



MERLEX ENGINEERING LTD.

CONSULTING GEOTECHNICAL ENGINEERS

FINAL FOUNDATION INVESTIGATION AND DESIGN REPORT

GWP 175-98-00 WP 5161-01-00

FOUNDATION AREA D

Highway 17, Township of Calvin

Pimisi Bay Culvert,

Culvert Site 43-261

MEL Ref. No.: 05/07/05090-FD April 2006

Submitted to:

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MTO Geocres No. 31L-102



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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 was initiated following a structural assessment of the culvert, carried out by Earth Tech (Canada) Inc., during which it was concluded that remediation was required due to severe corrosion at approximately 0.9 to 1.0 m above the invert. There is a section loss of the steel plate, continuous at a common location for almost half of the culvert length, exposing the granular backfill. The terms of reference for the scope of work are outlined in MEL's proposal 05/07/05090-FD dated November 24, 2005, and Addendum # 1 dated December 19, 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 comments for replacement. This report addresses Foundation Area D (MTO Site No. 43-261), a centerline culvert located on Highway 17, ± 5.1 km west of the junction of Highway 17 and secondary Highway 630, in the Township of Calvin (see Enclosure No. 2: Key Plan). MEL investigated the foundation area by the drilling of boreholes (employing hollow stem augers and diamond core drilling techniques), 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 comments and recommendations on the geotechnical aspects of the culvert replacement, along with discussions on excavations, fills and embankment design.

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 investigation 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 D 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 location of the centerline culvert on Highway 17 is in the Township of Calvin, some 5.1 km west of Highway 630, at Station 13+296.6.

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 sands, with gravel, cobbles and boulders containing varying amounts of silt, occasionally overlain by organic (peat) deposits.

The highway embankment is elevated some ± 7.0 m above the bottom of Pimisi Bay. Site inspection indicated that the ± 3.0 m diameter culvert projects beyond the embankment slope



with no wing walls or head wall. In September 2005, the water level in the culvert was measured some 0.7 m above the invert with virtually no flow in a south to north direction. The shoreline of Pimisi Bay generally supports brush and mature deciduous and coniferous species. A MTO picnic area and commercial tent and trailer campground are located north of Highway 17, along the east shoreline of the bay.

2.2 Existing Conditions

The existing centreline culvert, at Station 13+296.6, Township of Calvin, is a 3060 mm diameter, structural plate corrugated steel pipe, approximately 43.6 m in length and oriented in a north-south direction. The size of the culvert allows passage of small boat/canoe size craft, as such Navigable Waters criteria requires that the existing opening size be maintained. Flow through the culvert is in a south to north direction at this location. During the field investigation it was observed that there was virtually no flow through the culvert since it is essentially acting as an equalizing culvert. It was observed during the site inspection that the vertical alignment of the existing culvert was true (see Photo 1, Appendix D), indicating that culvert settlement, which could be related to poor, weak subgrade conditions, has not developed. It is reported that the culvert was constructed around 1963 (43 years old). Earth Tech (Canada) Inc.'s structural assessment of the culvert concluded that immediate remediation was required, due to severe corrosion at approximately 0.9 to 1.0 m above the invert. There is a section loss of the steel plate, continuous at a common location for almost half of the culvert length, which has exposed the granular backfill to potential erosion during periods of high flow.

The vertical alignment of the centreline of the existing embankment was reviewed in the area of the existing culvert and did not show signs of excessive settlement or distortion which would trigger settlement or stability concerns. The existing embankment slopes are at approximately a



2.5H:1V slope at the culvert location and somewhat shallower, either side of the culvert, where the shoreline extends out beyond the culvert ends. The slopes show no signs of instability.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out over a nine (9) day period, during the latter part of December 2005 and into January and February 2006. Semi-continuous heavy snowfalls during January and February 2006 limited drill equipment access to the top of the embankment. A decrease in snow storm activity allowed access to the top of the embankment such that Borehole No. 104 could be advanced on February 28, 2006 (see Table 1, Appendix B).

The field investigation was carried out using a Bombardier mounted CME 45B drilling rig, operated by MEL and supervised by a Senior Technician, Mr. E. Sullivan, of MEL. The drilling rig was equipped with hollow stem augers, BQ coring equipment, 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. The granular deposits contained numerous cobbles and boulders. Upon encountering practical refusal on the augers, the borehole was advanced, where possible, by running a BQ core barrel ahead and following up with BW casing. Soil samples were obtained at regular intervals of depth (where possible) using the standard 50 mm O.D. split spoon sampler advanced in accordance with the Standard Penetration Test (SPT) procedures or by sampling directly from the auger flights, at depths less than 1.0 m. In-situ vane testing, using an MTO "N" size vane, was carried out in the amorphous silty peat deposits.

Groundwater conditions in the open boreholes were observed during and immediately following completion of the individual boreholes and temporary standpipe was installed in select boreholes for the duration of the drilling operation. A set of water level observations were taken



prior to removal of any temporary standpipe. All open boreholes were backfilled upon completion with the auger cuttings, in the order they were removed, using reverse augering techniques. Where necessary, additional imported granular fill was used to backfill the upper portion of the hole to 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 and grain size analysis (sieve and/or hydrometer). The results of the laboratory testing are presented on the individual Record of Borehole Sheets (Appendix B) with a summary of 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 previously painted highway chainage and offset from existing highway centerline. The contract package for this project is being prepared in a "No Plans Format".

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 D: Culvert at 13+298, 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, five (5) sampled boreholes were put down at four (4) locations at this site (Borehole Nos. 101C, 102D, 103E, 104, and 104B). Borehole Nos. 103E, 104, and 104B were put down through the highway embankment on the south and north side, respectively. Borehole No. 103 was originally located east of the culvert, right side of the highway, however shallow auger refusal, on boulder/cobble size obstructions at Borehole Nos. 103 and 103A, at depths of 1.5 m and 2.3 m respectively, necessitated relocating the borehole to the west side of the existing culvert (see Table 1, Appendix B). Borehole Nos. 101C and 102D were put down at the ends of the existing culvert on the north and south ends respectively. At the above noted four (4) locations, several attempts had to be made to advance the augers past cobble/boulder size obstructions in the embankment fill, and underlying native granular deposits.

At Borehole Nos. 103E, 104, and 104B, advanced from the right and left shoulder, a frozen pavement structure layer, consisting of crushed granular over sand fill was penetrated to depths of some 0.75 to 1.0 m. The underlying embankment fill consisted of fine to medium sands, trace to some gravel, trace to some silt and frequent cobble and boulder sizes. The cobble and boulder size particles may be natural cobbles/boulders in the embankment, rock fill, or a combination of both used during embankment construction. Borehole No. 103E had to be relocated five times on the right shoulder area due to practical auger refusal at depths ranging from 1.3 to 2.5 m below existing grade (see Table 1, Appendix B). At the location of Borehole No. 103E, the augers were advanced past the cobble/boulder size obstructions in the



embankment fill to a depth of 6.1 m. Following retrieval of a split spoon sample, an attempt to further advance the hollow stem augers was made, however the lead auger sheared off above the 1.5 m keyed coupling. The broken lead auger could not be retrieved and the borehole location had to be abandoned and was backfilled to grade. Two boreholes, Borehole Nos. 104 and 104B, were advanced through the embankment fill on the left (north) shoulder. The embankment fill, as sampled, consisted of sands with some gravel and varying silt content. Grain size analysis was carried out on two samples of the embankment fill and indicated 13 to 20% gravel size particles, 62 to 75% sand size particles, and 5 to 25% silt and clay size particles. The specific distribution curves are shown on the Summary of Grain Size Analysis Graph (Appendix C, Figure L-3). It must be noted that the standard split spoon has a 37.5 mm inside diameter, as such gradation results do not reflect the coarse gravel, cobble, and boulder size content. Based on response to drilling, numerous oversize particles are present in the embankment fill. The natural moisture content in these samples was measured at 5 to 13%. Standard Penetration Test "N" values recorded in conjunction with the split spoon sampling within this stratum returned values of 12 to 39 blows per 300 mm penetration, indicating a compactness of compact to dense in the embankment fill. Based on the grain size analysis of Sample No. 2, Borehole No. 103E Hazen's D_{10} method, an estimate of the coefficient of permeability of 2.6×10^{-2} cm/sec can be made. However, the following sample tested at Borehole No. 103E (Sample No. 3) had some 25% fines (silt/clay) which would decrease the permeability of the deposit.

Borehole Nos. 101C and 102D were advanced through the toe of slope at the ends of the culvert left (north) and right (south), respectively. At both locations a thin surficial deposit of fill, consisting of fine and medium sands with gravel, occasional cobbles, was penetrated to depths of 0.7 and 1.0 m below grade. At Borehole No. 101C, a 400 mm thick layer of silty clay was encountered in the fill. It is interpreted that this fill has been deposited over the natural organic



silty peat deposits, beyond the original toe of slope, over the 43 year life of this culvert. Directly below the thin fill layer, a deposit of dark brown to black, non-fibrous amorphous silty peat was encountered. This deposit varied in thickness from 1.1 to 2.2 m at Borehole Nos. 101C and 102D, respectively. The natural moisture content in this peat deposit varied from 57 to 246% with an average value of 122%. In-situ vane strength test returned values ranging from 26 to 40 kPa, indicating a consistency of firm. At Borehole Nos. 104 and 104B, the deposit of organic, fine fibrous and non-fibrous amorphous silty peat varied in thickness from 0.6 to 0.7 m. This deposit of compressed organics extended between approximately elevation 178.2 to 177.5 m at Borehole No. 104, and 177.7 to 177.1 m at Borehole No. 104B. Standard Penetration Test values across this compressed organic deposit returned relatively high “N” values of 9 and 11 blows per 300 mm penetration. A further indication of the very stiff consistency of this compressed organic deposit is indicated by the in-situ shear strength value, which was measured in Borehole No. 104B at 160 kPa.

