



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
FERGUS ROAD BRIDGE REPLACEMENT
TOWNSHIP OF OPASATIKA, SITE 38C-150
COCHRANE / NEW LISKEARD DISTRICT
G.W.P. NO. 5141-14-00**

GEOCRES No. 42G-63

Report

to

LEA Consulting Ltd.

Date: November 8, 2016
File: 11532



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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) at the existing Fergus Road Bridge in the Township of Opasatika, Ontario. Thurber carried out the investigation as a consultant to LEA Consulting Limited (LEA), under the Ministry of Transportation Ontario (MTO) Agreement Number 5014-E-0056.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole locations plan and soil strata drawing, records of boreholes, laboratory test results and a written description of the subsurface conditions.

2. SITE DESCRIPTION

The site of the proposed bridge replacement is located on Bourinot Road 62 (referred to as Fergus Road), about 57 km south of Highway 11 in the Township of Opasatika and approximately 68 km from Kapuskasing, Cochrane / New Liskeard District.

The existing bridge, constructed in 1951, is a five-span structure approximately 30.2 m long and 6.5 m wide. The bridge is supported on rock filled timber cribs. As indicated in the MTO Inspection Report dated November 20, 2013, the bridge is in poor condition with deteriorating abutment walls, wingwalls, pier caps and other elements, which necessitated posting of a load carrying capacity limit of 25 tonnes at the bridge.

At the bridge location, the Opasatika River flows from east to west. The areas surrounding the bridge are vegetated with tall grass, shrubs and forested. The local topography is of low relief to

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gently undulating with bedrock outcrops noticeable in the vicinity of the bridge. There is a camp site on the southeast shore of the site area and a boat launch near the northwest approach to the bridge.

Photographs in Appendix C show the general nature of the site and the existing bridge.

Based on published geological information, the general area of the project is covered by glaciolacustrine sediments of clays and silts deposited during the Pleistocene period. These deposits are often varved clays, but massive clays are also present in some areas. Below the varved clays are glacial outwash deposits of silt, sand and gravel, and glacial till underlain by Precambrian intrusive rocks.

3. INVESTIGATION PROCEDURES

The field investigation for this project was carried out between July 15 and 17, 2016, during which time six boreholes denoted as Boreholes 16F-01 to 16F-06 were advanced along the roadway near the south and north approaches to the bridge. Boreholes 16F-02 and 16F-03 were drilled near the north abutment, and Boreholes 16F-04 and 16F-05 were located near the south abutment. The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawing provided in Appendix D.

A track-mounted CME-55 drill rig was used at this site in conjunction with NW casing and NQ rock coring techniques. The boreholes were advanced to depths between 6.9 m and 9.9 m. In all boreholes, soil samples were obtained at selected intervals with a 50 mm outside diameter split spoon sampler driven in conjunction with the Standard Penetration Testing (SPT) procedures (ASTM D-1586-99).

The field investigation was supervised on a full time basis by a member of Thurber's technical staff who marked the boreholes in the field, arranged for the clearance of subsurface utilities, directed the drilling, sampling and in-situ testing operations, logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions were observed in the open boreholes throughout the drilling operations and on completion of drilling. Standpipe piezometers were installed in Borehole 16F-03 and 16F-04 to monitor the groundwater level after drilling. The piezometers will be decommissioned after



the final water level readings are taken. The boreholes were decommissioned in general accordance with Ontario Regulation 903 (amended by Ontario Reg. 372).

Details of the borehole completion are summarized as follows:

Table 3.1 – Borehole Completion Details

Borehole Location	Boreholes Number	Borehole Depth/Base Elevation (m)	Completion Details
South Approach	16F-01	7.7 / 251.5	Bentonite holeplug and cuttings to surface.
South Abutment	16F-02	7.8 / 251.4	Bentonite holeplug and cuttings to surface.
	16F-03	8.1 / 251.1	Bentonite to 4.9 m, sand to 3.2 m, and bentonite holeplug to 2.9 then cuttings to surface.
North Abutment	16F-04	8.7 / 250.0	Bentonite to 5.5 m, sand to 3.7 m, and bentonite holeplug to 3.0, then cuttings to surface.
	16F-05	9.9 / 248.8	Bentonite holeplug and cuttings to surface.
North Approach	16F-06	6.9 / 252.0	Bentonite holeplug and cuttings to surface.

4. LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (hydrometer and/or sieve) and Atterberg Limits testing where appropriate. All laboratory tests were carried out to MTO and / or ASTM Standards, as appropriate. Laboratory testing results are summarized on the Record of Borehole sheets included in Appendix A and are presented on the figures included in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and



must be used for interpretation of the site conditions. It should be recognized and expected that soil conditions may vary between and beyond borehole locations.

In general, the subsurface conditions encountered in these boreholes consisted of road base/granular fill underlain by a silty clay fill, which in turn overlies sand and gravel deposits, glacial till and granite bedrock. Descriptions of the individual strata are presented below.

5.1 Sand and Gravel Fill

A layer of sand and gravel fill forming a road base was encountered extending from the ground surface to approximately 0.3 m depth, except in Borehole 16F-04 where the fill was found extending to 0.8 m depth. Some silt and occasional cobbles were encountered in this fill. A layer of geogrid was noted beneath the road base fill separating it from the underlying silty clay fill.

The results of grain size distribution analyses carried out on a sample of the fill are presented on the Record of Borehole sheet included in Appendix A and on Figure B1 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	50
Sand	39
Silt and Clay	11

A moisture content of 7 % was measured on a sample.

5.2 Silty Clay Fill

Underlying the road base was a silty clay fill with trace to some sand and trace to some gravel. Occasional cobbles and lenses of organic matter, including rootlets and wood fragments, were observed in the fill. The silty clay fill layer varied in thickness from 1.9 m to 2.7 m with the underside at depths between 2.4 m and 3.0 m (Elev. 256.0 and 256.8).

SPT 'N' values within the silty clay fill ranged from 2 to 25 blows per 0.3 m of penetration, indicating a soft to very stiff consistency. Occasional SPT 'N' values of greater than 100 blows for less than 0.3 m penetration were recorded, indicating presence of cobbles. Measured moisture contents within the silty clay fill varied between 22 percent and 30 percent.



The results of grain size distribution analyses and Atterberg Limits testing carried out on selected samples of the silty clay fill are presented on the Record of Borehole sheets included in Appendix A and on Figures B2 and B5 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0
Sand	4 to 10
Silt	39 to 56
Clay	34 to 52

The results of Atterberg Limits testing are summarized below:

Index Property	Percentage (%)
Plastic Limit	17 to 20
Liquid Limit	34 to 43
Plasticity Index	15 to 25

The results of the Atterberg Limits testing indicate the fill is of low to intermediate plasticity with group symbols of CL or CI.

5.3 Sand and Gravel

Underlying the silty clay fill was a deposit of predominantly sand and gravel with trace to some silt and trace to some clay. Occasional cobbles and trace of organic matter (rootlets and wood fragments) were observed in the deposit. In Borehole 16F-05, the cohesionless deposit was thicker with greater content of organic matter with occasional pockets of fibrous peat. The deposit was typically grey to dark grey, loose and wet. The thickness of the sand and gravel varied from 0.5 m to 1.6 m, with the underside of the deposit at depths varied from 3.4 m to 4.3 m depth or from Elev. 254.4 to 255.8.

SPT 'N' values within the sand and gravel typically ranged from 8 to 26 blows per 0.3 m of penetration, indicating a loose to compact condition. Occasionally, SPT 'N' values greater than 100 blows for less than 0.3 m penetration were recorded, indicating the presence of cobbles. The moisture contents measured on two samples of the sand and gravel were 15 percent and 52 percent; the latter value indicates the presence of peat in the sample.

5.4 Glacial Till

A glacial till was encountered underlying the river bed deposit. The till ranged in composition from silty clay, some to with sand, on the south side of the river to sandy silt with some clay on the north side of the river. Trace to some gravel and occasional cobbles were noted in the deposit. Trace organic matter was noted in the upper zone immediately underlying the cohesionless deposit. The thickness of till varied from 0.4 m to 2.3 m at the borehole locations. The underside of the till was observed between depths of 4.1 m and 6.6 m (Elev. 252.1 and Elev. 254.8).

