

Appendix A

March 12, 2015

Mr. Brian Gillis

CBCL Limited

164 Charlotte Street, Suite A
Sydney, NS B1P 6H4

Dear Mr. Gillis,

**Re: Geotechnical Investigation – Proposed Effies Brook Culvert Replacement
Cape Breton Highlands National Park, Cape Breton, NS**

This is our geotechnical investigation report for the proposed culvert replacement south of Effies Brook in in the Cape Breton National Park, Cape Breton, NS. The conditions at the proposed culvert are generally favourable; however, further evaluation of the existing fill will be required during construction.

The subsurface conditions within the proposed culvert replacement area generally consist of fill overlying alluvium and till (sand, gravel, and silt). The fill consists of asphalt surface and silty sand or gravel and was 4.4 m and 4.8 m thick. The native soils generally consisted of silty sand with gravel or silt. Bedrock was not encountered during drilling. Groundwater was encountered during drilling at depths of 5.0 m and 4.9 m. The boreholes were drilled to depths up to 9.7 m.

The main findings/recommendations from our investigation are as follows:

- Conditions at the proposed culvert are generally favourable for foundations and approach embankments. Footing founded on the undisturbed soil layers (as noted on the Borehole Records) or structural fill, would be a possible foundation system for the proposed culvert foundation.
- Depending on the design culvert elevation, the conditions of the existing fill will have to be reviewed further. Based on the findings at the boreholes, the fill would be generally suitable as is, but over-excavation up to 450 mm beyond the footing elevation should be anticipated to remove loose to saturated soils and replacement with approved structural rockfill.
- The conditions at the proposed site indicate that the construction of the culvert would be practical following site work as discussed in this report. It is anticipated that the majority of excavations for the culvert will be into fill.
- Excavated, inorganic materials may be considered for reuse.
- Geotechnical inspection of earthworks is recommended.

Please contact us if you have any questions.

Thank you,



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1.0 INTRODUCTION

We have conducted a geotechnical investigation for the proposed culvert replacement south of Effies Brook in the Cape Breton National Park, Cape Breton, Nova Scotia at the request of CBCL Limited. The purpose of this investigation was to evaluate the subsurface conditions on the site and to provide recommendations.

This report presents all of our findings and our recommendations for culvert replacement and general site work. This report includes recommendations for geotechnical works only.

2.0 SITE DESCRIPTION AND GEOLOGY

The proposed culvert replacement is located near South Harbour along the Cabot Trail in the Cape Breton Highlands National Park, NS. The existing culvert is located under the two-lane Cabot Trail and is approximately 25 km north of Ingonish, NS. The site is currently a paved roadway with thick tree cover to the north and south. The exiting culvert is approximately 3.65 m long.

Photograph A shows a view of the site looking west along the Cabot Trail.

Based on geological mapping, the principal soil type in this area is lodgement till. Bedrock is shown to be fluvial-lacustrine sandstone, siltstone, shale, or limestone of the Horton Group based on geological mapping.



Photograph A: View of the site looking west during drilling.

3.0 SUMMARIZED SUBSURFACE CONDITIONS

The field program consisted of two boreholes (Borehole 1 and Borehole 2) completed on March 5, 2015. The borehole location is shown in Figure A (Drawing 1 in the appendix is a complete location plan).

The boreholes were conducted using a truck-mounted drill rig. Representative samples were taken during the field work and the conditions at the boreholes were logged in detail. The soil conditions encountered at the site are described in detail on the appended Borehole Records and summarized in the following paragraphs.

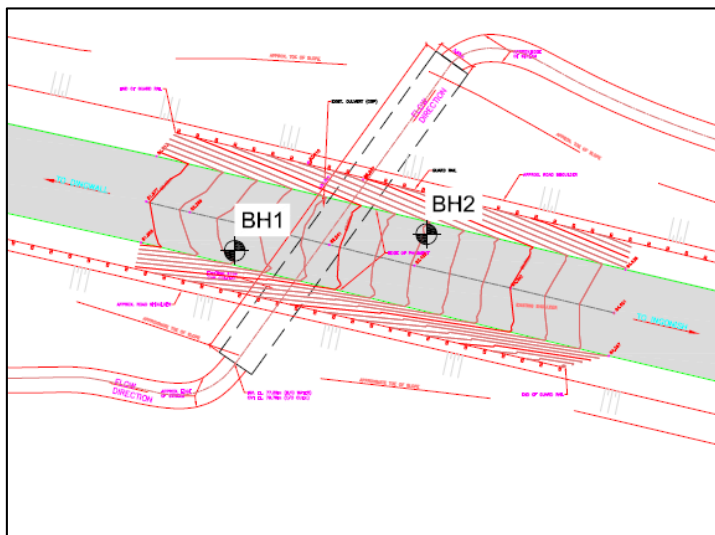


Figure A: Borehole Locations

The subsurface conditions within the proposed culvert replacement area generally consist of fill overlying alluvium and till (sand, gravel, and silt). The fill consists of asphalt surface and silty sand or gravel and was 4.4 m and 4.8 m thick. The native soils generally consisted of silty sand with gravel or silt. Bedrock was not encountered during drilling. Groundwater was encountered during drilling at depths of 5.0 m and 4.9 m. The boreholes were drilled to depths up to 9.7 m.