Below this organic deposit, a relatively well graded sand to gravelly sand deposit with varying silt content and numerous cobble and boulder sizes was penetrated below elevations 177.5 and 176.4 m at Borehole Nos. 101C and 102D respectively and below elevation 177.5 and 177.1 m at Borehole Nos. 104 and 104B respectively. Based on the SPT results, which ranged between 5 and 66 blows per 300 mm penetration the compactness of this deposit ranged from loose to very dense (generally compact). Grain size analysis carried out on split spoon samples from this deposit indicated 5 to 36% gravel size particles, 50 to 93% sand size particles, and 3 to 23% silt and clay size particles. The specific grain size distribution curves for the samples tested are shown on the Summary of Grain Size Analysis Graph (Appendix C, Figures L-1, L-2, and L-4). Based on the grain size analysis of Sample No. 4 at Borehole No. 101C, Sample Nos. 6, 7, and 8 at Borehole No. 102D, Sample No. 7c at Borehole No. 104, Sample Nos. 4 and 5 at Borehole No. 104B, and Hazen’s D_{10} method, an estimate of the coefficient of permeability of 1



$\times 10^{-2}$ to 8×10^{-2} cm/sec can be made. However, higher fines content in several samples indicates possible seams/layers of lesser permeable material, which would decrease the permeability of the deposit. It is again noted that the standard split spoon sampler is 37.5 mm inside diameter, as such gradation results do not reflect the coarse gravel, cobble, and boulder sizes present within the deposit. Borehole No. 102D was terminated in this deposit at a depth of 11.1 m (elevation 168.5), whereas at Borehole No. 101C the gravelly sand deposit ended at the contact with bedrock, which was encountered at a depth of 8.2 m (elevation 171.1 m). Based on core samples of the bedrock it is classified as a sound grey granitic gneiss with a recovery of 93% and RQD value of 77%.

4.2 Groundwater Conditions

Groundwater levels were encountered in the boreholes with final water levels recorded in Borehole Nos. 101C and 102D at elevations 179.15 and 179.2 m, respectively. The water level in the culvert was recorded at elevation 179.1 m on January 20, 2006. Water levels will fluctuate seasonally.

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5.0 DESIGN COMMENTS AND RECOMMENDATIONS

5.1 General

The existing ± 3.0 m diameter Structured Plate Pipe (SPCSP) culvert has an overall length of 43.6 m. The culvert was constructed around 1963 and connects the north and south parts of Pimisi Bay. There was virtually no flow observed through the culvert and the water level in the culvert was at a depth of ± 0.7 m (October 2005 and February 2006). A review of the vertical alignment of the existing culvert indicates no sign of appreciable distortion/settlement along the obvert (see Photo No. 1, Appendix D). The existing longitudinal alignment of the highway embankment over the culvert location was reviewed and did not reveal any sags or distortions which would be indicative of deep deposits of weak/compressible soils. A structural review of the culvert, carried out by Earth Tech (Canada) Inc., revealed continuous section loss, at a distance of some 0.9 to 1.0 m above the invert, for approximately 45% of the culvert length. Backfill exposed in these areas of corrosion is susceptible to washout during a large flow event. Complete culvert replacement is recommended.

Earth Tech (Canada) Inc. has concluded that the SPCSP can be replaced with a 42 m long precast concrete box culvert, 3.5 m wide by some 3.0 m high, with an invert elevation of 178.00 m at both ends.

The soil borings advanced at the embankment toe, beyond the ends of the existing culverts, revealed a shallow fill overlying an organic deposit of amorphous silty peat, varying from 1.1 to 2.2 m thick (Borehole Nos. 101C and 102D, respectively). The organic layer was underlain by a compact to dense sand with varying gravel and silt content, which extended to bedrock contact at Borehole No. 101C (elevation 171.1 m) and to a depth of 11.1 m (elevation 168.5 m) where Borehole No. 102D was terminated.



The 103 series boreholes, put down on the right (south) shoulder of the embankment met practical auger refusal at five (5) locations at a shallow depth before Borehole No. 103E was advanced to a depth of 6.6 m (elevation 178.5 m), where refusal was met on cobble/boulder sizes in the embankment fill. Borehole Nos. 104 and 104B penetrated the compact to dense embankment fills and encountered a 600 to 700 mm thick layer of compressed organic silt and peat. This compressed organic deposit was present just below the existing culvert invert and underlain by the competent compact to dense sand and gravel, cobbles, and boulders.

Earth Tech (Canada) Inc. reviewed culvert replacement operations with the Ministry and it was concluded that the culvert replacement would be carried out as a continuous (24 hour) operation with traffic flow reduced to one lane and traffic control as per Book 7 using a flagging operation. Following Earth Tech (Canada) Inc.'s review of the Geotechnical borings, advanced from the top of the embankment up and down chainage from the culvert and reported under separate cover, they concluded that the embankment can be temporarily lowered, by up to some 1.5 m at the culvert location, which will result in an excavation depth of approximately 6 m, to the underside of the culvert bedding (see geotechnical correspondence, Appendix D, Enclosure No. 9). Lowering the grade will allow construction of open excavations with 1:1 side slopes, as required by the OHSA and as such, a roadway protection system (ie. shoring, etc.) should not be required. Since replacement will be similar to a conventional smaller diameter centreline culvert, no design for staging will be included in the contract documents.

5.2 Foundations – Excavation and Dewatering

The invert of the proposed box culvert will be set at elevation 178.0 m, both ends. Allowing for box thickness and 300 mm of 19 mm clear stone bedding, general excavation will be required to a minimum elevation of ± 177.4 m. The underside of the compressed organic silt and peat deposit was identified below the embankment at elevation 177.5 m and 177.1 m, at Borehole



Nos. 104 and 104B, respectively. As such, the majority of this deposit will likely be excavated to allow for installation of the culvert bedding installation. The contractor must be prepared to remove all of the organic layers/pockets that may be present below the design subgrade and replace with culvert bedding. Considering the “good” performance of this culvert, with respect to settlement, we don’t anticipate substantial thickness of this compressible organic layer beyond that indicated at the 104 series boreholes.

As noted previously, by lowering the embankment grade and, provided adequate groundwater control is carried out, temporary construction slopes of 1H:1V can be considered for the embankment granular fills, which are considered a Type 3 soil in accordance with the Occupational Health & Safety Act (OHSA) and Regulations for Construction Projects. A stability analysis, using the commercially available SlopeW computer program, has been carried out for a temporary open excavation through the embankment granular fills, along the longitudinal axis with the groundwater lowered below the excavation base. The factor of safety is at or slightly greater than unity, for the condition of full rotational slip into the excavation. The analysis indicates that the factor of safety against local surficial sliding along the slope face is less than 1.0 (see Appendix D, Enclosure No. 10). The stability of granular slopes is dependent upon the mechanical locking of the soil grains, which can be adversely impacted by drying or periods of rainfall. The temporary slope must be continually monitored during construction and should signs of local sliding develop along the face, the operation should be temporarily halted and corrective action taken immediately. Should unforeseen delays develop during the continuous excavation operation, the contractor must be prepared to immediately backfill the temporary excavation slopes to a more stable angle of 1.5H:1V, or flatter, or take other corrective actions.

Parallel to the culvert alignment, cutting the slope back to a 1H:1V to the bottom of the excavation will result in a shallower slope overtop of the existing culvert end, which will protrude



beyond the 1H:1V slope. This shallower slope, combined with the confining stresses in the soil around the inside corners of the excavation, will combine to increase the factor of safety along this working face, however, as noted, it must be continuously monitored during construction for signs of surficial sloughing and possible development of tension cracks along the crest. The length of excavation, open to its maximum depth, should also be limited to the length required to install a single section of the box culvert.

The existing ± 3.0 m SPCSP has been reinforced with temporary timber supports. The locations of these supports may have to be adjusted to coincide with the locations where the contractor intends to cut the SPCSP.

Excavation, at a maximum, must be carried out locally to below elevation 176.5 m at the cutoff walls and generally to below the underside of the culvert bedding at elevation 177.4 m. The water level in the bay was measured at elevation ± 179.1 m. To maintain a stable temporary open excavation face and a stable subgrade, it is imperative that the groundwater pressures be controlled under all circumstances. As such, we do not consider the conventional construction method of pumping from filtered sump holes in the excavation base an adequate method of safely satisfying the above requirements, especially when one considers the granular water bearing subgrade. A deep well system would impact a substantial area with higher risk due to radial extent of impact. To safely control the approximately 2.5 m head of groundwater, a vacuum well point system, surrounding the excavation, is probably the better solution, although installation of the points may be problematic due to cobble/boulder size obstructions in the soil deposits, which must be noted in the contract documents. Dewatering, employing a vacuum well point system will increase the tension forces between soil particles and improve the stability of the excavation face. Ultimately, groundwater control is the responsibility of the contractor and may vary depending upon their method of operation, experience, equipment, scheduling, etc.



However, at a minimum, the groundwater control system must be engineered by a dewatering specialist and proposed method must be submitted for review by the Contract Administration a minimum of 10 days before planned commencement of this operation. As part of the groundwater control system, cofferdams will be required at the ends of the existing culvert to isolate the excavation area. The presence of numerous cobble/boulder sizes in the underlying gravelly sand deposit will probably limit driving of interlocking sheet piling. As such, the temporary cofferdam will likely be designed as a gravity system (ie. sand bag type dam). Since this culvert is acting essentially as an equalizer, flow through the culvert can be temporarily stopped during the anticipated short duration of the construction operation (estimated 4 to 5 working days). Special Provision No. 902S01, dated March 2005, covering excavation, backfilling, and dewatering will be included in the contract package.