SPT 'N' values within the cohesive till ranged from 4 blows per 0.3 m penetration to greater than 100 blows for less than 0.3 m of penetration, indicating a firm to hard consistency. In the sandy silt till, the 'N' values ranged from 8 to 18 blows per 0.3 m of penetration indicating a loose to compact condition. In Boreholes 16F-03 and 16-F-06, the SPT 'N' values of greater than 100 blows for less than 0.3 m penetration were recorded, indicating either the presence of cobbles or the top of bedrock. Measured moisture contents within the till deposit varied from 10 percent to 35 percent. The higher values of the moisture content indicates the presence of organic matter in the samples.

The results of grain size distribution analysis carried out on selected samples of the till are presented on the Record of Borehole sheets included in Appendix A and on Figures B3 and B4 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0 to 8
Sand	18 to 35
Silt	40 to 53
Clay	17 to 29

Glacial tills inherently contain cobbles and boulders.

5.5 Bedrock

Granite bedrock was encountered in all boreholes below the glacial till at depths ranging from 4.1 m to 6.6 m. The top of bedrock may vary between the borehole locations. Bedrock was proved by coring in all six boreholes. Table 5.1 summarizes the depths and elevations to the top of bedrock at the borehole locations.

Table 5.1 – Depths and Elevations of Top of Bedrock

Foundation Element	Borehole	Top of Bedrock	
		Depth (m)	Elevation (m)
South Approach	16F-01	4.7	254.5
South Abutment	16F-02	4.6	254.6
	16F-03	5.0	254.2
North Abutment	16F-04	5.6	253.1
	16F-05	6.6	252.1
North Approach	16F-06	4.1	254.8

The bedrock was described as moderately to slightly weathered, mottled pink and grey, medium strong. Occasional seams of white quartz were noted in the rock core samples.

Total Core Recovery (TCR) in the bedrock ranged from 65% to 100%. The lowest values of TCR between 65% and 78% were obtained for the cores retrieved from the upper 2 m zone in Borehole 16F-02. The RQD values ranged from 0% to 77%, which indicates a very poor to good rock quality. The very poor to poor quality rock quality was encountered in Borehole 16F-02.

The Fracture Index (FI) of the rock, expressed as number of fractures per 0.3 m of core run, ranged typically from 1 to 8. The Fracture Index was greater than 25 in Borehole 16F-02 where highly fractured rock cores were obtained.

The unconfined compressive strength of the rock interpreted from point load tests conducted on core samples ranged from 47 to 303 MPa, indicating a medium strong to extremely strong rock.

The unconfined compressive strengths interpreted from point load tests are presented on the Point Load Test Sheet provided in Appendix B.

5.1 Groundwater Conditions

Water levels were observed in the open boreholes during drilling operations. Wash boring techniques were used to advance the boreholes in the overburden and water was used during rock coring; therefore, water levels recorded during or upon completion of drilling may not reflect natural groundwater levels. The water levels measured in the boreholes on completion of drilling are shown in Table 5.2, below.



Table 5.2 – Water Level Measurements

Borehole	Date	Water Level		Comment
		Depth (m)	Elevation (m)	
16F-01	July 16, 2016	3.2	256.0	Open borehole
16F-02	July 17, 2016	2.6	256.6	Open borehole
16F-03	July 17, 2017	2.7	256.5	Piezometer
16F-04	July 15, 2016	3.1	255.6	Piezometer
	July 16, 2016	2.7	256.0	
16F-05	July 16, 2016	2.7	256.0	Open borehole
16F-06	July 16, 2016	2.9	256.0	Open borehole

The above water levels are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the water level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

The water level in the Opatatika River was indicated on the preliminary General Arrangement drawing at Elev. 256.5 in December 2015.

6. MISCELLANEOUS

Thurber marked the borehole locations in the field and obtained subsurface utility clearances prior to drilling.

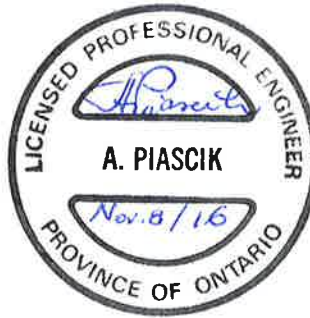
Eastern Ontario Diamond Drilling of Hawkesbury, Ontario supplied a track-mounted CME-55 drill rig and conducted the drilling, sampling and in-situ testing operations. The drilling operations were supervised by Mr. Zane Bourk of Thurber.

Overall supervision of the field program was carried out by Mr. Stephane Loranger, CET. The coordinates and ground surface elevations at the borehole locations were established by Thurber from the drawings provided by LEA.

Routine laboratory testing was carried out at Thurber's geotechnical laboratory. Interpretation of the field data and preparation of this report was carried out by Ms. Anna Piascik, P.Eng. The report was reviewed by Mr. Sydney Pang, P.Eng 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 an interpretation of the geotechnical data in the factual report and provides foundation recommendations for the proposed replacement of the existing Fergus River Bridge located on Bourinot Road 62 (referred to as Fergus Road) in the Township of Opasatika, Cochrane/New Liskeard District, Ontario.

This foundation investigation and design report with the interpretations and recommendations is intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractors. The contractors must make their own interpretations based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

At present, the bridge carries Bourinot Road (referred to as Fergus) over the Opasatika River on a five span structure constructed in 1951. The existing superstructure has a total length of approximately 30.2 m and a deck width of 6.5 m, and consists of a steel girder main span and sawn girder approach spans. The superstructure is supported on rock filled timber cribs at the abutments and piers.

Based on the Evaluation Report titled "The Fergus Road LRB Bridge, Site 38C-150, Cochrane District, New Liskeard Area, Evaluation Tables and Plans, Alternatives for the Fergus Road LRB Replacement" dated March 2016, prepared for MTO by LEA Consulting Limited (LEA), the highest

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ranked option is for the replacement structure to consist of a new single span modular or steel girder bridge supported on spread footings on engineered fill and located on the existing alignment. An accelerated replacement strategy involving a short time (up to 10 days) full road closure has been envisioned for the bridge replacement.

As shown on a preliminary General Arrangement (GA) drawing dated June 2016 provided by LEA, the new bridge will be approximately 39.5 m in length and 7.4 m in width (5.5 m roadway width). The new bridge is proposed to be supported on concrete spread footings placed on engineered fill foundation pads.

The south approach embankment will remain at the same grade while the north approach will be raised by approximately 0.5 m.

The discussions and recommendations presented in this report are based on information shown in the preliminary GA drawing and on the factual data obtained during the course of this investigation.

8. STRUCTURE FOUNDATIONS

In summary, the subsurface conditions encountered in these boreholes consisted of road base/granular fill underlain by a soft to very stiff silty clay fill overlying loose to compact sand and gravel. Glacial till deposits consisting of firm silty clay or loose to compact sandy silt underlie the above soils. The site is underlain by granite bedrock at depths ranging from 4.1 m to 6.6 m or from Elev. 252.1 to Elev. 254.8. Groundwater levels measured in the piezometers were at 2.7 m depth or Elev. 256.5. It is anticipated that the groundwater level is influenced by the water level in the river.

The following foundation options were considered for the support of this bridge:

- spread footings placed on the existing fill,
- spread footings placed on bedrock,
- spread footings placed on engineered fill, and
- driven steel H-piles.

Recommendations for design of the feasible foundation alternatives are presented in the following sections together with the corresponding geotechnical design parameters where applicable. A preferred foundation alternative from a geotechnical perspective is indicated.



8.1 Spread Footings on Existing Fill

Given the low strength, compressible and heterogeneous nature of the silty clay fill encountered immediately below the road base, and the significant depth to a competent foundation stratum, spread footings placed directly on the existing fill to support the abutments are not recommended.

8.2 Spread Footings on Bedrock

Placement of spread footings on bedrock would require 4.1 m to 6.6 m deep excavations with the lower part of excavations extending below the groundwater and river water levels. Dewatering and temporary protection system would be required to construct the foundations in the dry. Although technically feasible, this option is not cost effective and is not practical for a rapid replacement.

8.3 Spread Footings on Engineered Fill Material

A modular bridge with abutments supported on concrete footings placed on granular fill pads can be considered at this site. The preliminary GA drawing indicates the finished road grade at approximate Elev. 259.2 at the south abutment, and Elev. 259.6 at the north abutment. The underside of the engineered fill pads is shown at approximate Elev. 256.5 and this can be considered in the design. It is noted that the footings are located close to the river slopes that will result in lower bearing resistances.

