Englobe
Soils Materials Environment

Submitted to AECOM Canada Ltd.
189 Wyld Street Suite 103, North Bay, Ontario P1B 1Z2
On Behalf of the Ontario Ministry of Transportation

Culvert Replacement
Highway 60
Station 11+698 - Twp. of Chaffey
GWP 5005-05-00

FINAL FOUNDATION INVESTIGATION REPORT

Date: July 15, 2016
Ref. Nº: 14/07/14083-F10

Geocres No. 31E-363

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Prepared by:

Alexander Tepylo, P. Eng.
Englobe – Project Engineer

Sen Hu, P. Eng.
Englobe – Senior Geotechnical Engineer

Reviewed by:

Michael H. MacKay, P. Eng.
Vice President – Expertise
Pavement Technology & Geotechnical Engineering
MTO Designated Contact

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Client:
AECOM Canada Ltd.
189 Wyld Street, Suite 103
North Bay, Ontario
P1B 1Z2
Attention: **Mr. Al Rose**

REVISION AND PUBLICATION REGISTER		
Revision N°	**Date**	**Modification And/Or Publication Details**
00	2016-03-03	DRAFT FIDR Issued
01	2016-07-15	Final FIR Issued

REPORT DISTRIBUTION	
5 hard copies and 1 electronic copy	MTO Project Manager
1 hard copy and 1 electronic copy	MTO Pavement and Foundations Section, Foundation Group
1 hard copy	File

1 INTRODUCTION

EnGlobe Corp. (Englobe), formerly LVM-Merlex, a Division of Englobe Corp., has been retained by AECOM Canada Ltd., on behalf of the Ministry of Transportation of Ontario (MTO), to carry out a foundation investigation at an existing centreline culvert site. The site is located at Station 11+698 in the Township of Chaffey on Highway 60, approximately 0.8 km west of King William Street.

The foundation investigation location was specified by the MTO in the Terms of Reference for Change Order No. 3 under Agreement No. 5013-E-0032 – GWP 5005-05-00. The terms of reference for the scope of work are outlined in Englobe's Proposal 14/04/14083 Rev 2, dated August 14, 2015. The purpose of this investigation was to determine the subsurface conditions in the area of the existing culvert for the contract preparation of the Detailed Design package. Englobe investigated the foundation area by the drilling of boreholes, carrying out in-situ tests, and performing geotechnical laboratory testing on select samples.

2 SITE DESCRIPTION

A Corrugated Steel Pipe (CSP) culvert is located on Highway 60 at Station 11+698 in the Township of Chaffey. The topography in the area of this site is generally rolling. The existing highway embankment currently supports three undivided lanes of highway (two lanes with an eastbound passing lane), running in a west-east direction. The existing highway at the culvert location is constructed on a granular embankment, containing mixed rock pieces, that is approximately 6.3 m in height, with centreline Elevation of 329.6 m at the culvert location. The existing embankment slopes in the area of the culvert have been generally established at angles of approximately 1.9H:1V to 2.0H:1V. The culvert at this location is an 800 mm diameter Corrugated Steel Pipe (CSP) culvert, approximately 37.4 m in length. Flow through the culvert is from the south to the north (right to left). To the south of the embankment at the culvert location, a municipal road (Shay Road) runs parallel to the highway.

It is understood that there is no other infrastructure (below or above grade services) at the culvert location.

2.1 SITE PHYSIOGRAPHY AND SURFICIAL GEOLOGY

This project is located in the Geomorphic Sub-province known as the Muskoka Ridges and Pockets. The topography on this section of Highway 60 is generally rolling. Layers of earth overlie bedrock. Within the project area, native overburden consists primarily of sands overlying bedrock. Organic materials were also observed.

Bedrock in the area, based on Ontario Geologic Survey (OGS) Map MRD-126, consists of migmatitic rocks and gneisses of undetermined protolith.