Grain size testing conducted on two samples of the fill shows 14% and 41% gravel, 65% and 53% sand, and 22% and 6% fines (clay and silt). The moisture content of the fill ranged from 8.5% to 11.7%. Grain size testing conducted on two samples of the till shows 0% and 2% gravel, 2% and 28% sand, and 98% and 70% fines (clay and silt). The moisture content of the till ranged from 17.6% to 30.2%. The grain size curves are shown in Figure 1 in the appendix.

Table A: Summary of Findings

Location	Borehole Elevation ¹ (m)	Fill Thickness (m)	Depth to Native Soil (m)	Depth to Groundwater ² (m)	Borehole Depth (m)
Borehole 1	82.5	4.4	4.4	5.0	8.8
Borehole 2	83.4	4.8	4.8	4.9	9.7

Notes: ¹Geodetic Datum. Taken from the CBCL Limited survey.

²Groundwater depth encountered during borehole drilling.

4.0 DISCUSSION AND RECOMMENDATIONS

4.1 Main Findings

It is understood that Public Works and Government Services Canada (PWGSC) is proposing to replace the existing South of Effies Brook Culvert with a new river crossing structure. The existing culvert is located along the Cabot Trail in the Cape Breton Highlands National Park, NS and is approximately 3.65 m long and accommodates two lanes of traffic. The proposed culvert is to conform to current NSTIR design standards. The conditions at the culvert site are generally favourable.

The main findings/recommendations from our investigation are as follows:

- Conditions at the proposed culvert are generally favourable for foundations and approach embankments. Footing founded on the undisturbed soil layers (as noted on the Borehole Records) or structural fill, would be a possible foundation system for the proposed culvert foundation.
- Depending on the design culvert elevation, the conditions of the existing fill will have to be reviewed further. Based on the findings at the boreholes, the fill would be generally suitable as is, but over-excavation up to 450 mm beyond the footing elevation should be anticipated to remove loose to saturated soils and replacement with approved structural rockfill.
- The conditions at the proposed site indicate that the construction of the culvert would be practical following site work as discussed in this report. It is anticipated that the majority of excavations for the culvert will be into fill.
- Excavated, inorganic materials may be considered for reuse.
- Geotechnical inspection of earthworks is recommended.

The following sections outline our geotechnical recommendations for site preparation and design.

4.2 Foundations

Spread footings should bear directly on undisturbed soils (as noted on the Borehole Records) or approved structural fill. For analysis using Limit States Design, we calculated bearing capacities for square and strip footings up to 3 m for a settlement tolerance of 25 mm. Other bearing capacities for other footing sizes (or settlement tolerances) can be provided at your request. Bearing resistance values for square and strip footings are plotted on Figures 2 and 3 in the appendix.

For analysis using the old Working Stress design approach, we recommend an allowable bearing pressure of 200 kPa (4000 psf) for a tolerable settlement of 25 mm and footing size up to 1.5 m; for a footing founded on native soils or approved structural fill. This includes a global factor of safety of 3.

Exterior footings should be founded a minimum of 1.2 m below grade for frost protection, or insulation provided.

4.3 Earthworks

Earthworks for this project will involve excavation into existing fill or native soil for the proposed culvert, and placement of the backfill material.

4.3.1 Surface Water Control and Erosion Control

Prior to excavations, surface water drainage controls should be provided on the up-gradient side of the site to minimize run-off onto exposed soils. Suitable erosion and sedimentation control measures should be employed. These may include silt fences, check dams in ditches, and granular working pads.

4.3.2 Excavation

Excavation into the site soils will be practical with conventional earth-moving equipment.

Within the proposed culvert area and roadway approaches, a proof-roll inspection of the subgrade should be conducted using a 10 tonne roller or hydraulic tamper on an excavator prior to placement of additional fill to achieve design grades. An allowance for over-excavation up to 450 mm beyond the culvert footing elevation should be anticipated to remove loose to saturated soils and replacement with approved structural rockfill.

Temporary excavated side slopes in soil should be stable at one horizontal to one vertical (1H:1V).

Material that is planned for re-use should be placed directly in the intended areas or compacted in stockpiles for later use. Unsuitable materials should be used in landscaped areas or wasted off-site.

4.3.3 Dewatering of Excavations

With proper surface water controls, dewatering of excavations through the use of ditches and swales draining to sumps would be practical. Sumps and pumps should be anticipated by the contractor for the culvert excavation. A temporary cofferdam or temporary sheet piling cofferdam (depending on preferred method of excavation and backfill) should be constructed on both sides of the culvert in order to prevent flooding of the work area. Water should be diverted to the downstream side through use of sumps and pumps.

