STEM AUGERS / WASH BORING, NQ ROCK CORING COMPILED BY KC
DATUM GEODETIC DATE 2012-11-9 CHECKED BY HA

Depth (m)	Graphic Log	GENERAL DESCRIPTION	Run Elev Depth	Recovery	Elevation (m)	Weathering Zones	UCS (MPa) 5 25 50 100 250 Estimated Strength	Natural Fractures Frequency Spacing	Laboratory Testing	Comments	Elevation (m)
		Rock coring started at 11.6m below grade	274.7m								
12		Gneiss, light grey, thinly bedded, strong to very strong; joints are dipping; biotite to quartzofeldspathic, unweathered, massive to strongly foliated / gneissic	11.6m R1	TCR = 84% SCR = 42% RQD = 42%	274					— 11.6-11.7m: localized rubble zones — 11.9-12.0m: localized rubble zones	274
13			12.1m R2	TCR = 98% SCR = 98% RQD = 93%	273						273
14			273.1m 13.1m R3	TCR = 100% SCR = 100% RQD = 100%	272					— 14.4-14.5m: localized rubble zones	272
			271.6m 14.7m R4	TCR = 100% SCR = 100% RQD = 100%							

END OF BOREHOLE

Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.

RECORD OF BOREHOLE No JC2-P

1 of 1

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:292916.53 N:5058920.53 ORIGINATED BY WZ
DIST HWY 520 BOREHOLE TYPE SOLID STEM AUGERS COMPILED BY KC
DATUM GEODETIC DATE 2012-11-9 CHECKED BY HA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE			20	40	60	80	100					
286.3	GROUND SURFACE																
	120mm ASPHALTIC CONCRETE																
285.9	280mm AGGREGATE																
0.4	FILL, sand, trace gravel, trace silt and clay; very dense, brown, damp																
			1	SS	74												
			2	AS													
285.0																	
1.4																	

END OF BOREHOLE

Borehole was dry and open upon
completion of drilling.

...at 1.4m, auger
refusal

library: library - mto gint.glb report: mto-terroprobe soil path: \\pds\server1\project files\11-geotechnical\2012\11-12-2100 - 2100\11-12-2130\gint\jenkins\11-12-2130 bh logs (new temp).gpl

RECORD OF BOREHOLE No JC3

1 of 1

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:292920.94 N:5058936.9 ORIGINATED BY WZ
DIST HWY 520 BOREHOLE TYPE HOLLOW STEM AUGERS / WASH BORING, CONE TEST, NQ ROCK CORING COMPILED BY KC
DATUM GEODETTIC DATE 2012-10-31 CHECKED BY HA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			SHEAR STRENGTH (kPa)		w_p	w	w_L		
280.0	GROUND SURFACE						20 40 60 80 100						
279.8	170mm TOPSOIL						20 40 60 80 100						
0.2	FILL, clayey silt, trace sand, rootlets, some organics; firm, brown, moist		1	SS	6							40	
279.2	FILL, sand, with gravel, trace silt; compact, brown, wet		2	SS	19								...at 0.8m, drilling fluid was added
0.8													
278.4	SAND, some silt and clay, some gravel, loose to compact, brown, wet		3	SS	4								
1.5			4	SS	10								10 65 (25)
276.8			5	SS	100 / 50mm								...at 3.1m, spoon refusal
3.2	Coring started at 3.2m. Refer to Core Log JC3 for complete details.		1	RUN									
			2	RUN									
			3	RUN									
			4	RUN									
272.9													
7.0													

END OF BOREHOLE

Borehole contained drill water upon
completion of drilling. Unstabilized
water level and cave not measured.

+³, X³: Numbers refer to
Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF ROCK CORE No JC3

1 of 1

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:292920.94 N:5058936.9 ORIGINATED BY WZ
DIST HWY 520 BOREHOLE TYPE HOLLOW STEM AUGERS / WASH BORING, CONE TEST, NQ ROCK CORING COMPILED BY KC
DATUM GEODETIC DATE 2012-10-31 CHECKED BY HA

Depth (m)	Graphic Log	GENERAL DESCRIPTION	Run Elev Depth	Recovery	Elevation (m)	Weathering Zones	UCS (MPa) ● 5 25 50 100 250 Estimated Strength	Natural Fractures Frequency Spacing	Laboratory Testing	Comments	Elevation (m)
		Rock coring started at 3.2m below grade	276.8m								
		Gneiss, light grey, thinly bedded, strong to very strong; joints are dipping; biotite to quartzofeldspathic, unweathered, massive to strongly foliated / gneissic	3.2m R1	TCR = 100% SCR = 100% RQD = 50%						3.2-3.3m: localized rubble zones	
			3.5m								
4				R2	TCR = 100% SCR = 100% RQD = 92%					4.1-4.2m: localized rubble zones	276
			275.1m							4.6-4.7m: localized rubble zones	
5			4.9m							4.9-5.7m: localized rubble zones	275
				R3	TCR = 100% SCR = 100% RQD = 94%						
6											274
			273.6m								
			6.3m								
				R4	TCR = 100% SCR = 80% RQD = 90%					6.6-7.0m: localized rubble zones	
7			272.9m								273

END OF BOREHOLE

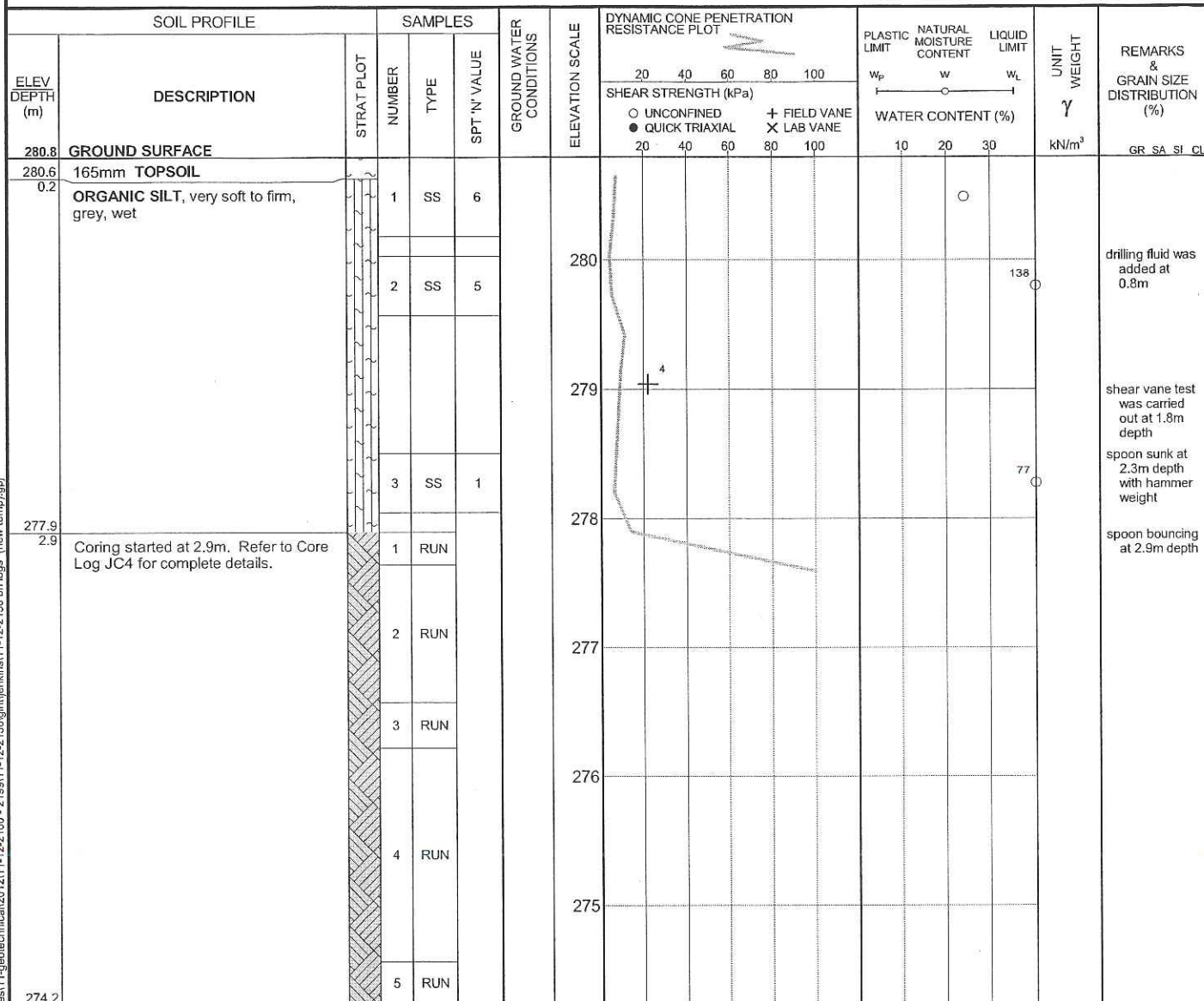
Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.