3 INVESTIGATION PROCEDURES

The fieldwork for this investigation was carried out during the period of November 30th to December 18th, 2015, during which time five (5) sampled boreholes were advanced. Three (3) boreholes were advanced through the embankment. A single borehole was also advanced at both inlet (south) and outlet (north) ends of the culvert.

The field investigation was carried out using a truck and bombardier mounted CME drilling rigs equipped with hollow stem augers, standard augers, casing equipment, coring equipment and routine geotechnical sampling equipment. Soil samples were obtained at the borehole locations at regular intervals of depth using the standard 50 mm O.D. split spoon sampler advanced in accordance with the Standard Penetration Test (SPT) procedures (ASTM D-1586). The SPT method involves advancing a 50 mm O.D. split spoon sampler with the force of a 63.5 kg hammer freely dropping 760 mm. The number of blows per 300 mm penetration was recorded as the "N" value. If refusal to further advance of the augers was encountered within the proposed depth of borehole, the boring was advanced through diamond drilling, using H size coring equipment. All samples taken during this investigation were stored in labeled containers for transport to our North Bay laboratory for visual examination and select laboratory testing.

During the field investigation, three boreholes (Borehole No. 1, 2, and 3) were advanced through the existing embankment. Fragmented rock was encountered within the embankment at each of these boreholes. At Borehole No. 1, hollow stem augers were able to advance past the fragmented rock within the embankment. However, at Borehole Nos. 2 and 3, coring equipment was employed to penetrate through the fragmented rock. At these boreholes, hollow stem auger and split spoon sampling was limited to a 1.5 m depth in the embankment fills containing the fragmented rock, below which H casing was used to advance deeper. Sampling was undertaken by advancing the HQ core barrel to the sampling depth at which split spoon sampling was undertaken from the bottom of the HQ core barrel. Following sampling, the HQ core barrel was then advanced to the depth of the next sample. The rock (gravel, cobble, and boulder sizes) encountered during the coring was retrieved to provide estimates of the concentration of rock within the embankment fill. The percent recovery of the split spoon samples and retrieved rock has been provided on Tables Nos. R-1 and R-2, Appendix 2.

At Boreholes Nos. 1, 4, and 5, when auger refusal was encountered, NQ size diamond coring equipment was used to determine the nature of refusal (bedrock). At Borehole Nos. 2 and 3, HQ size diamond coring equipment was used to penetrate the embankment fills and bedrock.

Groundwater conditions in the open boreholes were observed during the advancement of and immediately following completion of the individual boreholes. A 25 mm diameter piezometer was installed in Borehole Nos. 1 and 5 prior to backfilling to allow for further monitoring of the shallow groundwater levels. All open boreholes were backfilled upon completion with compacted auger cuttings in the general order they were removed, and where necessary,

bentonite pellet backfill was added to the boreholes to bring them up to grade in accordance with requirements of Ontario Regulation 903. At the borehole(s) through the embankment, the upper portion of the hole, where necessary, was backfilled with an asphalt cold patch to seal the existing asphalt surface.

The fieldwork for this investigation was under the full time direction of a senior member of the Englobe engineering staff (Jame Lavigne) who was responsible for locating the boreholes, clearing the borehole locations of underground services, in-situ sampling and testing operations, logging of the boreholes, labeling and preparation of samples for transport to our North Bay laboratory, plus overall drill supervision. All samples received a visual confirmatory inspection at the North Bay Englobe laboratory. Laboratory testing of select samples carried out at the North Bay Englobe laboratory included routine testing for natural moisture content determination and particle size analysis. The results of the laboratory testing are presented on the individual Record of Borehole Sheets (Appendix 2). Unconfined compressive strength tests (UTC) were carried out by Golder Associates Limited on select rock samples recovered at Borehole Nos. 2 and 3. A summary of results presented on the laboratory sheets in Appendix 3 (Figures Nos. L-1 to L-8 and Table No. L-9).