5.3 Design Bearing Resistance

Based on the above noted soil conditions, the culvert bedding will be supported on compact to dense gravelly sands. For this bearing surface we have determined a factored ultimate bearing resistance at ULS of 300 kPa. A SLS bearing resistance of 200 kPa reflects settlement considerations of 25 mm or less. The above values consider that the 300 mm thick bedding layer of 19 mm clear stone is properly prepared and leveled, as per OPSS 422, prior to placement of the precast culvert sections and the subgrade is not unduly disturbed during construction. Sliding resistance between the concrete box culvert and bedding can be assessed using a coefficient of friction for the coarse grained bedding of 0.55.

5.4 Lateral Earth Pressures

The rigid head wall must be designed to resist the pressures associated with the embankment fill. It is recommended that a Granular B Type I, as per OPSS Form 1010 requirements, be used as backfill to the culvert.



Lateral earth pressures should be computed in accordance with CHBDC. For design purposes, the following parameters can be used:

	Granular B Type I	Rock Fill
Angle of Internal Friction ($^{\circ}$)	30	43
Unit Weight (kN/m^3)	21	18.5
Active Earth Pressure (K_a)	0.33	0.19
At-Rest Earth Pressure (K_o)	0.50	0.32

5.5 Embankment Fills

Geotechnical borings advanced along the top of the embankment encountered no further penetration (NFP) on boulders or rock fill in the embankment at depths ranging from 1.3 m to greater than 2 m at off-set distances from the existing centreline culvert of ± 100 m up and down chainage. As noted in the attached geotechnical comment (Appendix D, Enclosure No. 9), to avoid disturbing the chinking of the existing rock fill, for design purposes, the excavation grade should be set at 150 mm above the existing rock subgrade. The contractor should be notified, by a special provision, that if the surface of the existing rock fill is disturbed it must be reinstated prior to constructing the temporary pavement structure.

Considering the limited depth of fill required to reinstate the embankment profile, following temporary lowering of the embankment for culvert installation, we recommend that granular material, conforming to Select Subgrade Material (SSM) OPSS Form 1010, be used for embankment reconstruction to the underside of the pavement structure as identified in the Supplement Pavement Design Report for WP 5161-01-00.



The existing embankment is constructed with predominately granular fills with cobble and boulder sizes (either natural or rock fill), as such the final embankment side slopes should be set at a stable angle of 2H:1V or shallower. Newly exposed earth cut slopes should be covered with top soil and seeded as soon as practical. 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.



6.0 CLOSURE

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

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

MERLEX ENGINEERING LTD.

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Principal

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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

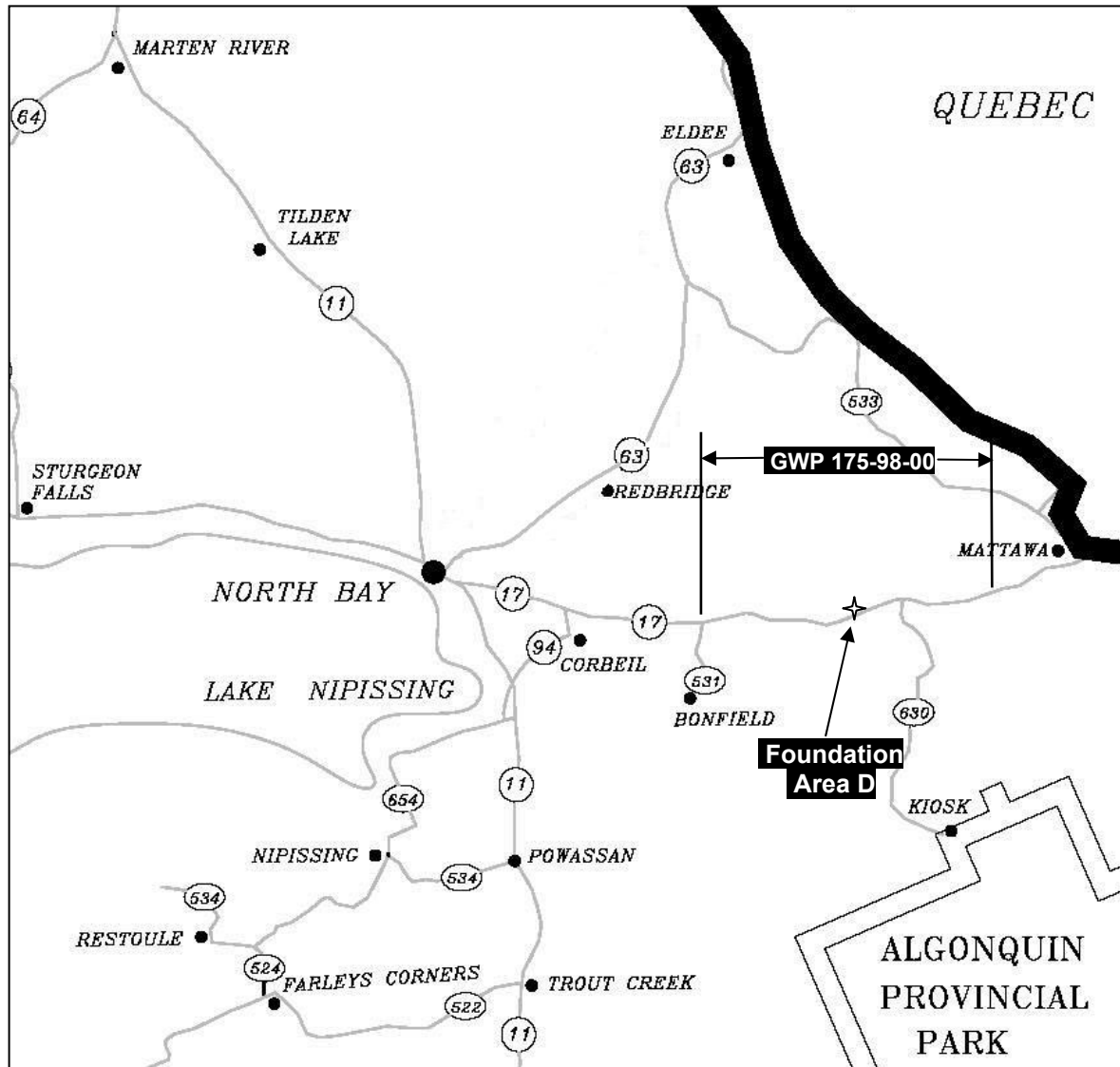


SAMPLE DESCRIPTION NOTES:

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

FINAL FOUNDATION INVESTIGATION AND DESIGN REPORT

GWP 175-98-00 WP 5161-01-00 - FOUNDATION AREA D
Highway 17, Township of Calvin
Pimisi Bay Culvert,
Culvert Site 43+261

MEL Reference No. 05/07/05090-FD

April 2006



MERLEX ENGINEERING LTD.
CONSULTING GEOTECHNICAL ENGINEERS

APPENDIX B

Enclosure Nos. 3 to 7: Record of Borehole Sheets

Table 1: Chronological Summary of Borehole Advancement

METRIC**RECORD OF BOREHOLE No. 101C**

REFERENCE 05/07/05090FD DATUM Geodetic LOCATION 13+288 23.4 m Lt, Township of Calvin ORIGINATED BY ELS
 PROJECT Hwy 17 - Pimisi Bay Culvert BOREHOLE TYPE Hollow Stem Augers with BW Casing & BQ Core COMPILED BY DVL
 CLIENT Earth Tech (Canada) DATE (Started/Completed) 21/12/05 - 4/1/06 TIME _____ CHECKED BY MAM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
179.3 0.0	Ground Surface FILL													
	300 mm Fine and Medium Sand trace of Gravel		1	AS										
178.6 0.7	400 mm Silty Clay PEAT		2	SS	WH									
	Dark Brown/Black Non-Fibrous Amorphous Silty Peat (Firm)													
177.5 1.8	SAND		3	SS	5									
	Grey Sand with Gravel, Silt and Numerous Cobble and Boulder Sizes		4	SS	41									
	(Advanced Hole through Sands with Cobbles/Boulders using BQ Size Core in BW Casing)													
	Runs Depth Recovery RQD													
	1 3.7 - 5.0 27% 0													
	2 5.5 - 5.6 0% 0													
	3 5.6 - 6.5 51% 0													
	4 7.8 - 8.2 0% 0													
			5	SS	55									
171.1 8.2	BEDROCK													
	Grey Granitic Gneiss Good Quality		Run 5	BQ RC	Rec 93% RQD 77%									
169.7 9.6	End of Coring End of Borehole													
COMMENTS See Attached Table 1 for Chronological Order of Borehole Advancement.								+ 3, X 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa		WATER LEVEL RECORDS				
								○ 3% STRAIN AT FAILURE		Date (yy/mm/dd)/Time	Water Depth (m)	Cave In (m)		
										1) 21/12/05 10:45:00 AM	-	2.8		
										2) 21/12/05 11:00:00 AM	-	2.4		
										3) 21/12/05 3:08:00 PM	0.15	2		

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

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MEL-GEO 05090-F-PIMISI CULVERT.GPJ MEL-GEO.GDT 5/5/06

METRIC**RECORD OF BOREHOLE No. 102D**

REFERENCE 05/07/05090FD DATUM Geodetic LOCATION 13+288 24.0 m Rt, Township of Calvin ORIGINATED BY ELS
 PROJECT Hwy 17 - Pimisi Bay Culvert BOREHOLE TYPE Hollow Stem Augers COMPILED BY DVL
 CLIENT Earth Tech (Canada) DATE (Started/Completed) 21/12/05 - 10/1/06 TIME _____ CHECKED BY MAM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 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)
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES						
179.6 0.0	Ground Surface FILL 100 mm Sandy Organics over Sand Fill with Gravel & Cobbles/Boulders		1	AS							
178.6 1.0	PEAT Dark Brown/Black Non-Fibrous Amorphous Silty Peat (Firm)		2	SS	3						
			3	SS	WH						
			4	SS	WH						
176.4 3.2	SANDS Grey Gravelly Sands Varying Silt Content with Numerous Cobble and Boulder Sizes (Loose/Dense)		5	SS	14						
			6	SS	43						
			7	SS	15						
			8	SS	5						
			9	SS	49						
	Silt content increasing with depth										
	Continued Next Page										

COMMENTS
See Attached Table 1 for Chronological Order of Borehole Advancement.

