MERLEX ENGINEERING LTD.

CONSULTING GEOTECHNICAL ENGINEERS

FINAL
FOUNDATION INVESTIGATION AND DESIGN REPORT

GWP 175-98-00 WP 5161-01-00
FOUNDATION AREA A
Highway 17, Township of Bonfield
Culvert at Station 25+025

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

Submitted to:

Earth Tech (Canada) Inc.
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MTO Geocres No. 31L-98

TABLE OF CONTENTS

APPENDICES

APPENDIX A

Enclosure No. 1	List of Abbreviations and Symbols
Enclosure No. 2	Key Plan

APPENDIX B

Enclosure Nos. 3 to 8	Record of Borehole Sheets (Borehole Nos. A1, A2, A3, A4, A5, and A6)

APPENDIX C

Figure No. 1	Plan and Profile
Figure L-1 to L-4	Summary Grain Size Analysis Graph
Figure L-5	Plasticity Chart

APPENDIX D

Enclosure No. 9	Photo Essay

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 fill embankment along the existing highway in order to provide detail design recommendations for replacement. This report addresses Foundation Area A, a centerline culvert located on Highway 17, ± 8.9 km east of the junction of Highway 17 and Highway 531, in the Township of Bonfield at Station ±25+025 (see Enclosure No. 2: Key Plan). MEL investigated the foundation area by the drilling of boreholes, carrying out in-situ tests, carrying out Dynamic Cone Penetration Tests (DCPT), 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 A 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 25+025, Twp. of Bonfield, east of the City of North Bay. . At the time of this investigation, the culvert at this site consisted of a 910 mm diameter x 35.6 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 in the investigation area by several meters. The land to the north and south of the highway is lowland swamp with little or no trees. At the edges of the swamp area, the vegetation consists of predominantly mature deciduous and coniferous species.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out during the period of November 2 and 3, 2005, and December 12, 2005, and consisted of a total of six (6) sampled boreholes.

The field investigation was carried out using a Bombardier mounted CME 45B drilling rig, operated by MEL and supervised by Mr. E. Sullivan, of MEL. The drilling rig was equipped with hollow stem augers and all routine geotechnical sampling equipment. The boreholes were advanced using 165 mm O.D. continuous flight hollow stem augers or 110 mm O.D. continuous flight standard augers. 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 or auger sample directly off the auger flights. At Borehole No. A6, a Dynamic Cone Penetration Test (DCPT) was advanced from the bottom of the borehole to refusal depth to establish the general relative density characteristics of the overburden at this location. In-situ 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 and if required, a temporary standpipe was installed for the duration of the drilling operation. A set of water level observations were taken prior to removal of any temporary standpipes. All open boreholes were backfilled upon completion with the auger cuttings in the order they were removed, using reverse augering techniques. 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 A: Culvert at 25+025, Bonfield 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. A1 to A6). Borehole Nos. A1 and A2, and Borehole Nos. A3 and A4, were put down through the highway embankment on the south and north sides

respectively. Borehole Nos. A5 and A6 were put down at the ends of the existing culvert on the south and north ends respectively.

At the surface of Borehole Nos. A1 to A4 inclusive, a layer of crushed gravel some 300 to 400 mm thick was penetrated. Underlying this surficial deposit at these borings, and at the surface of Borehole No. A6, a sand fill containing trace/some silt, some gravel, and occasional cobbles and boulders was encountered. Standard Penetration "N" values recorded in conjunction with the split spoon sampling within this stratum returned values of 4 to 65 blows/0.3 m indicating a compactness of loose to very dense. It should be noted however that the higher "N' values were likely a result of 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 5 to 18%. Gradation analyses was carried out on three samples of this deposit which indicated 2 to 20% gravel size particles, 71 to 92% sand size particles, and 6 to 13% 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 ranging from 3.7 m (Borehole No. A1, elevation 229.3 m) to 6.4 m (Borehole No. A2, elevation 226.6 m). At Borehole No. A6, at a depth of some 800 mm, a stratum of peat some 700 mm thick was encountered, sandwiched in the sand fill which extended to a depth of 2.9 m (elevation ±226.3 m).

Underlying the sand fill at Borehole Nos. A1 to A4 inclusive, at depths of ±3.7, 6.4, 6.2 and 4.6 m respectively (elevations 229.3, 226.6, 226.8, and 228.4 m), a deposit of silty fine sand was penetrated. This deposit was classified as fill at Borehole Nos. A1, A3, and A4. Standard Penetration "N" values recorded in conjunction with the split spoon sampling within this stratum returned values of 5 to 20 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 10

to 25%. Gradation analyses was carried out on two samples of this deposit which indicated 0% gravel size particles, 67 to 68% sand size particles, and 32 to 33% silt and clay size particles. The specific distribution curve can be found on the Summary of Laboratory Testing sheets (Appendix C, Figure No. L-2).

At the surface of Borehole No. A5, a deposit of dark brown peat trace fine fibres was encountered that extended to a depth of some 2.3 m (elevation ±227.9 m). The sampler was advanced under its own weight in this deposit. Natural moisture content determinations carried out on samples from this stratum indicated values of 141 to 258%. An in-situ vane shear test in this deposit returned a value of 38 kPa. The peat was underlain by approximately 500 mm of fine sand some silt.

Underlying the silty sand stratum at Borehole Nos. A1 and A2, and the fine sand at Borehole No. A5, at depths of ±5.3, 7.8, and 2.8 m respectively (elevations 227.7, 225.2, and 227.4 m), a stratum of silt and clay was encountered. At Borehole No. A1, the silt and clay deposit was classified as fill. Natural moisture content determinations carried out on samples from this stratum indicated values of 20 to 42 %. The results of a sieve and hydrometer analysis carried out on two samples obtained from this stratum indicated 0% gravel size particles, 5 to 15% sand size particles, 42 to 62% silt sized particles, and 33 to 43% clay sized particles. The specific distribution curve can be found on the Summary of Laboratory Testing sheets (Appendix C, Figure No. L-3). Atterberg Limits determinations carried out on two samples from this stratum indicate a CI (Inorganic Silty Clay of Medium Plasticity) to a CL (Inorganic Silty Clay of Low Plasticity) designation with Plastic Limits of 18.7 to 20.3% and Liquid Limits of 33.7 to 39.6% (see Appendix C, Figure No. L-5). This deposit extended to depths of 7.6, 8.8, and 4.8 m (elevations 225.4, 224.2, and 225.4 m) at Borehole Nos. A1, A2 and A5 respectively.

A thin stratum (±300 mm) of silty fine sand was encountered underlying the silt and clay at Borehole No. A1.

Underlying the silty sand fill at Borehole Nos. A1, A3, and A4, at depths of ±7.9, 7.5, and 7.9 m respectively (elevations 225.1, 225.5, and 225.1), and the sand fill at Borehole No. A6 at a depth of 2.9 m (elevation 226.3 m), a deposit of peat was penetrated. The peat was dark brown and fine to medium fibrous in texture. Natural moisture content determinations carried out on samples from this stratum indicated values of 70 to 495%. In-situ vane shear tests were carried out in this layer at each of Borehole Nos. A1, A3, A4, and A6 returning values of 50, 160, 136, and 41 kPa respectively.

At Borehole Nos. A4 and A6, immediately underlying the peat, a thin stratum (i.e. ±200 mm) of organic silt and clay was observed.

