MERLEX ENGINEERING LTD.

CONSULTING GEOTECHNICAL ENGINEERS

FINAL
FOUNDATION INVESTIGATION AND
DESIGN REPORT
ROADWAY PROTECTION
Station 18+513 Twp of Dunnet
CULVERT SITE NO. 46-487

GWP 372-00-00

Highway 17, From Highway 535 (Hagar)
Easterly To Highway 539 (Warren), 8.4 km and
Highway 539, From Highway 17 Northerly 0.5 km

MEL Ref. No.: 06/11/06160-F3 February 2008

Submitted to:

Earth Tech (Canada) Inc.
189 Wyld Street
North Bay, Ontario
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Geocres No. 41I-221

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1.0 INTRODUCTION

Merlex Engineering Ltd. (MEL) has been retained by Earth Tech (Canada) Inc., on behalf of the Ministry of Transportation of Ontario (MTO), to carry out a foundation investigation at Culvert Site No. 46-487, Township of Dunnet, on Highway 17 (GWP 372-00-00) for a Roadway Protection Plan. The limits of GWP 372-00-00 are described as: Highway 17 from Highway 535 in Hagar, Easterly 8.4 km to Highway 539 in Warren, and Highway 539 from Highway 17 northerly a distance of 0.5 km (see Enclosure No. 2, Key Plan, Appendix A). The foundation component of this project originally involved the replacement of two (2) culvert structures, however during detailed design foundation information was required for roadway protection plans at Culvert Site No. 46-391 and Culvert Site No. 46-487, along with information for replacement of the headwall at the right end of the culvert located at Station 17+160 Twp of Dunnet. Culvert Site No. 46-487, which is addressed in this report, is situated on Highway 17 Station 18+513, Township of Dunnet some 130 m west of the intersection with Highway 539.

The original foundation investigation locations were specified by the MTO in the RFP/TPM documentation Agreement No. 5005-E-0011. The terms of reference for the scope of work were outlined in MEL's proposal P-06-103R dated August 24, 2006 and in our subsequent proposal letters of June 26, 2007 and September 13, 2007. The purpose of this investigation was to determine the subsurface conditions in the area of the north shoulder of the highway at the culvert location for the purpose of road way protection. MEL investigated the foundation area by the drilling of boreholes, carrying out in-situ tests, and performing laboratory testing on select samples.

2.0 SITE DESCRIPTION

Culvert Site No. 46-487 is situated on Highway 17, 130 m west of the intersection with Highway 539 in the Town of Warren. The topography at the site is generally of low relief and the stream flows through the culvert from north to south and into the Veuve River some 160 m to the south. The existing highway embankment supports two undivided lanes of highway, running in an east west direction, plus an east bound right turn taper. The existing road embankment is some 8.5 m higher than the grade level to the north side of the road. The stream originally meandered through this section, before it was channeled to flow through the CPR and Highway culverts (see Topographic Plan, Enclosure 3). The CPR embankment parallels the north side of the highway and, at this location the concrete wing wall for the CPR culvert is located very close to the north inlet of the highway culvert (see Photo 1).

2.1 Site Geology

Bedrock in the area is late to middle Precambrian, comprising of metasediment deposits of conglomerate, sand stone, silt stone, chert, and iron formation. The rock units exist as metamorphosed equivalent of the rock types (OGS Map 2440). For the project area, the surficial geology maps indicate that surficial conditions generally consist of bedrock at shallow depth and overburdened soils comprising of glaciolacustrine plain deposits of silts/clays and sands through which the Veuve River meanders in an easterly direction. Sand and gravel deposits are identified in glaciolacustrine raised beaches north of Warren. Frequent organic deposits are encountered between the rock outcrops (OGS Map 5003).

3.0 INVESTIGATION PROCEDURES

The field work for this part of the investigation was carried out on November 6 and 7, 2007, and consisted of a total of two (2) sampled boreholes, advanced along the north shoulder of the highway at the location shown on the enclosed Borehole Location Plan and Soils Strata (Figure No 1 in Appendix C).

The field investigation was carried out using a Bombardier mounted CME 45B drilling rig equipped with hollow stem augers and routine geotechnical sampling equipment. The boreholes were advanced using 165 mm O.D. continuous flight hollow stem auger. Soil samples were obtained 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 at all borehole locations. An automatic (trip) hammer was used to advance the sampler. In-situ field vane testing, using an MTO “N” size vane, was carried out where appropriate and possible.