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) 21/12/05 2:20:00 PM	0.4	3
2)	-	-
3)	-	-

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METRIC**RECORD OF BOREHOLE No. 102D**

REFERENCE 05/07/05090FD DATUM Geodetic LOCATION 13+288 24.0 m Rt, Township of Calvin ORIGINATED BY ELS
 PROJECT Hwy 17 - Pimisi Bay Culvert BOREHOLE TYPE Hollow Stem Augers COMPILED BY DVL
 CLIENT Earth Tech (Canada) DATE (Started/Completed) 21/12/05 - 10/1/06 TIME _____ CHECKED BY MAM

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
							20	40	60	80	100	W _p	W	W _L		
	Continued from Previous Page															
168.5	Gravelly Sands with Varying Silt Content, Cobbles & Boulders		10	SS	42											26 57 (17)
11.1	End of Sampling End of Borehole															

MEL-GEO 05090-F-PIMISI CULVERT.GPJ MEL-GEO.GDT 5/5/06

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METRIC**RECORD OF BOREHOLE No. 103E**

REFERENCE 05/07/05090FD DATUM Geodetic LOCATION 13+292.1 5.8 m Rt, Township of Calvin ORIGINATED BY ELS
 PROJECT Hwy 17 - Pimisi Bay Culvert BOREHOLE TYPE Hollow Stem Augers COMPILED BY DVL
 CLIENT Earth Tech (Canada) DATE (Started/Completed) 16/1/06 - 19/2/06 TIME 4:10:00 PM CHECKED BY MAM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20	40	60	80	100	20	40	60			
185.1	Embankment Surface - Right Shoulder																
0.0	30 mm Asphalt 200 mm \pm Crushed Gravel																
	FILL																
	Fine and Medium Sand																
184.1	SANDS																
1.0	Sands Some/With Gravel and Silt Frequent Cobble/Boulder Sizes (Possible Rockfill) Below 1.5 m Depth.																
	(Compact/Dense)																
	(Embankment Fill)																
			1	SS	17												
			2	SS	39												
			3	SS	12												
			4	SS	32												
178.5	Auger Refusal Probably Boulder Size Obstruction End of Borehole																
6.6																	

COMMENTS

See Attached Table 1 for Chronological Order of Borehole Advancement.

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) 16/2/06 2:48:00 PM	DRY	3.4
2)	-	-
3)	-	-

MEL-GEO 05090-F-PIMISI CULVERT.GPJ MEL-GEO.GDT 5/5/06

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METRIC**RECORD OF BOREHOLE No. 104**

REFERENCE 05/07/05090FD DATUM Geodetic LOCATION 13+294.0, 5.3 m Lt, Township of Calvin ORIGINATED BY ELS
 PROJECT Hwy 17 - Pimisi Bay Culvert BOREHOLE TYPE Hollow Stem Augers COMPILED BY DVL
 CLIENT Earth Tech (Canada) DATE (Started/Completed) 28/2/06 - 28/2/06 TIME 11:42:00 AM CHECKED BY MAM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 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)
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES						
185.2 0.0	Embankment Surface - Left Shoulder 750 mm Granular Fill (Frozen)						185				
184.4 0.8	FILL		1	AS			184				
	Sands Some/With Gravel and Silt, Frequent Cobble and Boulder Sizes (Compact/Loose) (Embankment Fill)		2	SS	21		183				
			3	SS	24		182				
			4	SS	29		181				
			5	SS	6		180				
178.2 7.0	350 mm Fine Fibrous Peat		6	SS	9		179				
177.5 7.7	350 mm Organic Silt						178				
	SANDS		7	SS	42		177				
	Grey Sands with Gravel, Numerous Cobbles and Boulders (Dense)										
176.5 8.7	Auger Refusal Probably Boulder Size Obstruction End of Borehole										

COMMENTS

1) BH 104A - 13+292.0, 5.3 m Lt - Auger Refusal at 2.2 m Depth 2) Boreholes Backfilled to Grade immediately upon completion.

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) 28/2/06 11:42:00 AM	DRY	-
2)	-	-
3)	-	-

MEL-GEO 05090-F-PIMISI CULVERT.GPJ MEL-GEO.GDT 5/5/06

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SOIL PROFILE				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)	
ELEV DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES			SHEAR STRENGTH kPa							
			NUMBER			TYPE	"N" VALUES						
185.2 0.0	Embankment Surface - Left Shoulder ±750 mm Granular Fill (Crushed Gravel over Sand) (Frozen)												
184.4 0.8	FILL Sands Some/With Gravel and Silt, Frequent Cobble and Boulder Sizes (Embankment Fill) (Compact)												

METRIC**RECORD OF BOREHOLE No. 104B**

REFERENCE 05/07/05090FD DATUM Geodetic LOCATION 13+292.5, 5.3 m Lt, Township of Calvin ORIGINATED BY ELS
 PROJECT Hwy 17 - Pimisi Bay Culvert BOREHOLE TYPE Hollow Stem Augers COMPILED BY DVL
 CLIENT Earth Tech (Canada) DATE (Started/Completed) 28/2/06 - 28/2/06 TIME 5:05:00 PM CHECKED BY MAM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W _p	W	W _L		
	Continued from Previous Page																
174.2	SANDS																
11.0	Grey Sands with Gravel, Numerous Cobbles and Boulders		5	SS	60												
	(Compact/Very Dense)																
	End of Sampling																
	End of Borehole																

MEL-GEO 05090-F-PIMISI CULVERT.GPJ MEL-GEO.GDT 5/5/06

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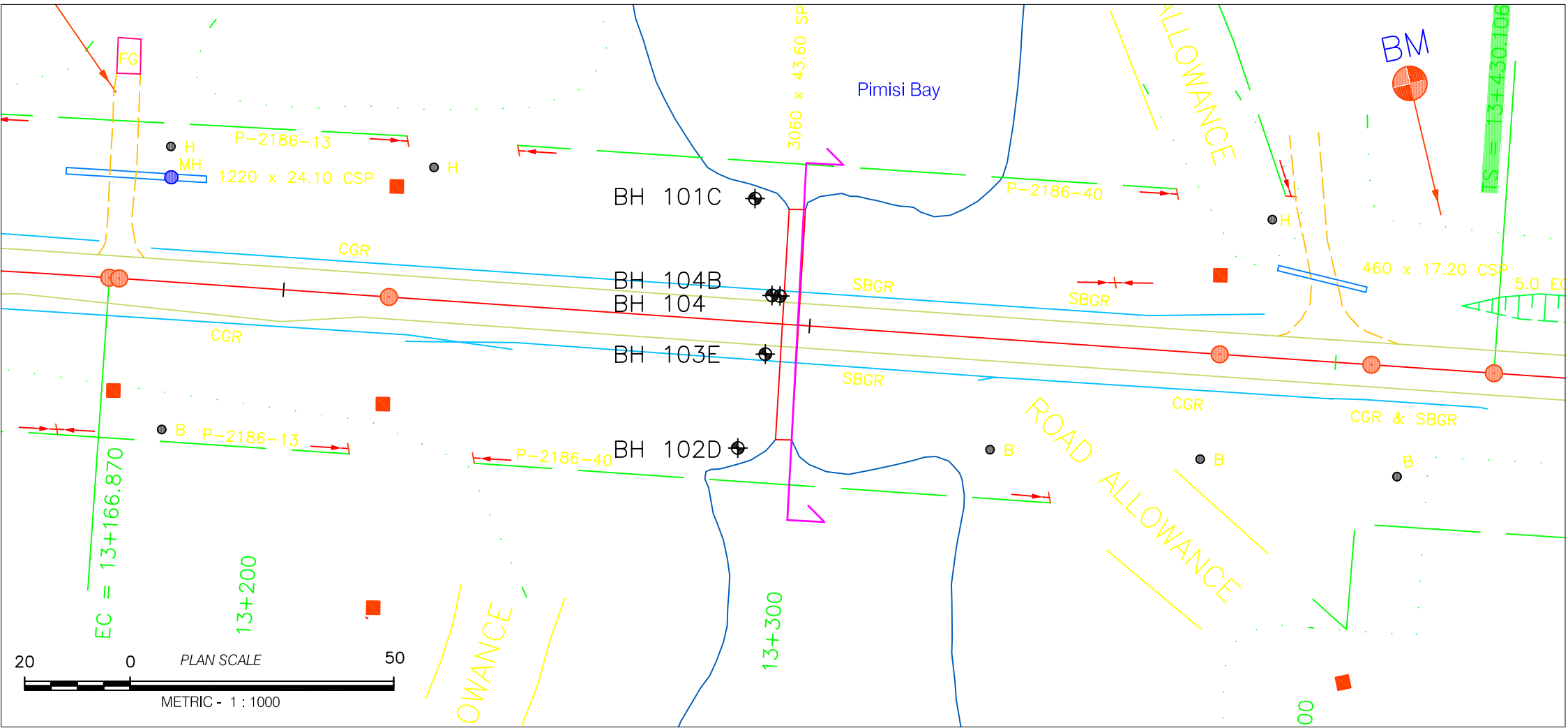
Table 1
Chronological Summary of Borehole Advancement