Underlying the silt and clay at Borehole Nos. A2 and A5, and underlying the peat at Borehole Nos. A1, A3, A4, and A6, a deposit of fine to medium sand with varying silt content was penetrated. Natural moisture content determinations carried out on samples from this stratum indicated values of 18 to 23%. The results of a sieve analysis carried out on one sample obtained from this stratum indicated 16% gravel size particles, 61% sand size particles, and 23% silt and clay sized particles. The specific distribution curve can be found on the Summary of Laboratory Testing sheets (Appendix C, Figure No. L-4).

Auger refusal was encountered in Borehole Nos. A1 and A5 at depths of 9.7 and 5.8 m respectively (elevations 223.3 and 224.4 m). Borehole Nos. A2, A3, and A4 were terminated in the sand deposit at a depth of 9.6 m below existing grade (elevations 223.4, 223.4, and 223.4 m respectively). Sampling was terminated in the sand deposit at Borehole No. A6 at a depth of

6.7 m (elevation 222.5 m) from which point a DCPT was driven. Refusal on the DCPT was encountered at a depth of 8.8 m (elevation 220.4 m).

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. A1 and A3. Groundwater levels and cave-in depths are summarized on the individual Record of Borehole Log Sheets (Appendix B).

Approximately ±14 days post completion of the drilling operations, the groundwater level was measured in the temporary standpipes at elevations ranging between ±228.8 to 228.9 m (i.e. ±4.1 to 4.2 m below the existing embankment). The groundwater level was measured in Borehole Nos. A4, A5 and A6, generally upon completion, at elevations 228.8, 228.7, and 228.0 m respectively.

Groundwater levels will fluctuate seasonally. In general, the groundwater levels are higher in the spring, during the spring melt and runoff, and also during the fall rainy season.

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5.0 DESIGN COMMENTS AND RECOMMENDATIONS

5.1 General

A foundation investigation was originally identified in the RFP for culvert replacement and for detour construction at the culvert located at Station 25+025, Township of Bonfield, ± 8.9 km east of the junction of Highway 17 and Highway 531. This culvert location was labeled as Foundation Area A.

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 ±3 m higher than the land to the south of the embankment and ±4 m higher than the land to the north of the culvert. Based on the embankment cross section through the culvert alignment, provided by Earth Tech Canada Inc., the north side of the embankment is presently at a slope of 2.5H:1V. The south side of the embankment has a slope of 1.3H:1V. Up and down chainage from the culvert location, the embankment side slopes are shallower at 3H:1V or flatter. Borehole Nos. A1 to A4 inclusive were put down through the existing embankment. Borehole Nos. A5 and A6 were put down to the south and north of the embankment respectively, near the ends of the culvert. Based on our

soils exploration program in the vicinity of this culvert, the embankment consists of granular fill overlying silty sand fill and/or silt and clay fill. Fill deposits were encountered to depths of 6.4 to 7.9 m (elevations 226.6 to 225.1 m). The invert of the culvert openings to the north and south of the embankment are at approximately elevations 228.3 m and 228.0 m, respectively. As such, it appears that the existing culvert is bedded in the granular or silty sand embankment fill.

The existing culvert section is a corrugated steel pipe 910 mm in diameter by 35.6 m long. No significant structural problems, other than aging, have been reported at this culvert system. The new culvert will be a 1000 mm diameter concrete pipe, generally similar in length to the existing. The culvert is located in an area where the embankment width is some ± 19 m. It is proposed to use the wider alignment at this location to allow continued flow of traffic during the replacement operations. The culvert replacement will be carried out as continuous operation and controlled by traffic control personnel. At times, traffic flow may be reduced to one lane. It is anticipated that open excavations will be completed in one day. As such, no embankment construction for a detour will be required. The widened alignment in this area will allow the slopes of open excavations to be cut back to the geometry required by the OHSA. As such, a protection system (i.e. shoring, etc.) should not be required. Although not anticipated, local sliver widening may be required to maintain a minimum lane width during culvert replacement. A typical detail will be provided in the contract. The vertical alignment 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.

5.3 Culvert Design Comments

This culvert can be replaced using trench reinstatement and standard bedding. As noted, it appears that the existing culvert is bedded in the granular or silty sand embankment fill. Based on the OHSA Construction Regulations, this soil is classified as Type 3. Temporary open excavations in this type of soil will be stable at an angle of 1H:1V with adequate groundwater control. All excavations must be sloped or shored in accordance with the OHSA.

The boreholes through the top of the embankment revealed the presence of a compressed peat deposit underlying the embankment fill at select locations. The peat deposit, at Borehole NOs. A1, A3, and A4, ranged in thickness from ±900 mm to 1.6 m. In–situ shear strengths measured in the peat ranged from 136 to 160 kPa. There appears to be approximately 2.0 to 3.2 m of fill between the invert of the culvert (i.e. elevation 228.3 m) and the top of the peat. To remove the organics, excavation would be of substantial depth and would require a roadway protection system. As noted previously, settlement of the embankment has not been reported at this site and visual observations do not indicate that settlement of the embankment is occurring. As such, excavation of the compressed peat deposit, from below the embankment at the culvert location, is not considered necessary since the new replacement culvert will not increase load on the compressed peat, therefore settlement associated with further compression of this peat deposit is not anticipated.

The purpose of this culvert is equalization between the swamps located to the north and south of the highway embankment. Flow rates through the culvert are low. The culvert will be embedded at a minimum depth below existing stream bottom of 10% of culvert diameter, to allow the natural build up of sedimentation along the culvert length. The collar of the culvert will be supplied with a rip-rap collar on the slope to prevent slope erosion. This rip-rap will extend

out in front of the culvert, at invert level. This rip-rap apron will be located at both inlet and outlet and will prevent development of scour paths through the bedding material. This is an equalizing culvert and considering the low flow velocities, scour should not develop, therefore a clay seal is not considered necessary. A Class II Geotextile with an F.O.S. of between 50 to 100 µm should be used below the rock protection layer as this material will be used elsewhere on the project.

At the time of this investigation, the groundwater level was measured, at the borehole locations, to be between elevations ± 228.8 and 228.9 m. The culvert replacement is to be carried out "in the dry". Ultimately, groundwater control during construction is the responsibility of the contractor and may vary depending upon their method of operation, scheduling, etc. It is anticipated that a cofferdam may be constructed around the ends of the culvert, to separate the culvert replacement operation from the swamps. It should then be possible to dewater and control any groundwater seepage through pumping from a number of strategically placed filtered sump holes, located in the base of the excavation outside the area of influence of the replacement operation. Dewatering should be carried out with reference to OPSS 517.

Bedding for rigid pipe culverts shall be Granular 'A'; cover material shall be Granular 'B' Type I. The cover and bedding thicknesses, shown in the OPSD 800 series will be sufficient.

Culvert backfill material may be either granular materials or native materials, depending on the site conditions. If native backfill is used, it must be replaced in the same order in which it was removed. If at the time of construction it is found that the native earth backfill material cannot be properly placed and compacted, granular backfill may be used. If the native material is not used, culvert backfill material should be Granular 'B' Type I.

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 embankment fill materials are generally sandy in nature. The upper portion of the embankment fill consisted of granular material, acceptable as OPSS Granular B Type I or SSM and, as such, have a low susceptibility to surficial erosion. No special erosion protection measures are required. Newly exposed earth cut slopes should be covered with top soil and seeded as soon as practical.