The location of the individual boreholes was determined in the field using highway chainage (established by exp Services) and offsets relative to highway centreline. The MTO co-ordinates, northing and easting, were then established for the boring locations, using coordinates from MTM Zone 10, NAD 83 CSRS. The borehole elevations are based on coordinating the borehole locations with the highway survey carried out by exp. Services. Elevations contained in this report are referenced to geodetic datum.

4 SUBSURFACE CONDITIONS

Details of the subsurface conditions revealed by the investigation program are presented on the enclosed Records of Borehole Sheets (Appendix 2) and on Drawing No. 2 (Appendix 3). Please note that stratigraphic delineation presented on the borehole logs and soil strata plot are the results of non-continuous sampling, response to drilling progress, the results of SPT, plus field observations. Typically such boundaries represent transitions from one zone to another and are not an exact demarcation of specific geological unit. Additional consideration should be given to the fact that subsurface conditions may vary markedly between adjacent boreholes and beyond any specific boring location, and are shown on the drawings for illustration purposes only.

4.1 CULVERT STATION 11+698, TWP OF CHAFFEY

A plan and profile illustrating the borehole locations and stratigraphic sequences is shown on Drawing No. 2, Appendix 3. During the course of the exploration program, five (5) sampled boreholes were put down at this site, with Borehole Nos. 1 to 3 advanced through the embankment, Borehole No. 4 advanced at the culvert outlet, and Borehole No. 5 advanced at

the culvert inlet. At the time of the subsurface investigation, the ground surface elevations at Boreholes Nos. 1 to 5 were recorded at Elevations 329.6, 329.6, 329.4, 323.7, and 324.3 m, respectively.

4.1.1 Pavement Structure

Borehole Nos. 1, 2, and 3 were advanced through the embankment where a pavement structure consisting of 90 to 140 mm asphalt concrete was penetrated underlain by a base/subbase layer of crushed gravel approximately 260 to 360 mm thick.

4.1.2 Granular Fill

Underlying the pavement structure at Borehole Nos. 1, 2, and 3, a layer of granular fill consisting of brown sand, some gravel to gravelly, trace to some silt was penetrated. The natural moisture content measured on retrieved samples of this deposit was generally in the order of 2 to 7%. Gradation analyses were carried out on four (4) samples of this deposit, the results of which indicated 14 to 53% gravel size particles, 39 to 75% sand size particles, and 8 to 14% silt and clay size particles (Figure No. L-1, Appendix 3). This deposit was encountered to depths of 1.4, 0.9, and 1.1 m below grade at Borehole Nos. 1, 2, and 3, respectively (Elevations 328.2, 328.7, and 328.3 m, respectively).

4.1.3 Mixed Fill

Underlying the granular fill at Borehole Nos. 1, 2, and 3, a layer of mixed fill consisting of brown sandy gravel, trace to some silt was penetrated. Cobble to boulder sized rock pieces were encountered in the mixed fill layer.

As noted in Section 3, HQ coring was undertaken through the mixed embankment fills. Core recovery examination indicated that the approximate percentage of rock pieces within the mixed fill at Borehole Nos. 2 and 3 ranged from 4 to 76%. The percent recovery of rock pieces is included in Table No. R-2 (Appendix 2). The recovery of split spoon samples in the mixed fills was also recorded and ranged from 0 to 17%, see Table R-1, Appendix 2. Photos of the rock returned from the coring through the embankment are enclosed (Photo Nos. 1 and 2 (Appendix 2)). In general, the rock pieces returned were gravel to cobble size (<200 mm diameter), however occasional boulder sized rock pieces (between 200 and 400 mm diameter) were cored through at Borehole Nos. 2 and 3. One unconfined compressive strength test (UCT) was carried out on an intact rock sample recovered at Borehole 3, at a depth of 2.4 m, and indicated an unconfined compressive strength of 130.8 MPa (Appendix 3).