RECORD OF BOREHOLE No JC4

1 of 1

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:292933.74 N:5058932.18 ORIGINATED BY WZ
DIST HWY 520 BOREHOLE TYPE HOLLOW STEM AUGERS / WASH BORING, CONE TEST, NQ ROCK CORING COMPILED BY KC
DATUM GEODETIC DATE 2012-10-31 CHECKED BY HA



+³, X³: Numbers refer to
Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF ROCK CORE No JC4

1 of 1

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:292933.74 N:5058932.18 ORIGINATED BY WZ
DIST HWY 520 BOREHOLE TYPE HOLLOW STEM AUGERS / WASH BORING, CONE TEST, NQ ROCK CORING COMPILED BY KC
DATUM GEODETIC DATE 2012-10-31 CHECKED BY HA

Depth (m)	Graphic Log	GENERAL DESCRIPTION	R _h m Elev Depth	Recovery	Elevation (m)	Weathering Zones	UCS (MPa) ● 5 25 50 100 250 Estimated Strength	Natural Fractures Frequency Spacing	Laboratory Testing	Comments	Elevation (m)
		Rock coring started at 2.9m below grade	277.9m								
3		Gneiss, light grey, thinly bedded, strong to very strong; joints are dipping; biotite to quartzofeldspathic, unweathered, massive to strongly foliated / gneissic	2.9m R1	TCR = 100% SCR = 52% RQD = 0%						— 3.0-3.1m: localized rubble zones	
			3.2m							— 3.2-3.3m: localized rubble zones	
				TCR = 91% SCR = 66% RQD = 66%	277					— 3.5-3.6m: localized rubble zones	277
4			276.6m							— 4.0-4.1m: localized rubble zones	
			4.2m	TCR = 80% SCR = 80% RQD = 57%							
			4.6m		276						276
5				TCR = 100% SCR = 100% RQD = 100%	275						275
6			274.6m								
			6.2m	TCR = 100% SCR = 100% RQD = 89%							

END OF BOREHOLE

Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.

RECORD OF BOREHOLE No JC5

1 of 1

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:292917.63 N:5058942.41 ORIGINATED BY WZ
DIST HWY 520 BOREHOLE TYPE HOLLOW STEM AUGERS / WASH BORING, CONE TEST, NQ ROCK CORING COMPILED BY KC
DATUM GEODETIC DATE 2012-10-30 CHECKED BY HA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE								
281.2	GROUND SURFACE											
281.0	190mm TOPSOIL											
0.2	SILT AND SAND, trace clay, loose to compact, brown, wet ...at 0.3m, trace organics ...at 0.8m, gravelly, trace silt		1	SS	9							...at 0.8m, drilling fluid was added
			2	SS	9							
			3	SS	22							1 47 49 3
			4	SS	12							
			5	SS	8							
			6	SS	5							
275.3	Coring started at 5.9m. Refer to Core Log JC5 for complete details.		7	SS	100 / 25mm							...at 5.9m, Spoon bouncing
5.9			1	RUN								
			2	RUN								
			3	RUN								
271.8	END OF BOREHOLE											
9.4	Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.											

Library: library - mto gnl.glb report: mto-terraprobe soil path: \pdc\server1-project files\11-geotechnical\2012\11-12-2100 - 219911-12-2130\gint\jnt\11-12-2130 bh logs (new temp).gpl

RECORD OF ROCK CORE No JC5

1 of 1

METRIC

G.W.P.: 5446-09-00 LOCATION Coords: E:292917.63 N:5058942.41 ORIGINATED BY WZ
DIST HWY 520 BOREHOLE TYPE HOLLOW STEM AUGERS / WASH BORING, CONE TEST, NQ ROCK CORING COMPILED BY KC
DATUM GEODETIC DATE 2012-10-30 CHECKED BY HA

Depth (m)	Graphic Log	GENERAL DESCRIPTION	Run Elev Depth	Recovery	Elevation (m)	Weathering Zones	UCS (MPa)						Natural Fractures		Laboratory Testing	Comments	Elevation (m)
							5	25	50	100	250	Estimated Strength		Frequency	Spacing		
		Rock coring started at 5.9m below grade	275.3m														
6		Gneiss, light grey, thinly bedded, strong to very strong; joints are dipping; biotite to quartzofeldspathic, unweathered, massive to strongly foliated / gneissic	5.9m R1	TCR = 80% SCR = 60% RQD = 60%	275											5.9-6.0m: localized rubble zones	275
			6.3m													6.3-6.4m: localized rubble zones	
7			R2	TCR = 100% SCR = 100% RQD = 98%	274											7.1-7.2m: localized rubble zones	274
8			273.3m 7.8m		273											8.6-8.7m: localized rubble zones	273
9			R3	TCR = 97% SCR = 97% RQD = 97%	272											8.9-9.0m: localized rubble zones	272
			271.8m														

END OF BOREHOLE

Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.