4.3.4 Fill Placement and Compaction

Fill required for the culvert trench backfill should consist of the following materials:

- approved, drier portions of the excavated material from the site, or;
- imported, quarried rockfill, or sand and gravel pit run.

A free-draining backfill material is preferred along the sides of the proposed culvert. Re-use of approved, drier portions of the fill and till may be practical but may require some careful planning by

the contractor and low amounts of precipitation during site grading due to the high fines (silt and clay) content in the till. Excavated organic material will not be suitable for re-use.

The lift thickness used during placement of fills must be compatible with the compaction equipment and the material type to ensure the specified density throughout. The lift thickness should not exceed approximately 450 mm for mass filling and 200 mm for backfilling of foundations and services. The maximum particle size should be no larger than $\frac{2}{3}$ of the lift thickness.

Fill materials should be compacted to project specification pertaining to fill in roadways and services trenches.

4.3.5 Frost Protection

The trench for the culvert should provide a minimum cover over the pipe of 1.2 m from finished grade to provide frost protection, or as required by Transportation or Parks Canada.

4.3.6 Slopes and Toe Drainage

Permanent fill slopes should be 2H:1V, or lower, and permanent cut slopes in soil should be stable at 3H:1V for slope heights of less than 2 m. Cut slopes of greater heights will require a 300 mm thick granular blanket or deep root vegetation to reinforce slopes. A toe drain or swale should be provided for drainage at the base of cut slopes.

In addition, protection adjacent to the culvert inlet and outlet would be necessary (eg; concrete headwall or suitable armour stone overlying filter fabric).

4.3.7 Inspection and Testing

It is recommended that inspection and testing during site grading and backfilling operations be conducted by experienced geotechnical personnel.

4.4 Culvert Walls

For design of the culvert walls, the following parameters can be used:

- Total unit weight of soil, $\gamma_T = 19 \text{ kN/m}^3$ (in-situ)
- Total unit weight of soil, $\gamma_T = 20 \text{ kN/m}^3$ (granular backfill)
- Passive earth pressure coefficient, $K_p = 3.2$
- Active earth pressure coefficient, $K_a = 0.3$
- At-rest earth pressure coefficient, $K_o = 0.5$
- Ultimate friction factor for sliding, $\mu = 0.35$ (cast-in-place concrete on existing soils)
- Angle of internal friction, $\Phi = 32$ degrees (in-situ soils)
- Angle of internal friction, $\Phi = 33$ degrees (granular backfill)
- Wall friction angle, $\delta = 22$ degrees (granular backfill)

The earth pressure coefficients are based on horizontal backfill. The culvert wall design should include the influence of sloping backfill or surcharge loads behind the wall. Drainage from the backfill zone with a positive outlet is recommended.

4.5 Pavement Structure

Within proposed pavement areas over and around the culvert and for the approaches, the subgrade should be proof-rolled and approved by the Geotechnical Consultant or TIR prior to placement of base gravels. The following pavement structure is recommended.

Table B: Pavement Structure Thicknesses

Material	Typical Parks Canada Pavement
Asphalt Concrete: Surface Course, Type C Base Course, Type B	100 mm (placed in two lifts) -
Type 1 Gravel	150 mm
Type 2 Gravel	300 mm

All aggregate and asphalt concrete materials should meet the DTIR Standard Specifications and match the thickness of the adjacent pavement. The gravels should be compacted to 100% of Standard Proctor maximum dry density. Asphalt concrete should be compacted to 92.5% of Maximum Theoretical Relative Density.

4.6 Seismic Classification

The site classification for seismic site response was based on our investigation results and local experience. Bedrock was not encountered during our investigation.

The recommended site classification for seismic site response, as per Table 4.1.8.4.A of NBCC 2005 is Site Class C.

4.7 Additional Geotechnical Services

Additional geotechnical input at the final design and tendering stage is recommended to ensure that the project fully considered all of the information from the geotechnical investigation.

5.0 CLOSURE

This report has been prepared for the sole benefit of CBCL Limited, its designates, nominees and partners. Any use or reliance on this report under any of the following conditions would render this report inapplicable:

- where there have been any change in site conditions; or
- where used for purposes not intended or delineated in this report; or
- where used by third parties without express written agreement of Conquest Engineering.

Any use of, or reliance upon, this report under such circumstances or by such parties is strictly prohibited and without risk or liability to Conquest.

Conquest Engineering used reasonable care, skill, competence and judgment in the preparation of this report. The information and conclusions contained in this report are based upon work undertaken by trained professional and technical staff in accordance with generally accepted engineering and scientific practices current at the time the work was performed. The information and conclusions contained in this report are generally consistent with professional standards for individuals providing similar services at the same time, in the same locale and under like circumstances.