Groundwater conditions in the open boreholes were observed during and immediately following completion of the individual boreholes All open boreholes were backfilled upon completion with the auger cuttings, in the general order in which they were removed.

The field work for this investigation was under the full time direction of a senior member of our engineering staff, 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 in our laboratory. Laboratory testing of select samples included routine testing for natural moisture content determination, Atterberg Limits determination, grain size analysis (sieve and/or hydrometer), and specific gravity testing. The results of the laboratory testing are presented on the individual

Record of Borehole Sheets (Appendix B), with a summary of select results presented on the laboratory sheets in Appendix C (Figures L-1 to L-3).

The location of the individual boreholes were established in the field using highway chainage and offset relative to highway centerline.

4.0 SUBSURFACE CONDITIONS

Details of the subsurface conditions revealed by the investigation program are presented on the enclosed Record of Borehole Logs (Appendix B) and on Figure No. 1 (Appendix C). 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, and the results of SPT and DCPT, 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.

4.1 Roadway Protection-Culvert Site No. 46-487, Station18+513, Township of Dunnet

A plan and profile showing the borehole locations and stratigraphic sequences is shown on Figure No. 1. During the course of this stage of the exploration program, two (2) sampled boreholes (Borehole Nos. 4 and 5) were advanced from the surface of the existing highway embankment along the north shoulder of the highway.

Boreholes Nos. 4 and 5 were advanced from the top of the embankment, at Stations18+520 and 18+502, respectively, at an off-set distance of 4.6 m to the left of centerline. The boreholes revealed a layer of granular fill (sand and gravel (shoulder material)) varying from 0.9 to 1.0 m in thickness which was underlain by embankment fill. The stream originally meandered through

this section, before it was channeled to flow through the CPR and Highway culverts, as such the embankment fill extends a distance back from the culvert side walls. At the borehole locations the embankment fill consisted predominately of sand, brown to grey/brown in colour with silt and gravel content varying from a trace to with. Grain size analysis carried out on samples from this embankment fill stratum indicated 1 to 12% gravel size particles, 69 to 86% sand sizes particles, and 10 to 23% silt and clay size particles. Specific grain size analysis curves for this stratum are presented on Figure No. L-1. The measured water content in the samples from this deposit was 12 to 19%. Standard Penetration Test "N" values in this deposit ranged from 5 to 11 blows per 0.3 m of penetration indicating a compact to loose state of compactness. At a depth of approximately 3 m silty clay pockets/layers were encountered in the sand fill. At Borehole No. 4 the embankment fill, consisted of a silty clay, between depths of 5.5 to 8.3 m. Atterberg limits testing carried out on two samples from this deposit returned liquid limit values of 22.0 and 37.3% with plastic limit values of 11.6 and 20.1% , indicating the upper part of this fill was a silty clay of low plasticity with the lower part having a medium plasticity. The embankment fill extended to depths of approximately 8.3 m at both boreholes.

Underlying the embankment fill, at Boreholes Nos. 4 and 5, a deposit of grey, fine and medium sand with a trace to with silt and gravel was penetrated to the depth at which the boreholes were terminated at 13.7 m and 11.6 m respectively. Grain size analysis carried out on samples from this stratum indicated 0 to 36% gravel size particles, 57 to 94 % sand size particles and 6 to 25% silt and clay size particles. Grain size analysis curves are shown on Figure L-3. Based on the SPT values, which varied from 46 to WH (static weight of hammer and rods) per 300 mm penetration and in consideration of the DCPT results the deposit is considered to be in a dense to loose state of compactness, generally compact.

4.2 Groundwater Conditions

Groundwater levels in the open boreholes were taken during the advance of the individual borings and upon completion. These water levels were recorded on the individual Record of Borehole Log Sheets (Appendix B). At Borehole No. 4 a cave-in depth of 7.0 m was recorded with a water level at a depth of 4.6 m upon completion. At Borehole No. 5 a cave-in depth of 6.1 m was recorded with a water level recorded at a depth of 3.1 m below the top of embankment upon completion. This data indicated the water level was high in the embankment relative to the water level in the stream, which was at a depth of some 8.1 m below the top of the embankment at the time of the investigation. These water levels will fluctuate seasonally.

