MERLEX ENGINEERING LTD.

CONSULTING GEOTECHNICAL ENGINEERS

FINAL
FOUNDATION INVESTIGATION AND DESIGN REPORT

GWP 175-98-00 WP 5161-01-00
FOUNDATION AREA B
Highway 17, Township of Calvin
Culvert at Station 10+470

MEL Ref. No.: 05/07/05090-FB February 2006

Submitted to:

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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 for WP 5161-01-00. The general work project (GWP 175-98-00) is located on Highway 17 from 0.2 km west of Highway 531 to 8.5 km east of Highway 630 for 26.4 km, within the Townships of Bonfield, Calvin and Papineau. Highway 17 is an undivided two lane Rural Arterial King's Highway (RAU110). Highway 17 intersects with Highway 417, approximately 24 km west of Kanata, and runs westerly a distance of 2,129 km to the Ontario/Manitoba Provincial Boundary, approximately 55 km west of Kenora. This east/west route forms part of the Trans Canada Highway system.

The foundation investigation location was specified by the MTO in the RFP/TPM documentation Agreement No. 5004-E-0053. The terms of reference for the scope of work are outlined in MEL's proposal P-05-038 dated May 27, 2005. The purpose of the investigation was to determine the subsurface conditions at the location of a centerline culvert within a high fill embankment along the existing highway in order to provide detail design recommendations for replacement. This report addresses Foundation Area B, a centerline culvert located on Highway 17, ± 9.6 km east of the junction of Highway 17 and Highway 531, in the Township of Calvin at Station ±10+470 (see Enclosure No. 2: Key Plan). MEL investigated the foundation area by the drilling of boreholes, carrying out in-situ tests, and performing laboratory testing on selected samples. Based on the information recovered from this program and our interpretation of the conditions that were encountered at the subject site, we have provided recommendations on the geotechnical aspects of the culvert replacement, along with discussions on excavations, fills and embankment design.

The ETR plans and centerline profiles for Highway 17, in the area of the foundation investigation, were provided by Earth Tech (Canada) Inc. Prior to commencing the fieldwork, stations and offsets in the area of the foundation investigations were surveyed by others and this field data was incorporated in preparation of the plans and profiles presented in this report. The locations of the boreholes are referenced to chainage painted in the field and the borehole elevations were established relative to centerline grade. The plan and profile information for Foundation Area B is presented on Figure No. 1. Stratigraphic information contained on the noted figure is based on our evaluation of conditions encountered in the field.

2.0 SITE DESCRIPTION

The specific location of the centerline culvert on Highway 17 is Station 10+470, Twp. of Calvin, east of the Town of Rutherglen, ± 9.6 km east of the junction of Highway 17 and Highway 531. At the time of this investigation, the culvert at this site consisted of a 760 mm diameter x 43.5 m CSP (see Photos in Appendix D).

2.1 Physiography and Surficial Geology

This Highway 17 project borders on the south limits of the geomorphic sub-provinces known as the Muskoka Ridges and Pockets, and the Algonquin Uplands and the north limit of the Eastern Sandy Uplands. The topography at the site is generally rolling. There are exposed bedrock ridges; at some locations significant layers of earth overburden overlay the bedrock. Within the project area overburden conditions consist primarily of sand containing varying amounts of silt, occasionally overlain by organic (peat) deposits.

The highway embankment is elevated above the surrounding topography. To the north of the highway, the embankment is approximately ±2 m in height and the invert of the culvert inlet is at elevation ±254.2 m. To the south of the highway embankment, the land drops off steeply from

the top of the embankment by some ±10 m. The invert of the outlet of the culvert is at elevation ±246.4 m. The vertical alignment of the culvert below the highway is unknown. The surrounding land is forested and the vegetation consists of predominantly mature deciduous (birch and alders) and coniferous species.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out on November 4 and 8, 2005, and consisted of a total of four (4) sampled boreholes.

The field investigation was carried out using a Bombardier mounted CME 45B drilling rig operated by Merlex Engineering Ltd. and under the supervision of Mr. E. Sullivan, of MEL. The drill rig is equipped with hollow stem augers and all routine geotechnical sampling equipment. Boreholes were advanced using 165 mm O.D. continuous flight hollow stem augers or 110 mm I.D. continuous flight standard augers. Boreholes were advanced with hand operated equipment where the local topography limited access with the drill rig. 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 and/or auger samples where applicable. Maximum exploration depth was 12.6 m at both Borehole Nos. B3 and B4.

Groundwater conditions in the open boreholes were observed during and immediately following completion of the individual boreholes and temporary standpipes were installed for the duration of the drilling operation. A set of water level observations were taken prior to removal of the temporary standpipes. All open boreholes were backfilled upon completion with the auger cuttings in the order they were removed. Where necessary, imported bentonite was used to seal the hole at grade.

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 natural water 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-4).

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

4.0 SUBSURFACE CONDITIONS

Details of 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, 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 Foundation Area B: Culvert at 10+470, Calvin Twp.

A plan and profile showing the borehole locations and stratigraphic sequences is shown on Figure No. 1. During the course of our exploration program, six (6) sampled boreholes were put down at this site (Borehole Nos. B1 to B6). Borehole Nos. B1 and B2 were put down on the north side of the embankment, on the east and west sides of the existing culvert respectively. Borehole Nos. B3 and B4 were put down on the south side of the embankment, on the west and east sides of the existing culvert respectively. The ground surface elevation at Borehole Nos. B1 to B 4 inclusive was ±255.9, 256.0, 256.2, and 256.2 m respectively. Borehole No. B5 was put down to the north of the embankment, in the area of the culvert inlet and Borehole No. B6 was put down to the south of the embankment in the area of the culvert outlet. The ground surface elevation at Borehole Nos. B5 and B6 was ± 253.3 and 245.7 m respectively.

At the surface of Borehole Nos. B1 to B4 inclusive, a layer of crushed gravel some 100 to 300 mm thick was penetrated. Underlying this surficial deposit at Borehole Nos. B1 and B2, a layer of gravelly fine to medium sand with occasional cobbles was penetrated to depths of 400 and 600 mm respectively. Underlying this layer, and the surficial layer at Borehole Nos. B3 and B4, a deposit of fine to medium sand fill trace to some silt and trace gravel was penetrated. At Borehole Nos. B3 and B4, this deposit was found to contain occasional cobbles based on the response of the augers during advancement. Standard Penetration “N” values recorded in conjunction with the split spoon sampling within this stratum returned values of 16 to 39 blows/0.3 m indicating a compactness of compact to dense. It should be noted however that the higher “N’ values may have been influenced by the presence of occasional cobbles and/or boulders in the stratum. Natural moisture content determinations carried out on samples from this stratum indicated values of 3 to 18%. Gradation analyses was carried out on three samples of this deposit which indicated 9 to 24% gravel size particles, 70 to 79% sand size particles, and 6 to 15% silt and clay size particles. The specific distribution curve can be found on the

Summary of Laboratory Testing sheets (Appendix C, Figure No. L-1). The granular fill deposit was penetrated to depths below existing grade of ±1.8 m and 1.5 m at Borehole Nos. B1 and B2 respectively (elevations ±254.1 and 254.5 m). At Borehole Nos. B3 and B4, the granular fill was penetrated to depths of ±5.5 m and 3.1 m respectively (elevations ±250.7 and 253.1 m).

Underlying the granular fill at Borehole No. B1 at a depth of some 1.8 m (elevation 254.1 m), a thin stratum (i.e. ±300 mm thick) of fill consisting of a mix of sand, silt and clay was encountered.

Underlying the sand fill at Borehole No. B4, a deposit of fill was penetrated consisting of a mix of fine sand, silt and silty clay with trace organics and occasional cobbles. This deposit extended to a depth of some ±6.3 m (elevation ±249.9 m). Standard Penetration "N" values recorded in conjunction with the split spoon sampling within this stratum returned values of 4 to 6 blows/0.3 m indicating a compactness of loose. Natural moisture content determinations carried out on samples from this stratum indicated values of 13 to 23%. Gradation analyses was carried out on one sample of this deposit which indicated 0% gravel size particles, 21% sand size particles, 53% silt size particles, and 26% clay size particles. The specific distribution curve can be found on the Summary of Laboratory Testing sheets (Appendix C, Figure No. L-1). Atterberg Limits determinations carried out on one sample obtained form the bottom of this stratum indicate a CL (Inorganic Silty Clay of Low Plasticity) designation with a Plastic Limit of 20% and a Liquid Limit of 28% (Appendix C, Figure No. L-4).