RECORD OF BOREHOLE No JC6

1 of 1

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:292894.75 N:5058919.12 ORIGINATED BY WZ
DIST HWY 520 BOREHOLE TYPE HOLLOW STEM AUGERS / WASH BORING, CONE TEST, NQ ROCK CORING COMPILED BY KC
DATUM GEODETIC DATE 2012-11-5 CHECKED BY HA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT N' VALUE			20 40 60 80 100	20 40 60 80 100	W _p W W _L	WATER CONTENT (%)		
283.2	GROUND SURFACE												
283.0 0.2	165mm TOPSOIL												
	ORGANIC SILT, firm, dark brown, wet		1	SS	8		283					134	
			2	SS	6		282						
282.0 1.1	Coring started at 1.3m. Refer to Core Log JC6 for complete details.		1	RUN			281						
			2	RUN			280						
			3	RUN			279						
278.4 4.8	END OF BOREHOLE												

END OF BOREHOLE

Borehole contained drill water upon
completion of drilling. Unstabilized
water level and cave not measured.

library: library - mto gnu.glb report: mto-terraprobe soil path: \\pdcserver1-project_files\11-geotechnical\2012\11-12-2\100 - 2199\11-12-2\100\mto-terraprobe soil logs (new temp).gpl

+³, X³: Numbers refer to
Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF ROCK CORE No JC6

1 of 1

METRIC

G.W.P.: 5446-09-00 LOCATION Coords: E:292894.75 N:5058919.12 ORIGINATED BY WZ
DIST HWY 520 BOREHOLE TYPE HOLLOW STEM AUGERS / WASH BORING, CONE TEST, NQ ROCK CORING COMPILED BY KC
DATUM GEODETIC DATE 2012-11-5 CHECKED BY HA

Depth (m)	Graphic Log	GENERAL DESCRIPTION	Run Elev Depth	Recovery	Elevation (m)	Weathering Zones								UCS (MPa)		Natural Fractures		Laboratory Testing	Comments	Elevation (m)
						Z1	Z2	Z3	Z4	Z5	Z6	Z7	Z8	5	25	50	100	250		
		Rock coring started at 1.3m below grade	281.9m																	
		Gneiss, light grey, thinly bedded, strong to very strong; joints are dipping; biotite to quartzofeldspathic, unweathered, massive to strongly foliated / gneissic (continued)	1.1m	TCR = 100% SCR = 100% RQD = 97%																
2		(continued)	281.3m																	
			1.9m																	
				TCR = 100% SCR = 100% RQD = 95%	281															281
3																				
			279.9m																	280
			3.3m																	
4				TCR = 99% SCR = 99% RQD = 99%	279															279
			278.4m																	

END OF BOREHOLE

Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.

RECORD OF BOREHOLE No JC7

1 of 1

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:292907.39 N:5058907.29 ORIGINATED BY WZ
DIST HWY 520 BOREHOLE TYPE HOLLOW STEM AUGERS / WASH BORING, CONE TEST, NQ ROCK CORING COMPILED BY KC
DATUM GEODETTIC DATE 2012-11-2 CHECKED BY HA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE			SHEAR STRENGTH (kPa)		WATER CONTENT (%)					
								\circ UNCONFINED \bullet QUICK TRIAXIAL	$+$ FIELD VANE \times LAB VANE	w_p	w	w_L			
281.4	GROUND SURFACE					20	40	60	80	100	10	20	30		GR SA SI CL
	80mm TOPSOIL		1	SS	33										
	FILL, sand, with gravel, trace silt; compact to dense, brown, wet		2	SS	22										
279.9															
1.5	ORGANIC SILT, soft to firm, grey, wet		3	SS	4									64	
			4	SS	14										
278.4															
3.1	SAND, some silt, trace clay, compact, grey, wet		5	SS	14										
277.8			6	SS	100 / 50mm										
3.7	Coring started at 3.7m. Refer to Core Log JC7 for complete details.		1	RUN											...at 3.7m, spoon bouncing
			2	RUN											
			3	RUN											
274.7															

END OF BOREHOLE

Borehole contained drill water upon
completion of drilling. Unstabilized
water level and cave not measured.

RECORD OF ROCK CORE No JC7

1 of 1

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:292907.39 N:5058907.29 ORIGINATED BY WZ
DIST HWY 520 BOREHOLE TYPE HOLLOW STEM AUGERS / WASH BORING, CONE TEST, NQ ROCK CORING COMPILED BY KC
DATUM GEODETIC DATE 2012-11-2 CHECKED BY HA

Depth (m)	Graphic Log	GENERAL DESCRIPTION	Run	Recovery	Elevation (m)	Weathering Zones	UCS (MPa)		Natural Fractures		Laboratory Testing	Comments	Elevation (m)
			Elev Depth				5	25	50	100	250		
		Rock coring started at 3.7m below grade	277.8m										
4		Gneiss, light grey, thinly bedded, strong to very strong; joints are dipping; biotite to quartzofeldspathic, unweathered, massive to strongly foliated / gneissic	3.7m									— 3.7-3.8m: localized rubble zones	
			R1	TCR = 100% SCR = 96% RQD = 96%	277							— 4.3-4.4m: localized rubble zones	277
			276.7m										
5			4.7m									— 5.0-5.1m: localized rubble zones	
			R2	TCR = 100% SCR = 100% RQD = 100%	276							— 5.5-5.6m: localized rubble zones	276
												— 5.9-6.0m: localized rubble zones	
6			275.2m										
			6.2m									— 6.5-6.6m: localized rubble zones	275
			R3	TCR = 100% SCR = 100% RQD = 100%	275								

END OF BOREHOLE

Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.

RECORD OF BOREHOLE No JC8

1 of 1

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:292907.54 N:5058896.91 ORIGINATED BY WZ
DIST HWY 520 BOREHOLE TYPE HOLLOW STEM AUGERS / WASH BORING, CONE TEST, NQ ROCK CORING COMPILED BY KC
DATUM GEODETIC DATE 2012-11-1 CHECKED BY HA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	20 40 60 80 100	w_p	w	w_L		
284.1	GROUND SURFACE												
283.9 0.2	185mm TOPSOIL		1	SS	9								
	SILT, with clay, some sand, loose to compact, brown, wet ...at 0.3m, trace organics		2	SS	14								0 17 61 22
			3	SS	6								0 6 70 24
281.2 2.9	...at 2.8m, some tree roots obstruction		4	SS	100 / 25mm								
281.0 3.1	SAND, some gravel, very dense, brown, wet Coring started at 3.1m. Refer to Core Log JC8 for complete details.		1	RUN	NQ								...at 3.1m, spoon bouncing
			2	RUN	NQ								
			3	RUN	NQ								
277.6 6.5	END OF BOREHOLE												

END OF BOREHOLE

Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.

+³, X³: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF ROCK CORE No JC8

1 of 1

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:292907.54 N:5058896.91 ORIGINATED BY WZ
DIST HWY 520 BOREHOLE TYPE HOLLOW STEM AUGERS / WASH BORING, CONE TEST, NQ ROCK CORING COMPILED BY KC
DATUM GEODETIC DATE 2012-11-1 CHECKED BY HA

Depth (m)	Graphic Log	GENERAL DESCRIPTION	Run Elev Depth	Recovery	Elevation (m)	Weathering Zones								UCS (MPa)		Natural Fractures		Laboratory Testing	Comments	Elevation (m)
						W1	W2	W3	W4	W5	W6	W7	W8	5	25	50	100	250		
		Rock coring started at 3.1m below grade	281.0m											Estimated Strength		Frequency	Spacing			
		Gneiss, light grey, thinly bedded, strong to very strong; joints are dipping; biotite to quartzofeldspathic, unweathered, massive to strongly foliated / gneissic	3.1m	TCR = 96% SCR = 96% RQD = 96%																3.3-3.5m: localized rubble zones
4			3.7m																	4.1-4.2m: localized rubble zones
5			278.8m	TCR = 100% SCR = 95% RQD = 95%																
			5.3m																	5.5-5.6m: localized rubble zones
6				TCR = 100% SCR = 100% RQD = 100%																
			277.6m																	6.4-6.5m: localized rubble zones

END OF BOREHOLE

Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.