Borehole	Station	Offset	Date	D from C/L	Auger Refusal
BH 101	Station 13+289	23.4m Lt	Dec 21, 2005	D=-6.2	A/R at 2.7m(Blds)
BH101A	Station 13+287	23.4m Lt	Dec 21, 2005	D=-6.5	A/R at 2.8m(Blds)
BH101B	Station 13+290	23.4m Lt	Dec 21, 2005	D=-5.9	A/R at 2.3m(Blds)
BH101	Station 13+289	23.4m Lt	Jan 3, 2006	D=-6.2	Broke Casing, Hole Abandoned.
BH101C	Station 13+288	23.4m Lt	Jan 3 & 6, 2006	D=-6.5	See Record of BH101C
BH 102	Station 13+293	24.0m Rt	Dec 21, 2005	D=-5.9	A/R at 4.4m(Blds)
BH102A	Station 13+291	24.0m Rt	Dec 21, 2005	D=-5.9	A/R at 4.1m(Blds)
BH102B	Station 13+289	24.0m Rt	Dec 21, 2005	D=-5.7	A/R at 4.7m(Blds)
BH102C	Station 13+289	24.0m Rt	Jan 5, 2006	D=-5.7	Broke Casing, Hole Abandoned.
BH102D	Station 13+288	24.0m Rt	Jan 9, 2006	D=-5.7	See Record of BH102D
BH103	Station 13+300	5.9m Rt	Jan 19, 2006	D=0	A/R at 1.5m(Blds)
BH103A	Station 13+300	5.8m Rt	Jan 19, 2006	D=0	A/R at 2.3m(Blds)
BH103B	Station 13+294	5.8m Rt	Jan 19, 2006	D=0	A/R at 1.4m(Blds)
BH103C	Station 13+293.7	5.8m Rt	Jan 19, 2006	D=0	A/R at 1.5m(Blds)
BH103D	Station 13+292.5	5.8m Rt	Jan 19, 2006	D=0	A/R at 2.5m(Blds)
BH103E	Station 13+292.1	5.8m Rt	Feb 16, 2006	D=0	See Record of BH103E
BH104	Station 13+294	5.3m Lt	Feb 28, 2006	D=0	A/R at 8.7 m - See Record of BH104
BH104A	Station 13+292	5.3m Lt	Feb 28, 2006	D=0	A/R at 2.2 m (Blds)
BH104B	Station 13+292.5	5.3m Lt	Feb 28, 2006	D=0	See Record of BH104B

APPENDIX C

Figure 1: Plan and Profile

Figures L-1 to L-4: Summary Grain Size Analysis Graphs



GWP No 175-98-00

WP No 5161-01-00



HWY 17 Calvin Twp.

Foundation Area D

Pimisi Bay Culvert

BOREHOLE LOCATIONS & SOIL STRATA

MTO Geocres No. 31L-102

Figure

1



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Consulting Geotechnical Engineers

STRATIGRAPHY LEGEND



TOPSOIL



ORGANIC SILTS/
PEAT



VARVED/
INTERLAYERED
CLAYS & SILTS



FILL



ASPHALT



SAND



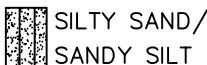
SAND & GRAVEL



CLAY



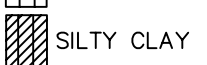
TILL



SILTY SAND/
SANDY SILT



SILT



SILTY CLAY



CRUSHED
GRAVEL

LEGEND



Borehole

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

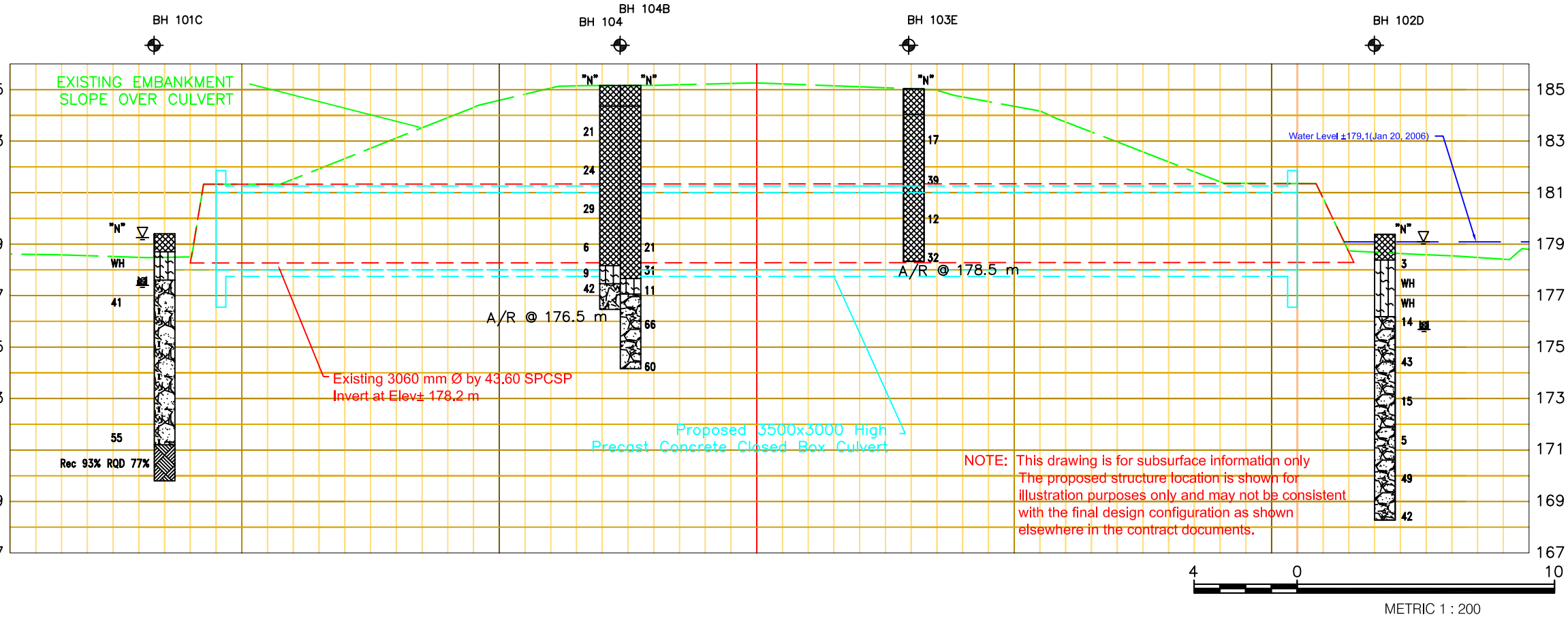
Borehole No.	Stations		Elevation
	Station	Offset	
Borehole No. 101C	13+288	23.4 Lt	179.3
Borehole No. 102D	13+288	24.0 Rt	179.6
Borehole No. 103E	13+292	5.8 Rt	185.1
Borehole No. 104	13+294	5.3 Lt	185.2
Borehole No. 104B	13+292	5.3 Lt	185.2

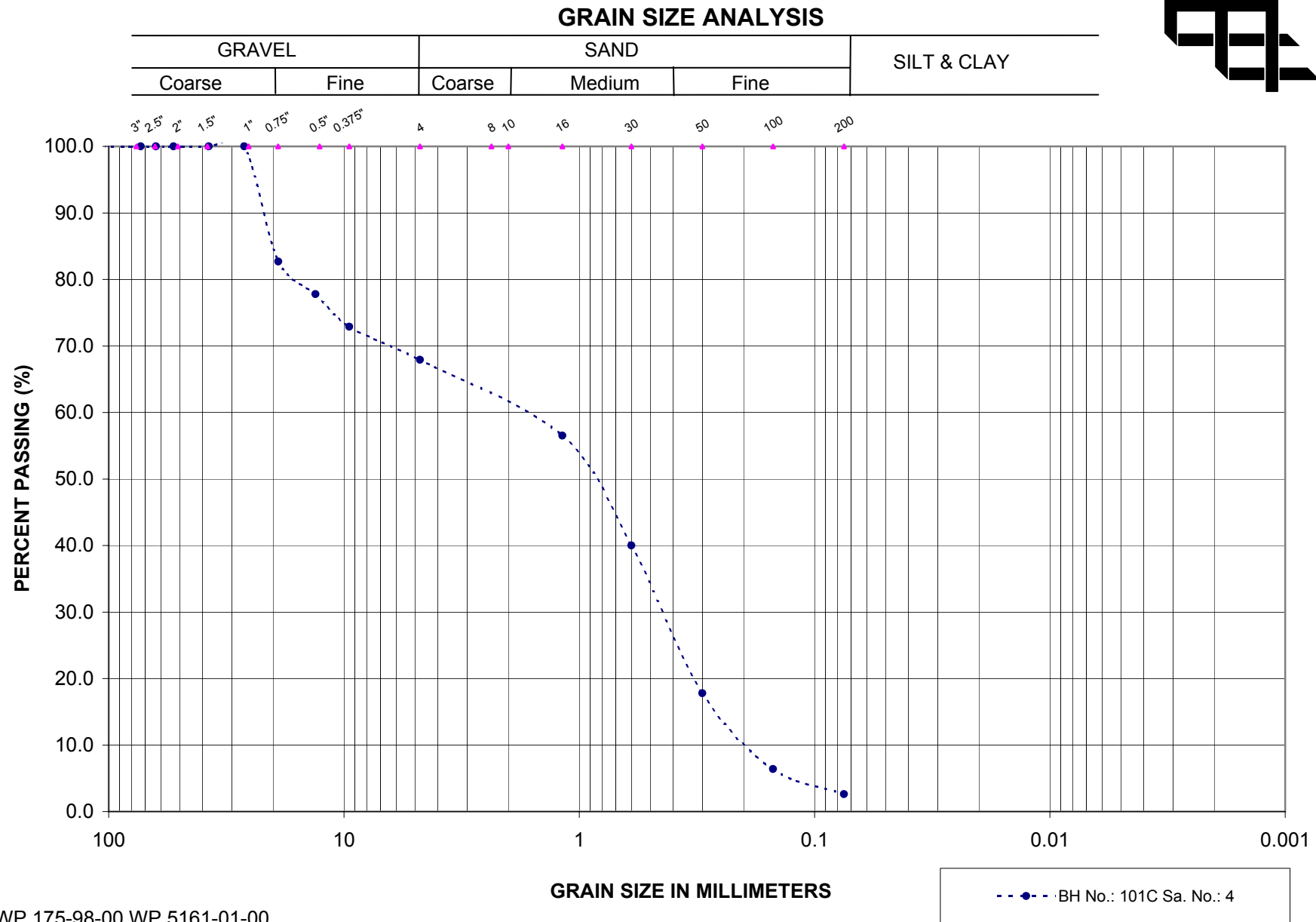
NOTE 1:

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
	25/01/06	DVL	REV 0 - Borehole Stations & Plots
	25/01/06	DVL	REV 1- Cross Sections
	01/03/06	DVL	REV 2- Added BH 104B

HWY No. 17 - 13+300			DIST
DWG File: 05090FD - Pimisi Bay Culvert - MEL			
DRAWN DVL	CHK	MAM	DATE 05/01/06
			FIG A2



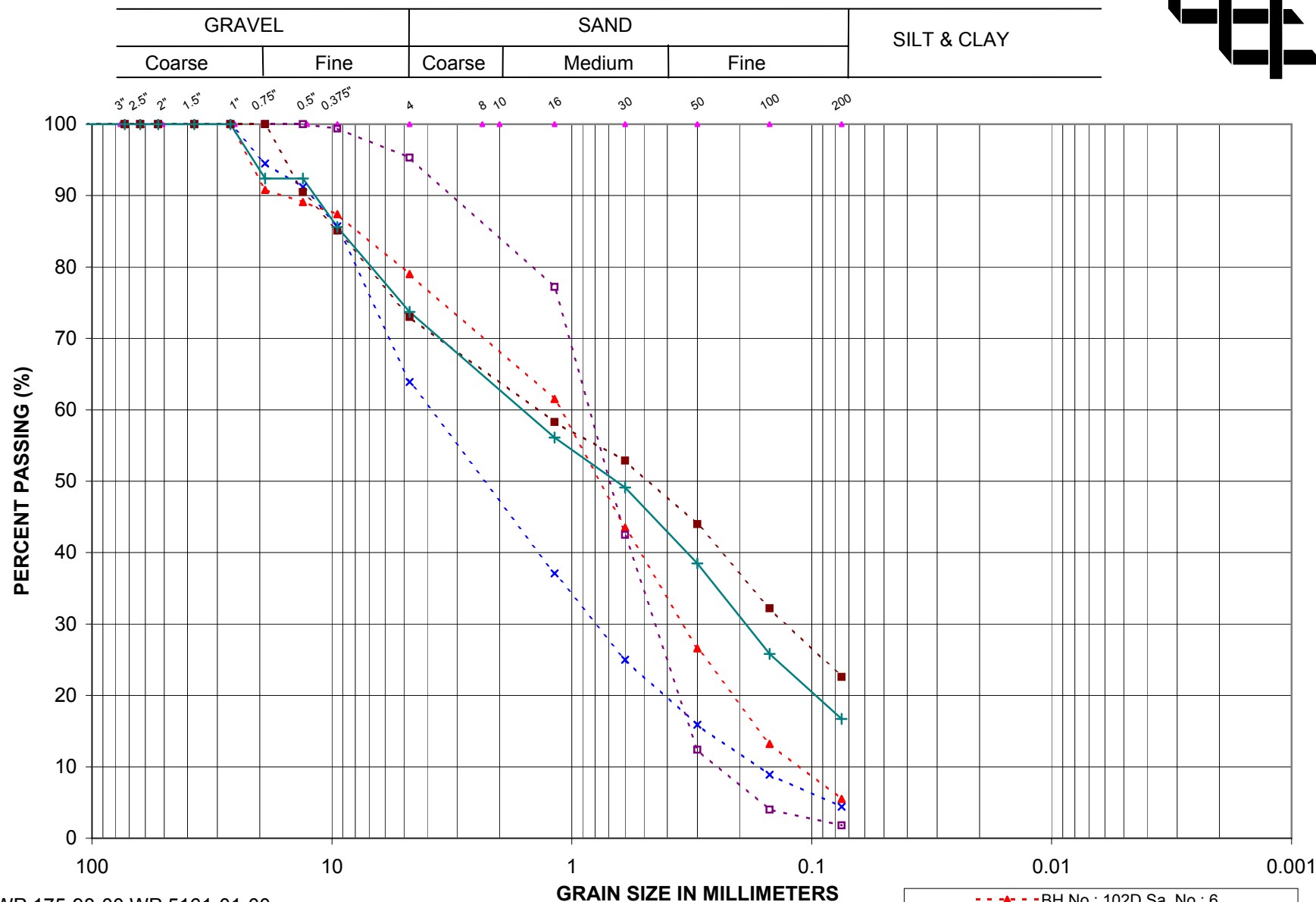


GWP 175-98-00 WP 5161-01-00
 Foundation Area D
 Highway 17, Township of Calvin
 Pimisi Bay Culvert