Underlying the fill at Borehole Nos. B1 and B2, a stratum of silt was penetrated. This deposit was tan in colour and contained ±5 mm thick reddish-brown silty clay varves every ±20 mm and may possibly be fill native to the area. Standard Penetration "N" values recorded in conjunction with the split spoon sampling within this stratum returned values of 4 to 12 blows/0.3 m

indicating a compactness of loose to compact. Natural moisture content determinations carried out on samples from this stratum indicated values of 26 to 34%. Gradation analyses was carried out on one sample of this deposit which indicated 0% gravel size particles, 4% sand size particles, 75% silt size particles, and 21% clay size particles. The specific distribution curve can be found on the Summary of Laboratory Testing sheets (Appendix C, No. L-3). Atterberg Limits determinations carried out on one sample obtained from this stratum indicate a ML (Inorganic Silt of Slight Plasticity) designation with a Plastic Limit of 22% and a Liquid Limit of 25% (Appendix C, Figure No. L-4). This deposit was penetrated at Borehole Nos. B1 and B2 to depths of ±4.3 and 4.7 m respectively (elevations ±251.6 and 251.3 m).

Underlying the silt at Borehole Nos. B1 and B2 and the fill at Borehole Nos. B3 and B4, a deposit of fine to medium sand trace silt was encountered. Standard Penetration “N” values recorded in conjunction with the split spoon sampling within this stratum returned values of 10 to 21 blows/0.3 m indicating a compactness of compact. Natural moisture content determinations carried out on samples from this stratum indicated values of 4 to 29%. Gradation analyses was carried out on four samples of this deposit which indicated 0% gravel size particles, 85 to 96% sand size particles, and 4 to 15% silt and clay size particles. The specific distribution curves can be found on the Summary of Laboratory Testing sheets (Appendix C, No. L-2). Borehole Nos. B1 to B4 inclusive were terminated in this sand deposit at depths of 9.4, 9.4, 12.6 and 12.6 m below existing grade respectively (elevations ±246.5, 246.6, 243.6, and 243.6).

At Borehole No. B5, put down to the north of the embankment near the inlet of the culvert, a deposit of brown fine to medium sand with gravel and with silt was penetrated to a depth of 1.7 m at which point the borehole was terminated (elevation ±252.1 m).

At Borehole No. 6, put down near the outlet of the culvert at the base of the high embankment to the south, brown fine to medium sands with gravel and with silt were penetrated to a depth of 600 mm (elevation ±254.4 m) at which point refusal to further penetration of the equipment was encountered on boulders.

4.2 Groundwater Conditions

Groundwater levels in the open boreholes were taken during the advance of the individual borings and upon completion. Temporary standpipes were installed in Borehole Nos. B1 and B3. Groundwater levels and cave-in depths are summarized on the individual Record of Borehole Log Sheets (Appendix B).

Borehole No. B1 was found to be dry to 9.4 m twelve days post completion of the borehole. Approximately four days post completion of the drilling operations, the groundwater level was measured in the temporary standpipe in Borehole No. B3 at elevation ±244.4 m (i.e. 11.8 m below existing grade).

Groundwater levels will fluctuate seasonally. In general, the groundwater levels are higher in the spring during the spring melt and runoff and during the fall rainy season. Typically, the groundwater levels in this area will be at their lowest in mid to late summer.

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5.0 DESIGN COMMENTS AND RECOMMENDATIONS

5.1 General

A foundation investigation was identified in the RFP for detour construction at the culvert located at Station 10+470, Township of Calvin, ± 9.6 km east of the junction of Highway 17 and Highway 531. This culvert location was labeled as Foundation Area B.

This section of the report provides our recommendations on the foundation aspects of design for the culvert. A foundation investigation was carried out at this location to obtain sufficient subsurface information to verify design assumptions and provide adequate subsurface descriptions to provide recommendations for culvert replacement. It must be noted that the interpretations and recommendations are intended only for use by the design engineer. Where comments are made on construction they are provided only in order to highlight those aspects that could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction method and scheduling.

5.2 Existing Conditions

At the culvert location, the embankment is approximately ±2 m higher than the natural ground surface to the north of the embankment and ±10 m higher than the land to the south of the culvert. Based on the embankment cross section through the culvert location provided by ET, the north side of the embankment has a slope of 3.7H:1V. The south side of the embankment has a slope of 2.2H:1V. Borehole Nos. B1 to B4 inclusive were put down through the existing embankment. Borehole Nos. B5 and B6 were put down to the north and south of the embankment respectively. Based on our soils exploration program in the vicinity of this culvert, the embankment is constructed of granular fill. At a depth of some 3 m in Borehole No. B4, the fill was found to consist of a mix of fine sand, silt and silty clay to a depth of ±6.3 m. There is

approximately 1.5 m of fill on the north side of the embankment that is underlain by a stratum of silt (possible fill) followed by sand. The fill along the south side of the embankment was found to be some ±5.5 to 6.3 m thick and overlaid a deposit of sand. Based on the response of the drilling equipment, the fill deposits along the south side of the embankment were found to contain occasional cobbles or boulders (i.e. possibly one or two per 1.5 m of depth drilled). On the north side of the embankment, occasional cobbles were encountered in the upper portion of the fill deposit.

The centerline elevation of the highway at the culvert location is 256.2 m. The existing culvert section is a corrugated steel pipe 760 mm in diameter by 43.5 m long. To the north of the highway, the obvert of the existing culvert inlet is at elevation ±254.2 m. To the south of the highway embankment, the land drops off sharply by ±10 m. The obvert of the outlet of the culvert is at elevation ±246.5 m. Based on the elevation difference between the inlet and outlet of the culvert, the culvert has at least one, or more, vertical bends, along its' alignment. The vertical alignment of the culvert through the highway embankment is not known. No significant structural problems, other than aging, have been reported at this culvert location. It is proposed to replace the existing culvert with a culvert of similar dimension however, the new culvert will be installed through the embankment at a relatively shallow depth at a shallow horizontal alignment slope (i.e. no vertical bends) with a slight downwards gradient of 8 to 10%. The culvert will be installed through a jack and bore operation as open cut methods would result in excessively deep excavations.

The culvert is located in an area with a passing lane and, as such, the wider embankment platform at this location should allow continued flow of traffic during the replacement operations. The culvert replacement will be carried out as a continuous operation and, if necessary, traffic will be controlled by traffic control personnel. No embankment construction for a detour will be

required. If open cuts are necessary for installation of a culvert at a shallow depth (i.e. invert at ±3 m below centerline grade), the wider embankment in this area will allow the slopes of open excavations to be cut back to the geometry required by the OHSA. As such, it is not anticipated that a roadway protection system (i.e. shoring, etc.) will be required. The vertical alignment of the highway at the culvert and along the embankment will essentially remain constant, or increase slightly (order of ±100 mm or less), to allow for proposed highway improvements.

Based on visual observations, the existing embankment is stable and does not exhibit any signs of distress that would indicate problems with settlement or embankment slippage. Frost heaving has not been reported at this location.

To the north of the embankment, there are overhead hydro lines. To the south of the embankment there are buried Bell and natural gas lines. It is understood that there are fibre optic cables in the buried Bell lines. The natural gas line was not identified on the plans provided. The Bell lines are identified on the plan provided by ET and, based on the plan it appears that the Bell lines are some ±18 m right of centerline. The gas line is located several meters to the south of the Bell line. It is understood that the new culvert will be installed at a relatively shallow depth. With an inlet obvert established at elevation 254.2 m on the north side of the embankment, and assuming the culvert is provided with an 8 to 10% gradient, it is estimated that the culvert should breakout of the south side of the embankment at some ±5 m up slope from the underground services. Therefore, it is not anticipated that the presence of the underground Bell and natural gas lines will cause problems with regards to the jack and bore operation however, this should be confirmed by the design team once the final depth and alignment of the new culvert is established. It is not anticipated that the overhead hydro lines will adversely impact a jack and bore operation.

5.3 Culvert Design Comments

This culvert will be replaced by using the method of jack and boring through the embankment (see OPSS 416). Based on the height of the embankment (i.e. ±10 m), the installation of a new culvert through open cut method could result in very large open excavations, possible requiring roadway protection depending upon the final alignment.

As noted, it appears that the existing culvert is bedded in the embankment fill. Based on the OHSA construction regulations, the embankment fill would be classified as a Type 3 soil. Temporary open excavations in this type of soil will be stable above the groundwater table at an angle of 1Hto1V with adequate groundwater control. All open excavations must be sloped or shored in accordance with the OHSA.

At the time of this investigation, the groundwater level was encountered at elevation ±244.4 m, well below the top of the embankment. The inlet of the culvert was dry, however, water flow was observed at the outlet of the culvert. The launch area for the jack and bore operation can be kept dry by temporarily blocking any water flow in the ditch on the north side of the highway with a cofferdam and by pumping from filtered sump holes located in the bottom of the launch excavation. Dewatering should be carried out with reference to OPSS 517.