The natural moisture content measured on retrieved samples (i.e. sand and gravel portion) of the mixed fill layer deposit was generally in the order of 1 to 6%. Gradation analyses were carried out on two (2) samples of this deposit, the results of which indicated 54 to 75% gravel size particles, 19 to 37% sand size particles, and 6 to 9% silt and clay size particles (Figure No.L-2, Appendix 3). Based on SPT ‘N’ values of 10 to 28 blows per 300 mm penetration and 10 blows per 76 mm penetration, the compactness of this deposit was described as compact to

very dense, and generally compact. This deposit was encountered to depths of 4.4, 4.6, and 4.3 m below grade at Borehole Nos. 1, 2, and 3, respectively (Elevations 325.2, 325.0, and 325.1 m, respectively).

4.1.4 Sand Fill

Underlying the mixed embankment fill at Borehole Nos. 1, 2, and 3, a layer of sand fill consisting of brown sand, trace gravel, trace to some silt, trace organics was penetrated. The natural moisture content measured on retrieved samples of this deposit was generally in the order of 20 to 25%. A gradation analysis was carried out on one (1) sample of this deposit, the results of which indicated 5% gravel size particles, 77% sand size particles, and 18% silt and clay size particles (Figure No. L-3, Appendix 3). Based on SPT 'N' values of 1 to 15 blows per 300 mm penetration, the relative density of this deposit was described as very loose to compact. This deposit was encountered to a depth of 6.1 m below grade at Borehole Nos. 1, 2, and 3 (Elevations 323.5, 323.5, and 323.3 m, respectively).

4.1.5 Organic Soils

At ground surface at Borehole Nos. 4 and 5, a layer of fine fibrous organics soil was penetrated. The natural moisture content of a sample of this organic layer was about 104%. This organic soil layer was encountered to approximate depths of 0.1 and 0.3 m below ground surface at Borehole Nos. 4 and 5, respectively (Elevations 323.6 and 324.0 m, respectively).

4.1.6 Sands and Silts to Sands

Underlying the sand fill at Borehole No. 3, and underlying the surficial organics at Borehole No. 4, a deposit of grey sand and silt to sand with to some silt, trace gravel, trace clay was penetrated. The natural moisture content measured on samples of this deposit ranged from 17 to 25%. Gradation (hydrometer) analyses were carried out on two (2) samples of this deposit, the results of which indicated 1 to 6% gravel size particles, 48 to 69% sand size particles, 23 to 42% silt size particles, and 2 to 9% and clay size particles (Figure No. L-4, Appendix 3). Based on SPT 'N' values of 3 to 37 blows per 300 mm penetration, this deposit was described as very loose to dense, generally compact. This deposit was encountered to depths of 7.3 and 2.1 m below grade at Borehole Nos. 3 and 4, respectively (Elevations 322.1 and 321.6 m, respectively).

4.1.7 Silts and Clayey Silts

Underlying the sand fills at Borehole Nos. 1 and 2, underlying the sands at Borehole No. 3, and underlying the surficial organics at Borehole No. 5, deposit of silt, some clay to clayey, trace gravel, trace to with sand, was penetrated. The natural moisture content measured on samples of this deposit ranged from 16 to 28%. Gradation (hydrometer) analyses were carried out on six (6) samples of this deposit, the results of which indicated 0 to 3% gravel size particles, 5 to 22% sand size particles, 56 to 83% silt size particles, and 11 to 25% clay size particles (Figure No. L-5, Appendix 3). Atterberg Limit Testing was carried out three (3) samples of this deposit from

Borehole nos. 2 to 5, the results of which indicated Plastic Limits of 15 to 19% and Liquid Limits of 17 to 22% (Figure No. L-7, Appendix 3). Atterberg Limit Testing was carried out on two (2) samples obtained from Borehole No. 1, the results of which indicated Plastic Limit of 17 to 18% and Liquid Limit of 23 to 25% (Figure No. L-7, Appendix 3).