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5.0 DESIGN COMMENTS AND RECOMMENDATIONS

5.1 General

The existing highway culvert is identified as a concrete box culvert 4880 by 2440. The north end of the culvert is to be rehabilitated and shortened by 1 m in length. The General Arrangement drawing by Earth Tech (Canada) Inc. indicates rehabilitation will involve removing a 2 m length of the top slab and 1.5 m length of the side walls down to the top of the bottom haunch. The side walls will be reconstructed for a 500 mm length and the top slab for a 1000 mm length. The top slab will support a 1200 mm headwall along with reconstruction of the wing walls. To allow excavation back from the north face of the existing culvert and not impact traffic flow in the west bound lane roadway protection is required along the north fore slope.

5.2 Roadway Protection System

The existing embankment is some 8.5 m high and is constructed of predominately sand fill with varying silt and gravel content and contains pockets/layers of silty clay. At Borehole No. 4, a deposit of silty clay fill was encountered between depths of 5.5 to 8.3 m. The fill deposit extends to a depth of some 8.3 m below the top of the embankment and is underlain by a deposit of sands with varying gravel and fines content, which was sampled to depths of 13.7 and 11.6 m, at Borehole Nos. 4 and 5 respectively. The results of the DCPT indicate similar deposits probably extend to the depth at which refusal on the DCPT was met at 19.2 m at Borehole No. 5. The free standing water level was measured at depths of 4.6 and 3.1 m, below top of embankment, in the open boreholes.

Sheet piling is considered appropriate for roadway protection during construction at this site. A sufficiently robust sheet pile section must be used to minimize installation difficulties. Over the actual culvert location, the sheeting would be carried down to top of slab elevation behind a suitably sized and connected anchorage system. A suitably sized whaler could be provided and

tied into the full depth piling and bracing at the wall edge in order to provide support at the top and bottom of the sheeting over the top of the culvert. The full depth piling sections generally extend to a depth of 4 to 6 m below excavation lines (depending upon the water level in the embankment at the time of construction) and extend up above the highway surface. Depending on the section properties of the sheeting, whalers and bracing struts or ground anchor support systems may be required.

5.3 Lateral Earth Pressure

Lateral earth pressures acting on a temporary support system should be computed in accordance with the CHBDC Section 6-7. The active earth condition (K_a) may be assumed to apply if the structure is designed to be yielding. For unyielding structures, the at rest condition (K_o) may be assumed to apply. The soil parameters for shoring design are tabulated below for each specific culvert site:

CULVERT- MTO SITE 43 – 83, Township of Widdifield Station 19+360

Elev. From – To (m)	* Water Elev. (m)	Soil Type	Unit ** Weight (Bulk) (KN/m^3)	Internal Angle of Friction (Deg)	Anchorage Coefficient (α_g)	Active Earth Pressure (K_a)	At Rest Earth Pressure (K_o)
208.9-200.6	± 205.8	Sand – Embankment Fill (Loose to Compact)	19.5	32	0.9	0.31	0.47
200.3-195.2		Sand some gravel and silt (compact)	19.0	30	0.6	0.33	0.50

* Note: Water level/cave-in measurement recorded upon completion of drilling and may not have stabilized. Water level will fluctuate seasonally.
** Below the water level submerged unit weights apply.

Surcharge loads must be included in the lateral pressure calculations. Depending on the section properties of the support system, walers with rakers and bracing or a tieback system will be required. If a tieback system is considered, the pull-out resistance (R) for grouted anchors in

cohesionless soils can be estimated from the following equation as supplied in the Canadian Foundation Engineering Manual (3rd Edition):

$\mathbf{R = \sigma_z' A_s L_s \alpha_g}$ Where: $\mathbf{\sigma_z'}$= effective vertical stress at the midpoint of the load carrying length

$\mathbf{A_s}$ = effective unit surface area of the anchor

$\mathbf{L_s}$ = effective embedment length of the anchor

α_g = anchorage coefficient dependent on the soil type and conditions as given in the above Tables

Unless the pull-out resistance (capacity) of the anchor is proven with a load test program, the allowable anchor load, as suggested by the Canadian Foundation Engineering Manual (3rd Edition), is commonly obtained by dividing the computed capacity of the anchor by a factor of safety of 3. Alternatively, proprietary anchor systems can be used.

