Foundation Investigation and Design Report

Culvert Replacement at LaChappelle Creek

GWP 70-97-00

Highway 527
106.5 km north of Highway 11/17

MTO Site No.: 48C-224C
Geocres No.: 52H14

Prepared for
Ministry of Transportation, Northwestern Region

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Part A FOUNDATION INVESTIGATION REPORT

1 Introduction

TBT Engineering has been retained by The Ministry of Transportation, Northwestern Region to carry out a Total Project Management (TPM) design assignment for the upgrading of Hwy 527 from 97.5 km north of Highway 11/17 northerly for 25.0 km. As a part of this assignment TBT Engineering has provided Foundation Engineering services for the proposed culvert replacement at LaChappelle Creek, Site No. 48C-224C.

The site is located on Highway 527, approximately 106.5 km north of Highway 11/17.

Two existing culverts are to be replaced with a new culvert-type structure.

A foundation investigation was carried out to investigate subsurface conditions at the site. This investigation consisted of a number of boreholes drilled in the vicinity of the proposed new structure location, test pits to supplement the boreholes, laboratory testing and geotechnical analysis of the data. This report provides a summary of that work and of the conditions encountered.

The foundation section has assigned GEOCRES No. 52H-14 to this site.

2 Site Description

The site is located on Highway 527, approximately 106.5 km north of Highway 11/17. At this location Highway 527 runs generally in a north-south direction. The LaChappelle Creek runs in a slightly skewed southwest to northeast direction through the culverts. The two existing CSP culverts are to be replaced with a single culvert.

The area surrounding the culvert site is isolated and generally covered with mixed forest. The terrain in the immediate surrounding area is bedrock controlled, with the Creek following a zone of low ground. The quaternary geology of the site is mapped as a zone of glacio-fluvial outwash deposits surrounded by large areas of undifferentiated pre-cambrian bedrock. (Ministry of Northern Development and Mines, Ontario Geological Survey, Map 2554).

The creek and its flood plain are about 6 m below the current road grade. Upstream of the culverts the creek is wider with shallow vegetated banks. Downstream the channel is better defined. The visible creek bed is made up of coarse sands, gravels and cobbles. Numerous large boulders are present at the site. The water level in the tributary was at approximately 443.5 m elevation at the time of our investigation (Summer 2003).

The road embankment is about six metres high with fore slopes close to 1.5 h:1v. The culvert is located at the base of a gully through the local undulating bedrock topography. The depth of the embankment decreases north and south of the culvert as the adjacent lands rise.

The road profile is in a cut section both north and south of the Creek embankment. The fill section across the creek is about 80 m in length.

Highway 527 is a two lane paved section through the culvert site. There is no known history of settlements or distortions at this embankment.

Culvert Site, From the West, Site No. 48C-224C (Upstream side)

3 Investigation Procedures

A site investigation was undertaken in several phases between July 23 and September 18, 2003. Various investigation techniques were used depending on the conditions encountered.

A truck mounted CME 55 was used for geotechnical sampling and testing at locations accessible to the truck mounted rig. A track mounted CME 45 drill rig was used at boreholes that were not truck accessible. At Borehole 9, drilled through the top of the roadway embankment, a water well drill rig was used to advance a casing through the rock fill. The borehole was advanced from the bottom of the casing using the CME 55 drill.

Bedrock was sampled at three boreholes using NQ diamond core equipment to obtain the cores.

A number of test holes drilled to investigate embankment conditions encountered shallow refusal in the rock fill, coarse gravels or on bedrock. A large Caterpillar 219 LC track-mounted backhoe was mobilized to the site to excavate test pits through the coarse materials. A total of 11 test pits were excavated.

Soil samples were obtained at the boreholes with a split spoon sampler as a part of the Standard Penetration Testing (SPT). The SPT involves driving a thick walled sampler into the soils under a standardized energy (63.5 kg, falling 760 mm). The number of blows required to drive the sampler 0.3 m, known as the SPT blow count (N), was recorded.

Borehole locations and elevations were referenced from Plan B & C – 491892-527-6 and E-491892-527-1, Hwy 527, Un-surveyed Territory Sta. 19+880 to 19+980.

The borehole characteristics and drill techniques utilized are summarized in Table 1.