Jenkins Creek Culvert Replacement
Agreement No. 5012-E-0001, GWP No. 5447-09-00, SITE 44-286/C



Bedrock Core Sample
Borehole: JC1
Runs: 1, 2, 3 & 4
Depth: 11.8m – 15.7m



Terraprobe Inc.

Project # 11-12-2130

Jenkins Creek Culvert Replacement
Agreement No. 5012-E-0001, GWP No. 5447-09-00, SITE 44-286/C



Bedrock Core Sample
Borehole: JC2
Runs: 1, 2, 3 & 4
Depth: 11.6m – 14.8m



Terraprobe Inc.

Project # 11-12-2130

Jenkins Creek Culvert Replacement
Agreement No. 5012-E-0001, GWP No. 5447-09-00, SITE 44-286/C



Bedrock Core Sample
Borehole: JC3
Runs: 1, 2, 3 & 4
Depth: 3.2m – 7.0m



Terraprobe Inc.

Project # 11-12-2130

Jenkins Creek Culvert Replacement
Agreement No. 5012-E-0001, GWP No. 5447-09-00, SITE 44-286/C



Bedrock Core Sample

Borehole: JC4
Runs: 1, 2, 3, 4 & 5
Depth: 2.9m – 6.6m



Terraprobe Inc.

Project # 11-12-2130

Jenkins Creek Culvert Replacement
Agreement No. 5012-E-0001, GWP No. 5447-09-00, SITE 44-286/C



Bedrock Core Sample

Borehole: JC5

Runs: 1, 2 & 3

Depth: 5.9m – 9.4m



Terraprobe Inc.

Project # 11-12-2130

Jenkins Creek Culvert Replacement
Agreement No. 5012-E-0001, GWP No. 5447-09-00, SITE 44-286/C



Bedrock Core Sample

Borehole: JC6

Runs: 1, 2 & 3

Depth: 1.3m – 4.8m



Terraprobe Inc.

Project # 11-12-2130

Jenkins Creek Culvert Replacement
Agreement No. 5012-E-0001, GWP No. 5447-09-00, SITE 44-286/C



Bedrock Core Sample

Borehole: JC7

Runs: 1, 2 & 3

Depth: 3.7m – 6.8m



Terraprobe Inc.

Project # 11-12-2130

Jenkins Creek Culvert Replacement
Agreement No. 5012-E-0001, GWP No. 5447-09-00, SITE 44-286/C



Bedrock Core Sample

Borehole: JC8

Runs: 1, 2 & 3

Depth: 3.1m – 6.5m

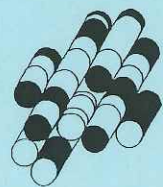


Terraprobe Inc.

Project # 11-12-2130

APPENDIX B

TERRAPROBE INC.





78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT			SAND			GRAVEL		
GRAIN SIZE IN MICROMETERS			Fine	Medium	Coarse	Fine	Coarse	

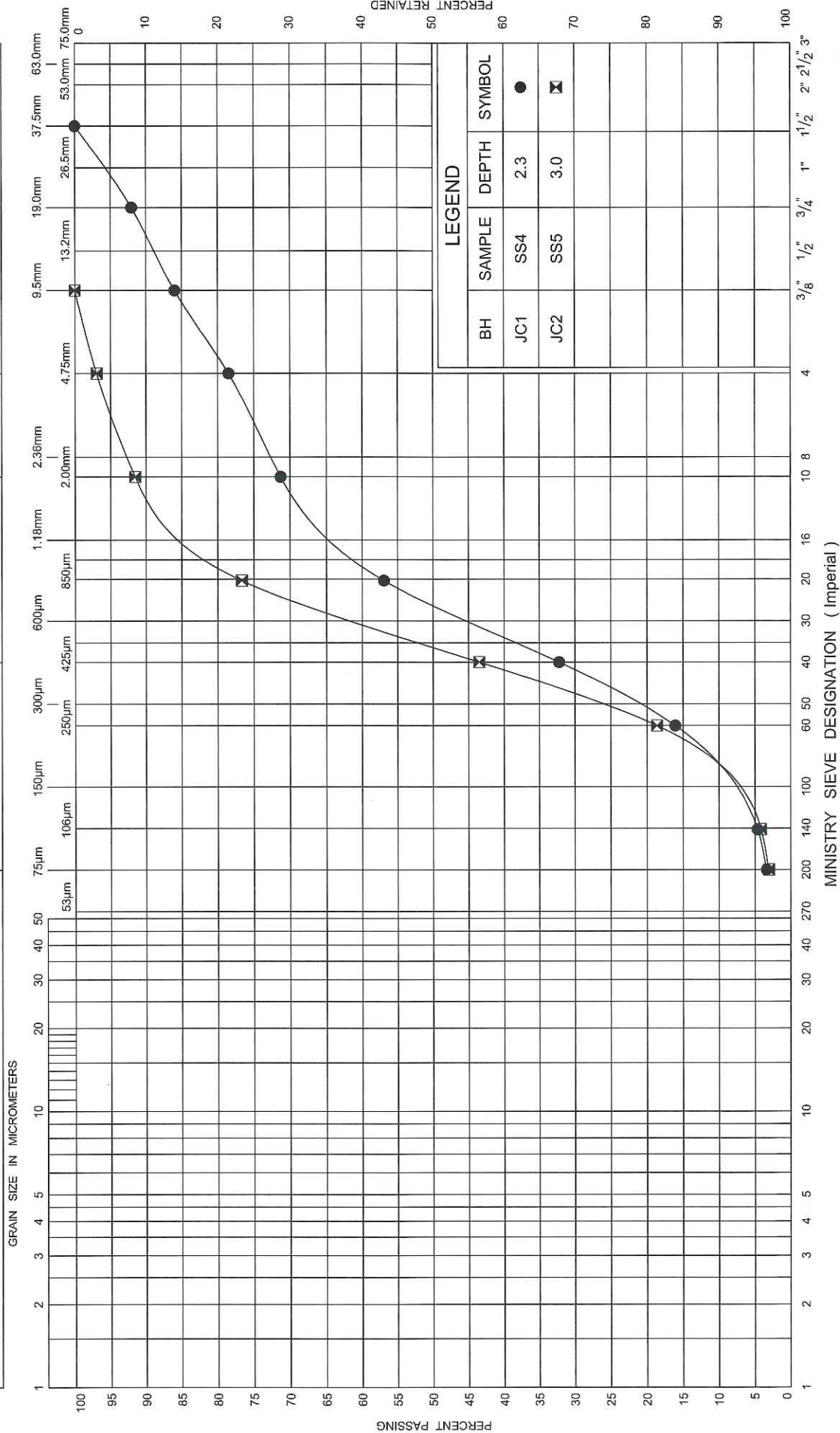


FIG No B1-1
GRAIN SIZE DISTRIBUTION
FILL-SAND



78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT			SAND			GRAVEL		
			Fine	Medium	Coarse	Fine	Coarse	