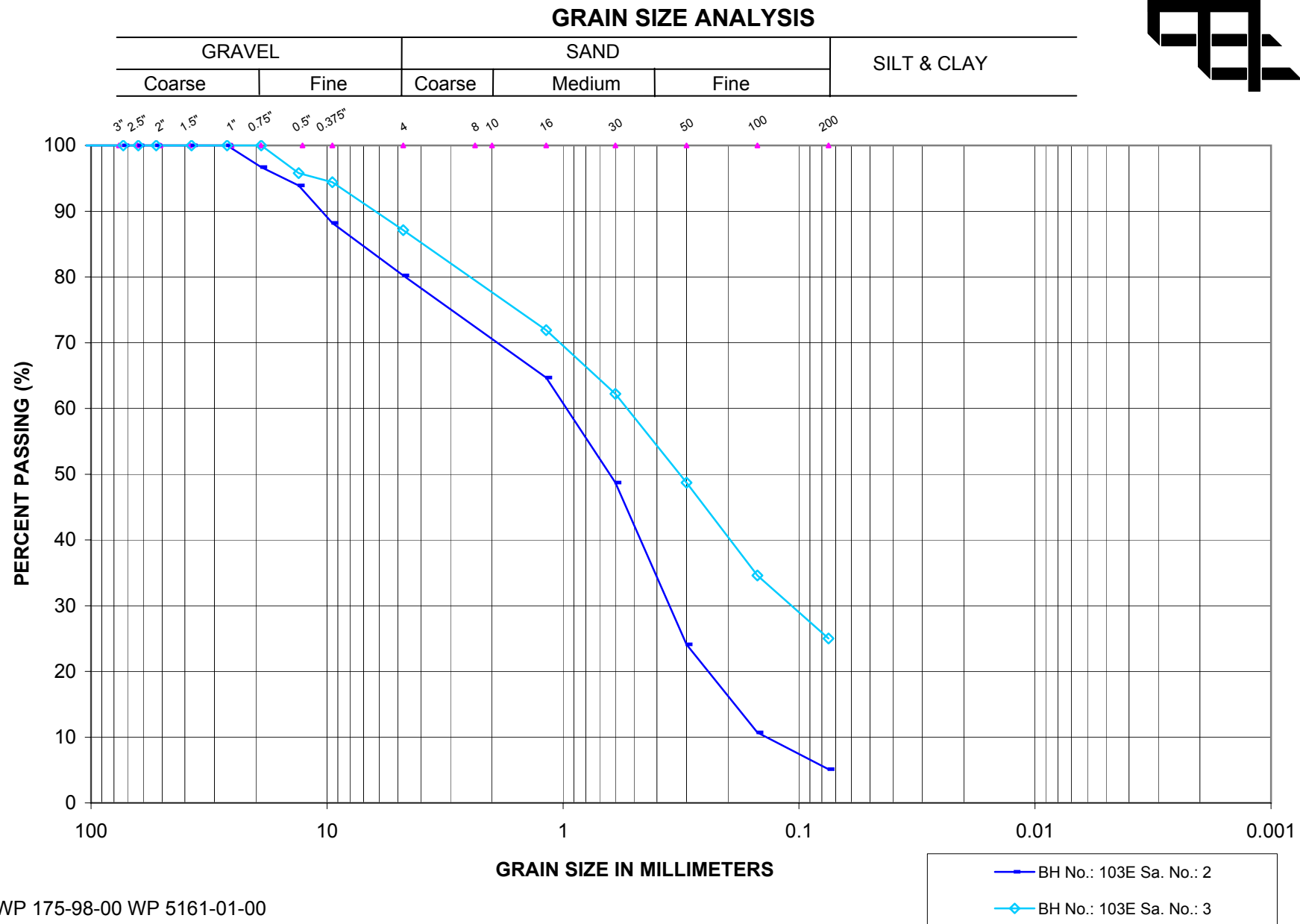
SANDS
 with Gravel, trace of Silt



GRAIN SIZE ANALYSIS

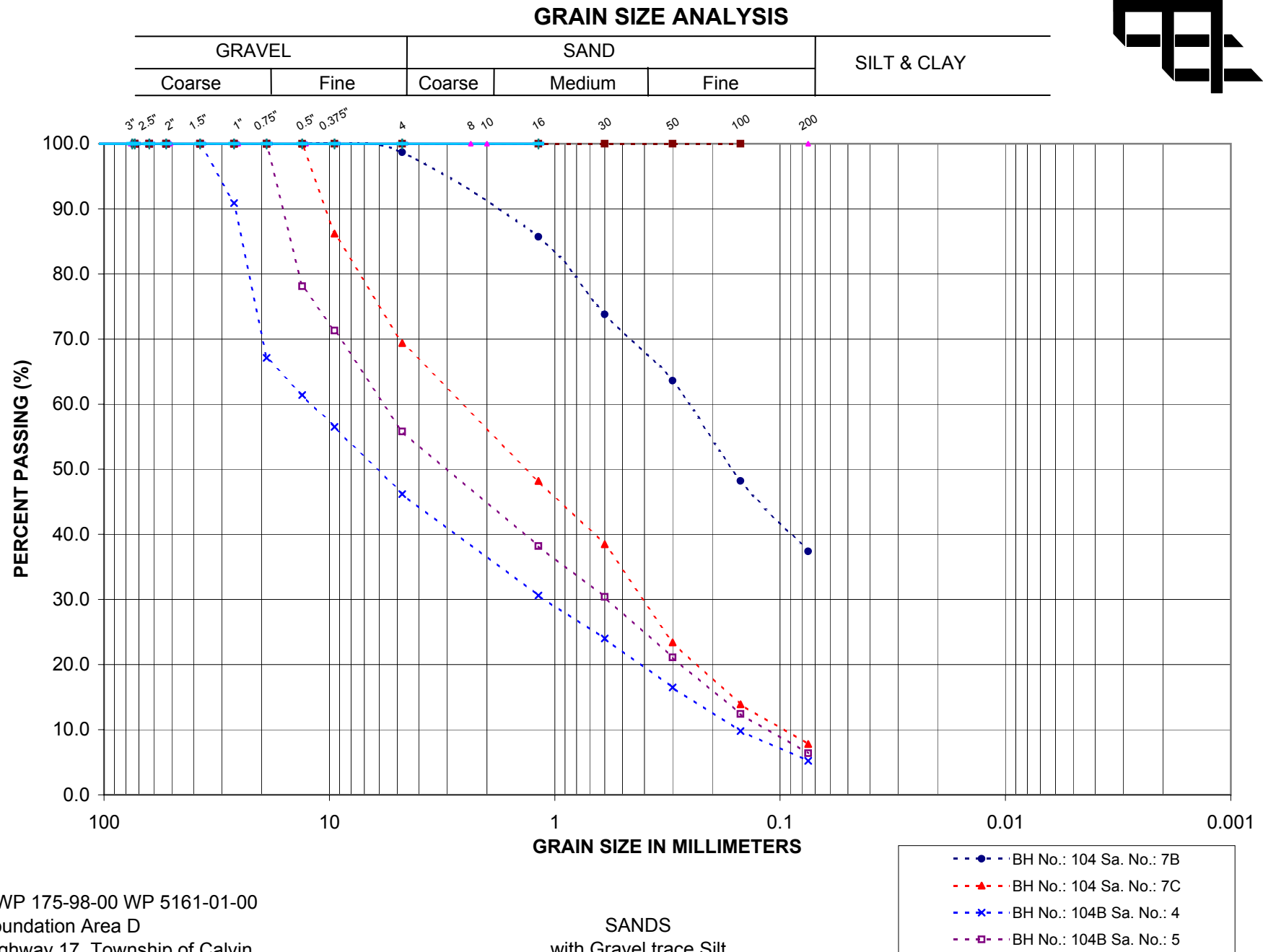


GWP 175-98-00 WP 5161-01-00
 Foundation Area D
 Highway 17, Township of Calvin
 Pimisi Bay Culvert



GWP 175-98-00 WP 5161-01-00
 Foundation Area D
 Highway 17, Township of Calvin
 Pimisi Bay Culvert

EMBANKMENT FILL
 SANDS - some Gravel, trace Silt frequent Cobbles/Boulder Sizes



APPENDIX D

- Enclosure No. 8: Photo Essay
- Enclosure No. 9: Geotechnical Data on Embankment
Grade Lowering
- Enclosure No. 10: Slope Stability Analysis



Photo: 1



Township of Calvin, Foundation Area D
 Interior Alignment of Culvert

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

Photo: 2



Township of Calvin, Foundation Area D
 Culvert Discharge – North Side of Embankment

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



Photo: 3



Township of Calvin, Foundation Area D
Culvert Inlet – South Side Embankment

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



MTO Project: GWP 175-98-00, WP 5161-01-00
Description: Highway. 17, Township of Calvin
Pimisi Bay Culvert, Station 13+300
Culvert Site 43-261

MEL Ref No.: 05/07/05090-FD
Date: January 23, 2006

The following is a copy of the email sent to Earth Tech (Canada) Inc. on January 23, 2006:

From: Evan Clinch [merlex@on.aibn.com]
Sent: January 23, 2006 12:40 PM
To: 'Terry.Barber@earthtech.ca'
Subject: Pimisi Bay Culvert BHs

Attachments: 05090-G1 - BH Logs - Pimisi Bay.doc

Terry,

Attached are the boreholes we drilled at the Pimisi Bay culvert site that you asked for.

When designing the excavation to lower the grade, the following should be considered:

1)

To avoid disturbing the chinking on the existing rock fill, for design purposes set the bottom of excavation a minimum of 150 mm above the existing rock subgrade. A special provision should be included in the contract stating that if the surface of the existing rock fill is disturbed (outside of the limits of the actual culvert excavation area) it must be reinstated prior to constructing the temporary pavement structure.

2)

The temporary pavement structure for the staging should consist of a minimum of 50 mm of temporary hot mix over a minimum of 100 mm of Granular 'A' base material, over the surface of the existing granular at the bottom of the excavation.

3)

There is an existing polystyrene frost heave treatment to the west of the culvert site. Most likely the excavation to lower the grade will miss this treatment, but if the polystyrene is effected it must be replaced. The polystyrene is noted on the borehole logs.

If you need more information, please let me know.

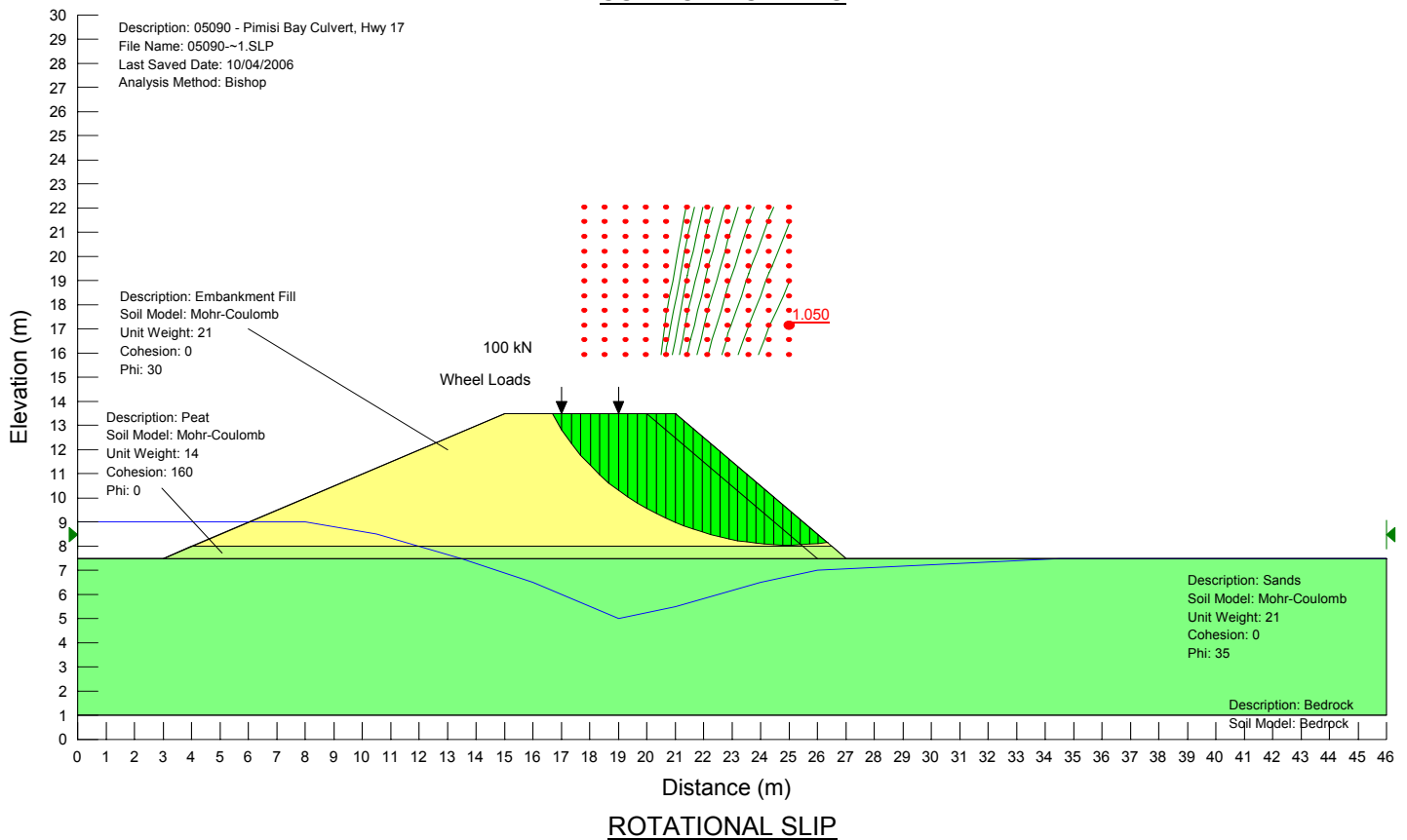
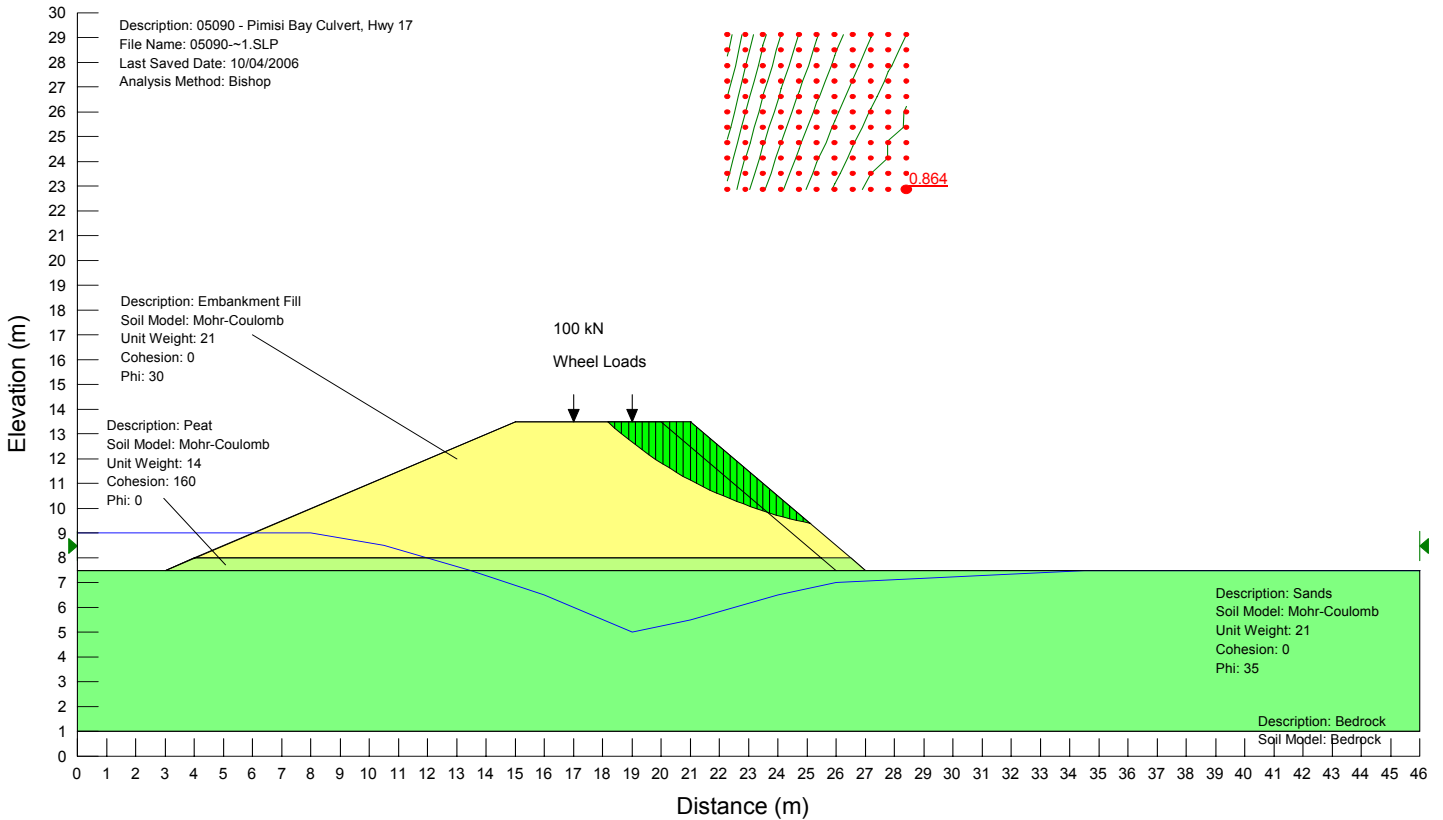
Regards
Evan