The engineered fill pad should be at least 1 m in thickness. The engineered fill should consist of OPSS Granular "A" or Granular B Type II placed in 150 mm lifts and compacted to 100% of its SPMDD at $\pm 2\%$ of optimum moisture content. The top of the engineered fill pad should be at least 1 m wider than the footprint of the spread footing. The subgrade for the engineered fill pad should be inspected and all organics, soft/loose soils, and deleterious materials should be removed from the footprint of the engineered fill excavation. Dewatering measures should be provided, as required, to place the engineered fill in the dry. A sketch of the abutment placed on compacted fill is enclosed in Appendix E.

The following values of factored Geotechnical Resistance at ULS and Geotechnical Reaction may be used for design of a continuous footing not less than 3.0 m in width and placed on properly compacted engineered fill as noted above, with the base of the engineered fill at Elev. 256.5:

Factored Geotechnical Resistance at ULS (kPa)	-	275 kPa
Geotechnical Reaction at SLS (kPa)	-	175 kPa.



The grade raise of 0.5 m at the north abutment will cause settlements in the order of 10 mm to 15 mm. Given that the footings will be supported in the approach fills, they will settle along with the embankments and the serviceability of the modular bridge is not expected to be affected.

The values of a Factored Geotechnical Resistance at ULS was assessed assuming a Consequence Factor equal to 1 (Typical), and a Resistance Factor equal to 0.5 (Typical degree of understanding of the subsurface conditions), as per CHBDC 2014. The Geotechnical Reaction at SLS was assessed assuming a factor of 0.8 for typical degree of understanding of the subsurface conditions.

The geotechnical resistance quoted above is for concentric, vertical loads only. In the case of eccentric or inclined loading, the geotechnical resistance should be calculated as illustrated in the CHBDC 2014 Clause 6.10.3 and Clause 6.10.4.

The lateral resistance of the footings founded on engineered fill may be computed using an unfactored friction coefficient of 0.6. This is an “ultimate” value and requires a degree of sliding movement to occur to fully mobilize the resistance.

The preliminary GA drawing indicates that the new abutment will be located some distance behind the existing abutments. In light of distress and erosion observed at the existing abutments, placement of new abutments some distance behind the existing timber cribs is considered to be beneficial.

8.4 Driven H-Pile Foundations

Steel H-piles driven to bedrock is technically feasible provided that a minimum pile length is satisfied from a structural perspective. The bedrock surface was encountered between 4.6 m and 5.0 m depth at the south abutment, and between 4.6 m and 6.6 m depth at the north abutment. The structural designer should establish the minimum pile length required and determine if the shallow bedrock allows this type of foundations.

This option is not developed further at this time unless the construction window currently envisaged can be modified and structural analysis results indicate that the current site conditions permit a driven pile foundation. Steel piles socketted into bedrock is technically feasible but will not be a cost effective option.



8.5 Recommended Foundation

From a foundations perspective and given the short construction time frame, supporting the replacement bridge on concrete spread footings placed on granular/engineered fill pads is considered the preferable foundation option. This option will also offer cost effectiveness and relative ease of construction.

8.6 Frost Cover

The depth of frost penetration at this site is approximately 2.5 m. Provision of frost cover for the concrete slab foundations to support a modular bridge founded on an engineered fill pads is not required.

Concrete slab foundations for modular bridge founded on an engineered fill pads should be provided with a minimum embedment of 0.5 m.

9. SCOUR AND EROSION CONTROL

The existing forward slopes appear to be experiencing erosion, as shown on the photograph enclosed in Appendix C. Adequate scour and erosion protection should be established to ensure that the forward slopes at the bridge, and the river bank slopes on both sides of the bridge, are protected. The design of the scour and erosion protection works should be undertaken by a specialist in this field.

A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion, in general accordance with OPSS.PROV 804.

10. EXCAVATION AND GROUNDWATER CONTROL

Excavation for works associated with the construction of the new abutments is expected to extend through the existing road base and into the embankment fill with the base of excavation located near the river water level. The excavation of the existing crib abutments may also be required; however, removal of the existing abutments below the river water level will be difficult and is not recommended.

As per the preliminary GA drawing and to satisfy the navigable clearance requirements, the existing timber crib piers located in the river will have to excavated and removed.



All excavations should be carried out in accordance with OPSS 902 and the requirements of the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the approach embankment fill within the depth of excavation may be classed as Type 3 soil above the water table and Type 4 below the water level.

Open cutting may be carried out at an inclination of 1H : 1V. Where space permits and where required, flatter slopes may be warranted to maintain stability.

The selection of the method of excavation is the responsibility of the Contractor and should be based on the Contractor's experience, equipment and interpretation of the site conditions. The existing timber cribs contain rock fill material. It is anticipated that a hydraulic excavator will be suitable for use at this site. Provision should be made for handling of potential obstructions in the fill such as cobbles and boulders.

The groundwater level is expected to be largely governed by the water level in the river. Excavation for the engineered fill pad construction will extend close to the water level in the river.

Seepage from the underlying sand and gravel may be handled by pumping from filtered sumps. The use of sand bagged cofferdams may be considered where required. The design of groundwater control system is the responsibility of the contractor.

11. ROADWAY PROTECTION SYSTEM

Given the 10-day road closure window, it is unlikely that there will be sufficient time for installing roadway protection systems.

However if a temporary protection system is used, the design of the protection system is typically the responsibility of the Contractor, as per OPSS.PROV 539. The protection system should be designed for Performance Level 2 (maximum 25 mm horizontal deflection). Temporary protection system may consist of steel soldier pile and timber lagging walls or continuous sheet pile walls.

Full hydrostatic pressure should be considered assuming a water level equal to the design river water level. The actual pressure distribution acting on the protection system is a function of the construction sequence and the relative flexibility of the wall.

All temporary protection systems should be designed by a Professional Engineer experienced in such designs.

12. APPROACH EMBANKMENTS



The existing approach embankments vary in height and could be as high as 3 m near the abutments. No evidence of instability of the existing approach embankments were noted during the time of the foundation investigation, although settlements at the abutments were evident. These settlements could be related to the river bank erosion leading to the undermining of the timber cribs and loss/washout of the abutment fill.

Based on the preliminary GA drawing, the grade of the existing north approach embankment will be raised by 0.5 m. The loading imposed by the additional fill could induce up to 15 mm of settlement. The majority of the estimated settlement will occur in the first three months following the fill placement. In light of the fact that this is a gravel, un-paved local road, it is anticipated that this ground settlement will be tolerable. Periodic maintenance of the road may be carried out as required.

In view of the soil conditions at this site, stability issues are not anticipated for the approach embankments.

13. CONSTRUCTION CONCERNS

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

- Seasonal fluctuations of the groundwater and river water levels are to be expected. In particular, the water level may be at a higher elevation after periods of heavy rainfall, which may impact the construction.
- Rock fill is present as fill in the timber cribs, and occasional cobbles and boulders may be present in the existing embankment fill and native soils. Cobbles and boulders may interfere with excavations or installation of temporary protection system should it be required.

14. CLOSURE

Engineering analysis and preparation of this report were carried out by Ms. Anna Piascik, P.Eng. The report was reviewed by Mr. Sydney Pang, P.Eng. and Mr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



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Client: LEA Consulting Limited

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E file: H:\10000+11532 Cochrane LRB Bridges 5014-E-0056\Fergus\Reports and Memos\2 - Draft FIDR - Aug 26
16\FINAL\11532 Fergus FINAL FIDR nov 16.docx

Date: November 8, 2016

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Appendix A

Record of Borehole Sheets

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


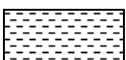

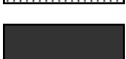

ROCK WEATHERING CLASSIFICATION

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 (MPa)	Approximate Uniaxial Compressive Strength (psi)	Field Estimation of Hardness*
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 16F-01

1 OF 1

METRIC

W.P. 5141-14-01 LOCATION Fergus Road Bridge N 5 444 227.0 E 369 789.7 ORIGINATED BY ZRB
 HWY Local BOREHOLE TYPE NQ Coring with NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2016.07.16 - 2016.07.16 CHECKED BY AMP

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			w _P w w _L				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
259.2	GROUND SURFACE														
0.0	SAND and GRAVEL , some silt, occasional cobbles						259								
258.9	Brown Moist (FILL) Geogrid layer at 0.3m														
0.3	Silty CLAY , trace sand, trace gravel, occasional lenses of organics and wood fragments Stiff to Soft Brown (FILL)		1	SS	9		258								
		2	SS	4											
	Occasional cobbles below 2.5m	3	SS	2	257										
256.2															
3.0	SAND and GRAVEL , some silt, trace clay, trace organics, occasional cobbles	4	SS	9	256										
255.5	Loose Dark Grey														
3.7	Wet														
	Silty CLAY , with sand, trace gravel Firm Grey Wet (TILL)						255								
254.5															
4.7	GRANITE BEDROCK moderately to slightly weathered, medium strong, pink and grey mottled with occasional seams of quartz		1	RUN		254									
	Broken core (75mm) at 4.7m, (50mm) at 5.1m and (25mm) at 6.6m														
	Quartz seams (175mm) at 6.4m and (150mm) at 7.3m		2	RUN		253									
251.5							252								
7.7	END OF BOREHOLE AT 7.7m. WATER LEVEL IN OPEN BOREHOLE AT 3.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.														