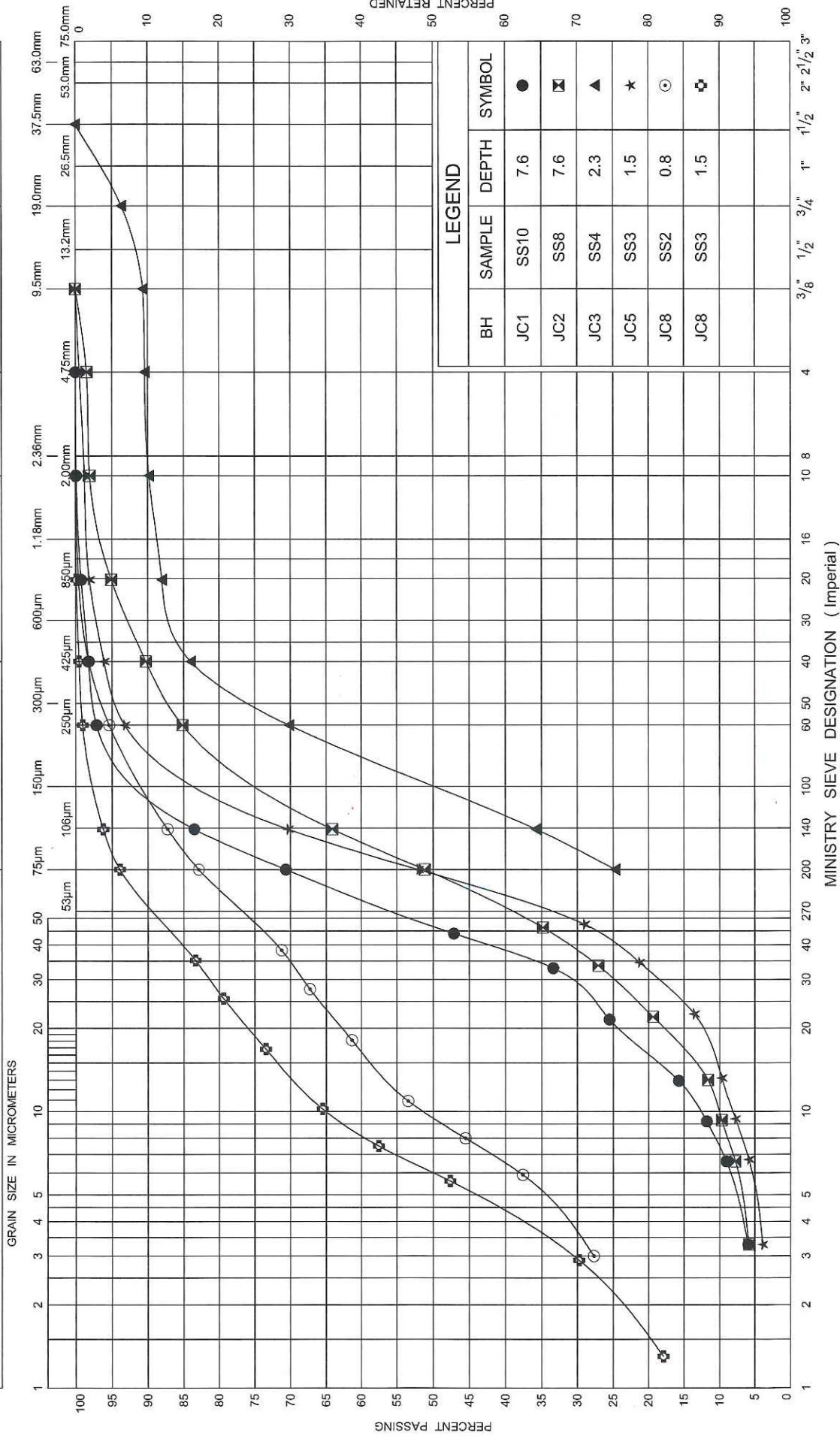


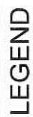
FIG No B1-2

GW P 5446-09-00

Jenkins Creek Culvert Replacement

GRAIN SIZE DISTRIBUTION

SAND TO SANDY SILT

[illegible]

PLASTICITY CHART

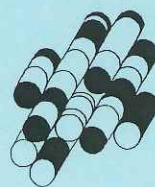
FIG No B1-3

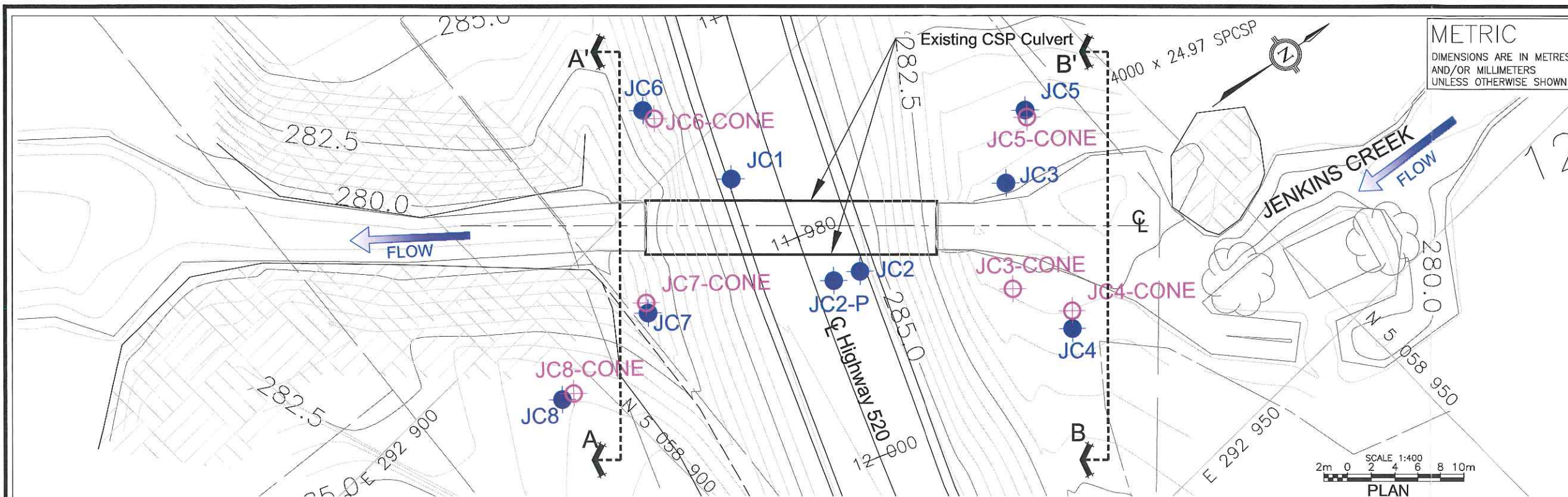
GW P 5446-09-00

Jenkins Creek Culvert Replacement

APPENDIX C

TERRAPROBE INC.