A field investigation is a limited sampling of a site. Some variation between sampling locations should be expected. The conclusions presented in this report represent the best technical judgment of Conquest Engineering based on the data obtained from the work. The conclusions are based on the site conditions observed by Conquest Engineering at the time the work was performed at the specific testing and/or sampling locations, and can only be extrapolated to an undefined limited area around these locations. The extent of the limited area depends on the soil and groundwater conditions, as well as the history of the site reflecting natural, construction and other activities. Due to the nature of the investigation and the limited data available, Conquest Engineering cannot warrant against undiscovered environmental liabilities.

If any conditions become apparent that differ significantly from our understanding of conditions as presented in this report, we request that we be notified immediately to reassess the conclusions provided herein. Further, if there are changes to the proposed work, such as adjustments in founding elevation or building loads, etc., we require that we be notified to allow for review of our recommendations.



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APPENDIX A

SOIL DESCRIPTION

Terminology describing common soil genesis:

<i>Topsoil</i>	- mixture of soil and humus capable of supporting good vegetative growth
<i>Peat</i>	- fibrous aggregate of visible and invisible fragments of decayed organic matter
<i>Till</i>	- unstratified glacial deposit which may range from clay to boulders
<i>Fill</i>	- any materials below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

<i>Desiccated</i>	- having visible signs of weathering by oxidation of clay minerals, shrinkage cracks, etc.
<i>Fissured</i>	- having cracks, and hence a blocky structure
<i>Varved</i>	- composed of regular alternating layers of silt and clay
<i>Stratified</i>	- composed of alternating successions of different soil types, e.g. silt and sand
<i>Layer</i>	- >75 mm
<i>Seam</i>	- 2 mm to 75 mm
<i>Parting</i>	- < 2 mm
<i>Well Graded</i>	- having wide range in grain sizes and substantial amounts of all intermediate particle sizes
<i>Uniformly Graded</i>	- predominantly of one grain size

Terminology describing soils on the basis of grain size and plasticity is based on the Unified Soil Classification System (USCS) (ASTM D-2488). The classification excludes particles larger than 76 mm (3 inches). This system provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present:

<i>Trace or occasional</i>	Less than 10%
<i>Some</i>	10-20%
<i>Numerous or Frequent</i>	20% - 50%

The standard terminology to describe cohesionless soils includes the compactness (formerly “relative density”), as determined by laboratory test or by the Standard Penetration Test ‘N’ – value.

Relative Density	‘N’ Value	Compactness %
<i>Very Loose</i>	<4	<15
<i>Loose</i>	4-10	15-35
<i>Compact</i>	10-30	35-65
<i>Dense</i>	30-50	65-85
<i>Very Dense</i>	>50	>85

The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by insitu vane tests, penetrometer tests, unconfined compression tests, or occasionally by standard penetration tests.

Consistency	Undrained Shear Strength		'N' Value (approx.)
	kips/sq.ft.	kPa	
<i>Very Soft</i>	< 0.25	< 12.5	< 2
<i>Soft</i>	0.25 – 0.5	12.5 – 25	2 – 4
<i>Firm</i>	0.5 – 1.0	25 – 50	4 – 8
<i>Stiff</i>	1.0 – 2.0	50 – 100	8 – 15
<i>Very Stiff</i>	2.0 – 4.0	100 – 200	15 – 30
<i>Hard</i>	> 4.0	> 200	> 30

ROCK DESCRIPTION

Rock Quality Designation (RQD)

The classification is based on a modified core recovery percentage in which all pieces of intact core over 100 mm long are totalled and divided by the core drilled length. The smaller pieces are considered to be due to close shearing, jointing, faulting, or weathering in the rock mass and are not counted. RQD was originally intended to be done on N-size (45 mm) core; however, it can be used on different core sizes if the bulk of the fractures caused by drilling stresses are easily distinguishable from in situ fractures.

RQD	ROCK QUALITY
90 – 100	very sound
75 – 90	sound
50 – 75	fractured
25 – 50	severely fractured
0 – 25	very severely fractured

Terminology describing rock mass:

Spacing (mm)	Bedding, Laminations, Bands	Discontinuities
2000 – 6000	<i>Very Thick</i>	<i>Very Wide</i>
600 – 2000	<i>Thick</i>	<i>Wide</i>
200 – 600	<i>Medium</i>	<i>Moderate</i>
60 – 200	<i>Thin</i>	<i>Close</i>
20 – 60	<i>Very Thin</i>	<i>Very Close</i>
< 20	<i>Laminated</i>	<i>Extremely Close</i>
< 6	<i>Thinly Laminated</i>	