As noted, occasional cobbles and/or boulders were encountered during the drilling operations, however, the drilling operations were generally not hindered by these materials. As such, it is not anticipated that there will be any major obstructions encountered during a jack and bore replacement operation. The pipe section should be robust enough such that it will not be damaged during the jacking operation if a cobble/boulder is encountered. The contractor should be made aware of the presence of occasional cobbles and/boulders. Typically, the soil around the culvert is compacted during the jacking operation and settlements do not usually develop.

Settlement of the highway surface along the new culvert alignment is not anticipated. It is recommended that the culvert replacement be carried out as early in the contract as possible and the surface of the highway above the new culvert monitored for visual signs of settlement by the contractor for the duration of the contract. Although not anticipated, if settlement is observed, it can be corrected prior to paving.

The purpose of this culvert is to provide a drainage path from the north side of the highway to the south side of the highway. Water flow through the culvert is intermittent. The inlet and outlet of the culvert should be provided with a rip rap (OPSS 511) apron to reduce/eliminate the development of flow paths along the outside face of the culvert and the resultant risk of internal erosion within the embankment. A Class II Geotextile with an F.O.S. of between 50 to 100 µm should be used below the rip rap layer as this material will be used elsewhere on the project. As noted previously, the alignment of the existing culvert through the highway embankment is unknown. The new culvert will basically be established at a horizontal alignment through the embankment (i.e. no bends) at a slight downwards gradient. As such, the outlet of the new culvert will be located in the upper part of the embankment south slope. It is recommended that the slope face below the outlet be protected against erosion with a layer of rip rap some 300 to 400 mm thick. A Class II Geotextile with an F.O.S. of between 50 to 100 µm should be used below the rip rap layer as this material will be used elsewhere on the project. Rip rap treatments for culvert outlets are illustrated in the OPSD 810 series. Newly exposed earth cut slopes elsewhere should be covered with topsoil and seeded as soon as practical.

It is anticipated that the existing culvert will be left in place. Once the new culvert is installed, the old culvert should be filled with non-shrink fill (i.e. grout) to prevent the culvert from collapsing in the future resulting in potential settlement in the highway embankment.

Based on the MTO Manual, Aspects of Prolonged Exposure of Pavements to Sub-Zero Temperatures, the depth of frost penetration used for design on this project shall be 2.0 m. The actual frost depth may vary.

The reconstruction of the pavement structure is detailed in the Pavement Design Report produced for this work project by Merlex Engineering Ltd. under separate cover.

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.

M. A. Merleau, P. Eng.
Principal

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APPENDIX A

Enclosure No. 1: List of Abbreviations and Symbols

Enclosure No. 2: Key Plan

LIST OF ABBREVIATIONS & DESCRIPTION OF TERMS

The abbreviations and terms, used to describe retrieved samples and commonly employed on the borehole logs, on the figures and in the report are as follows:

1. ABBREVIATIONS

AS Auger Sample
CS Chunk Sample
DS Denison type sample
FS Foil Sample
HB Hammer Bouncing
NFP No Further Progress
PH Sampler advanced by hydraulic pressure
PM Sampler advanced by manual pressure
RC Rock core with size & percentage of recovery
SS Split Spoon
ST Slotted Tube
TO Thin-walled, open
TP Thin-walled, piston
WH Sampler Advanced by static weight (weight of hammer and/or rods)
WS Wash Sample

2. PENETRATION RESISTANCE/"N"

Dynamic Cone Penetration Test (DCPT):

A continuous profile showing the number of blows for each 300 mm of penetration of a 50 mm diameter 90° point cone driven by a 63 kg hammer falling 760 mm.

Plotted as

Standard Penetration Test (SPT) or "N" Values

The number of blows of a 63 kg hammer falling 760 mm required to advance a 50 mm O.D. drive open sampler 300 mm.

3. SOIL DESCRIPTION

a) *Cohesionless Soils:*

"N" (blows/0.3 m)	*Relative Density*
0 to 4	very loose
4 to 10	loose
10 to 30	compact
30 to 50	dense
over 50	very dense

3. SOIL DESCRIPTION (Cont'd)

b) *Cohesive Soils:*

Undrained Shear Strength (kPa)	*Consistency*
Less than 12	very soft
12 to 25	soft
25 to 50	firm
50 to 100	stiff
100 to 200	very stiff
over 200	hard

c) *Method of Determination of Undrained Shear Strength of Cohesive Soils:*

+ 3.2 - Field Vane test in borehole. The number denotes the sensitivity to remoulding.

D - Laboratory Vane Test

¨ - Compression test in laboratory

For a saturated cohesive soil the undrained shear strength is taken as one-half of the undrained compressive strength.

4. TERMINOLOGY

Terminology used for describing soil strata is based on the proportion of individual particle sizes present in the samples (please note that, with the exception of those samples subject to a grain-size analysis, all samples were classified visually and the accuracy of visual examination is not sufficient to determine exact grain sizing):

Trace, or occasional	Less than 10%
Some	10 to 20%
With	20 to 30%
Adjective (i.e. silty or sandy)	30 to 40%
And (i.e. sand and gravel)	40 to 60%

5. LABORATORY TESTS

P Standard Proctor Test
A Atterberg Limit Test
GS Grain Size Analysis
H Hydrometer Analysis
C Consolidation

SAMPLE DESCRIPTION NOTES:

1. **FILL:** The term fill is used to designate all man-made deposits of natural soil and/or waste materials. The reader is cautioned that fill materials can be very heterogeneous in nature and variable in depth, density and degree of compaction. Fill materials can be expected to contain organics, waste materials, construction materials, shot rock, rip-rap, and/or larger obstructions such as boulders, concrete foundations, slabs, abandoned tanks, etc.; none of which may have been encountered in the borehole. The description of the material penetrated in the borehole therefore may not be applicable as a general description of the fill material on the site as boreholes cannot accurately define the nature of fill material. During the boring and sampling process, retrieved samples may have certain characteristics that identify them as 'fill'. Fill materials (or possible fill materials) will be designated on the Borehole Logs. If fill material is identified on the site, it is highly recommended that testpits be put down to delineate the nature of the fill material. However, even through the use of testpits defining the true nature and composition of the fill material cannot be guaranteed. Fill deposits often contain pockets or seams of organics, organically contaminated soils or other deleterious material that can cause settlement or result in the production of methane gas. It should be noted that the origins and history of fill material is frequently very vague or non-existent. Often fill material may be contaminated beyond environmental guidelines and the material will have to be disposed of at a designated site (i.e. registered landfill). Unless requested or stated otherwise in this report, fill material on this site has not been tested for contaminants however, environmental testing of the fill material can be carried out at your request. Detection of underground storage tanks cannot be determined with conventional geotechnical procedures.