The reconstruction for 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.

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Principal

J. R. Berghamer, P. Eng.

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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.

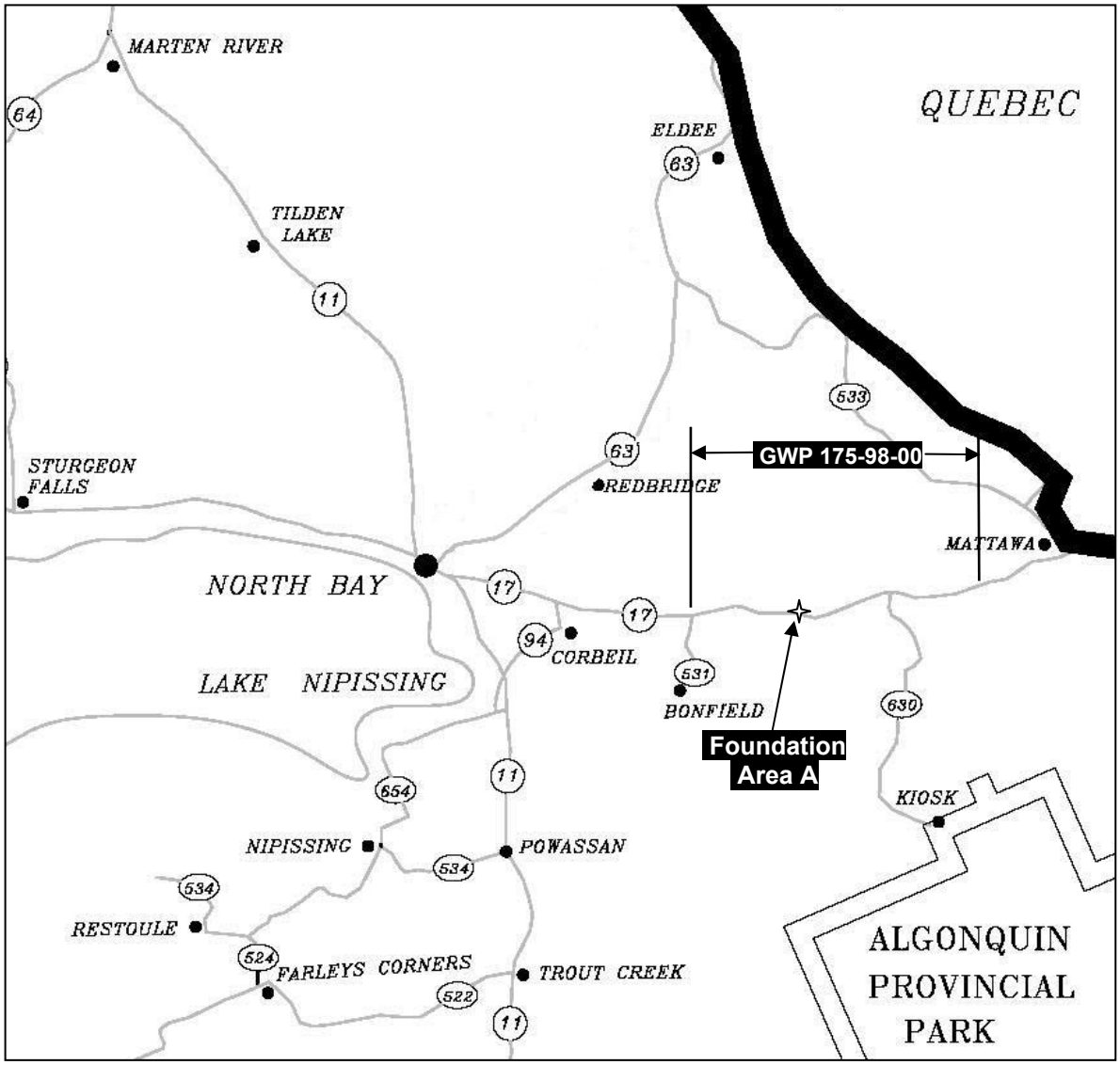
2. **TILL:** The term till indicates a material that is an unstratified, glacial deposit, heterogeneous in nature and, as such, may consist of mixtures and pockets of clay, silt, sand, gravel, cobbles and/or boulders. These heterogeneous deposits originate from a geological process associated with glaciation. 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 A
Highway 17, Township of Bonfield
Culvert at Station 25+025

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

MERLEX ENGINEERING LTD.
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. A1

REFERENCE 05/07/05090-FA DATUM Geodetic LOCATION 25+021.7 5.7 m Rt - Bonfield 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) 2/11/05 - 2/11/05 TIME 2:20:00 PM CHECKED BY JRB

ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "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)
233.0	Ground Surface										
0.0	300 mm Crushed Gravel SAND FILL Brown Fine to Medium Sand some Gravel trace Silt Occasional Cobbles/Boulders (Compact/Dense)		1	AS			232				20 71 (6)
			2	SS	32						
			3	SS	43		231				
			4	SS	65		230				
229.3											
3.7	SILTY SAND FILL Grey Silty Fine Sand (Compact/Loose)		5	AS		▼▽	229				
			6	SS	13		228				0 68 (32)
227.7											
5.3	SILT AND CLAY FILL Grey Silt and Clay Some Fine Sand		7	SS	4		227				0 15 42 43
							226				
225.4											
7.6	SILTY SAND FILL		8	SS	9		225				
225.1	Grey Silty Fine Sand										
7.9	PEAT Dark Brown Fine to Medium Fibrous Peat										
224.2							224				
8.8	SAND Grey Fine to Medium Sand trace Silt trace Wood (Compact)		9	SS	11						
223.3											
9.7	Auger Refusal End of Borehole										

COMMENTS

Temporary standpipe installed to 9.7 m. Standpipes removed on 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) 3/11/05 3:40:00 PM	4.2	-
2) 16/11/05 1:30:00 PM	4.2	-
3)	-	-

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

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

METRIC

RECORD OF BOREHOLE No. A2

REFERENCE 05/07/05090-FA DATUM Geodetic LOCATION 25+027 6.3 m Rt - Bonfield 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) 3/11/05 - 3/11/05 TIME 11:12:00 AM CHECKED BY JRB

ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	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 kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
233.0	Ground Surface										
0.0	300 mm Crushed Gravel SAND FILL Brown Fine to Medium Sand some Gravel trace Silt Occasional Cobbles/Boulders (Compact/Loose)		1	AS			232				
			2	SS	12		231				
			3	SS	4		230				
			4	SS	4		229				
			5	SS	6		228				
226.6			6	SS	5		227				
6.4	SAND Grey Silty Fine Sand						226				
225.2			7	SS	2		225				0 5 62 33
7.8	SILT AND CLAY Grey Silt and Clay										
224.2			8	SS	30		224				16 61 (23)
8.8	SAND Grey Fine to Medium Sand with Silt some Gravel Occasional Cobbles/Boulders										
223.4											
9.6	(Compact) 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-FA.GPJ MEL-GEO.GDT 5/5/06

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ENCLOSURE NO.: 5 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE No. A3

REFERENCE 05/07/05090-FA DATUM Geodetic LOCATION 25+027 5.6 m Lt - Bonfield 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) 3/11/05 - 3/11/05 TIME 1:40:00 PM CHECKED BY JRB

ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "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)
233.0	Ground Surface										
0.0	400 mm Crushed Gravel SAND FILL Brown Fine to Medium Sand some Gravel trace Silt Occasional Cobbles/Boulders (Loose/Compact)		1	AS			232				
			2	SS	6						
			3	SS	4		231				
			4	SS	17		230				
			5	SS	17	▼	229				
						▼	228				
226.8											
6.2	SILTY SAND FILL Grey Silty Fine Sand		6	SS	12		227				2 92 (6)
225.5							226				
7.5	PEAT Dark Brown Fine to Medium Fibrous Peat		7	SS	8		225	160 >>	1.3	396	
223.9							224				
9.1	SAND Grey Silty Fine Sand trace Gravel		8	SS	27						
223.4											
9.6	(Compact) End of Borehole										

COMMENTS

Temporary standpipe installed to 9.6 m. Standpipes removed on 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) 3/11/05 3:50:00 PM	5.1	-
2) 16/11/05 1:30:00 PM	4.1	-
3)	-	-

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

METRIC

RECORD OF BOREHOLE No. A4

REFERENCE 05/07/05090-FA DATUM Geodetic LOCATION 25+023 5.6 m Lt - Bonfield 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) 3/11/05 - 3/11/05 TIME 3:30:00 PM CHECKED BY JRB

ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	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 kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
233.0	Ground Surface										
0.0	400 mm Crushed Gravel										
	SAND FILL										
	Brown Fine to Medium Sand some Gravel trace Silt Occasional Cobbles/Boulders										
	(Loose/Compact)		1	AS			232				
			2	SS	6		231				13 74 (13)
			3	SS	11						
			4	SS	25		230				
228.4						▼	229				
4.6	SILTY SAND FILL		5	SS	20						0 67 (33)
	Grey Silty Fine Sand						228				
	Piece of Wood at ± 6.1 m		6	SS	8		227				
							226				
225.1	50mm Grey Silt and Clay		7	SS	3						
7.9	PEAT						225		136 >> 2	256	
	Dark Brown Fine to Medium Fibrous Peat										
							224				
223.6	200 mm Organic Silt and Clay		8	SS	25						
9.4											
223.4											
9.6	Grey Silty Fine Sand										
	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) 4/11/05 2:40:00 PM	4.2 ▼	- ▨
2)	- ▼	-
3)	- ▼	-

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

METRIC

RECORD OF BOREHOLE No. A5

REFERENCE 05/07/05090-FA DATUM Geodetic LOCATION 25+029 22.2 m Rt - Bonfield 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) 12/12/05 - 12/12/05 TIME 1:15:00 PM CHECKED BY JRB

ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS
230.2	Ground Surface					
0.0	PEAT Black Peat trace Fine Fibers		1	AS		
			2	AS	WH	
227.9						
2.3	SAND Grey Fine Sand some Silt		3	SS	WH	
227.4						
2.8	SILT AND CLAY Grey Silt and Clay		4	SS	WH	
225.4			5	SS	9	
4.8	SAND Grey Silty Fine Sand trace Gravel Occassional Cobbles/Boulders					
224.4						
5.8	Auger Refusal End of Borehole					

ELEVATION SCALE: 230, 229, 228, 227, 226, 225

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 (%) GR SA (SI CL)

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) 12/12/05 1:50:00 PM	2	3
2) 12/12/05 4:30:00 PM	1.5	3.96
3)	-	-

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

METRIC

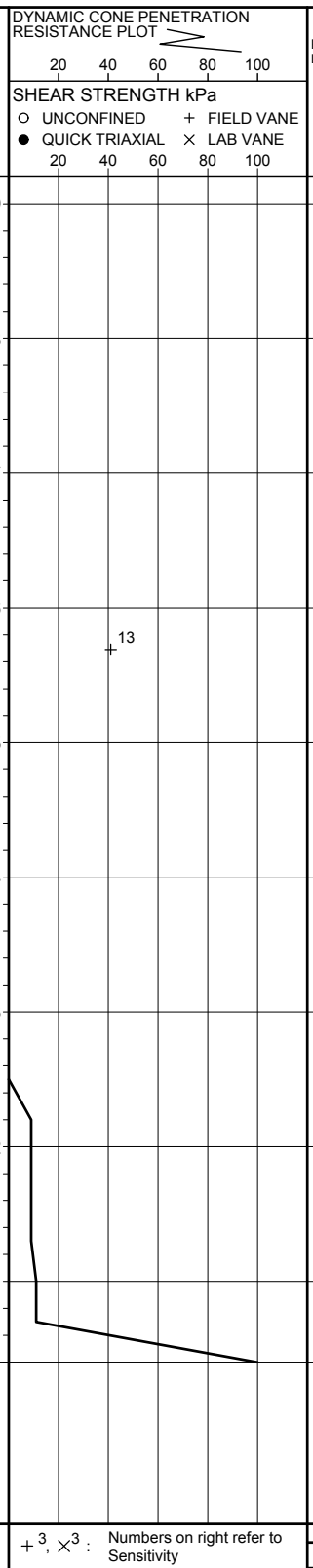
RECORD OF BOREHOLE No. A6

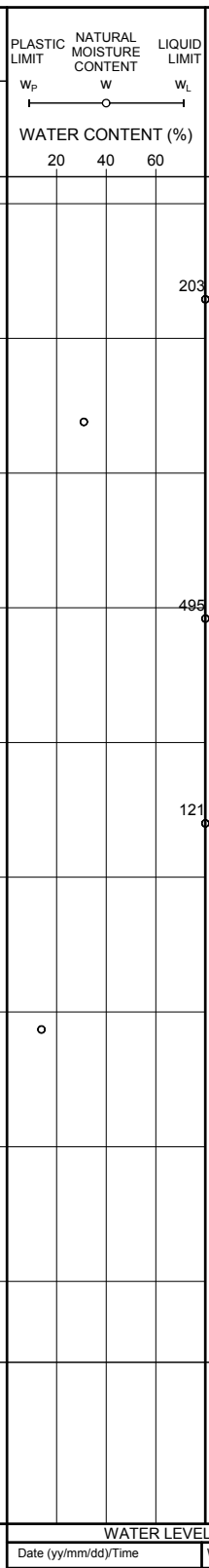
REFERENCE 05/07/05090-FA DATUM Geodetic LOCATION 25+031 23.2 m Lt - Bonfield Twp. ORIGINATED BY ELS

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

CLIENT Earth Tech (Canada) DATE (Started/Completed) 12/12/05 - 12/12/05 TIME 4:20:00 PM CHECKED BY JRB

ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS
229.2	Ground Surface					
0.0	SAND FILL Gravelly Sand trace Silt Occassional Cobbles/Boulders					
228.4						
0.8	PEAT Black Peat trace Fine Fibers		1	AS		▼
227.8						
1.4	SAND FILL Brown Fine to Medium Sand trace Silt trace Gravel trace Organics Occassional Cobbles/Boulders		2	SS	7	
			3	SS	15	
226.3						
2.9	PEAT Black Peat Fine to Medium Fibrous trace Wood		4	SS	2	▼
			5	SS	WH	
224.0	Organic Silt and Clay Seam					
5.2	SAND Grey Fine Sand with Silt trace Gravel Occassional Cobbles/Boulders		6	SS	7	
222.5						
6.7	End of Sampling Start DCPT Probably Sands					
220.4						
8.8	Refusal on DCPT End of Borehole					





UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)

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

$\circ^{3\%}$ STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (yy/mm/dd)/Time	Water Depth (m)	Cave In (m)
1) 12/12/05 4:35:00 PM	1.2 ▼	3 ▨
2)	- ▼	-
3)	- ▼	-

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

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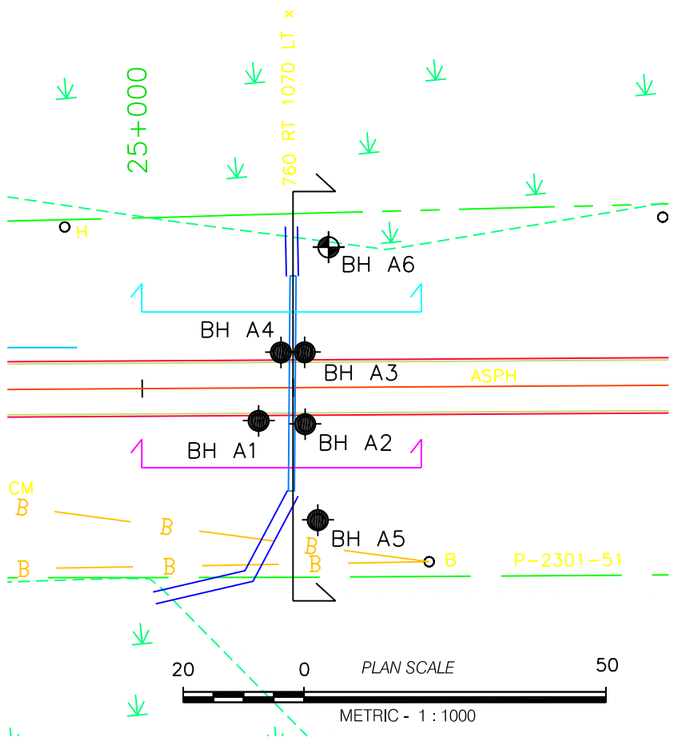
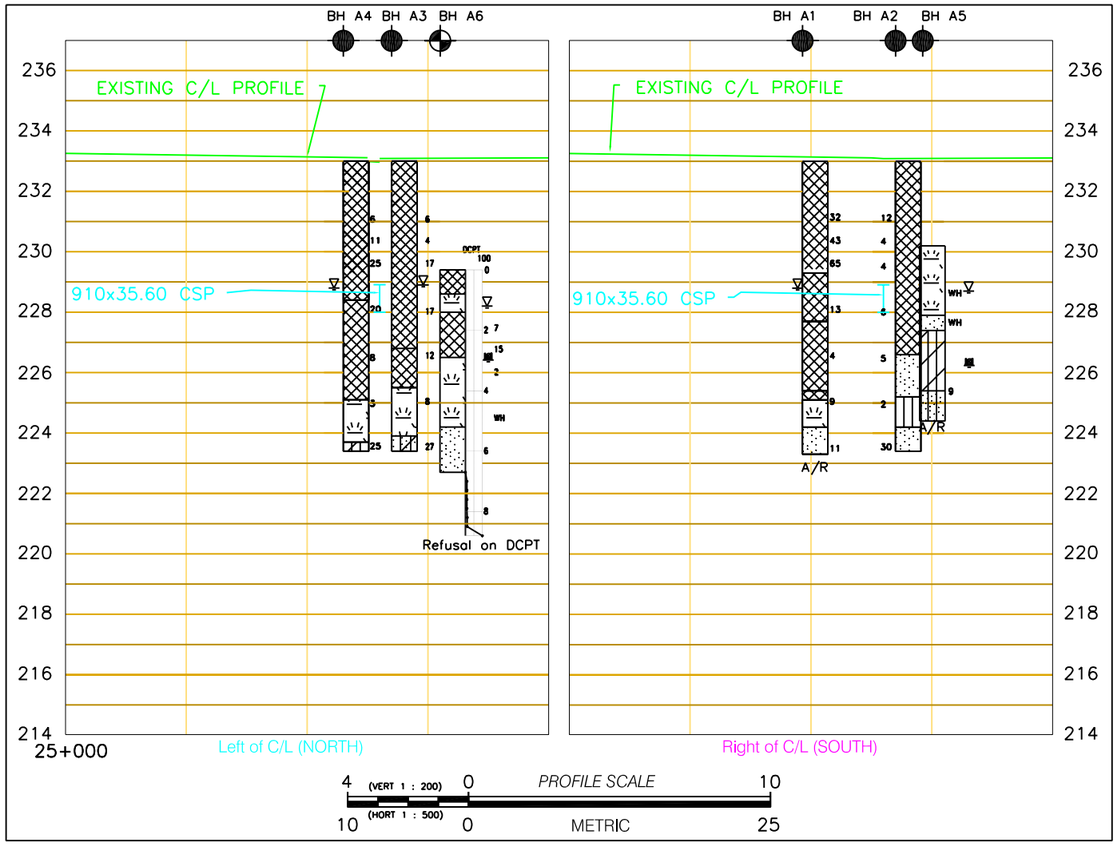
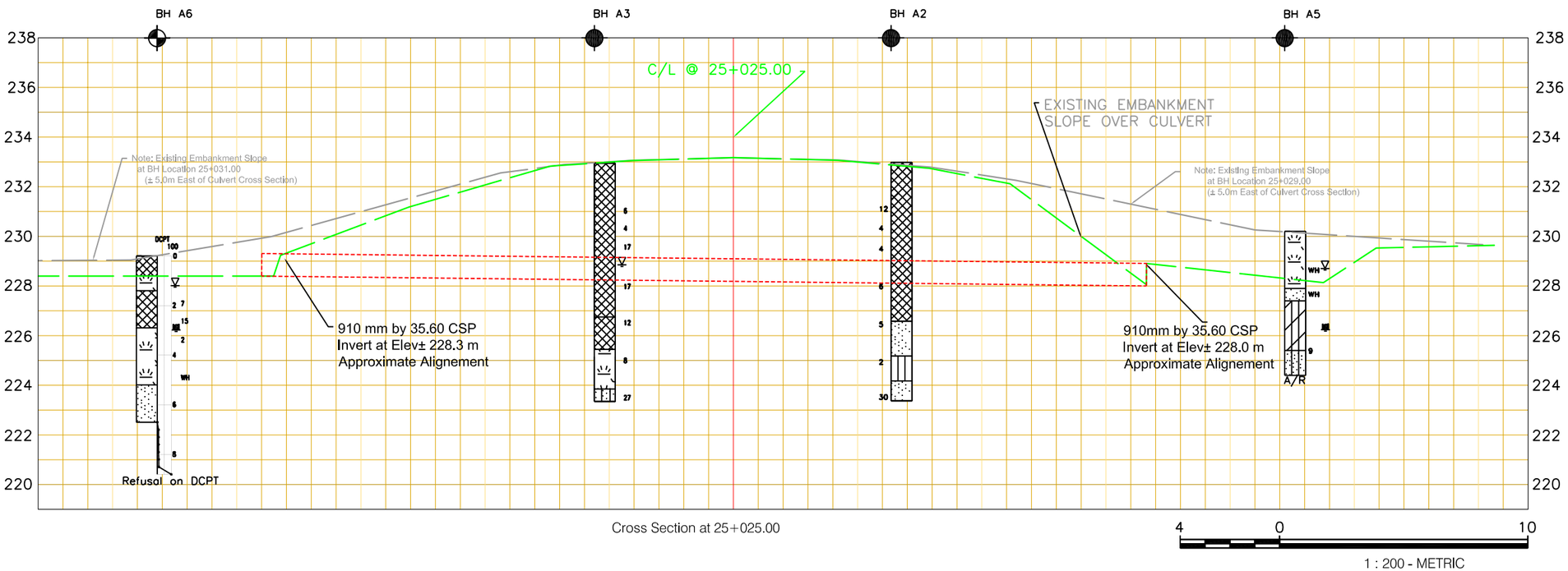
APPENDIX C