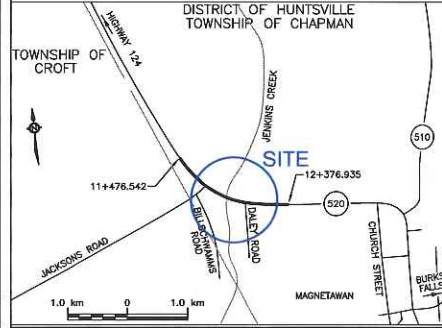
CONT. No. 2013-5115
GWP No. 5446-09-00

JENKINS CREEK CULVERT
REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

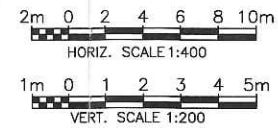
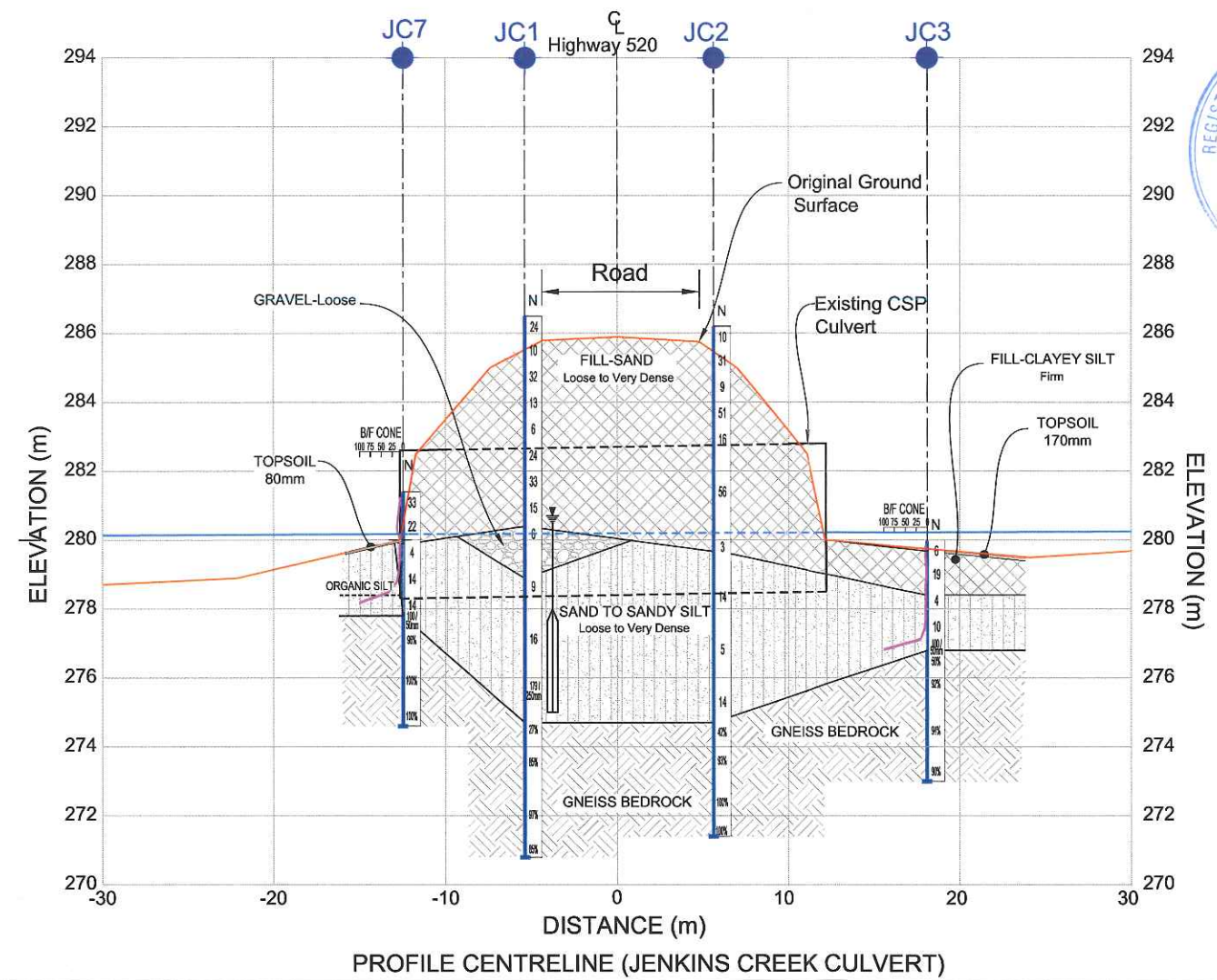
SHEET
1 OF 2

G.D. Jewell
ENGINEERING Inc.

Terraprobe Inc.
Consulting Geotechnical & Environmental Engineering
Construction Materials Engineering, Inspection & Testing
11 Indell Lane - Brampton Ontario L6T 3Y3 (905) 796-2650



LEGEND	
	Bore Hole
	Dynamic Cone Penetration Test
	Bore Hole And Cone
	Blows/0.3m (Std Pen Test, 475 J/blow)
	Blows/0.3m (60' Cone, 475 J/blow)
	WL at Time of Investigation
	WL in Piezometer (Dec. 2012)
	Piezometer
	90% Rock Quality Designation
	Auger Refusal

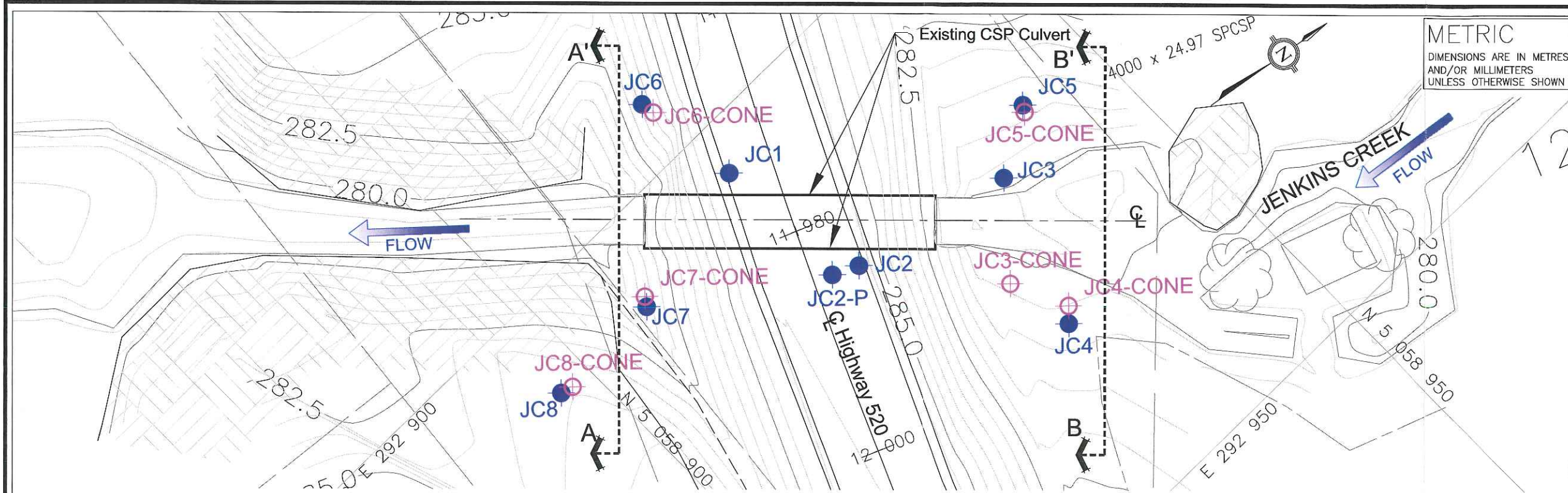


REFERENCE:		
PLAN AND PROFILE SECONDARY HIGHWAY 520 TOWNSHIP OF CHAPMAN DISTRICT OF PARRY SOUND 11+476.542 TO 12+376.935		
WP/WO 5447-09-00	PLAN 12-4566-03	PROFILE 12-4566-03
SURVEYED OCTOBER 2012		PLAN NOVEMBER 2012
DRAWN BY: FRANK TRUCHON, TULLOCH GEOMATICS INC.		