ONTMT4S MTO-11532.GPJ 2015TEMPLATE(MTO).GDT 8/22/16

+³, ×³: Numbers refer to
Sensitivity

20
15 10 5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16F-02

1 OF 1

METRIC

W.P. 5141-14-01 LOCATION Fergus Road Bridge N 5 444 225.3 E 369 795.8 ORIGINATED BY ZRB
 HWY Local BOREHOLE TYPE NQ Coring with NW Casing COMPILED BY AN
 DATUM Geodetic DATE 07/17/2016 - 2016.07.17 CHECKED BY AMP

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					
259.2	GROUND SURFACE												
0.0	SAND and GRAVEL , some silt, occasional cobbles						259						
0.3	Brown Moist (FILL) Geogrid at 0.3m												
	Silty CLAY , trace sand, occasional lenses of organics Firm to Soft Brown Occasional cobbles from 0.5m to 0.8m		1	SS	6		258						
			2	SS	2								0 4 46 50
256.8							257						
2.4	SAND and GRAVEL , trace silt, trace clay, occasional cobbles, trace organics (wood fragments and rootlets) Compact Grey Wet		3	SS	26		256						
255.8													
3.4	Silty CLAY , with sand, trace gravel, lenses of organics in the upper zone Firm Grey Moist (TILL)		4	SS	4		255						0 33 44 23
254.6			5	GS									
4.6	GRANITE BEDROCK moderately to slightly weathered, medium strong, pink and grey mottled with occasional seams of quartz		1	RUN			254						RUN #1 TCR=65% SCR=0% RQD=0%
	Broken core from 4.6m to 5.7m, 6.3m to 7.1m and (100mm) at 7.3m		2	RUN									RUN #2 TCR=77% SCR=67% RQD=21%
	Quartz seam (75mm) at 7.7m		3	RUN			253						RUN #3 TCR=78% SCR=19% RQD=0%
			4	RUN			252						RUN #4 TCR=100% SCR=76% RQD=35%
251.4	END OF BOREHOLE AT 7.8m. WATER LEVEL IN OPEN BOREHOLE AT 2.6m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPUG AND CUTTINGS TO SURFACE.												
7.8													

ONTMT4S MTO-11532.GPJ 2015TEMPLATE(MTO).GDT 8/22/16

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16F-03

1 OF 1

METRIC

W.P. 5141-14-01 LOCATION Fergus Road Bridge N 5 444 220.9 E 369 790.8 ORIGINATED BY ZRB
 HWY Local BOREHOLE TYPE NQ Coring with NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2016.07.16 - 2016.07.16 CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
							<div><div></div><div></div><div></div><div></div><div></div></div>							
259.2	GROUND SURFACE													
0.0	SAND and GRAVEL , some silt, occasional cobbles Compact Brown Moist (FILL) Geogrid at 0.3m Silty CLAY , some sand, trace gravel, occasional organics (wood fragments and rootlets), occasional cobbles Firm to Very Stiff Brown Moist (FILL)													
258.9														
0.3														
			1	SS	5									
			2	SS	7									
			3	SS	25									
256.2	SAND and GRAVEL , some silt, occasional cobbles, trace organics (wood fragments and rootlets) Very Dense Dark Grey Wet Silty CLAY , some sand, trace gravel, occasional cobbles Hard Grey Moist (TILL)													
3.0														
255.7														
3.5														
			4	SS	120/ 0.150									
			5	SS	120/ 0.150									
254.2	GRANITE BEDROCK moderately to slightly weathered, medium strong, pink and grey mottled with occasional seams of quartz Broken core (75mm) at 5.7m and (50mm) at 6.8m Highly fractured below 7.3m													
5.0														
			1	RUN										
			2	RUN										
			3	RUN										
251.1	END OF BOREHOLE AT 8.1m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2016.07.17 2.7 256.5													
8.1														

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

RECORD OF BOREHOLE No 16F-04

1 OF 2

METRIC

W.P. 5141-14-01 LOCATION Fergus Road Bridge N 5 444 194.8 E 369 821.9 ORIGINATED BY ZRB
 HWY Local BOREHOLE TYPE NQ Coring with NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2016.07.15 - 2016.07.15 CHECKED BY AMP

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 (%)			
258.7	GROUND SURFACE						20 40 60 80 100	20 40 60					GR SA SI CL
0.0	SAND and GRAVEL , some silt, occasional cobbles Brown Moist (FILL) Geogrid at 0.3m		1	GS									50 39 11 (SI+CL)
257.9													
0.8	Silty CLAY , trace sand, trace gravel, trace organics (rootlets and wood fragments), occasional cobbles Very Stiff to Stiff Brown Moist (FILL) Cobbles from 1.5m to 1.9m		2	SS	23								
			3	SS	10								0 9 39 52
256.0													
2.7	SAND and GRAVEL , some silt, some clay, trace organics (wood fragments and rootlets) Loose Dark Grey Wet		4	SS	9								
255.1													
3.6	Sandy SILT , some gravel, some clay Loose to Compact Grey Moist (TILL)		5	SS	8								
			6	SS	18								
253.1													
5.6	GRANITE BEDROCK moderately to slightly weathered, medium strong, pink and grey mottled with occasional seams of quartz Broken core (75mm) at 5.6m Quartz seams (150mm) at 5.8m and (25mm) at 8.4m		1	RUN									RUN #1 TCR=100% SCR=60% RQD=50%
			2	RUN									RUN #2 TCR=100% SCR=80% RQD=54%
250.0	END OF BOREHOLE AT 8.7m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m)												
8.7													

Continued Next Page

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

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METRIC

[illegible]

RECORD OF BOREHOLE No 16F-05

1 OF 2

METRIC

W.P. 5141-14-01 LOCATION Fergus Road Bridge N 5 444 190.4 E 369 816.9 ORIGINATED BY ZRB
 HWY Local BOREHOLE TYPE NQ Coring with NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2016.07.15 - 2016.07.16 CHECKED BY AMP

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					
258.7	GROUND SURFACE												
0.0	SAND and GRAVEL , some silt, occasional cobbles												
258.4	Brown Moist (FILL) Geogrid at 0.3m												
0.3													
	Silty CLAY , trace to some sand, occasional cobbles, occasional organics (rootlets) Firm to Stiff Brown Moist (FILL)		1	SS	8		258						
			2	SS	5		257						0 5 46 49
			3	SS	108/ 0.150		256						
256.0	Cobbles at 2.4m												
2.7	SAND and GRAVEL , some silt, occasional pockets of fibrous peat, occasional cobbles Loose Dark Grey Wet		4	SS	8		255						
254.4	Sandy SILT , some clay, trace to some gravel, occasional cobbles, trace organics in the upper zone Loose Grey Moist (TILL)		5	SS	8		254						8 35 40 17
							253						
252.1							252						
6.6	GRANITE BEDROCK moderately to slightly weathered, medium strong, pink and grey mottled with occasional seams of quartz Broken core (75mm) at 6.6m, (25mm) at 7.1m and 9.0m		1	RUN			251						RUN #1 TCR=100% SCR=79% RQD=52%
			2	RUN			250						RUN #2 TCR=100% SCR=74% RQD=59%
			3	RUN			249						RUN #3 TCR=100% SCR=81% RQD=63%
248.8													
9.9	END OF BOREHOLE AT 9.9m												

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16F-05

2 OF 2

METRIC

W.P. 5141-14-01 LOCATION Fergus Road Bridge N 5 444 190.4 E 369 816.9 ORIGINATED BY ZRB
 HWY Local BOREHOLE TYPE NQ Coring with NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2016.07.15 - 2016.07.16 CHECKED BY AMP

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
	Continued From Previous Page WATER LEVEL IN OPEN BOREHOLE AT 2.7m UPON COMPLETION.																