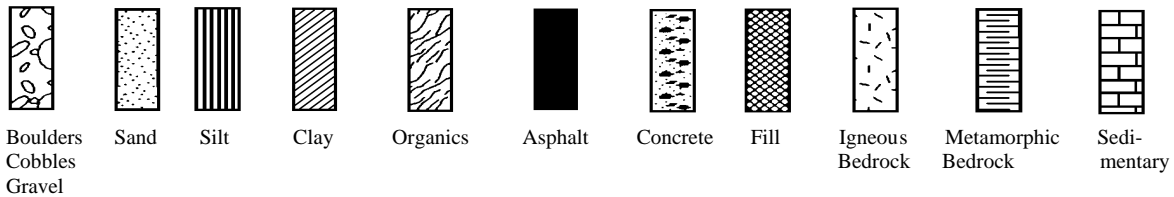
Strength Classification	Uniaxial Compressive Strength (MPa)
<i>Very Weak</i>	1 – 5
<i>Weak</i>	5 – 25
<i>Medium Strong</i>	25 – 50
<i>Strong</i>	50 – 100
<i>Very Strong</i>	100 – 250
<i>Extremely Strong</i>	> 250

Terminology describing weathering:

<i>Slight</i>	- Weathering limited to the surface of major discontinuities. Typically iron stained.
<i>Moderate</i>	- Weathering extends throughout rock mass. Rock is not friable.
<i>High</i>	- Weathering extends throughout rock mass. Rock is friable.

STRATA PLOT

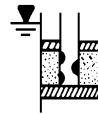
Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols:



WATER LEVEL MEASUREMENT



Borehole or
Standpipe



Piezometer

SAMPLE TYPE

SS	Split spoon sample (obtained by performing the standard Penetration Test)	AS	Auger Sample
ST	Shelby tube or thin wall tube	BS	Bulk Sample
PS	Piston sample	WS	Wash Sample
DC	Dynamic Cone Penetration	HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond drilling bits
SV	Field Shear Vane		

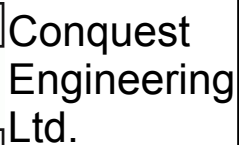
N- VALUE

Numbers in this column are the results of the Standard Penetration Test: the number of blows of a 140 pound (64kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (305 mm) into the soil. For split spoon samples where insufficient penetration was achieved and 'N' values cannot be presented, the blow count and penetration are shown.

OTHER TESTS

Symbols in this column indicate that the following laboratory tests have been carried out and the results are presented separately.

S	Sieve analysis	H	Hydrometer analysis
G _s	Specific gravity of soil particles	γ	Unit weight
k	Permeability	C	Consolidation
↓	Single packer permeability test; test interval from depth shown to bottom of borehole	CD	Consolidation drained triaxial
	Double packer permeability test; Test interval as indicated	CU	Consolidated undrained triaxial with pore pressure measurements
○↓	Falling head permeability test using casing	UU	Unconsolidated undrained triaxial
▽↓	Falling head permeability test using well point or piezometer	DS	Direct shear
		Q _u	Unconfined compression
		I _p	Point Load Index (I _p on Borehole Records equals I _p (50); the index corrected to a reference diameter of 50 mm)



Project Name: Proposed Effies Brook Culvert Replacement - Geotechnical Investigation

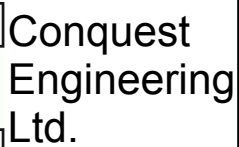
Borehole No.: 1

Page: 1 of 1

Date Drilled: March 5, 2015

Datum: Geodetic

[illegible]



Project Name: Proposed Effies Brook Culvert Replacement - Geotechnical Investigation

Borehole No.: 2

Page: 1 of 2

Date Drilled: March 5, 2015

Datum: Geodetic

[illegible]