Figure 1: Plan and Profile
Figures L-1 to L-4: Summary Grain Size Analysis Graph
Figure L-5: Plasticity Chart







GWP No 175-98-00

WP No 5161-01-00

N

HWY 17 Bonfield Twp.
Foundation Area A
25+000 to 25+040
BOREHOLE LOCATIONS & SOIL STRATA

Figure 1

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Consulting Geotechnical Engineers

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.A1	25+021.7	5.7m Rt	233.0
Borehole No.A2	25+027	6.3m Rt	233.0
Borehole No.A3	25+027	5.6m Lt	233.0
Borehole No.A4	25+023	5.6m Lt	233.0
Borehole No.A5	25+029	22.2m Rt	230.2
Borehole No.A6	25+031	23.2m Lt	229.2

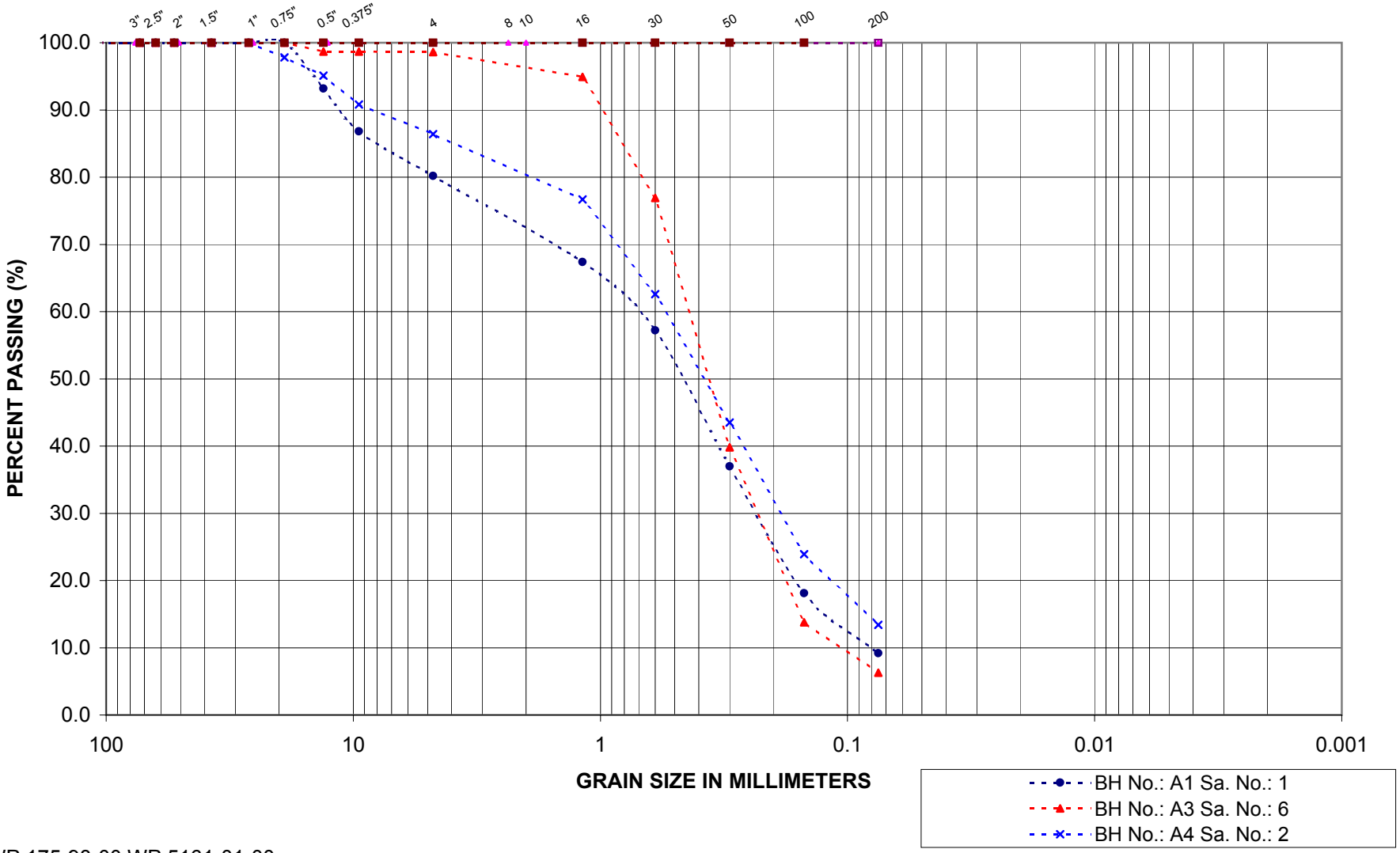
NOTE 1:
The boundaries between soil strata have been established at the borehole locations only. The boundaries between boreholes are assumed based on borehole data.

REVISIONS	DATE	BY	DESCRIPTION
	16/12/05	DVL	REV 0 – Borehole Stations & Plots
	04/01/06	DVL	REV 1– Cross Sections
	21/02/06	DVL	REV 2– MTO Comments and review

HWY No. 17 – 25+000 to 25+040			DIST
DWG File: 05090–FA – Plan and Profile – MEL			
DRAWN DVL	CHK JRB	DATE 05/01/06	FIG A2

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

GRAIN SIZE ANALYSIS



GWP 175-98-00 WP 5161-01-00
Foundation Area A
Highway 17, Township of Bonfield
Culvert at Station 25+025