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RECORD OF BOREHOLE No 16F-06

1 OF 1

METRIC

W.P. 5141-14-01 LOCATION Fergus Road Bridge N 5 444 188.9 E 369 822.8 ORIGINATED BY ZRB
 HWY Local BOREHOLE TYPE NQ Coring with NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2016.07.15 - 2016.07.15 CHECKED BY AMP

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				
258.9	GROUND SURFACE															
0.0	SAND and GRAVEL , some silt, occasional cobbles Compact Brown Moist (FILL) Geogrid at 0.3m Silty CLAY , trace to some sand, trace to some gravel, trace organics (rootlets) Stiff Brown Moist (FILL)															
258.6																
0.3																
			1	SS	12		258									
			2	SS	15		257									
			3	SS	8											
256.0																
2.9	SAND and GRAVEL , trace silt, occasional cobbles, occasional organics Compact Grey Wet Sandy SILT , some clay, trace to some gravel, occasional cobbles Very Dense Grey Moist (TILL) GRANITE BEDROCK moderately to slightly weathered, medium strong, pink and grey mottled with occasional seams of quartz Broken core (50mm) at 4.1m, (75mm) at 6.0m and (100mm) at 6.5m						256									
255.2																
3.7																
			4A	SS	106/		255									
254.8			4B	SS	0.150											
4.1																
			1	RUN			254									

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Appendix B

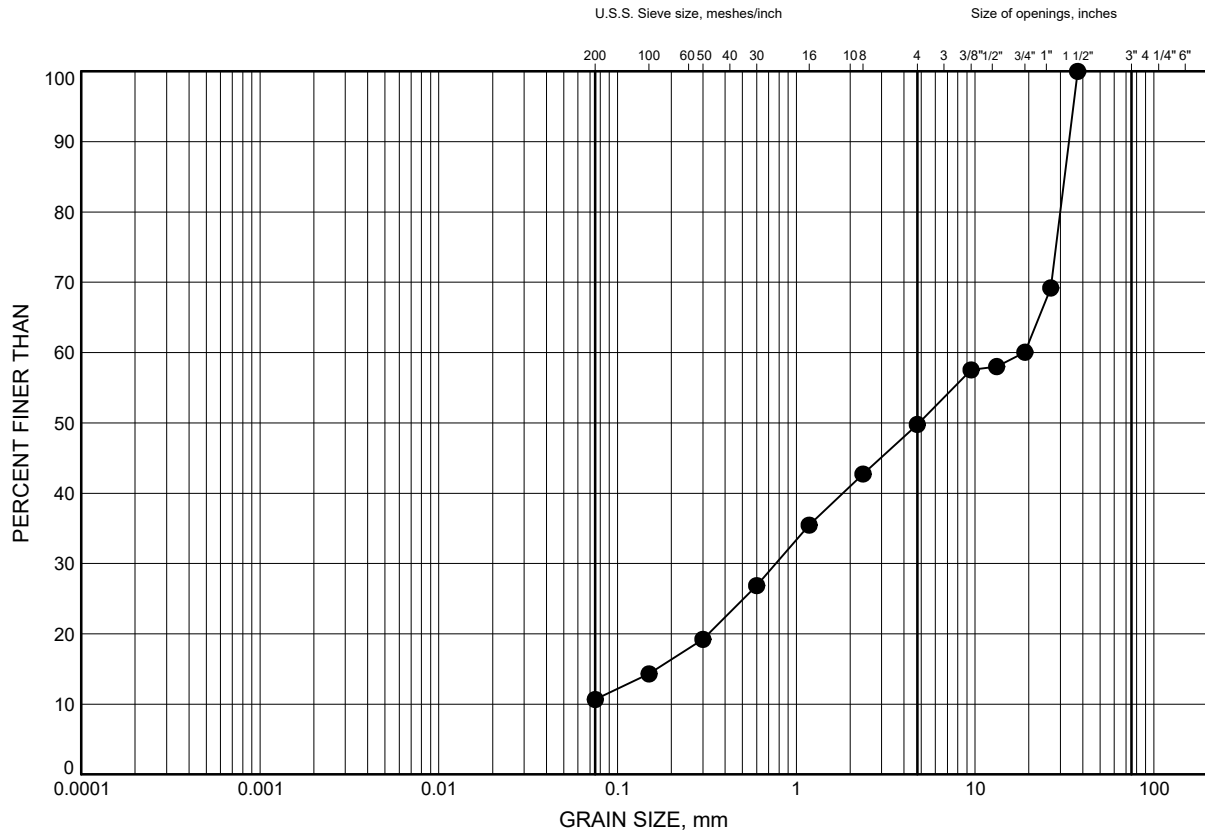
Laboratory Test Results

Fergus Road Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND and GRAVEL FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16F-04	0.15	258.55

Date July 2016
W.P. 5141-14-01



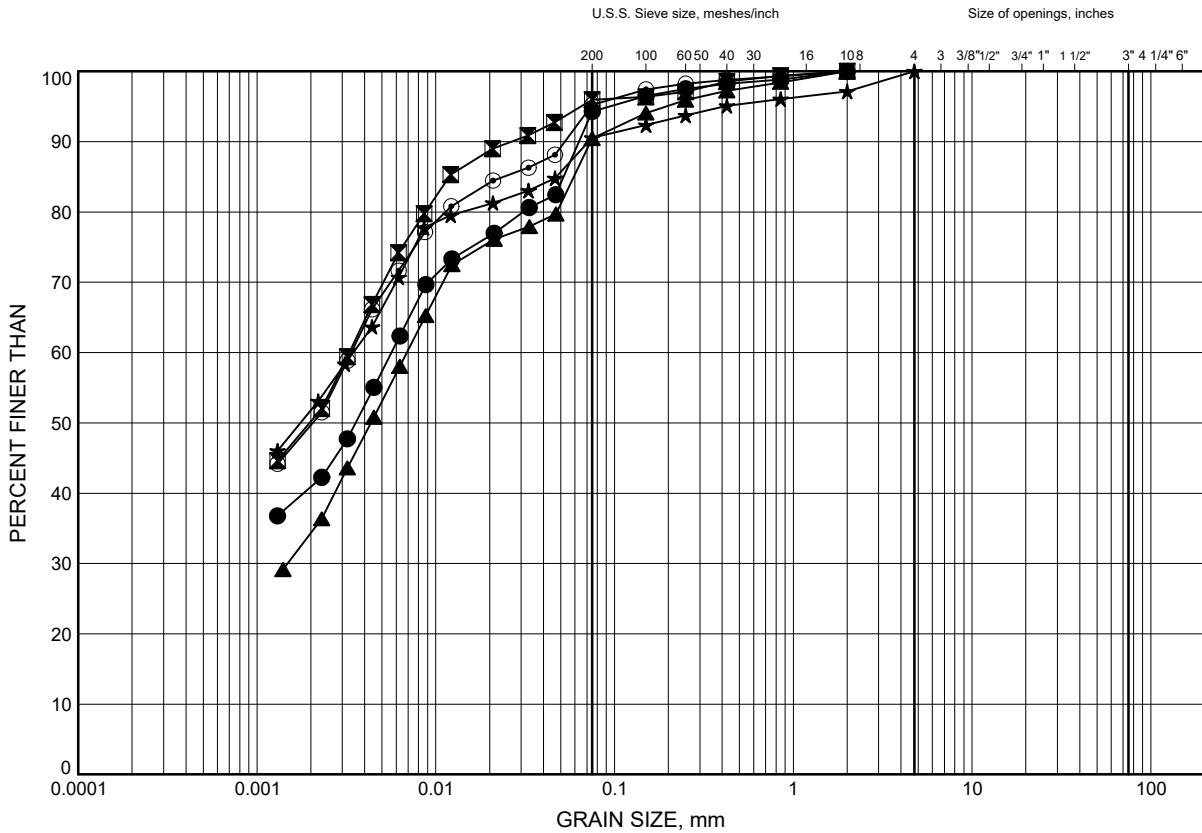
Prep'd AN
Chkd. AMP

Fergus Road Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B2

Silty CLAY FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16F-01	1.83	257.37
⊠	16F-02	1.83	257.37
▲	16F-03	1.83	257.37
★	16F-04	2.29	256.41
⊙	16F-05	1.83	256.87