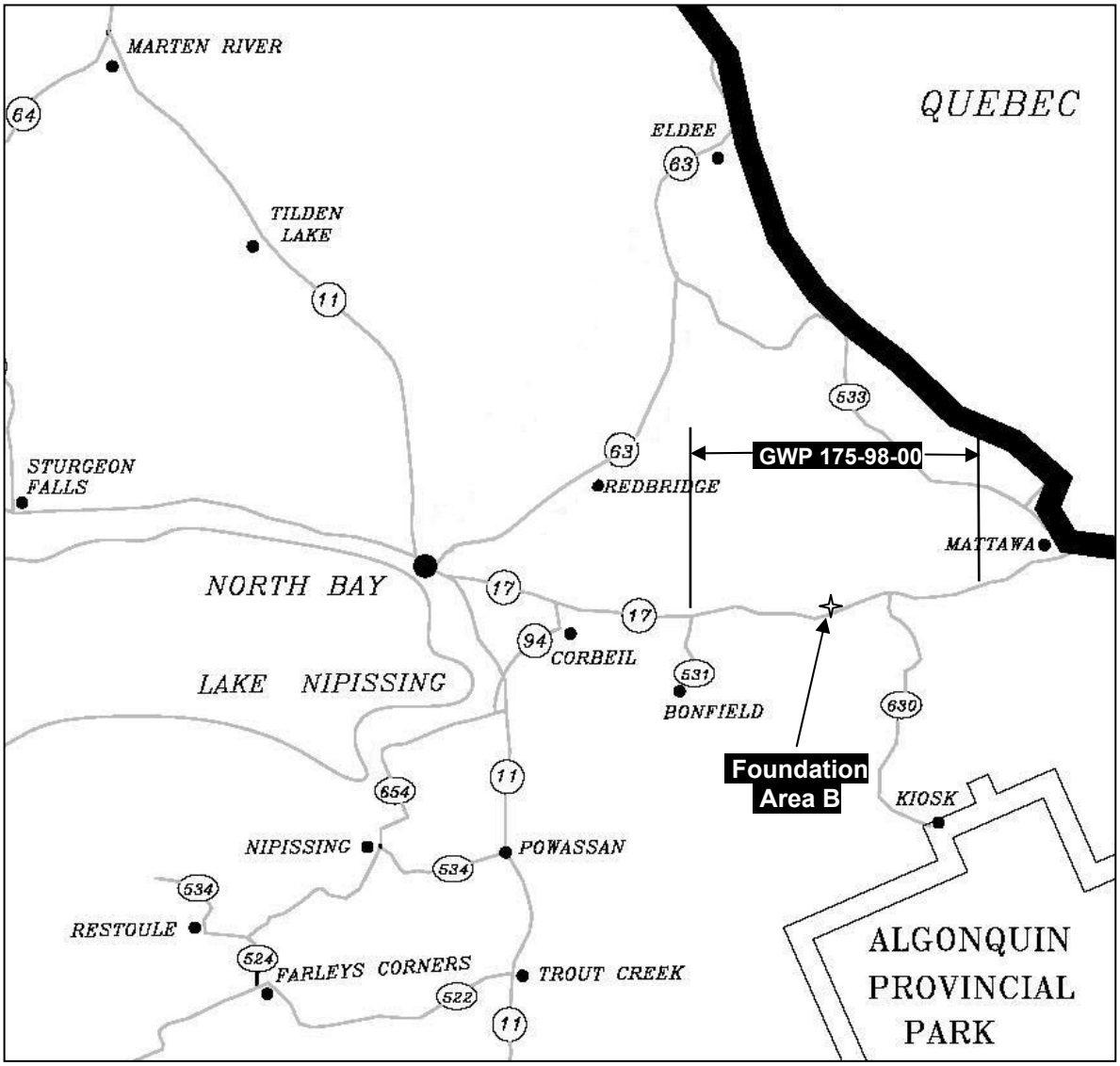
2. **TILL:** The term till indicates a material that is an unstratified, glacial deposit, heterogeneous in nature and, as such, may consist of mixtures and pockets of clay, silt, sand, gravel, cobbles and/or boulders. These heterogeneous deposits originate from a geological process associated with glaciation. It must be noted that due to the highly heterogeneous nature of till deposits, the description of the deposit on the borehole log may only be applicable to a very limited area and therefore, caution must be exercised when dealing with a till deposit. When excavating in till, contractors may encounter cobbles/boulders or possibly bedrock even if they are not indicated on the borehole logs. It must be appreciated that conventional geotechnical sampling equipment does not identify the nature or size of any obstruction.

3. **BEDROCK:** Auger refusal may be due to the presence of bedrock, but possibly could also be due to the presence of very dense underlying deposits, boulders or other large obstructions. Auger refusal is defined as the point at which an auger can no longer be practically advanced. It must be appreciated that conventional geotechnical sampling equipment does not differentiate between nature and size of obstructions that prevent further penetration of the boring below grade. Bedrock indicated on the borehole logs will be labeled 'possibly' or 'probable' etc. based on the response of the boring and sampling equipment, surrounding topography, etc. Bedrock can be proven at individual borehole locations, at your request, by diamond core drilling operations or, possibly, by testpits. It must also be appreciated that bedrock surfaces can be, and most times are, very erratic in nature (i.e. sheer drops, isolated rock knobs, etc.) and caution must be used when interpreting subsurface conditions between boreholes. A bedrock profile can be more accurately estimated, at the clients' request, through a series of closely positioned unsampled auger probes combined with core drilling.

4. **GROUNDWATER:** Although the groundwater table may have been encountered during this investigation and the elevation noted in the report and/or on the record of boreholes, it must be appreciated that the elevation of the groundwater table will fluctuate based upon seasonal conditions, localized changes, erratic changes in the underlying soil profile between boreholes, underlying soil layers with highly variable permeabilities, etc. These conditions may affect the design and type and nature of dewatering procedures. Cave-in levels recorded in borings give a general indication of the groundwater level in cohesionless soils however, it must be noted that cave-in levels may also be due to the relative density of the deposit, drilling operations etc.

KEY PLAN

Enclosure No. 2



Not to Scale

DRAFT
FOUNDATION INVESTIGATION AND DESIGN REPORT

GWP 175-98-00 WP 5161-01-00 - FOUNDATION AREA B
Highway 17, Township of Calvin
Culvert at Station 10+470

MEL Reference No. 05/07/05090-FB January 2006

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CONSULTING GEOTECHNICAL ENGINEERS

APPENDIX B

Enclosure Nos. 3 to 8: Record of Borehole Sheets

ENCLOSURE NO.: 3 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE No. B1

REFERENCE 05/07/05090-FB DATUM Geodetic LOCATION 10+468.8 8.8 m Lt - Calvin Twp. ORIGINATED BY ELS

PROJECT Hwy 17 - GWP-175-98-00 / WP-5161-01-00 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DVL

CLIENT Earth Tech (Canada) DATE (Started/Completed) 4/11/05 - 4/11/05 TIME 11:25:00 AM CHECKED BY JRB

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
255.9	Ground Surface						
0.0	100 mm Crushed Gravel 100 - 400 mm Gravelly Fine to Medium Sand with Cobbles SAND FILL Brown Fine Sand Trace/Some Silt trace Gravel	1	AS		255		
		2	SS	16			
254.1							
1.8	SAND, SILT AND CLAY MIX FILL				254		
253.8							
2.1	Pieces of Asphalt SILT Tan Silt with ±5 mm Reddish Brown Silty Clay Varves at ±20 mm	3	SS	12			
		4	SS	12	253		0 4 75 21
251.6					252		
4.3	SAND Brown Fine to Medium Sand trace Silt (Compact)	5	SS	13			0 96 (4)
		6	SS	15	251		
		7	SS	15	250		
		8	SS	16	249		
246.5					248		
9.4	End of Borehole				247		

SOIL PROFILE — STRATA PLOT — SAMPLES — GROUND WATER CONDITIONS

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%) (20 40 60)

COMMENTS

Temporary standpipe installed to 9.4 m. Standpipes removed on completion of the field drilling program.(Nov 16, 2005)

The stratification lines represent approximate boundaries. The transition may be gradual.

+³, ×³ : Numbers on right refer to Sensitivity. Numbers on left refer to values greater than 120 kPa

○ 3% STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (yy/mm/dd)/Time	Water Depth (m)	Cave In (m)
1)	-	-
2)	-	-
3)	-	-

MEL-GEO 05090-FB.GPJ MEL-GEO.GDT 5/5/06

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ENCLOSURE NO.: 4 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE No. B2

REFERENCE 05/07/05090-FB DATUM Geodetic LOCATION 10+464.8 8.8 m Lt - Calvin Twp. ORIGINATED BY ELS

PROJECT Hwy 17 - GWP-175-98-00 / WP-5161-01-00 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DVL

CLIENT Earth Tech (Canada) DATE (Started/Completed) 4/11/05 - 4/11/05 TIME 1:20:00 PM CHECKED BY JRB

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
256.0	Ground Surface						
0.0	100 mm Crushed Gravel 100 - 600 mm Gravelly Fine to Medium Sand with Cobbles SAND FILL Brown Fine Sand some Silt trace Gravel (Loose)	1	AS			255	9 76 (15)
254.5 1.5	SILT Tan Silt with ±5 mm Reddish Brown Silty Clay Varves at ±20 mm	2	SS	6			
		3	SS	6		254	
		4	SS	4		253	
		5	SS	10		252	
251.3 4.7	SAND Brown Fine to Medium Sand some Silt (Compact)	6	SS	15		251	
		7	SS	16		250	0 85 (15)
		8	SS	17		249	
246.6 9.4	End of Borehole					248	

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE: 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

COMMENTS

The stratification lines represent approximate boundaries. The transition may be gradual.