Table 1. Drill Summary

Location	Surface Elevation (metres)	Bedrock / Refusal (Elevation/Depth) (metres)	Bottom of Hole (Elevation/Depth) (metres)	Comments
BH 1	444.5	440.9/3.6	437.9/6.6	NQ Core obtained
BH 2	443.9	439.8/4.1	436.8/7.1	NQ Core obtained
BH 3	450.2	449.9/0.3	449.9/0.3	Refusal in rock fill
BH 4	452.0	451.1/0.9	451.1/0.9	Refusal on inferred bedrock
BH 5	453.3	451.5/1.8	451.5/1.8	Refusal on rock fill or fractured bedrock
BH 6	451.7	450.5/1.2	450.5/1.2	Refusal on boulder or possible bedrock
BH 7	449.8	447.5/2.3	447.5/2.3	Refusal in cobbles
BH 8	450.2	448.7/1.5	448.7/1.5	Refusal/Split Spoon "bouncing"
BH 9	449.8	440.5/9.3	432.8/17.0	8 m of NQ Core obtained

Table 2. Test Pit Summary

Location	Surface Elevation (metres)	Bedrock (Elevation/Depth) (metres)	Comments
TP 1	445.0	441.0/4.0	Refusal on bedrock
TP 2	451.2	449.4/1.8	Refusal on bedrock
TP 3	453.2		Excavation from shoulder rounding
TP 4	450.6	449.8/0.8	Refusal on bedrock
TP 5	444.0	442.3/1.7	Refusal on bedrock
TP 6	448.8	446.6/2.2	Refusal on bedrock
TP 7	449.8		Excavation from shoulder rounding
TP 8	451.6	450.7/0.9	Refusal on bedrock
TP 9	449.2	448.0/1.2	Refusal on bedrock
TP 10	444.6	441.3/3.3	Refusal on bedrock
TP 11	449.8		Excavation from shoulder rounding

The boreholes were backfilled at the completion of the investigations using a cement/bentonite backfill to ensure the environmental integrity of the site. Standpipe piezometers were removed.

Soil samples were transported to TBT Engineering's laboratory in Thunder Bay for testing. Routine testing included moisture content, grain size analysis and Atterberg

Limits. Bedrock samples were stored in core boxes for review with recovery and rock quality designation values determined. The results of this testing are shown on the Borehole Logs (Appendix A) and on the laboratory data reports (Appendix B). Photographs of some of the test pits are provided in Appendix C.

4 General Site Geology and Sub-Surface Conditions

4.1 Site Geology

The surficial geology of the area consists predominantly of glaciofluvial deposits – sand and gravel, till, and bedrock knobs, with an undulating to rolling surface relief. Pro-glacial and deltaic deposits are also mapped in the area (Quaternary Geology of Ontario, West-Central Sheet, Ontario Geological Survey, Map 2554).

The bedrock type observed in the area, and shown on published geological maps is a felsic igneous rock of the early Precambrian age. To the south of LaChappelle Creek mafic intrusive bedrock surfaces were observed in test pit excavations, identified on published geological maps as mafic igneous rocks of the middle to late Precambrian age.

4.2 Subsurface Conditions

Details of the subsurface conditions are provided on the Borehole Logs, Appendix A, and on the Section Plans, Drawings 1 and 2. In general, the subsurface conditions at the site consist of coarse sands and gravels overlying sloping bedrock. The sands and gravels include both embankment fill materials and similar native soils.

Groundwater levels near the culvert were similar to the level of the LaChappelle Creek at the time of the investigation. North and south of the Creek, the ground water levels rose with the bedrock profile.

4.2.1 Fill

There is approximately 0.8 m of pavement structure across at this site. This is made up of about 45 mm of hot mix, 150 mm of crushed granular base and 0.6 m of granular sub-base. Investigations undertaken as part of the pavement design aspects of the project indicate that little of the structural fill meets current gradation specifications for base and sub-base granulars.

The pavement structure is underlain with coarse embankment fill. This fill is composed of a mixture of blasted shot rock and sands and gravels similar to the native soils. The

embankment was likely originally constructed of fills obtained from both earth and rock borrow areas.

The grain size distribution of the fill varies widely (Figures 1 and 2). The size fractions of the fill range from silt sizes to boulders in excess of 0.8 m in diameter. In most zones the fill is relatively well graded with a range of all size fractions present. In a few zones the fill is very poorly graded, consisting of heterogeneous mixtures of coarse gravels, cobbles and boulders with little fine graded matrix. Because of the wide variation in grain size distributions, the hydraulic conductivity of the fill is expected to vary from less than 10^{-4} cm/sec to more than 10 cm/sec. Groundwater flows through the coarser fractions can be extremely rapid.