Date July 2016
W.P. 5141-14-01



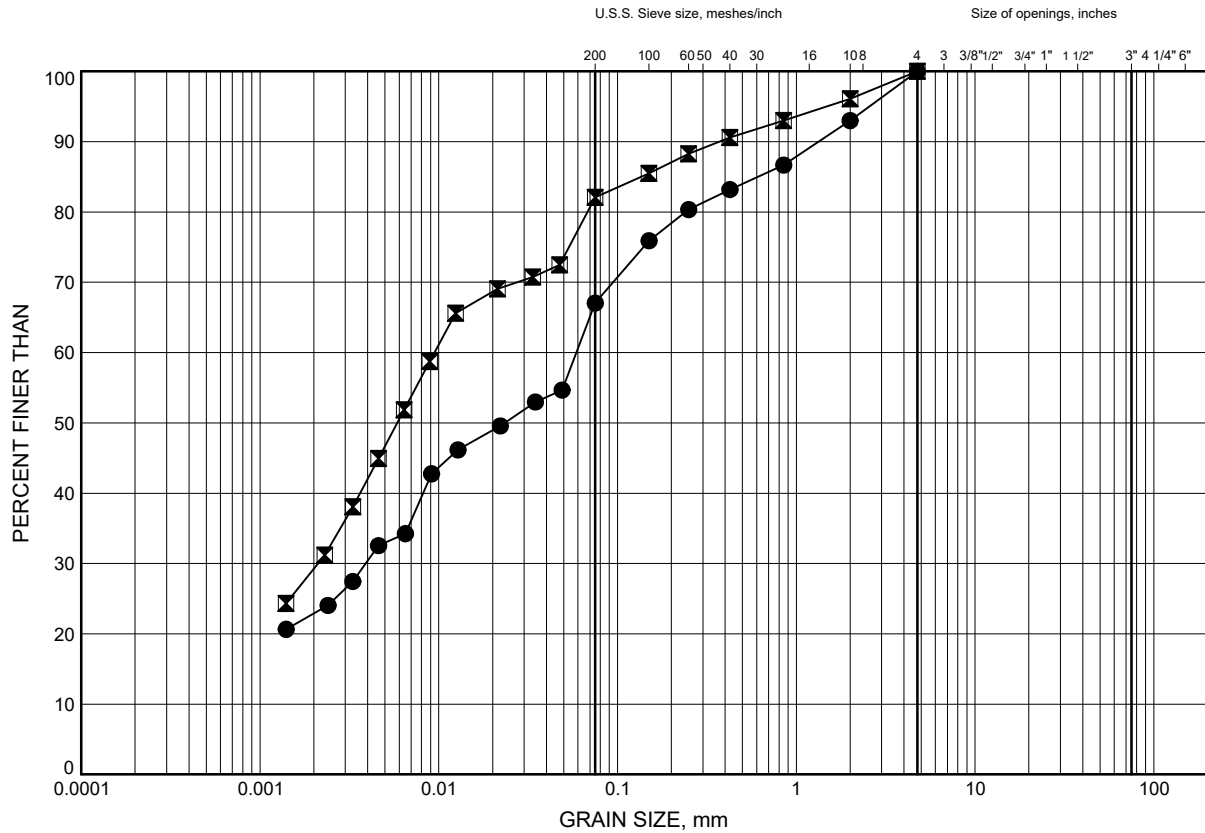
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Fergus Road Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B3

Sandy, Silty CLAY TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16F-02	3.76	255.44
⊠	16F-03	4.76	254.44

Date July 2016
W.P. 5141-14-01



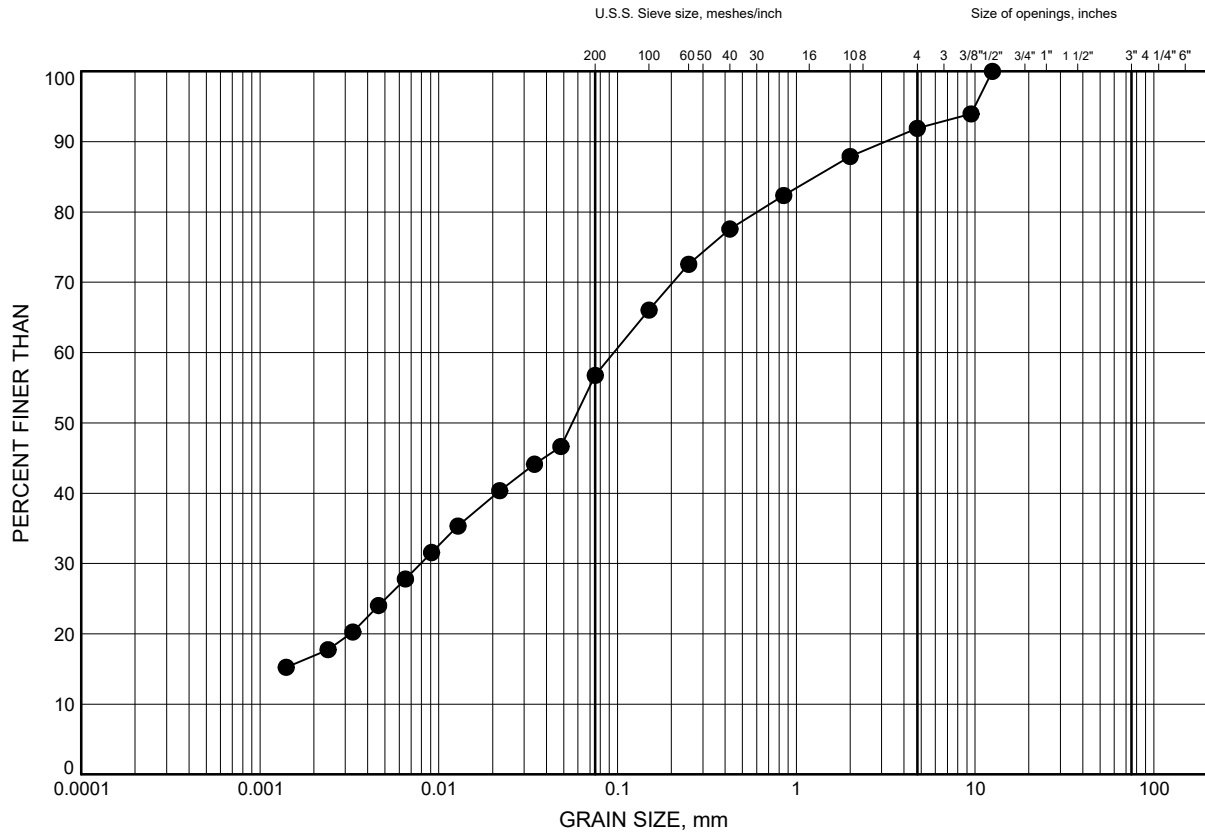
Prep'd AN
Chkd. AMP

Fergus Road Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B4

Sandy SILT TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16F-05	6.24	252.46