No	ELEV.	MTM COORDINATES	
		NORTHING	EASTING
JC1	286.5	5 058 920.35	292 904.19
JC2	286.2	5 058 922.68	292 917.54
JC2-P	286.3	5 058 920.53	292 916.53
JC3	280.0	5 058 936.9	292 920.94
JC3-CONE	280.1	5 058 930.97	292 927.79
JC4	280.8	5 058 932.18	292 933.74
JC4-CONE	280.4	5 058 933.22	292 932.64
JC5	281.2	5 058 942.41	292 917.63
JC5-CONE	281.1	5 058 942.1	292 918.16
JC6	283.2	5 058 919.12	292 894.75
JC6-CONE	283.2	5 058 919.31	292 895.92
JC7	281.4	5 058 907.29	292 907.39
JC7-CONE	281.7	5 058 907.79	292 906.66
JC8	284.1	5 058 896.91	292 907.54
JC8-CONE	284.1	5 058 897.97	292 907.85

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

REVISIONS		DATE		BY	DESCRIPTION
DESIGN	HA	CODE	CHBDC2006	LOAD	DATE MARCH 2013
DRAWN	KC	CHK	WL	STRUCT	GEORES 31E-325



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

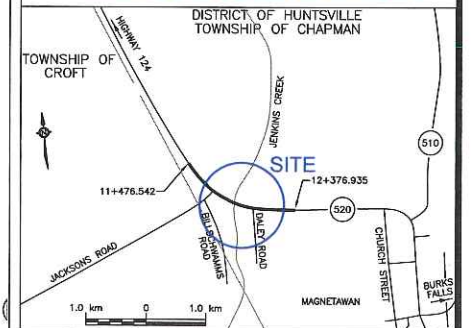
CONT. No. 2013-5115
GWP No. 5446-09-00

JENKINS CREEK CULVERT
REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
2 OF 2

G.D. Jewell
ENGINEERING Inc.

Terraprobe Inc.
Consulting Geotechnical & Environmental Engineering
Construction Materials Engineering, Inspection & Testing
11 Indell Lane - Brampton Ontario L6T 3Y3 (905) 796-2650

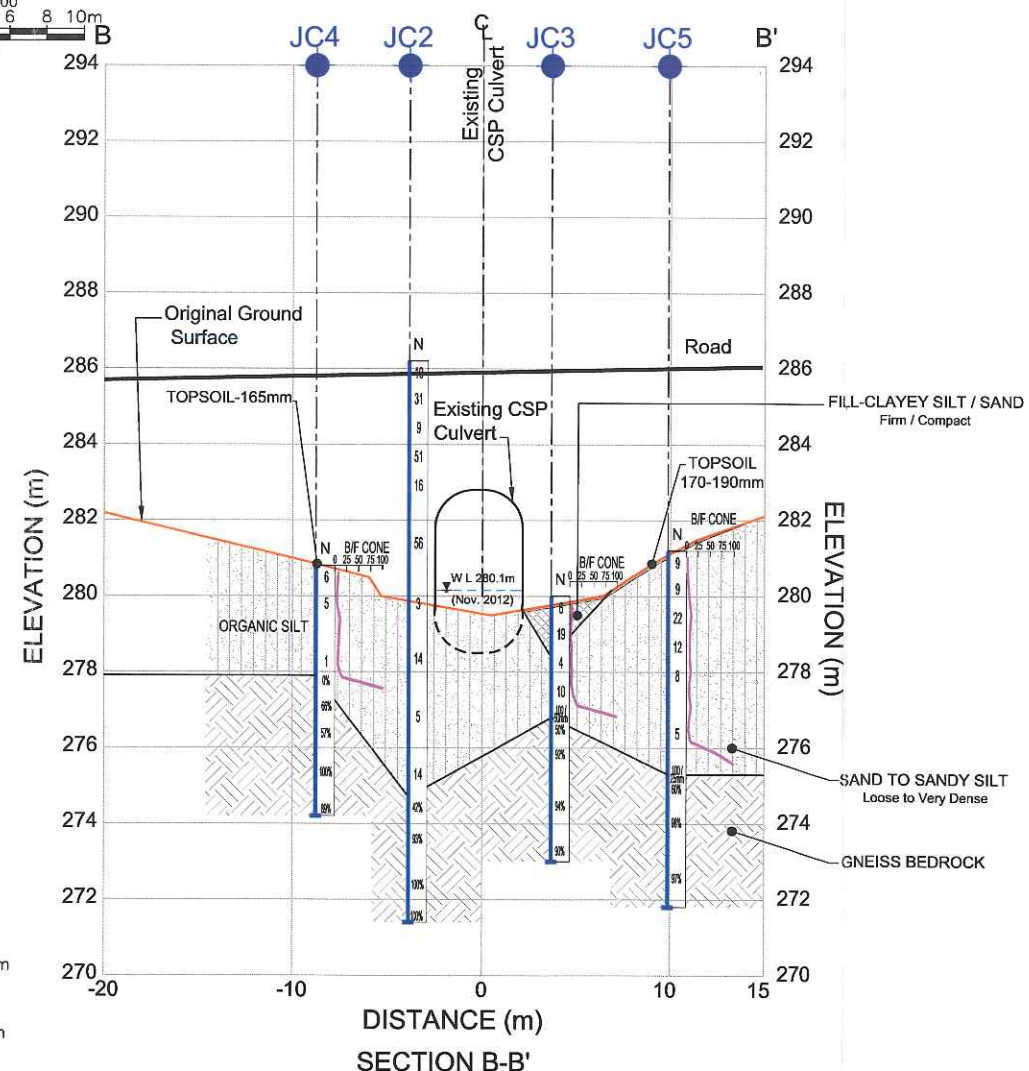
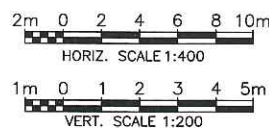
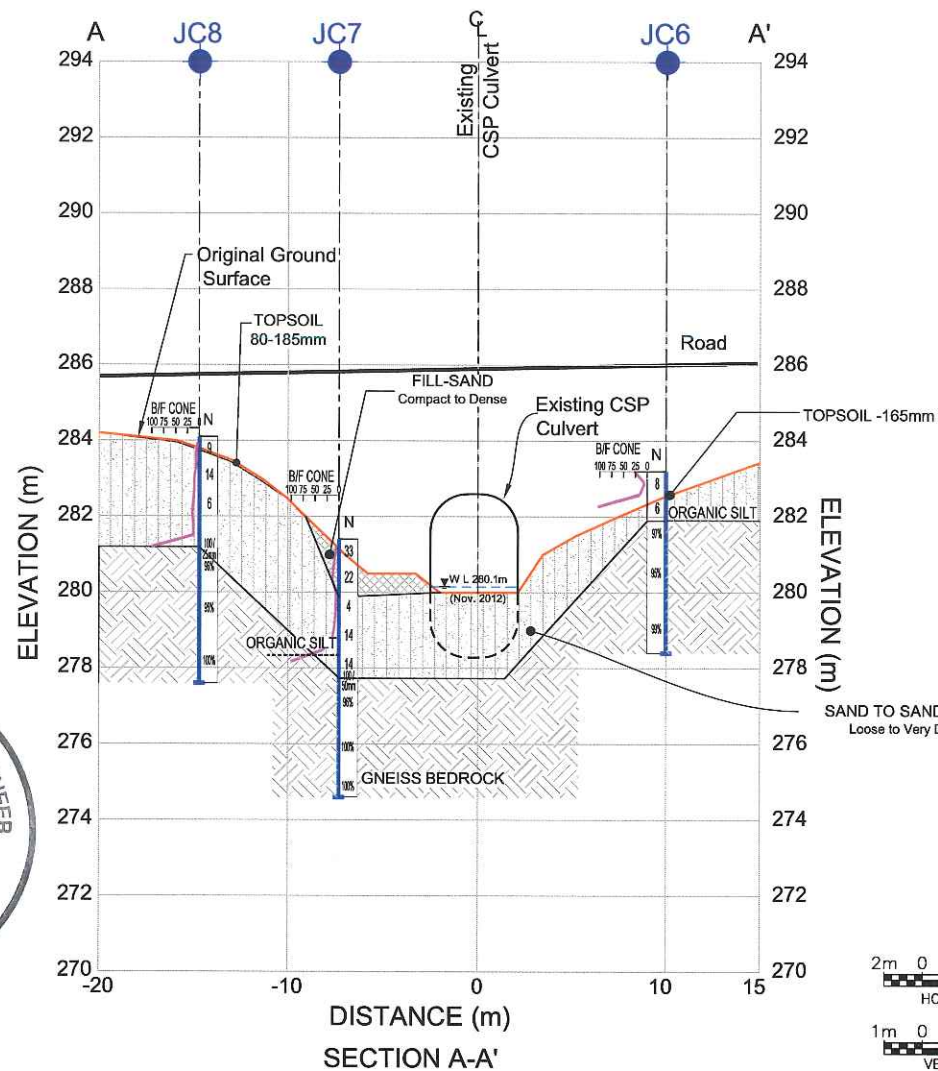