4.2.2 Sand and Gravel

In all boreholes and test pits, roadway fill materials were found overlying a deposit of sand and gravel (glacial till). The till typically consists of a heterogeneous mixture of sand and gravel, silts and clays, with frequent angular cobbles and boulders. The coarse fraction is angular (cobbles and boulders) and shows little evidence of weathering.

Within the vicinity of the culverts the till extends approximately to elevation 440 m, near 3 m below the culvert invert. Based on SPT data the till is in a compact to very dense condition.

Grain size analyses conducted on selected samples of the till (Figures 3-4) indicate a well graded material with a fines fraction (percent passing the 0.075 mm sieve) of 12 to 22 percent. In-situ hydraulic conductivities within the till are expected to be in the order of 10^{-2} to 10^{-5} cm/sec., based on grain size data. This material is considered susceptible to frost heave.

At Test Pits 5 and 10, a zone of very coarse gravel and cobbles (with boulders) was encountered with little finer grained soil matrix present. These materials may be shot rock fill zones resulting from earlier road building activities. Where these zones of

materials are present, in situ hydraulic conductivities will be very high and will be subject to rapid ground water flow.

Several test locations (BH 1, BH 2, TP 5, TP 10) encountered a thin (approximately 0.5 m thick) layer of very dense non-plastic sandy/clayey silt (hardpan) directly overlying bedrock. The layer was detected on both the west and east sides of Hwy 527. The dense 'hardpan' material is grey in colour and well graded with gradation fractions of 46 % silt, 33 % sand, 10 % clay, and 11% fine gravel sizes. As shown on the grain size distribution curve (Figure 5)

4.2.3 Bedrock

Bedrock outcrops can be observed throughout the ridges to the north and south of the site. Within the culvert and drainage channel area, no outcroppings of rock were evident at the time of investigation. The bedrock surface as interpreted from core data, refusals in the boreholes and test pit data, forms an east-west valley across the central part of the site.

Bedrock elevations in the vicinity of the proposed culvert range from 440.9 m at the east end (BH 1) to 439.7 at the west end (BH 2). Bedrock was encountered at elevation 440.5 m at Borehole 9 (south bound lane shoulder immediately south of the culverts), approximately 3 m below culvert invert.

Bedrock samples were collected using "NQ"-size diamond drill core. A minimum of three lineal metres of rock core was collected from each of Boreholes 1, 2, and 9. Rock cores were returned to our Thunder Bay laboratory for analysis. The following descriptive analysis of the rock mass within the immediate site area is based on MTO's *Guide to the Description of Rock for Engineering Purposes*:

> The rock mass at the subject site is a hard, coarse grained, pink, massive felsic intrusive rock with an engineering rock quality of fair, based on RQD values. The intact rock material is expected to be of high to very high strength, however the mass has closely to moderately spaced discontinuities infilled with precipitated non-softening clays (< 5mm) which further reduces

the quality of the mass, with reference to engineering properties. Rock cores from the rock mass, indicate the mass contains both open and filled joints with apertures in the range of <1 mm to 2 mm. Open joints were noted to have rough faces.

4.2.4 Ground Water

The ground water levels at the site generally correspond to water levels within the LaChappelle Creek at the time of the investigation. (Elevation 443.5 m). Near the creek these levels are expected to reflect hydrostatic conditions in the Creek, with some time lag, and should be expected to fluctuate with changes in the seasons. The ground water level will rise to the north and south reflecting topographic and bedrock influences.

PART B FOUNDATION DESIGN RECOMMENDATIONS

5 Discussions and Engineering Recommendations

5.1 Introduction

The existing two culverts at LaChappelle Creek, Site No. 48C-224C, across Highway 527 are to be replaced under WP 70-97-00. The design project is being carried out under a TPM Agreement between the Ministry of Transportation and TBT Engineering who are also providing Foundation Engineering services for the project.

The new culvert is now anticipated to be an open footing steel box shape with a span of approximately 7 m and a rise of 2.6 m above the footings. The design of the culvert will be conducted in accordance with the Canadian Highway Bridge Design Code (CHBDC).

The horizontal alignment of the Highway will remain essentially unchanged. A vertical grade raise of approximately 1.5 m is anticipated. The top of the embankment over the culvert will be near elevation 451.8 m, about 8 m above the normal water level in the creek (443.8 m).

The foundation investigation as described in Part A, was carried out to investigate subsurface conditions at the site. This investigation consisted of a number of boreholes and test pits advanced in the vicinity of the new structure, laboratory testing and geotechnical analysis of the data. The purpose of this section of the report (Part B) is to provide geotechnical design recommendations for the project. These are based on the conditions encountered at the test locations and our interpretation of the subsurface conditions at the site.