It is imperative that a stability analysis of the entire support system be undertaken prior to commencement of construction.

6.0 CLOSURE

Information provided in this report is valid only at the locations described above. Any assumptions of continuity of soil stratigraphy between boreholes, as shown on the enclosed cross-sections, is intended as an aid for design purposes only and does not constitute a statement of existing conditions for contractual or construction purposes.

Details of the investigation, the material analysis and recommendation in this report are considered to be complete. However, should any questions arise, please do not hesitate to contact the undersigned.

MERLEX ENGINEERING LTD.

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Principal

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WP No 372-00-00

Geocres No 41I-221

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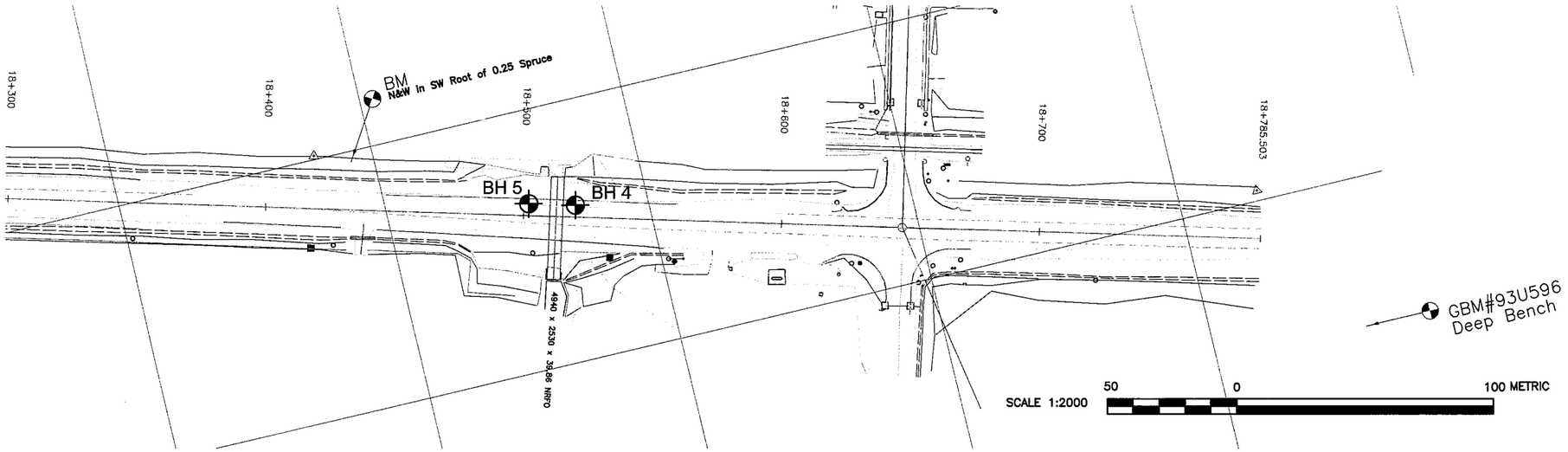
HWY 17 Twp. Dunnet