- LEGEND
- Bore Hole
 - Dynamic Cone Penetration Test
 - Bore Hole And Cone
 - 'N' Blows/0.3m (Std Pen Test, 475 J/blow)
 - CONE Blows/0.3m (60° Cone, 475 J/blow)
 - WL at Time of Investigation
 - WL in Piezometer (Dec. 2012)
 - Piezometer
 - 90% Rock Quality Designation
 - A/R Auger Refusal

No	ELEV.	MTM COORDINATES	
		NORTHING	EASTING
JC1	286.5	5 058 920.35	292 904.19
JC2	286.2	5 058 922.68	292 917.54
JC2-P	286.3	5 058 920.53	292 916.53
JC3	280.0	5 058 936.9	292 920.94
JC3-CONE	280.1	5 058 930.97	292 927.79
JC4	280.8	5 058 932.18	292 933.74
JC4-CONE	280.4	5 058 933.22	292 932.64
JC5	281.2	5 058 942.41	292 917.63
JC5-CONE	281.1	5 058 942.1	292 918.16
JC6	283.2	5 058 919.12	292 894.75
JC6-CONE	283.2	5 058 919.31	292 895.92
JC7	281.4	5 058 907.29	292 907.39
JC7-CONE	281.7	5 058 907.79	292 906.66
JC8	284.1	5 058 896.91	292 907.54
JC8-CONE	284.1	5 058 897.97	292 907.85

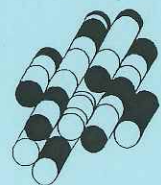
NOTE
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.
This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

REVISIONS	DATE	BY	DESCRIPTION		
			DESIGN	HA	CODE
			CHK	WL	STRUCT
					DATE MARCH 2013
					GEODES 31E-32S



APPENDIX D

TERRAPROBE INC.



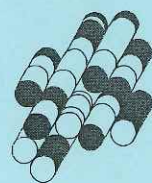
COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION
ELEMENT

Foundation Element	Granular A Pad	Spread Footing	Driven Piles
	<p><i>Advantages:</i></p> <ul style="list-style-type: none">i. Can be placed on low geotechnical resistance of soils.ii. Relatively short construction period. <p><i>Disadvantages:</i></p> <ul style="list-style-type: none">i. Potential for unacceptable settlements and differential settlementsii. Requires relatively large and deep excavations in order to found the Granular A pad on competent soils.	<p><i>Advantages:</i></p> <p>None</p> <p><i>Disadvantages:</i></p> <ul style="list-style-type: none">ii. Uneconomically large footings due to low geotechnical resistance of soils.iii. Unreliable performance and high risk due to settlement sensitive soils. Potential for unacceptable settlements and differential settlements.	<p><i>Advantages:</i></p> <ul style="list-style-type: none">i. High geotechnical resistances available by driving piles to effective refusal.ii. Readily installed.iii. Reliable performance and low risk. <p><i>Disadvantages:</i></p> <ul style="list-style-type: none">i. Construction concerns related to the possibility of piles being obstructed by obstacles or boulders during driving.



APPENDIX E

TERRAPROBE INC.



DEWATERING – Item No.

Non-Standard Special Provision

SCOPE

The work under this item includes the design, installation, operation, maintenance and removal of temporary dewatering systems to facilitate the Jenkins Creek culvert replacement.

Foundations for the replacement culvert will require excavation below the groundwater level. Cohesionless soils below the groundwater table will be subjected to conditions of unbalanced hydrostatic head and can slough, boil and cave in during temporary excavation work.

REFERENCES

- OPSS 517 Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation
- OPSS 518 Construction Specification for Control of Water from Dewatering Operations

SUBMISSION AND DESIGN REQUIREMENTS

Written details for the proposed dewatering system shall be submitted to the Contract Administrator for information purposes a minimum of ten business days prior to commencing dewatering operations. The Contractor shall reference borehole logs included in the Contract Documents as a guide in determining requirements.

CONSTRUCTION

Dewatering System

The Contractor is responsible for the design, installation, operation and maintenance of an adequate dewatering system to lower the groundwater level to at least 1.0 m below the founding level for the replacement culvert, to allow excavation, subgrade preparation and construction in dry conditions.

Operation

A continuous dewatering operation shall be provided to facilitate the installation of the replacement culvert at all times during the work. All components of the dewatering system shall be maintained in an effective, functioning and stable condition at all times during the work. Notwithstanding the above, the work shall be completed in accordance with the environmental and operational constraints specified elsewhere in the contract.

Restoration

All equipment and materials placed shall be removed from the right-of-way upon the completion of the work and all areas disturbed as part of this work shall be restored to their preconstruction conditions, unless specified otherwise.

BASIS OF PAYMENT

Payment at the contract price for the above tender item shall be full compensation for all labour, equipment and material to do the work.