+³, ×³ : Numbers on right refer to Sensitivity
Numbers on left refer to values greater than 120 kPa

○ 3% STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (yy/mm/dd)/Time	Water Depth (m)	Cave In (m)
1)	-	-
2)	-	-
3)	-	-

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METRIC

RECORD OF BOREHOLE No. B3

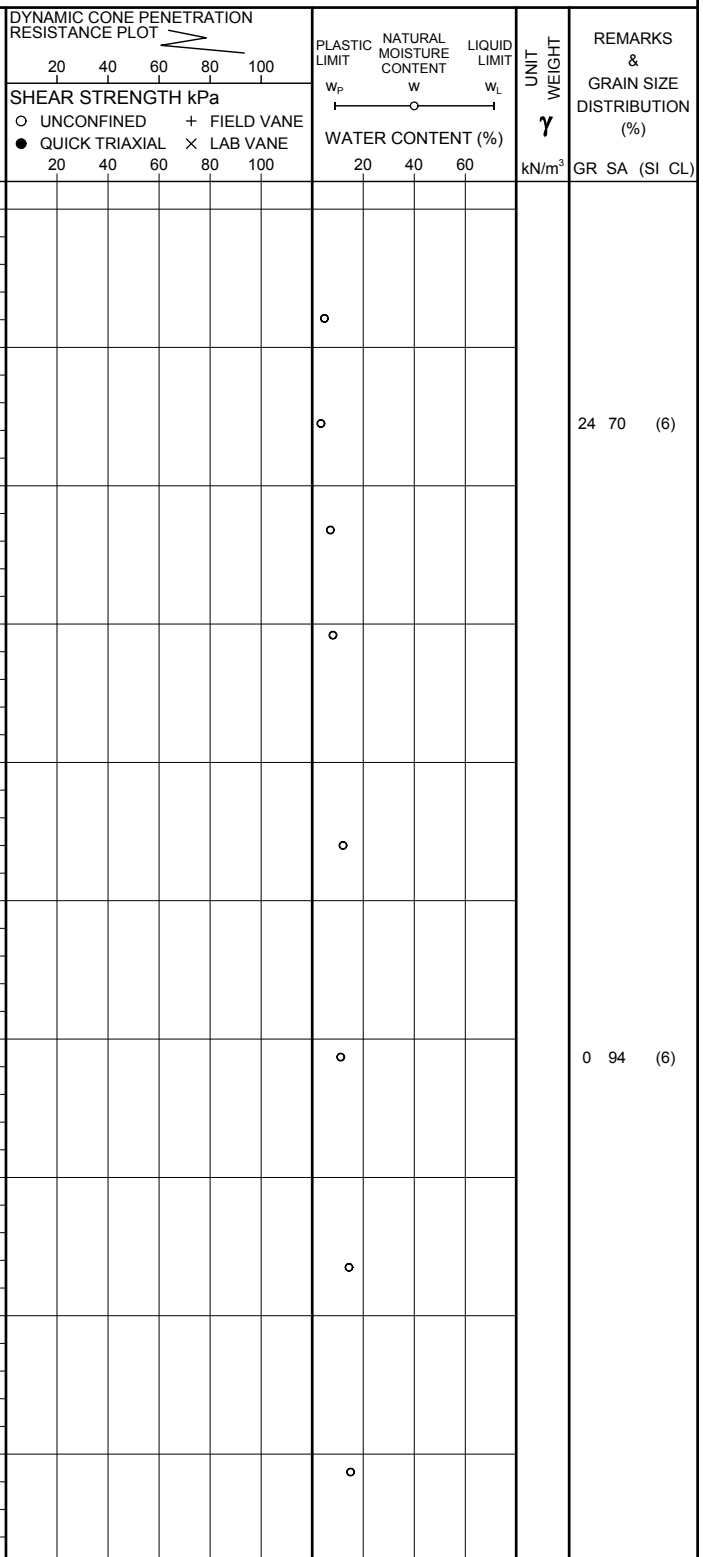
REFERENCE 05/07/05090-FB DATUM Geodetic LOCATION 10+467.9 4.9 m Rt - Calvin Twp. ORIGINATED BY ELS

PROJECT Hwy 17 - GWP-175-98-00 / WP-5161-01-00 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DVL

CLIENT Earth Tech (Canada) DATE (Started/Completed) 8/11/05 - 8/11/05 TIME 10:40:00 AM CHECKED BY JRB

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	(SI CL)
256.2	Ground Surface						
0.0	300 mm Crushed Gravel SAND FILL Brown Fine to Medium Sand trace Silt Occasional Cobbles at ±1.5 m (Compact)	1	AS				
		2	SS	33	24	70	(6)
		3	SS	39			
		4	SS	15			
		5	SS	17			
250.7 / 5.5	SAND Brown Fine to Medium Sand trace Silt Changing to Grey at 10.7 m. (Compact)	6	SS	11	0	94	(6)
		7	SS	12			
		8	SS	20			

Continued Next Page



REMARKS & GRAIN SIZE DISTRIBUTION (%)

COMMENTS

Temporary standpipe installed to 12.2 m. Standpipes removed on completion of the field drilling program.(Nov 16, 2005)

The stratification lines represent approximate boundaries. The transition may be gradual.

+³, ×³ : Numbers on right refer to Sensitivity
Numbers on left refer to values greater than 120 kPa

○ 3% STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (yy/mm/dd)/Time	Water Depth (m)	Cave In (m)
1) 8/11/05 1:55:00 PM	11.8	-
2) 16/11/05 2:00:00 PM	11.8	-
3)	-	-

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ENCLOSURE NO.: 5 (Pg. 2 of 2)

METRIC

RECORD OF BOREHOLE No. B3

REFERENCE 05/07/05090-FB DATUM Geodetic LOCATION 10+467.9 4.9 m Rt - Calvin Twp. ORIGINATED BY ELS

PROJECT Hwy 17 - GWP-175-98-00 / WP-5161-01-00 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DVL

CLIENT Earth Tech (Canada) DATE (Started/Completed) 8/11/05 - 8/11/05 TIME 10:40:00 AM CHECKED BY JRB

ELEV / DEPTH	DESCRIPTION (Continued from Previous Page)	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	NATURAL MOISTURE CONTENT (%)	GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
						246		
		9	SS	16			~29	0 91 (9)
						245		
					▼▽			
						244		
243.6		10	SS	21			~18	
12.6	End of Borehole							

Column headings: SOIL PROFILE; STRATA PLOT; SAMPLES; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%)

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ENCLOSURE NO.: 6 (Pg. 1 of 2)

METRIC

RECORD OF BOREHOLE No. B4

REFERENCE 05/07/05090-FB DATUM Geodetic LOCATION 10+472.4 4.9 m Rt - Calvin Twp. ORIGINATED BY ELS

PROJECT Hwy 17 - GWP-175-98-00 / WP-5161-01-00 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DVL

CLIENT Earth Tech (Canada) DATE (Started/Completed) 8/11/05 - 8/11/05 TIME 1:33:00 PM CHECKED BY JRB

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
256.2	Ground Surface						
0.0	300 mm Crushed Gravel SAND FILL Brown Fine to Medium Sand trace Silt trace Gravel Occasional Cobbles					256	
		1	AS				
	Trace Asphalt at ±2.6 m					255	
		2	SS	39			14 79 (7)
						254	
		3	SS	31			
253.1 3.1	SAND Fine Sand, Silt and Silty Clay Mix trace Organics Occasional Cobbles	4	SS	6		253	
						252	
		5	SS	4			
						251	
249.9 6.3	SAND Brown Fine to Medium Sand trace Silt. (Compact)	6	SS	20		250	0 21 53 26
						249	
		7	SS	19			
						248	
		8	SS	15		247	

Continued Next Page

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE: 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

COMMENTS

The stratification lines represent approximate boundaries. The transition may be gradual.

$+^3, \times^3$: Numbers on right refer to Sensitivity; Numbers on left refer to values greater than 120 kPa

○ 3% STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (yy/mm/dd)/Time	Water Depth (m)	Cave In (m)
1)	-	-
2)	-	-
3)	-	-

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ENCLOSURE NO.: 6 (Pg. 2 of 2)

METRIC

RECORD OF BOREHOLE No. B4

REFERENCE 05/07/05090-FB DATUM Geodetic LOCATION 10+472.4 4.9 m Rt - Calvin Twp. ORIGINATED BY ELS

PROJECT Hwy 17 - GWP-175-98-00 / WP-5161-01-00 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DVL

CLIENT Earth Tech (Canada) DATE (Started/Completed) 8/11/05 - 8/11/05 TIME 1:33:00 PM CHECKED BY JRB

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRATA PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
	Continued from Previous Page										
							246				
			9	SS	13						
							245				
							244				
			10	SS	20						
243.6 / 12.6	End of Borehole										

MEL-GEO 05090-FB.GPJ MEL-GEO.GDT 5/5/06

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ENCLOSURE NO.: 7 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE No. B5

REFERENCE 05/07/05090-FB DATUM Geodetic LOCATION 10+463 16.5 m Lt - Calvin Twp. ORIGINATED BY ELS

PROJECT Hwy 17 - GWP-175-98-00 / WP-5161-01-00 BOREHOLE TYPE Standard Augers COMPILED BY DVL

CLIENT Earth Tech (Canada) DATE (Started/Completed) 1/11/05 - 1/11/05 TIME CHECKED BY JRB

ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
253.3	Ground Surface										
0.0	SAND Brown Fine to Medium Sand with Gravel and Silt						253 252				
251.6 1.7	End of Borehole										

COMMENTS

The stratification lines represent approximate boundaries. The transition may be gradual.