Based on the results of the Atterberg Limits testing, this deposit was described as inorganic silts of slight plasticity (ML), however, samples of this deposit obtained from Borehole No. 1 indicated a slightly increased plasticity (i.e. clayey silts of low plasticity (CL-ML)).

Based on SPT 'N' values of 12 to 58 blows per 300 mm penetration, this deposit was described as compact to very dense. This deposit was encountered to depths of 9.1, 9.1, 8.4, and 2.9 m below ground surface at Borehole Nos. 1, 2, 3, and 5, respectively (Elevations 320.5, 320.5, 321.0, and 321.4 m).

4.1.8 Till

Underlying the silts and clayey silts at Borehole Nos. 1, 2, 3, and 5, a deposit of till described as silty sand, trace gravel to sand and gravel, some silt, was penetrated. The natural moisture content measured on samples of this deposit was in the order of 3 to 12%. Gradation (sieve) analyses were carried out on two (2) samples of this deposit, the results of which indicated 9 to 39% gravel size particles, 43 to 58% sand size particles, and 18 to 33% silt and clay size particles (Figure No. L-6, Appendix 3). Based on a SPT 'N' value of 19 to 90 blows per 300 mm penetration, this deposit was described as compact to very dense. This deposit was encountered to depths of 11.5, 11.7, 12.1, and 3.8 m below ground surface at Borehole Nos. 1, 2, 3, and 5, respectively (Elevations 318.1, 317.9, 317.3 and 320.5 m).

4.1.9 Bedrock

Underlying the sands at Borehole No. 4 and underlying the till at Borehole Nos. 1, 2, 3, and 5, bedrock was proven by diamond core drilling. The bedrock was described as black gneiss bedrock. Based on RQD values of 0 to 96%, the bedrock was described as very poor to excellent quality, generally good quality. Core photos are included in Appendix 2.

One unconfined compressive strength test (UCT) was carried out on an intact rock sample recovered at Borehole 2, at a depth of 12.4 m, and indicated an unconfined compressive strength of 60.7 MPa (see Appendix 3).

Sampling in the bedrock was terminated at depths of 14.6, 15.0, 12.5, 5.2, and 6.9 m below grade at Borehole Nos. 1 to 5, respectively (Elevations 315.0, 314.6, 316.9, 318.5, and 317.4 m, respectively). It should be noted that, when encountered, the underlying bedrock surfaces in this area can be very erratic in nature, varying substantially in Elevation over short horizontal distances.

4.2 GROUNDWATER DATA

At the time of this investigation period (November 30th to December 18th, 2015), a surface water level at Elevation 324.4 m was observed at the culvert inlet.

Measurements of the groundwater table and cave-in levels were undertaken, where possible, in the open boreholes during the advance of the individual borings and upon completion. A piezometer was installed in Borehole Nos. 1 and 5 to obtain post borehole completion water levels. These levels are recorded on the individual Record of Borehole Log Sheets (Appendix 2).

The water levels were measured at Elevations 324.6, 323.1, and 324.3 m at Borehole Nos. 1, 4, and 5, respectively.

The groundwater and surface water levels will fluctuate seasonally/yearly.

Appendix 1 Key Plan

Drawing No. 1 Key Plan

Appendix 2 Subsurface Data

Enclosure No. 1	List of Abbreviations and Symbols
Enclosure Nos. 2 to 6	Record of Borehole Sheet
Table Nos. R-1 and R-2:	Recovery Table
Enclosure No. 7:	Core Photos

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Appendix 3 Borehole Plan and Lab Data

Drawing No. 2: Borehole Location and Soil Strata
Figure Nos. L-1 to L-6: Grain Size Distribution Curves
Figure No. L-7: Atterberg Limits
Figure No. L-8: Rock Compressive Strength Results
Table No. L-9: Lab Test Summary Sheet

Appendix 4 Photo Essay

Enclosure No. 8: Photo Essay