SAND FILL

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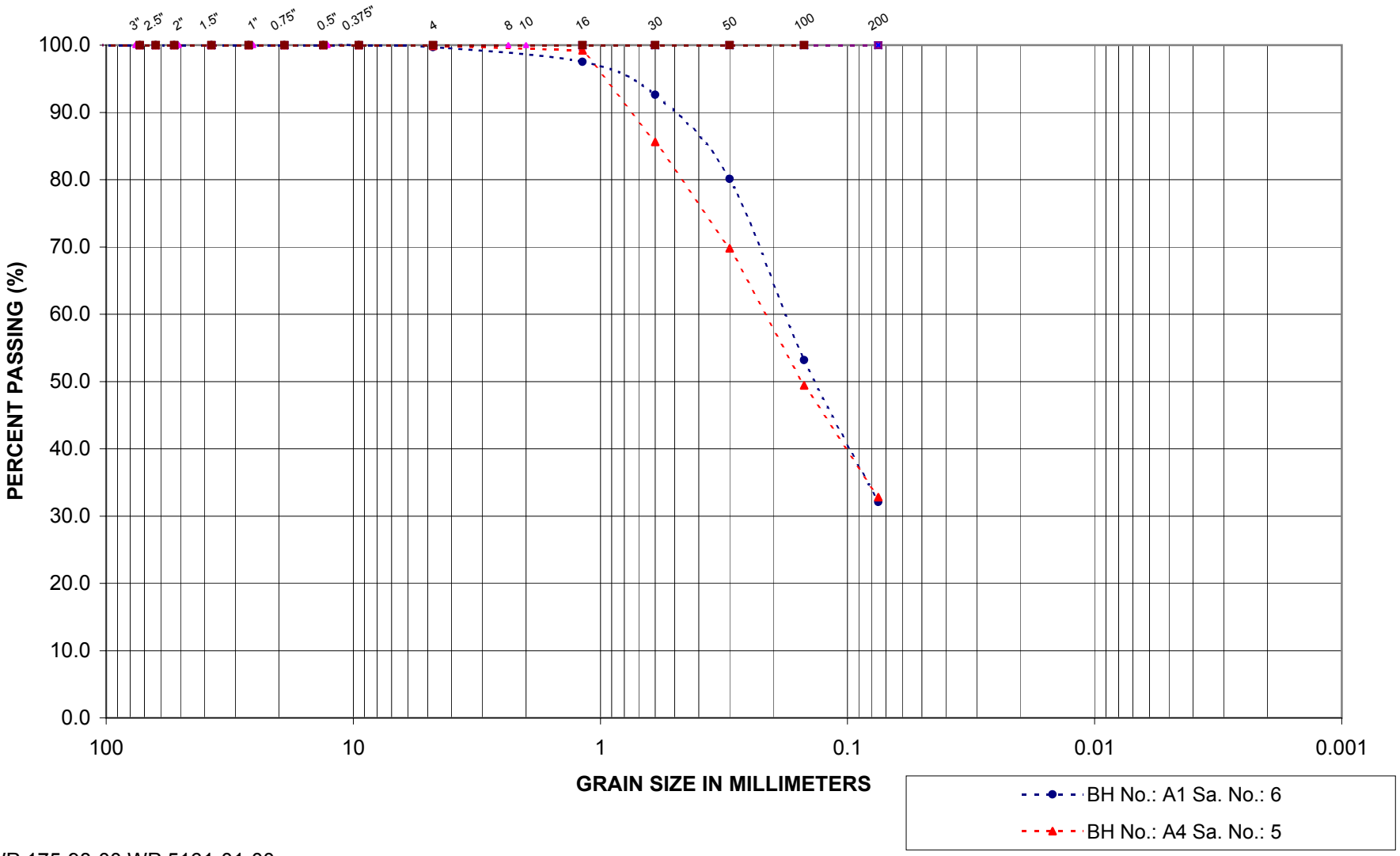
FIGURE L-1

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

GRAIN SIZE ANALYSIS



GWP 175-98-00 WP 5161-01-00
Foundation Area A
Highway 17, Township of Bonfield
Culvert at Station 25+025

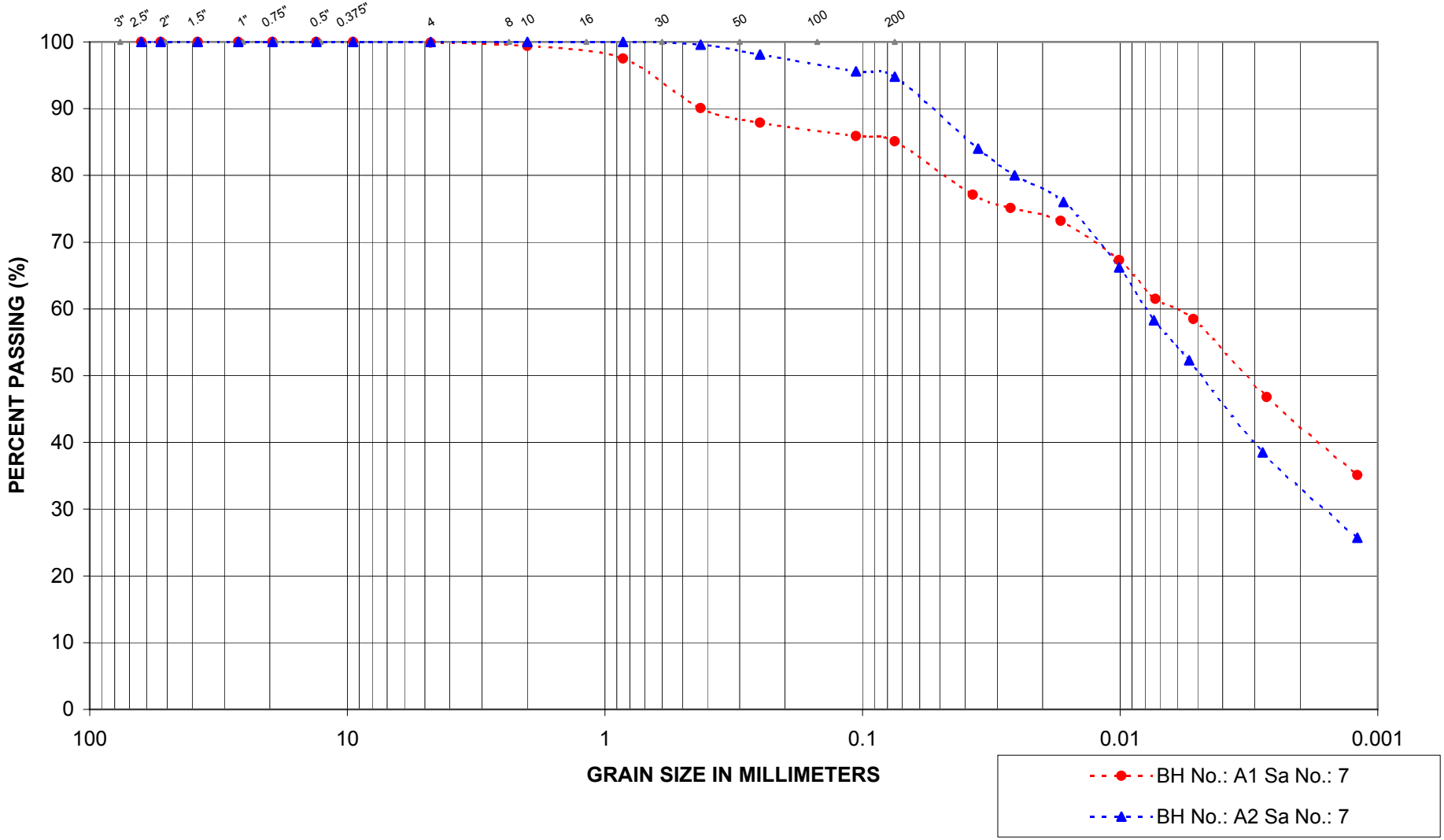
SILTY SAND FILL

MERLEX ENGINEERING LTD.