+ 3, × 3 : Numbers on right refer to Sensitivity
Numbers on left refer to values greater than 120 kPa

○ 3% STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (yy/mm/dd)/Time	Water Depth (m)	Cave In (m)
1)	-	-
2)	-	-
3)	-	-

MEL-GEO 05090-FB.GPJ MEL-GEO.GDT 5/5/06

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ENCLOSURE NO.: 8 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE No. B6

REFERENCE 05/07/05090-FB DATUM Geodetic LOCATION 10+474 28.0 m Rt - Calvin Twp. ORIGINATED BY ELS

PROJECT Hwy 17 - GWP-175-98-00 / WP-5161-01-00 BOREHOLE TYPE Standard Augers COMPILED BY DVL

CLIENT Earth Tech (Canada) DATE (Started/Completed) 1/11/05 - 1/11/05 TIME CHECKED BY JRB

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE			kN/m³	GR SA (SI CL)
245.8	Ground Surface										
0.0	SAND Medium Sand with Gravel and Silt										
245.2											
0.6	Auger Refusal on Boulders End of Borehole						245				

COMMENTS

The stratification lines represent approximate boundaries. The transition may be gradual.

+ 3, × 3 : Numbers on right refer to Sensitivity
Numbers on left refer to values greater than 120 kPa

○ 3% STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (yy/mm/dd)/Time	Water Depth (m)	Cave In (m)
1)	-	-
2)	-	-
3)	-	-

MEL-GEO 05090-FB.GPJ MEL-GEO.GDT 5/5/06

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APPENDIX C

Figure 1: Plan and Profile
Figures L-1 to L-3: Summary Grain Size Analysis Graph
Figure L-4: Plasticity Chart

GWP No - 175-98-00

WP No 5161-01-00

N

HWY 17 Calvin Twp.
Foundation Area B
10+460 to 10+500
BOREHOLE LOCATIONS & SOIL STRATA

Figure 1

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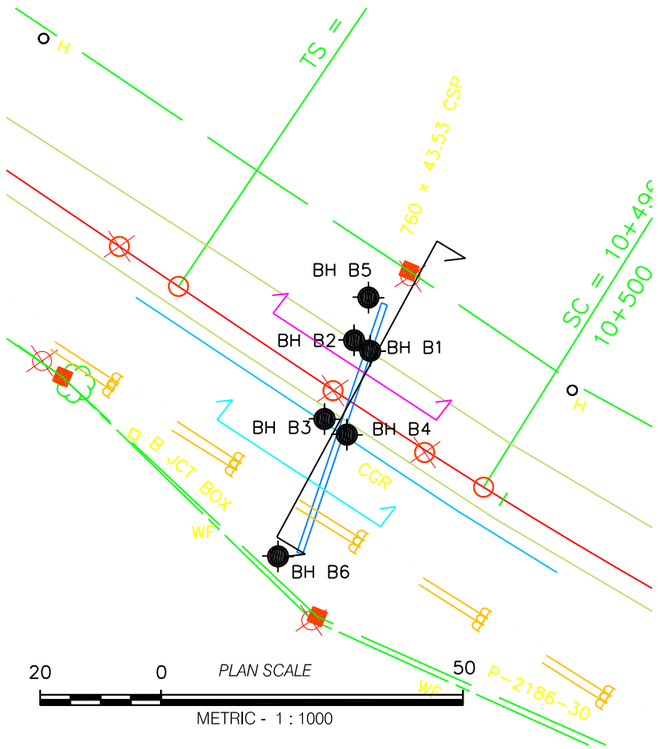
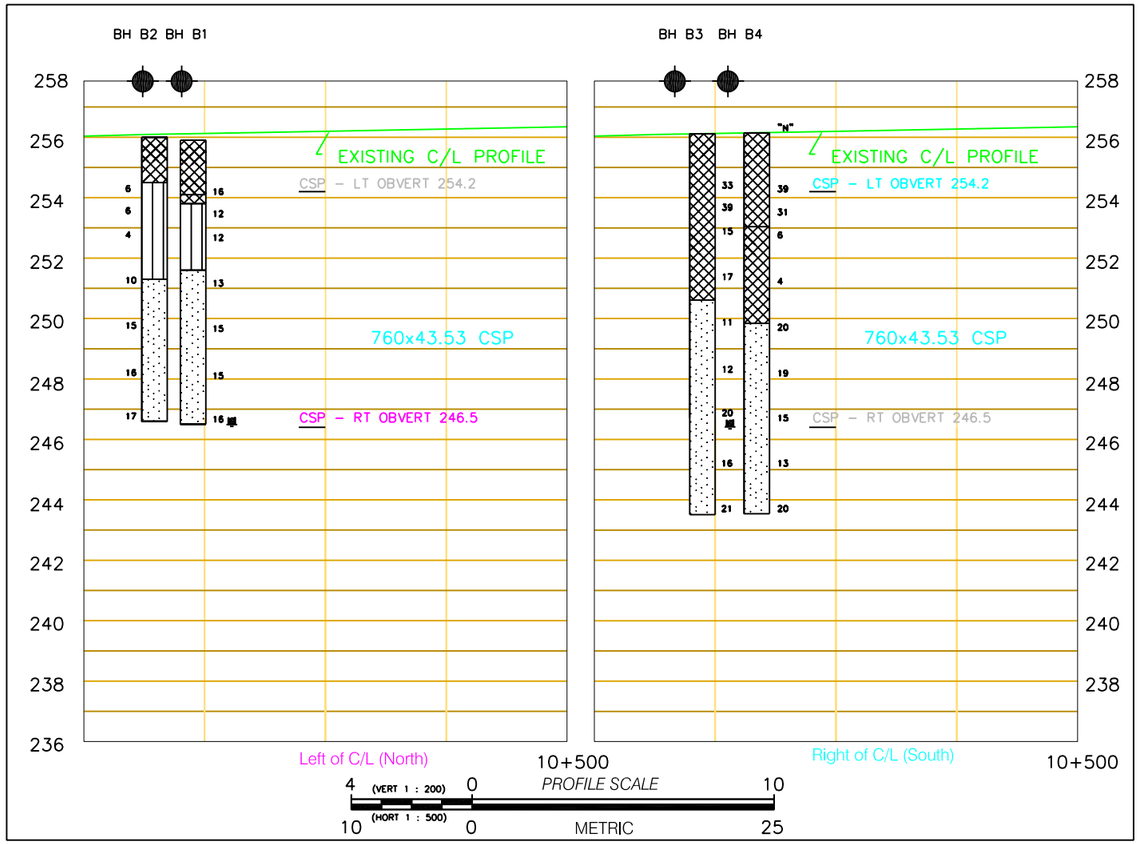
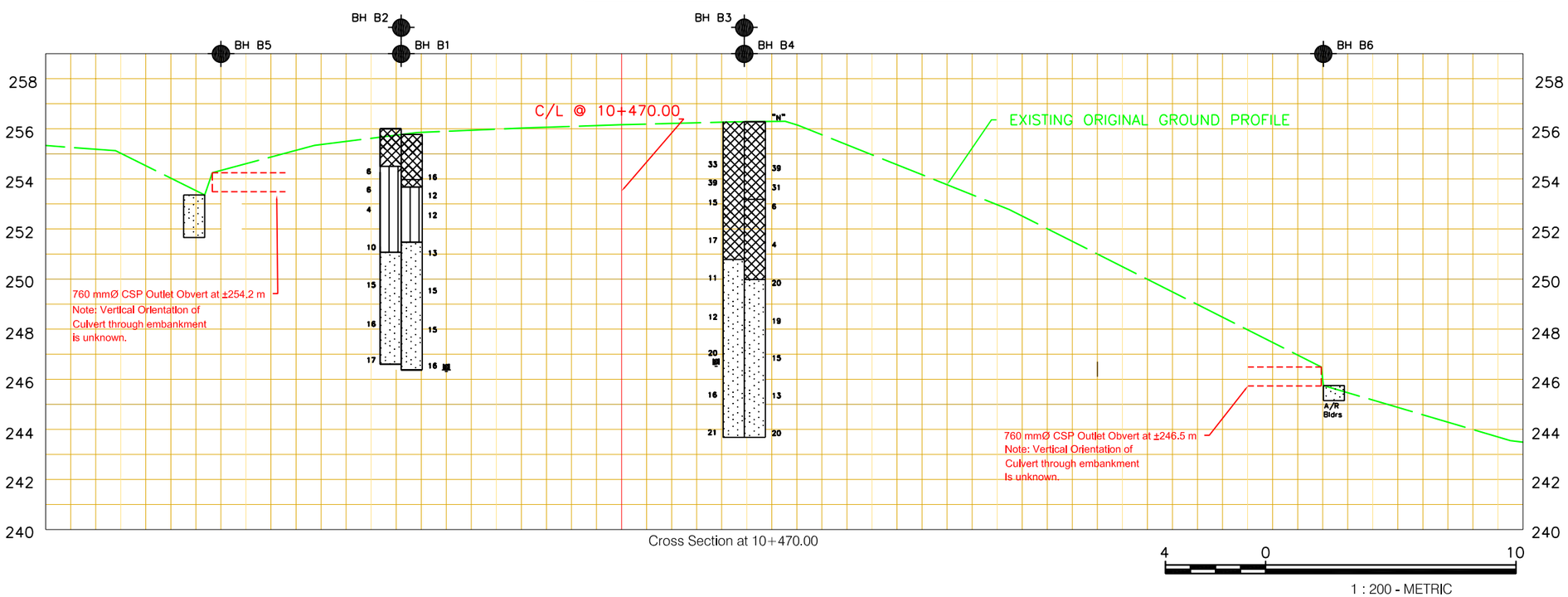
Consulting Geotechnical Engineers







Cross Section at 10+470.00

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

Borehole No.	Stations		Elevation
	Station	Offset	
Borehole No.B1	10+468.8	8.8m Lt	255.9
Borehole No.B2	10+464.8	8.8m Lt	256.0
Borehole No.B3	10+467.9	4.9m Rt	256.2
Borehole No.B4	10+472.4	4.9m Rt	256.2
Borehole No.B5	10+463	16.5m Lt	253.3
Borehole No.B6	10+474	28.0m Rt	245.8

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.