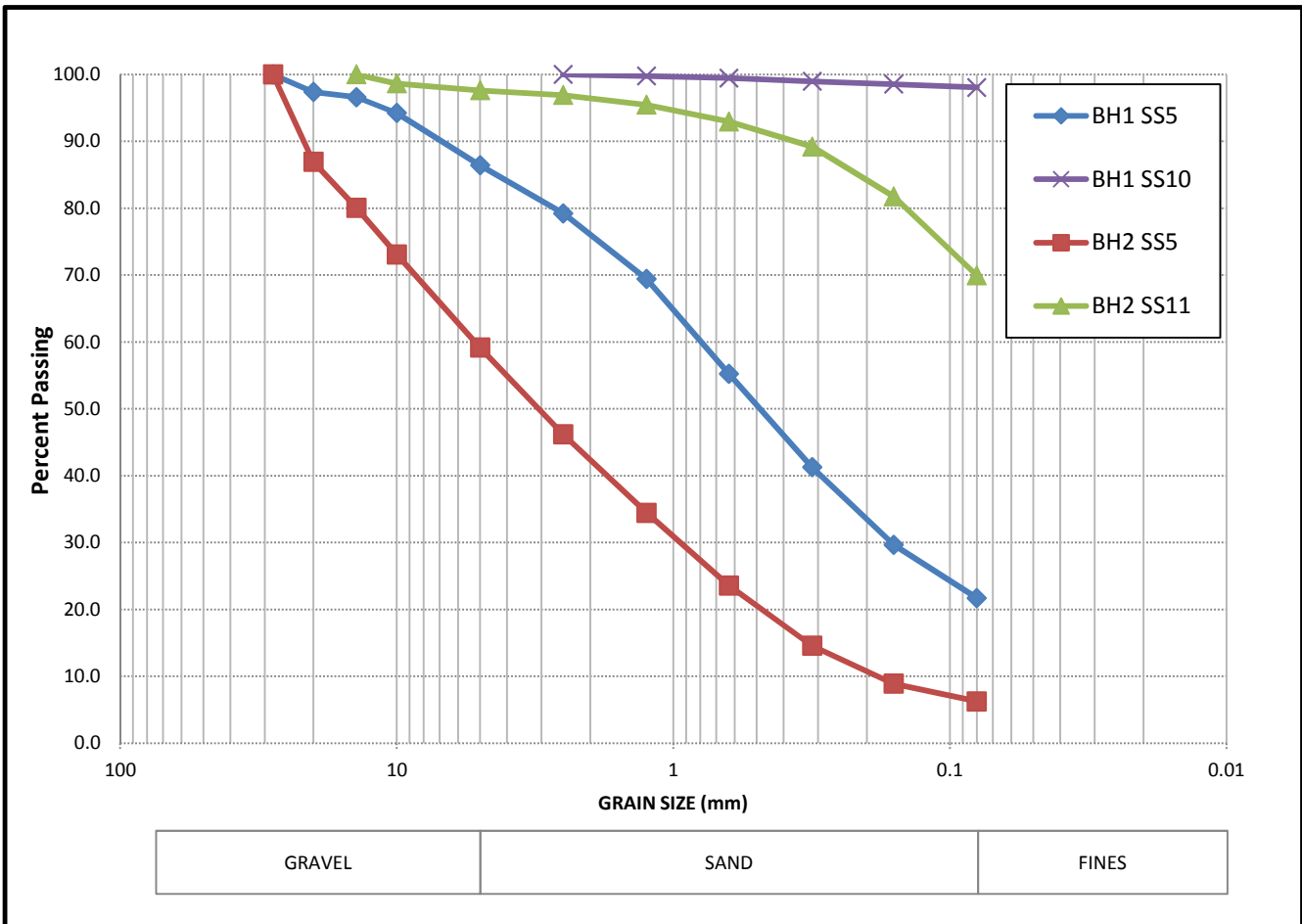
GRAIN SIZE REPORT

Project: Effies Brook Culvert Replacement, Cape Breton, NS

Client: CBCL Limited

Project No: 034-145

GRAIN SIZE DISTRIBUTION PLOT



SOIL CLASSIFICATION

Sample No.	Depth	Classification	Moisture Content (%)	Gravel (%)	Sand (%)	Silt and Clay (%)
BH1 SS5	3.5 m	FILL: silty sand	10.8	14	65	22
BH1 SS10	6.5 m	TILL: silt	30.2	0	2	98
BH2 SS5	3.3 m	FILL: sand with gravel	--	41	53	6
BH2 SS11	6.9 m	TILL: silt	--	2	28	70

Conquest Engineering Limited

348 Bluewater Road, Bedford, NS B4B 1J6
Office (902) 835-7313 • Fax (902) 835-1260

Comments: Samples taken from boreholes conducted on
March 5, 2015.

FACTORED ULS BEARING RESISTANCE (NATIVE SOIL OR STRUCTURAL FILL)