Date July 2016
W.P. 5141-14-01

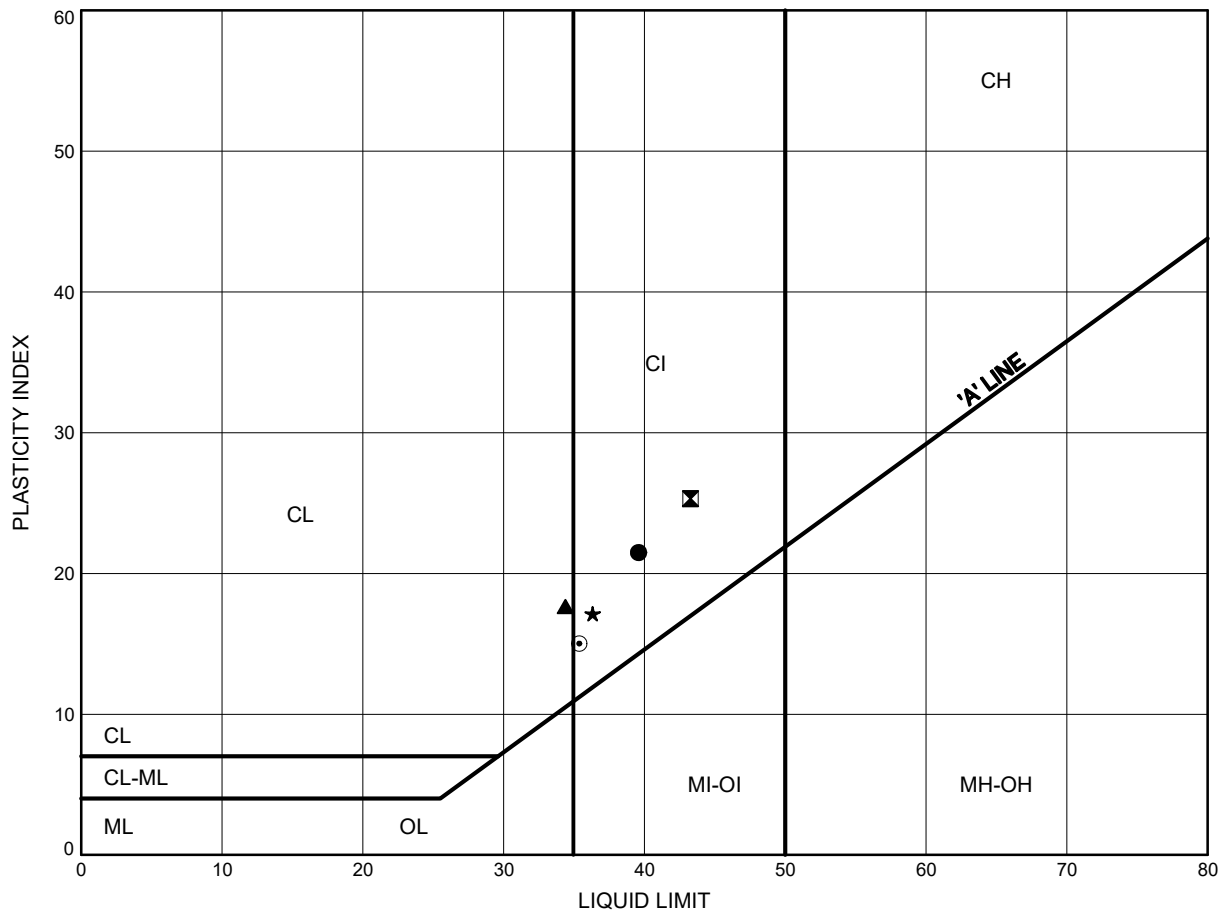


Prep'd AN
Chkd. AMP

Fergus Road Bridge
ATTERBERG LIMITS TEST RESULTS

FIGURE B5

Silty CLAY FILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16F-01	1.83	257.37
⊠	16F-02	1.83	257.37
▲	16F-03	1.83	257.37
★	16F-04	2.26	256.44
⊙	16F-05	1.83	256.87

Date July 2016
W.P. 5141-14-01



Prep'd AN
Chkd. AMP



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

Job No : 11532 Client : LEA Consulting
Date Drilled : Jul-16
Project Name : Cochrane LRB Bridges Date Tested : 22-Aug-16
Core Size : NQ BH No : 16F-01 Tester : RMT

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	UCS (MPa)	Rock Type	Notes
1		4.7	D	4.8	47.5	150.0	47.1	Granite	Medium Strong
2		5.2	D	12.8	47.5	150.0	125.9	Granite	Very Strong
3		5.5	D	22.5	47.5	150.0	221.7	Granite	Very Strong
4		6.0	D	30.5	47.5	150.0	300.3	Granite	Extremely Strong
5		6.4	D	18.7	47.5	150.0	184.1	Granite	Very Strong
6		6.7	D	30.8	47.5	150.0	303.3	Granite	Extremely Strong
7		7.0	D	28.4	47.5	150.0	279.9	Granite	Extremely Strong
8		7.1	D	26.5	47.5	150.0	261.5	Granite	Extremely Strong
9		7.4	D	13.7	47.5	150.0	134.6	Granite	Very Strong
10									
11									
12									
13									
14									
15									
16									
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33									
34									
35									

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.

Last Modified: August 15, 2013



Appendix C

Selected Site Photographs



Photograph 1 – Fergus Road Bridge looking north



Photograph 2 – Fergus Road Bridge looking south



Photograph 3 – East elevation of Fergus Road Bridge, looking north



Photograph 4 – West elevation of Fergus Road Bridge, looking north



Photograph 5 – Fergus Road Bridge, south abutment looking east



Photograph 6 – Fergus Road Bridge, south abutment looking south



Photograph 7 – Fergus Road Bridge; west approach and north abutment

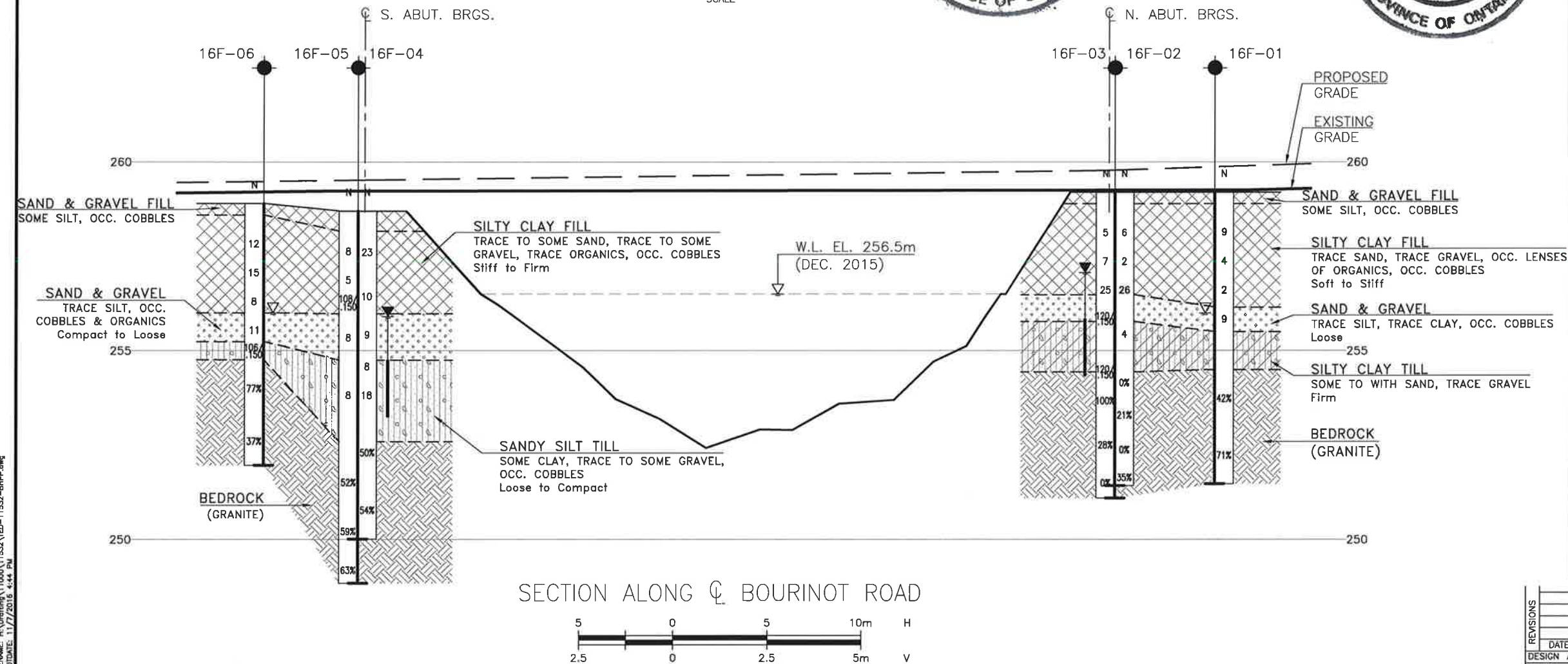
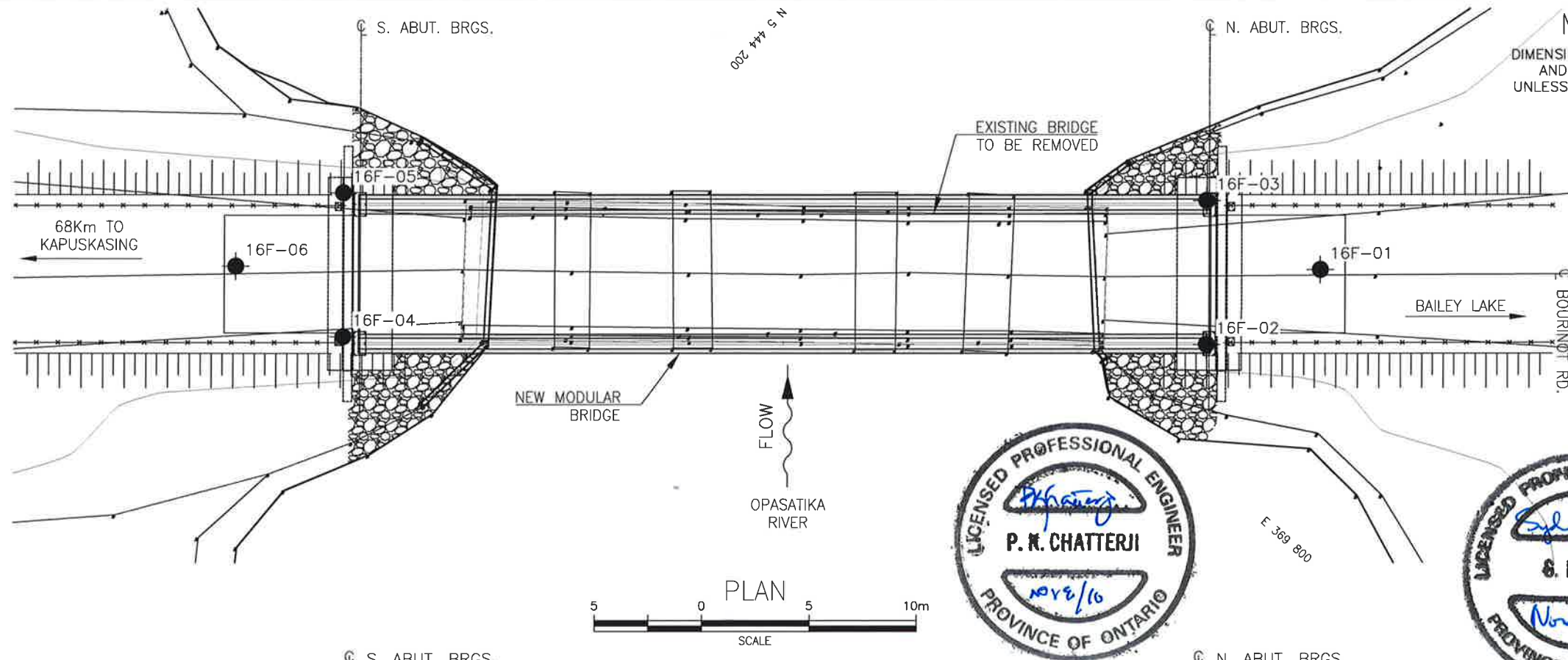