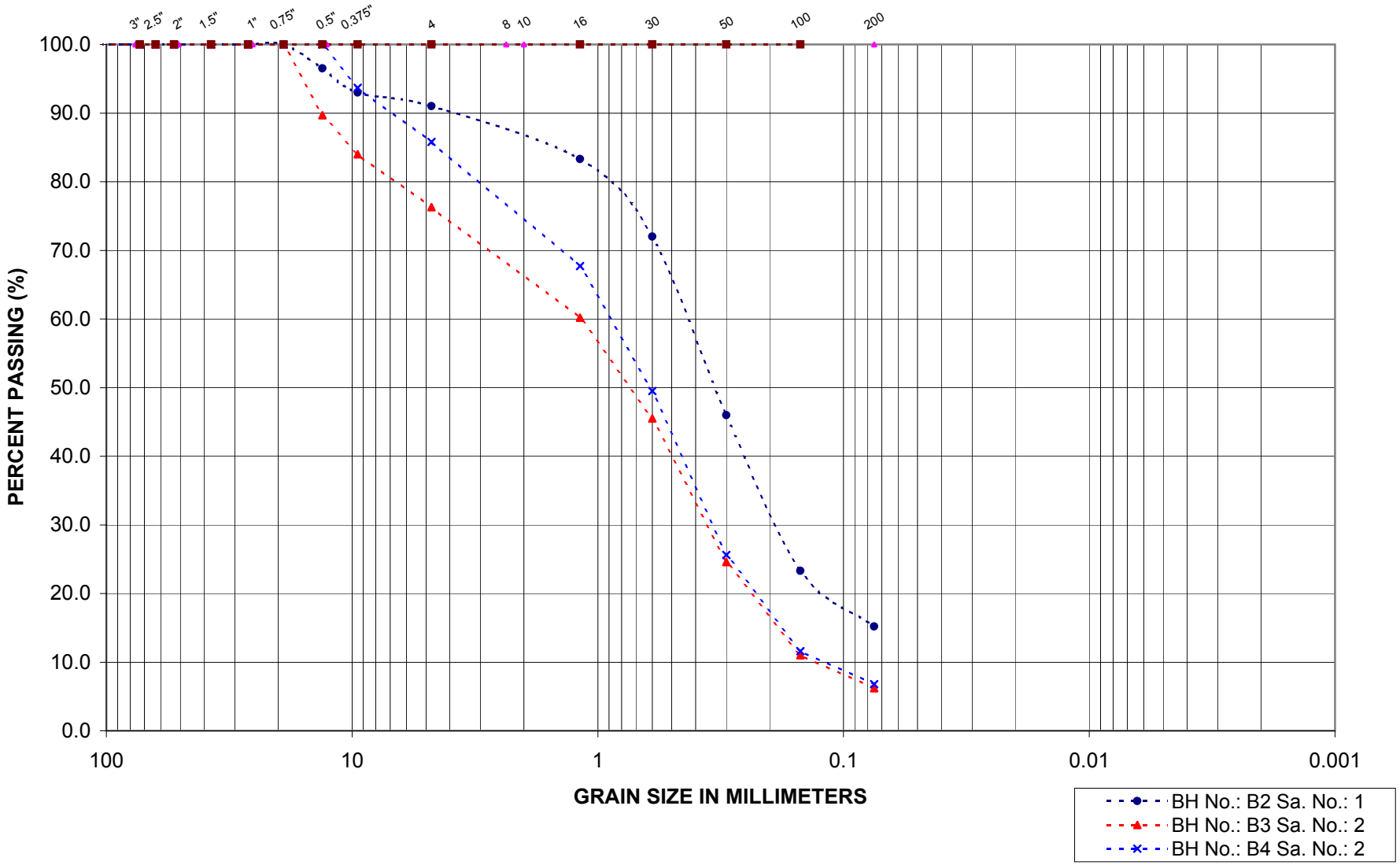
REVISIONS

DATE	BY	DESCRIPTION
16/12/05	DVL	REV 0 – Borehole Stations & Plots
04/01/06	DVL	REV 1– Cross Sections
22/02/06	DVL	REV 2– MTO Comments and Revisions

HWY No. 17 10+460 to 10+500			DIST
DWG File: 05090–FB – Plan and Profile – MEL			SITE
DRAWN DVL	CHK JRB	DATE 05/01/06	FIG B2

Reference No.: 05/07/05090-FB
Date: January 5, 2006

GRAIN SIZE ANALYSIS



GWP 175-98-00 WP 5161-01-00
Foundation Area B
Highway 17, Township of Calvin
Culvert at Station 10+470

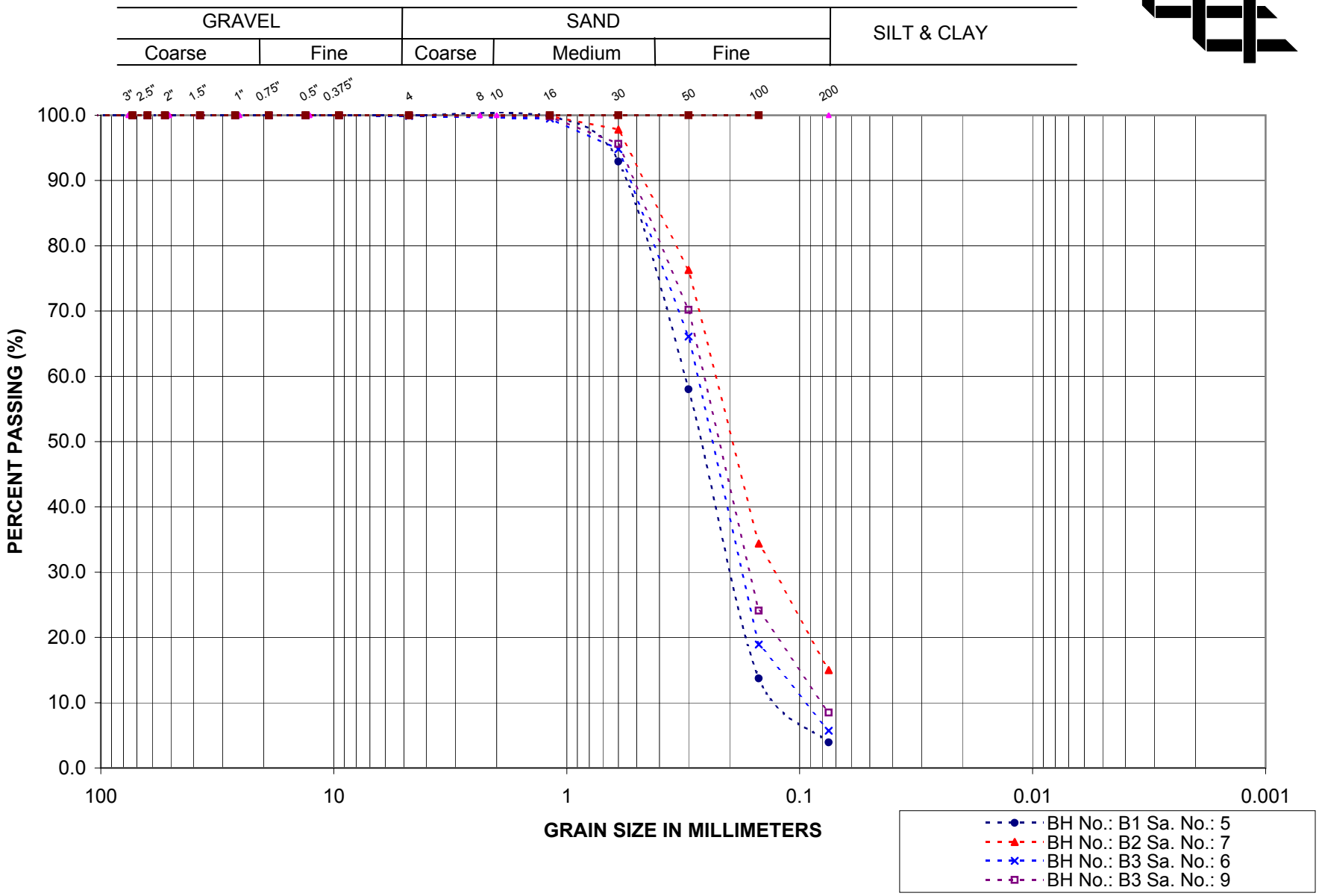
FILL

MERLEX ENGINEERING LTD.