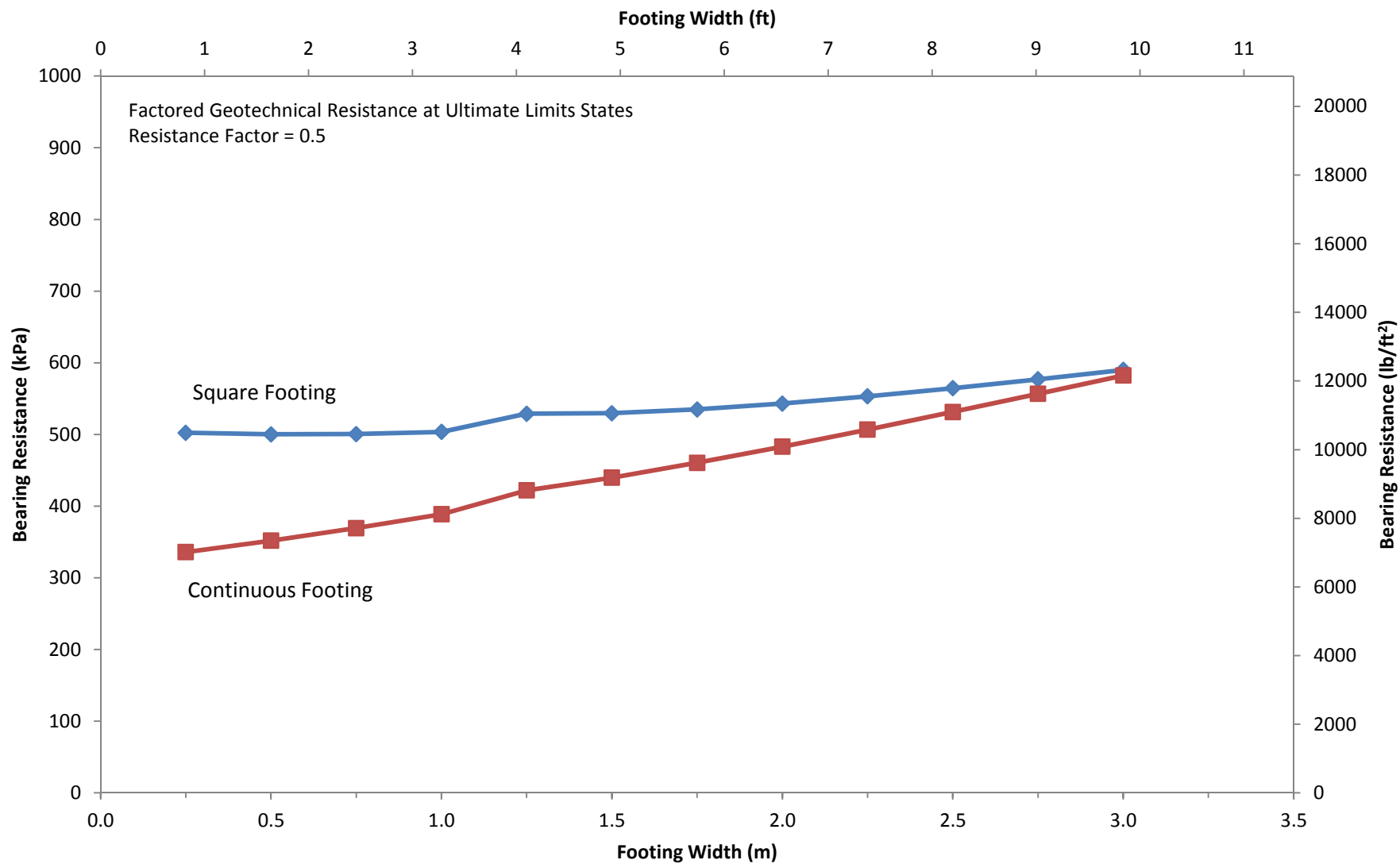


Figure 2

Project # 034-145

SLS BEARING RESISTANCE (NATIVE SOIL OR STRUCTURAL FILL)