FIGURE L-2

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

GRAIN SIZE ANALYSIS



GWP 175-98-00 WP 5161-01-00
Foundation Area A
Highway 17, Township of Bonfield
Culvert at Station 25+025

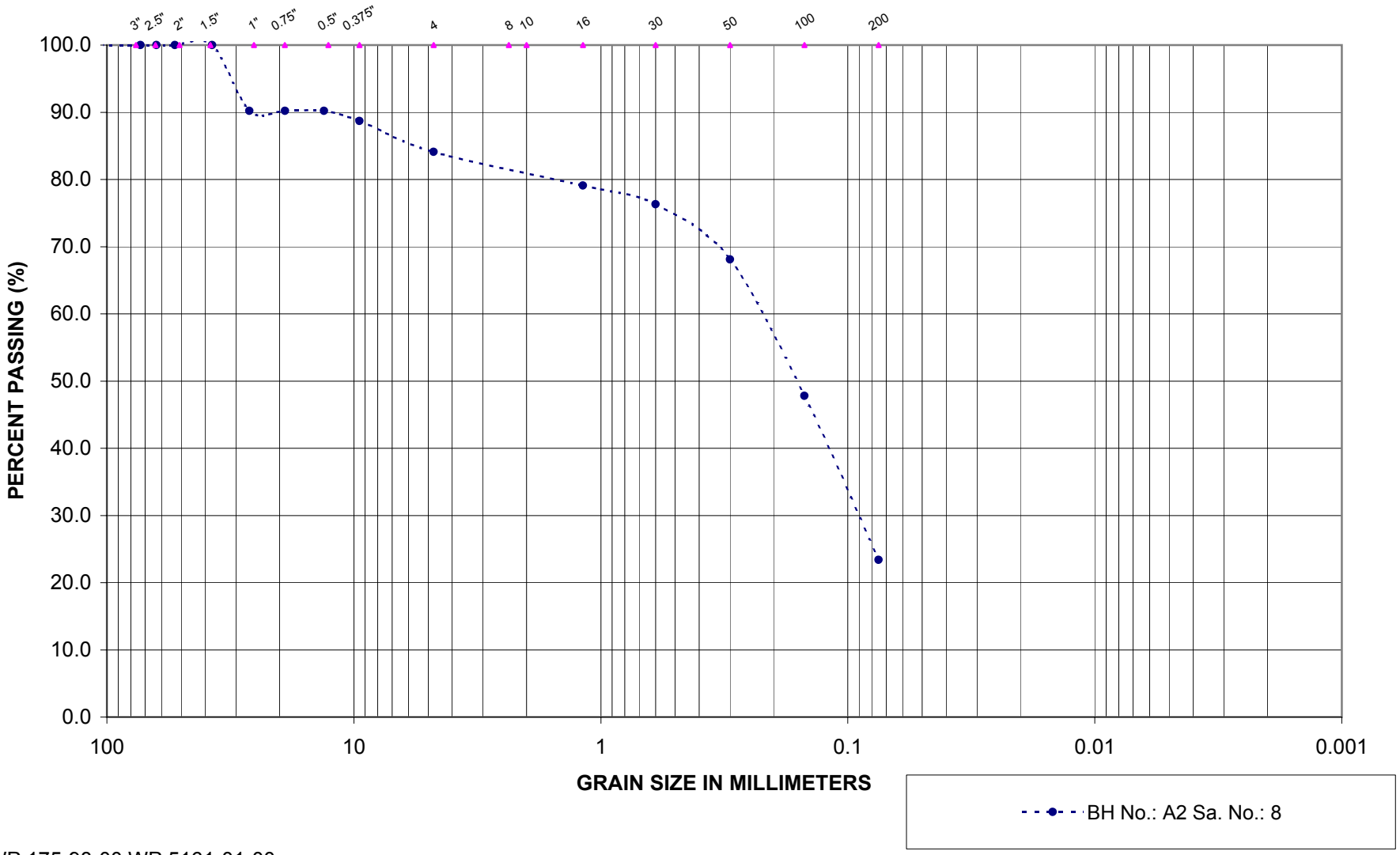
SILT and CLAY

MERLEX ENGINEERING LTD.

FIGURE L-3

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

GRAIN SIZE ANALYSIS



GWP 175-98-00 WP 5161-01-00
Foundation Area A
Highway 17, Township of Bonfield
Culvert at Station 25+025

SAND

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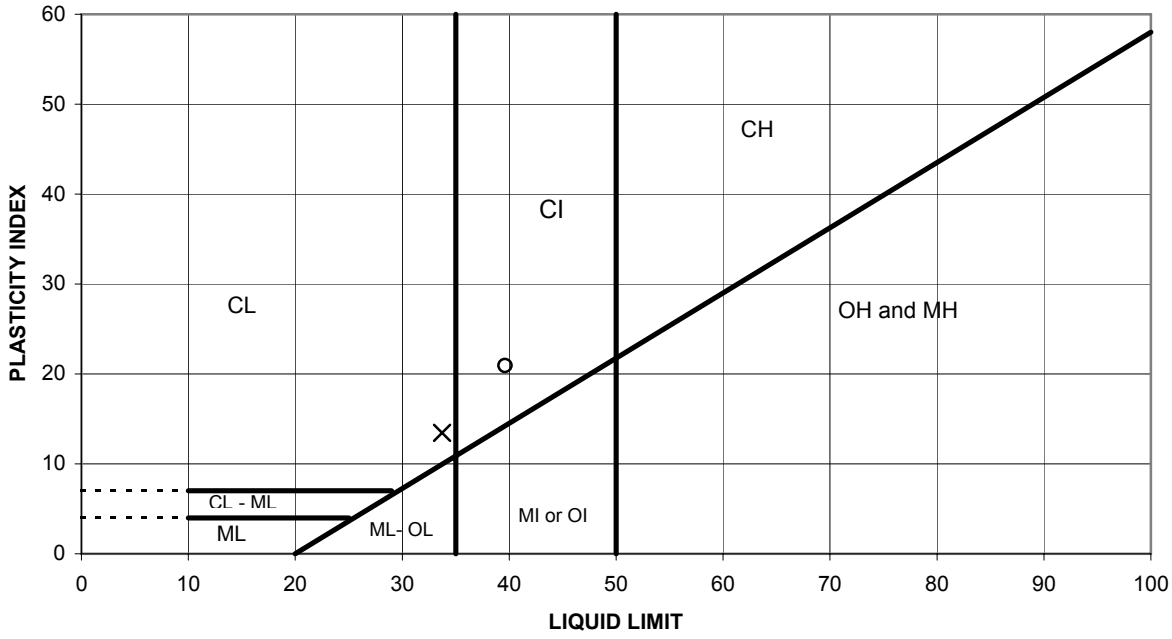
FIGURE L-4

ATTERBERG LIMITS TEST RESULTS

FIGURE L-5

ATTERBERG INDICES



SYMBOL	BH	Sa. No.	Depth(m)	Elev.(m)	Liquid Limit	Plasticity Index
o	A1	7	6.1 - 6.6	226.4	39.63	20.91
x	A2	7	7.6 - 8.2	225.2	33.73	13.46

Date: 21-Feb-06
Project: GWP 175-98-00 WP 5161-01-00
Foundation Area A, Highway 17, Township of Bonfield
Culvert at Station 25+025

Prep'd: DVL
Chkd: JRB

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APPENDIX D

Enclosure No. 9: Photo Essay

	Photo: 1

Township of Bonfield, Foundation Area A, Station 25+025. Looking easterly at right slope.	Taken By: E. Sullivan MEL Ref. No.: 05/07/05090-FA Date: 01/11/2005

	Photo: 2

Township of Bonfield, Foundation Area A, Station 25+025. Looking at left end of culvert.	Taken By: E. Sullivan MEL Ref. No.: 05/07/05090-FA Date: 01/11/2005