FIGURE L-1

Reference No.: 05/07/05090-FB
Date: January 5, 2006

GRAIN SIZE ANALYSIS



GWP 175-98-00 WP 5161-01-00
Foundation Area B
Highway 17, Township of Calvin
Culvert at Station 10+470

SAND

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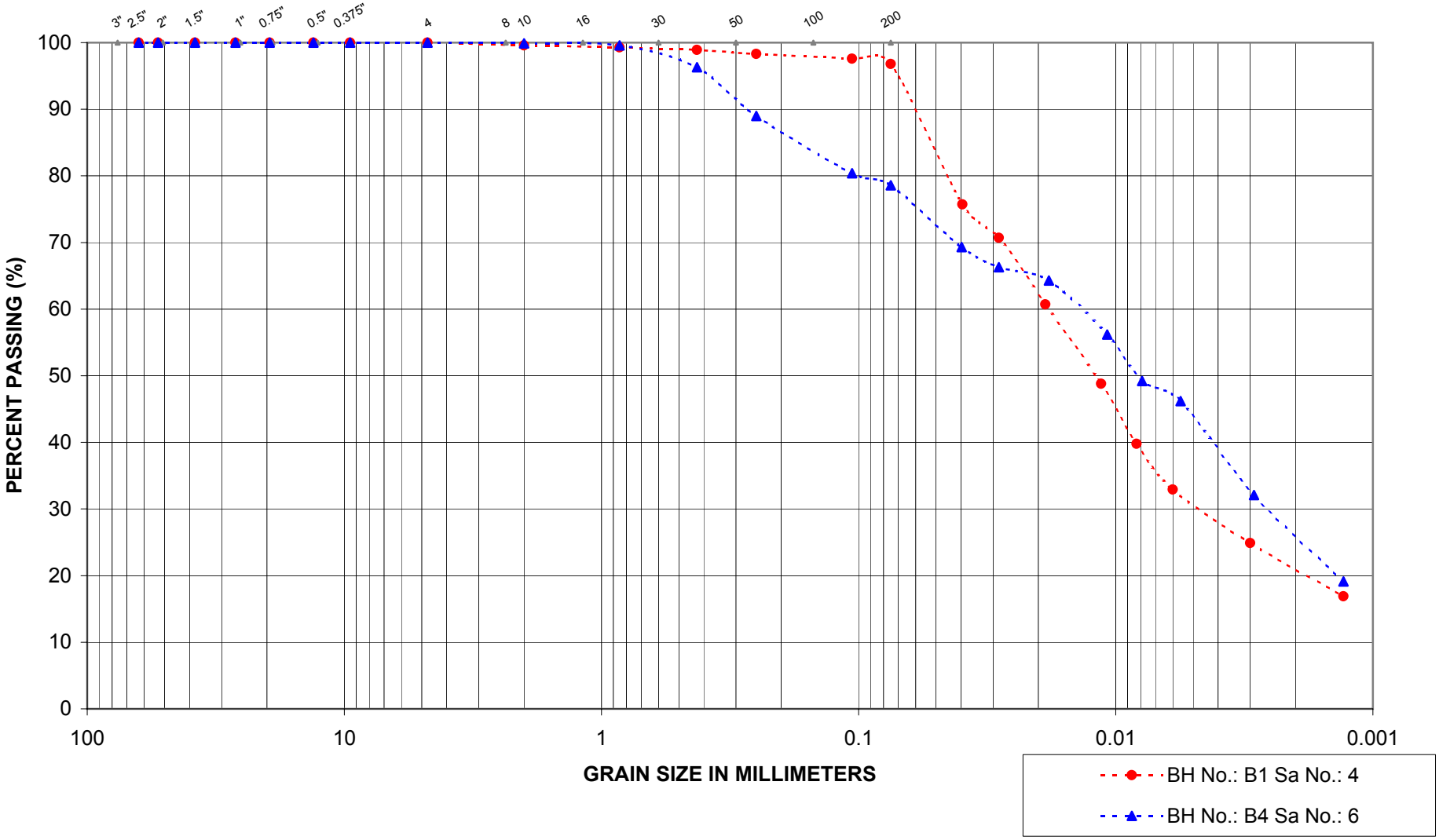
FIGURE L-2

Reference No.: 05/07/05090-FB
Date: January 5, 2006

GRAIN SIZE ANALYSIS



GWP 175-98-00 WP 5161-01-00
Foundation Area B
Highway 17, Township of Calvin
Culvert at Station 10+470

SILT

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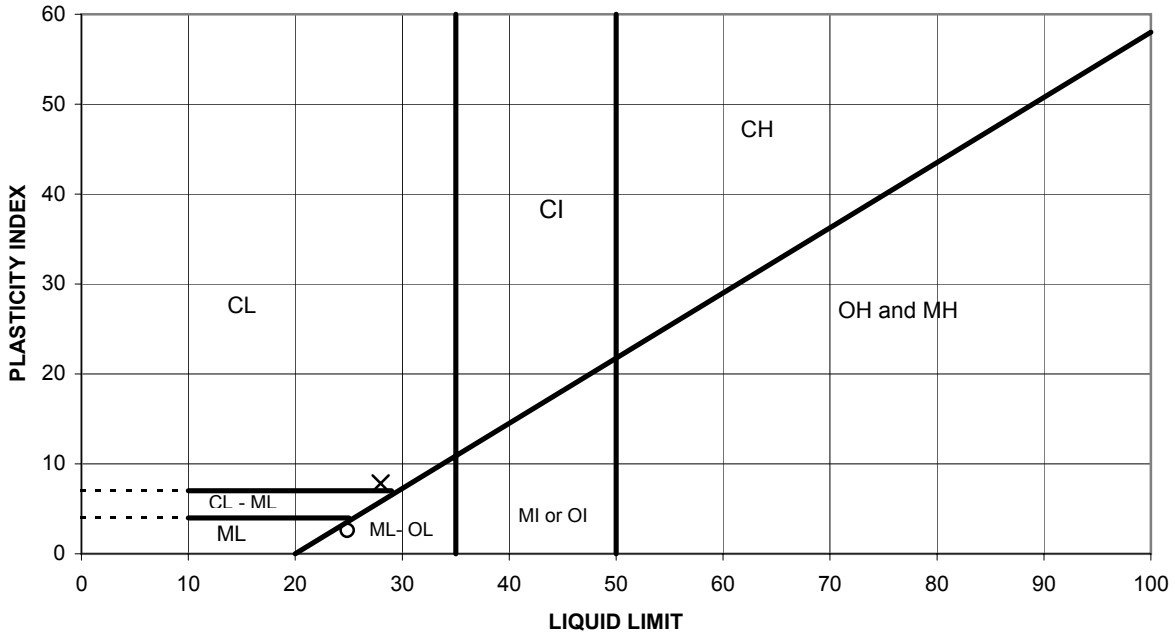
FIGURE L-3

ATTERBERG LIMITS TEST RESULTS

FIGURE L-4

ATTERBERG INDICES



SYMBOL	BH	Sa. No.	Depth(m)	Elev.(m)	Liquid Limit	Plasticity Index
o	B1	4	3.36	252.5	24.87	2.6
x	B4	6	6.56	249.6	27.97	7.84

Date: 22-Feb-06
Project: GWP 175-98-00 WP 5161-01-00
Foundation Area B
Hwy 17, Township of Calvin, Culvert Station 10+470

Prep'd: DVL
Chkd: JRB

MERLEX ENGINEERING LTD.

APPENDIX D

Enclosure No. 9: Photo Essay

Photo: 1

Township of Calvin, Foundation Area B, Station 10+400.
Looking easterly at left slope.

Taken By: E. Sullivan
MEL Ref. No.: 05/07/05090-FB
Date: 01/11/2005

Photo: 2

Township of Calvin, Foundation Area B, Station 10+450.
Looking easterly at right slope.

Taken By: E. Sullivan
MEL Ref. No.: 05/07/05090-FB
Date: 01/11/2005