13+050	7.8 m Lt C/L12/20	13+110	5.7 m Lt C/L12/20
0 - 300	Cr Gr	0 - 300	Cr Gr
300 - 500	Med F Sa Tr Gr Tr Si	300 - 500	Med F Sa Tr Gr Tr Si
500 - 700	Sh Rk or Blds	500 - 750	Sh Rk
700 - 725	Psty	750 - 1.6	Med F Sa Tr Gr Tr Si
725 - 1.25	Med F Sa Tr Gr Tr Si	1.6	NFP Sh Rk
1.25	NFP Sh Rk		
13+055	7.8 m Lt C/L12/20	13+130	4.8 m Lt C/L12/20
0 - 300	Cr Gr	0 - 350	Cr Gr
300 - 500	Med F Sa Tr Gr Tr Si	350 - 500	Med F Sa Tr Gr Tr Si
500 - 700	Sh Rk or Blds	500 - 900	Sh Rk
700 - 725	Psty	900 - 1.5	Med F Sa Tr Gr Tr Si
725 - 1.5	Med F Sa Tr Gr Tr Si	1.5	NFP Sh Rk
1.5	NFP BR or Blds		
13+060	7.8 m Lt C/L12/20	13+150	4.7 m Lt C/L12/20
0 - 300	Cr Gr	0 - 350	Cr Gr
300 - 500	Med F Sa Tr Gr Tr Si	350 - 600	Med F Sa Some Gr Tr Si
500 - 700	Sh Rk or Blds	600 - 800	Sh Rk
700 - 725	Psty	800 - 1.4	Med F Sa Tr Gr Tr Si
725 - 1.4	Med F Sa Some Gr Tr Si	1.4	NFP Sh Rk
1.4 - 2.1	Cl Si		
13+070	7.8 m Lt C/L12/20	13+170	4.7 m Lt C/L12/20
0 - 300	Cr Gr	0 - 350	Cr Gr
300 - 500	Med F Sa Tr Gr Tr Si Occ Cobs	350 - 550	Med F Sa Tr Gr Tr Si
500 - 700	Sh Rk or Blds	550 - 800	Sh Rk
700 - 725	Psty	800 - 1.4	Med F Sa Tr Gr Tr Si
725 - 1.45	Med F Sa Some Gr Tr Si	1.4	NFP Sh Rk
1.45- 2.1	Cl Si		
13+090	6.9 m Lt C/L12/20	13+190	4.7 m Lt C/L12/20
0 - 300	Cr Gr	0 - 350	Cr Gr
300 - 500	Med F Sa Tr Gr Tr Si	350 - 1.7	Med F Sa Tr Gr Tr Si Occ Cobs
500 - 700	Sh Rk	1.7	NFP Sh Rk
700 - 725	Psty		
725 - 1.7	Med F Sa	13+200	4.7 m Lt C/L12/20
1.7	NFP Sh Rk	0 - 350	Cr Gr
		350 - 1.4	Med F Sa Tr Gr Tr Si Occ Cobs
		1.4	NFP Sh Rk
13+104	5.6 m Lt C/L12/20	13+220	4.7 m Lt C/L12/20
0 - 350	Cr Gr	0 - 300	Cr Gr
350 - 500	Med F Sa Tr Gr Tr Si	300 - 1.3	Med F Sa Tr Gr Tr Si Occ Cobs
500 - 800	Sh Rk	1.3	NFP Sh Rk
800 - 1.1	Med F Sa Tr Gr Tr Si	13+240	5.3 m Lt C/L12/19
1.1 - 1.13	Psty (edge of Psty W side of borehole only)	0 - 300	Cr Gr
1.13- 1.6	Med F Sa Tr Gr Tr Si	300 - 2.0	Med F Sa Tr Gr Tr Si
1.6	NFP Sh Rk		Occ Cobs @ 1.2

13+260	5.3 m Lt C/L12/19	13+430	5.7 m Lt C/L12/19
0 - 300	Cr Gr	0 - 300	Cr Gr
300 - 2.0	Med F Sa Tr Gr Tr Si Occ Cobs	300 - 1.7	Med F Sa Tr Gr Tr Si 05MCH002
		1.7	NFP Bld or BR
13+280	5.3 m Lt C/L12/19	13+450	5.7 m Lt C/L12/19
0 - 300	Cr Gr	0 - 300	Cr Gr
300 - 1.2	Med F Sa Tr Gr Tr Si	300 - 900	Med F Sa Tr Si Tr Gr
1.2 - 2.0	Med F Sa Tr Gr Tr Si Occ Cobs	900	NFP Bld or BR
13+300	5.3 m Lt C/L12/19	13+470	5.7 m Lt C/L12/19
0 - 300	Cr Gr	0 - 300	Cr Gr
300 - 1.4	Med F Sa Tr Gr Tr Si Occ Cobs	300 - 1.1	Med F Sa Tr Si
1.4	NFP Bld or Sh RK	1.1	NFP Bld or BR
13+310	5.3 m Lt C/L12/19	13+490	6.0 m Lt C/L12/19
0 - 300	Cr Gr	0 - 300	Cr Gr
300 - 1.2	Med F Sa Tr Gr Tr Si	300 - 750	Med F Sa Tr Si
1.2 - 2.0	Med F Sa Tr Gr Tr Si Occ Cobs	750	NFP Bld or BR
13+330	5.3 m Lt C/L12/19	13+510	6.0 m Lt C/L12/19
0 - 300	Cr Gr	0 - 250	Cr Gr
300 - 1.2	Med F Sa Tr Gr Tr Si	250 - 800	Med F Sa Tr Gr Tr Si Occ Cobs
1.2 - 2.1	Med F Sa W Gr Tr Si Occ Cobs	800	NFP Bld or BR
13+350	5.3 m Lt C/L12/19	13+530	6.2 m Lt C/L12/19
0 - 300	Cr Gr	0 - 300	Cr Gr
300 - 1.1	F Sa Tr Si	300 - 900	Med F Sa Tr Gr Tr Si Occ Cobs
1.1 - 1.5	Sh Rk or Blds	900	NFP Bld or BR
1.5	NFP Sh Rk or Bld		
13+370	5.7 m Lt C/L12/19	13+550	6.5 m Lt C/L12/19
0 - 300	Cr Gr	0 - 80	Asph
300 - 1.1	F Sa Tr Si Tr Gr	80 - 300	Cr Gr
1.1 - 1.4	Med F Sa Tr Gr Tr Si Occ Cobs	300 - 1.4	Med F Sa Tr Gr Tr Si Occ Cobs
1.4	NFP Sh Rk/BR	1.4	NFP Bld or BR
13+390	5.9 m Lt C/L12/19		
0 - 60	Asph		
60 - 350	Cr Gr		
350 - 1.35	F Sa Tr Si Tr Gr		
1.35	NFP Sh Rk/BR		
13+410	5.7 m Lt C/L12/19		
0 - 300	Cr Gr		
300 - 1.1	F Sa Tr Gr Tr Si		
1.1	NFP Bld or BR		

Slope Stability Analysis
WP 5161-01-00 Foundation Area D
Pimisi Bay Culvert

ENCLOSURE NO. 10



Date: Apr-06
Project: 05/07/05090-FD

Drawn: JRB
Checked: MAM