Appendix D

Borehole Locations and Soil Strata Drawing

MINISTRY OF TRANSPORTATION, ONTARIO

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PLOTDATE: 11/7/2016 4:44 PM



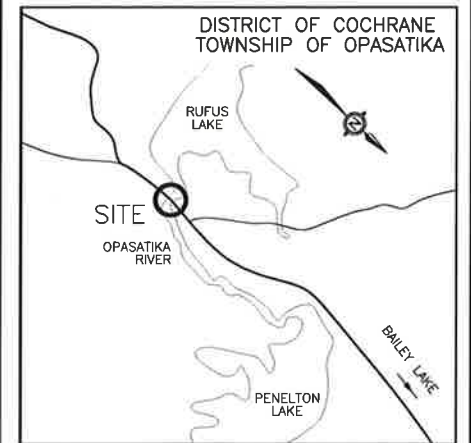
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 5163-14-01

FERGUS ROAD
LRB BRIDGE REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

●	Borehole
⊕	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level Observed During Drilling
↑	Water Level Observed In Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
16F-01	259.2	5 444 227.0	369 789.7
16F-02	259.2	5 444 225.3	369 795.8
16F-03	259.2	5 444 220.9	369 790.8
16F-04	258.7	5 444 194.8	369 821.9
16F-05	258.7	5 444 190.4	369 816.9
16F-06	258.9	5 444 188.9	369 822.8

-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.

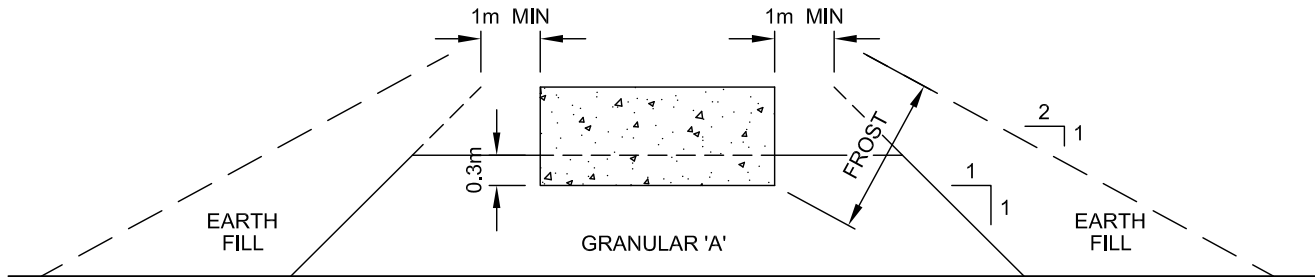
GEOCREs No. 42G-63

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	AMP	CHK	SKP
DRAWN	AN	CHK	AMP
		SITE	38C-150
		STRUCT	DWG
		DATE	NOV 2016

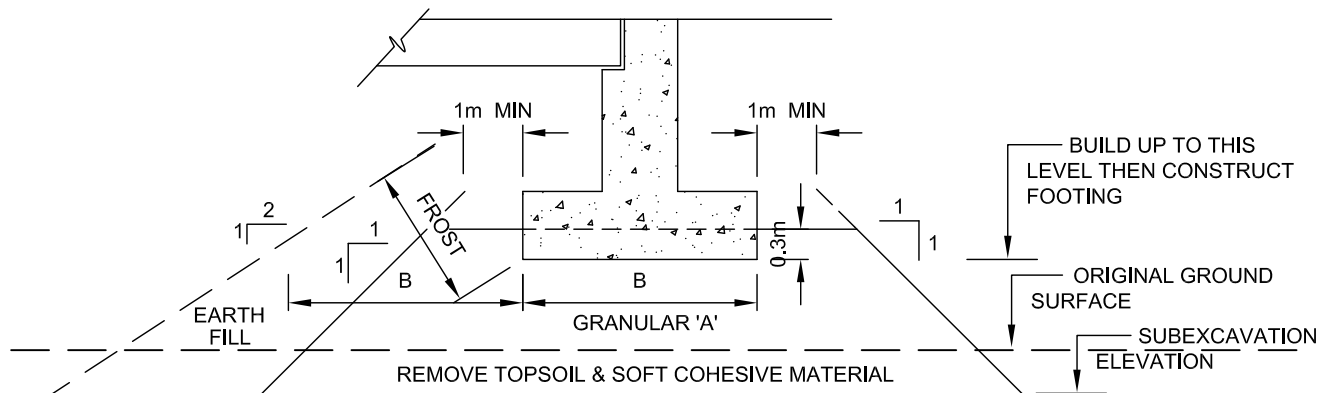


Appendix E

Abutment on Compacted Fill



CROSS-SECTION



LONGITUDINAL SECTION

NOT TO SCALE

NOTES:

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

ABUTMENT ON COMPACTED FILL SHOWING
GRANULAR A CORE



THURBER ENGINEERING LTD.
GEOTECHNICAL ■ ENVIRONMENTAL ■ MATERIALS

ENGINEER :

AEG

DRAWN :

AN

APPROVED :

PKC

DATE :

AUGUST 2016

SCALE :

N.T.S.

DRAWING No.

FIGURE 1



Appendix F
Comparison of Foundation Alternatives

COMPARISON OF FOUNDATION ALTERNATIVES

Spread Footings on Bedrock	Spread Footings on Granular Pad	Driven H-piles Socketed in Granite Bedrock
<p>Advantages:</p> <ul style="list-style-type: none"> i. Relative ease of construction. ii. More cost effective than deep foundations. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. Relative ease of construction. ii. More cost effective than other options considered. iii. Should fit the available construction window. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. Higher geotechnical resistance comparing to spread footings
<p>Disadvantages:</p> <ul style="list-style-type: none"> i. Potentially deep excavation at abutments ii. Will require groundwater control. iii. Longer construction period may be required 	<p>Disadvantages:</p> <ul style="list-style-type: none"> i. Lower bearing capacity than footings placed directly on bedrock. ii. May require groundwater control. 	<p>Disadvantages:</p> <ul style="list-style-type: none"> i. Higher unit costs than spread footings. ii. Longer construction period is required. iii. May require socketting in bedrock rendering it not cost effective.
TECHNICALLY FEASIBLE	RECOMMENDED	NOT RECOMMENDED