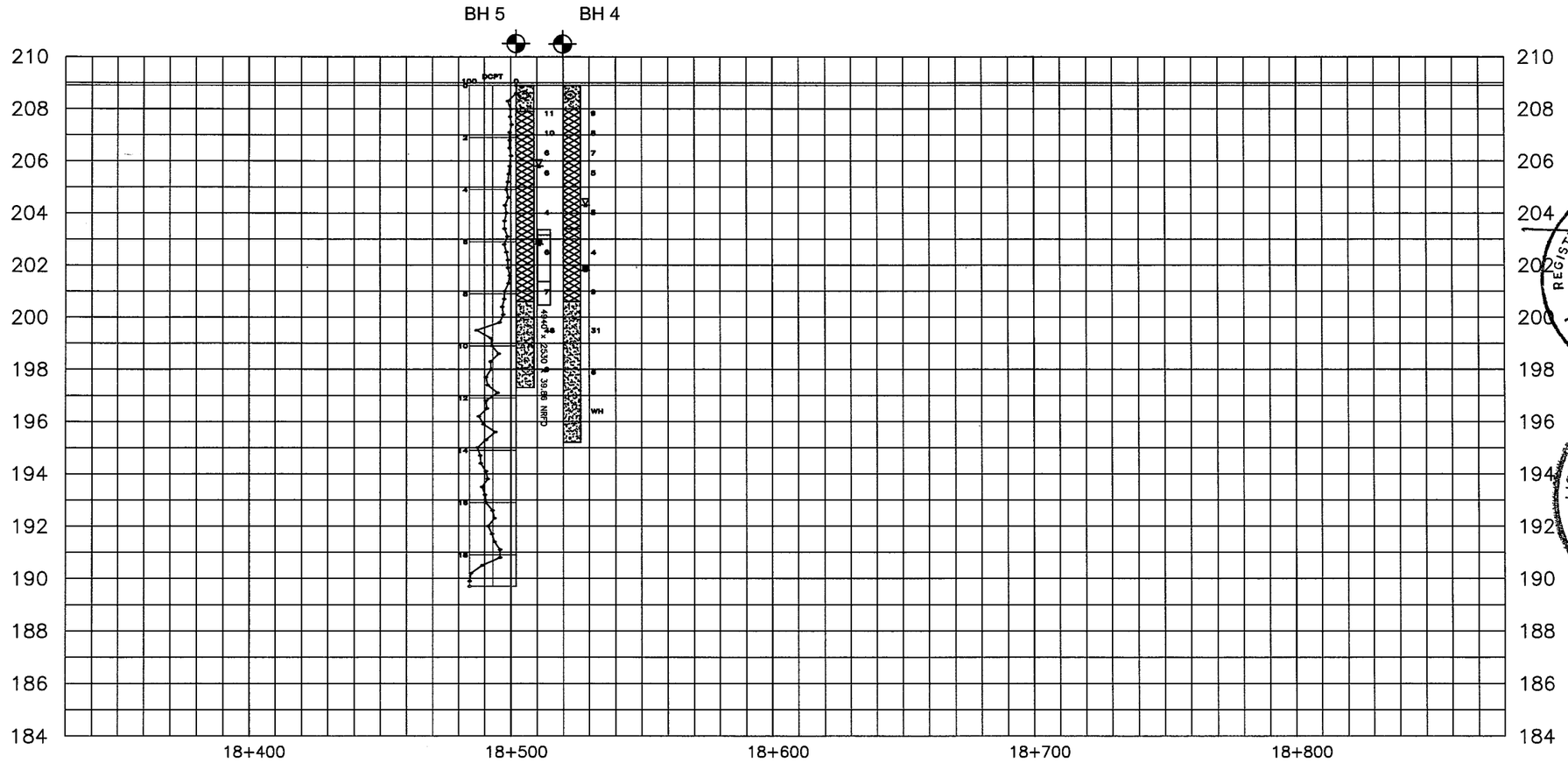
Culvert Site No. 46-487 at Station - 18+513

Roadway Protection

BOREHOLE LOCATIONS & SOIL STRATA

Figure 1





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STRATIGRAPHY LEGEND

TOPSOIL	SAND	SILTY SAND/ SANDY SILT
PEAT	SAND & GRAVEL	SILT
VARVED/ INTERLAYERED CLAYS & SILTS	CLAY	SILTY CLAY
FILL	TILL	CRUSHED GRAVEL
ASPHALT COATED	ORGANIC SILTS	

LEGEND

- Borehole and Dynamic Cone Penetration Test
- Borehole
- Dynamic Cone Penetration Test
- Blows/0.3 m (Std Pen Test, 475 J/blow)
- DCPT Blows/0.3 m (60° Cone, 475 J/blow)
- Water Level at Time of Investigation
- A/R Auger Refusal at Elevation

Borehole No.	Co-ordinates Station	Offset	Elevation
Borehole No.4	18+520	4.6 m Lt	208.9 m
Borehole No.5	18+502	4.6 m Lt	208.9 m

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NOTE 1:
The boundaries between soil strata have been established at the borehole locations only. The boundaries between boreholes are assumed based on borehole data.

REVISIONS	DATE	BY	DESCRIPTION
	00/00/03	DVL	
	00/00/03	DVL	
	00/00/03	DVL	
	00/00/03	DVL	

HWY No. 17 Culvert 46-487 – MEL Reference No. 06160-F3

SUBM'D		DATE 07/05/01	SITE
DRAWN DVL	CHK MAM	DATE 07/04/30	FIG 1