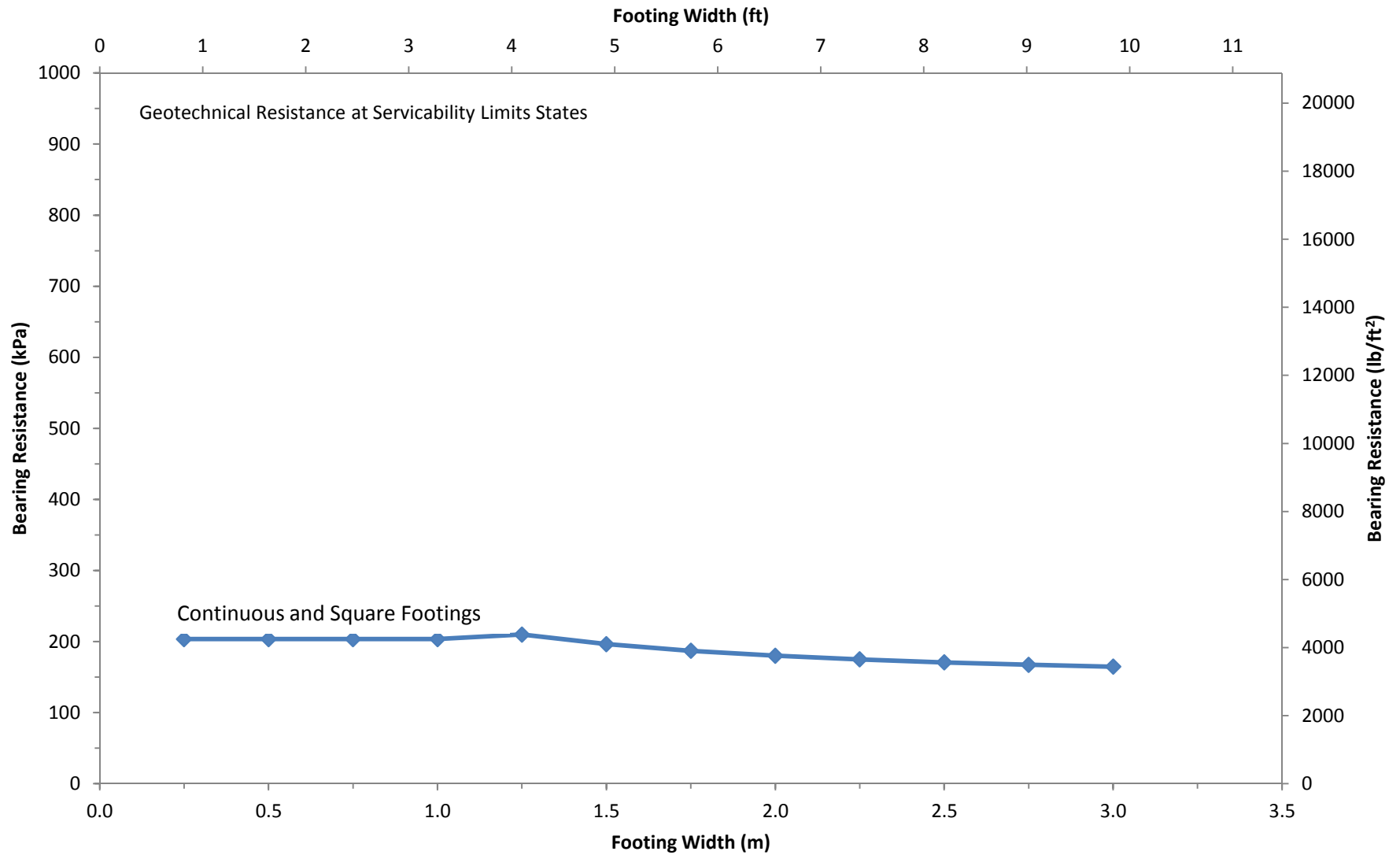
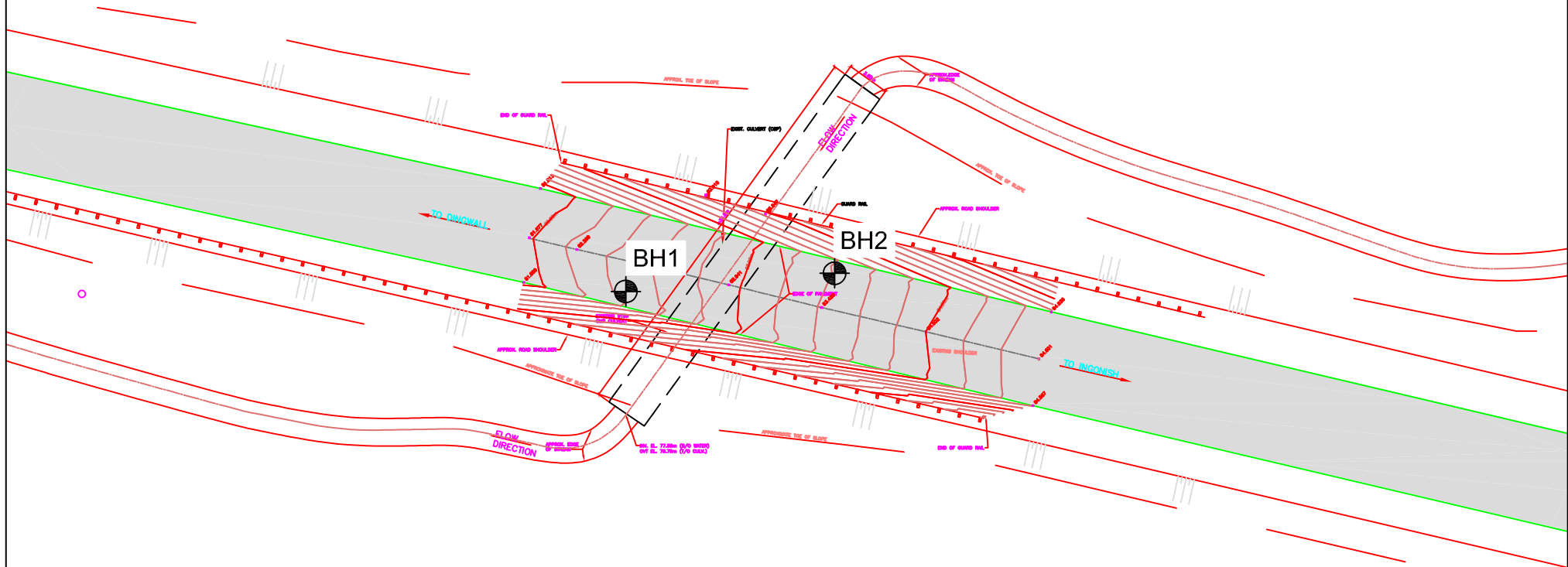


Figure 3

Project # 034-145



LEGEND



CONQUEST BOREHOLE LOCATIONS
(MARCH 2015)



**CONQUEST
ENGINEERING
LTD.**

348 Bluewater Road
Bedford, Nova Scotia
B4B 1J6

PROJECT:

BOREHOLE LOCATION PLAN
CULVERT REPLACEMENT
SOUTH EFFIES BROOK, NS

JOB #:

034-145

SCALE:

1:500

DATE:

12-MAR-2015

DRAWN BY:

CEM

CHECKED BY:

RBM

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DRAWING:

1

REV:

0