5.2 Culvert Foundations

The foundation system for the proposed structure must support the design loads within acceptable settlement tolerances and must accommodate all anticipated loadings. The soil conditions at this site include coarse fill materials with sand and gravels overlying relatively shallow bedrock.

The design configuration involves the use of a box shaped, open bottom steel culvert structure. Various culvert and foundation options were reviewed during the design process. Culvert options reviewed included arch shapes, concrete open bottom and closed box shapes. The use of both shallow and deep foundations were reviewed, however given the relatively shallow bedrock, the shallow depth to competent material and the structural configuration, conventional shallow foundations are recommended.

The base of the culvert (top of footing) is to be above the groundwater level, between elevations 443.7 (east end) and 444.0 m (west end). The bottom of the footing will be, approximately 1.5 m deeper, founded in overburden soils. The culvert will be about 7.0 m wide and 2.61 m high. Design of the culvert sections including specification of backfill will be carried out by the supplier.

It is understood that the proposed culvert structure will impose factored vertical linear foundation loadings in the order of 190 kN dead load plus 55 kN live load (ULS) and 160 kN dead load plus 30 kN live load (SLS).

The design frost depth for this project is 2.5 m.

5.3 Foundation Design - Culvert

The culvert foundations will be supported by concrete footings founded below the invert level. Footings designed with at least 1.2 m of soil cover may be designed using the capacities shown in Table 3.

Table 3, Strip Footing Design Capacities

Footing Width	Factored Geotechnical Resistance at ULS	Design Capacity (SLS) 25 mm settlement
1.0 -1.5 m	250 kPa	SLS Capacity does not govern

5.4 Foundation Design – Bailey Bridge

The Bailey bridge foundations will be carried by bin wall footings founded on the horizontal surface behind the crest of the temporary excavation for the culvert. The footings will be approximately 2.6 m wide and 9.1 m long.

A Factored Geotechnical Resistance at ULS of 125 kPa at the bottom of the bin wall can be attained providing the face of the footing is at least 1.0m or more from the face of the slope.

The SLS capacity of this footing at 30 mm settlement is greater than the ULS capacity and does not govern.

5.5 Soil Backfill

Design of the LaChappelle Creek culvert is to be carried out by the supplier. Construction shall conform to the supplier's requirements. Fill placed outside of the Granular A as required by the culvert manufacturer should be sloped using a frost taper, with d=300 mm and f=2.5 m (similar to frost taper shown on OPSD 3501.000).

To limit differential frost heave at the ends of the polystyrene, a transition zone is recommended.

Design unit weights for granular backfill are applicable as follows:

Granular A	22 kN/m3
Granular B (Type III)	21 kN/m3

Backfill behind the culvert must be free draining. The fill may be specified as Granular A or Granular B, Type III depending on the culvert supplier's requirements.

5.6 Embankment Stability- Longitudinal

The culvert will be designed to support vertical loadings above the foundation level. The culvert supplier normally does not carry out global stability design. The inclusion of an open bottom structure within the highway embankment has a potential to induce soil failures into the base of the channel. The primary driving force of the failure is the weight of the embankment fill adjacent to and above the culvert. The driving forces must be resisted by the mobilized shear strength of the embankment fill and base materials. The box culvert provides limited lateral support. The lateral structural strength available from the culvert section is in the order of 30 kN/m.

The culvert design requires the use of a 4.0 m thickness of polystyrene lightweight fill above the culvert section to limit vertical loadings on the culvert.

Stability calculations were carried out using Slope-W software and soil parameters determined by laboratory testing and from published correlations. A target factor of safety of 1.3 was utilized. The analysis was carried out using Janbu, Bishops and Morgenstern-Price analyses. The parameters listed in Table 4 were used for the stability analyses.

Table 4- Soil Parameters used in Stability Analyses

Soil	Unit Weight (KN/m^3)	Cohesion (kPa)	Phi (Degrees)
Embankment fill	19	0	38
Rock Fill	17	0	42
Sand and Gravel	19	0	36
Polystyrene	0.1	30	0

Stability analyses were carried out for two conditions. The initial conservative analyses were on the basis that the lightweight fill (LWF) did not have a significant compressive strength that could contribute lateral capacity to the system (Case 1). This was based on the strain compatibility issues between the granular/steel components and the softer polystyrene LWF which could not be resolved with the supplier. The Ministry has indicated (meeting of July 29, 2004) that based on their experience with these culverts a less conservative approach may be considered. As such a second approach was adopted for the analysis that includes the compressive capacity for the LWF and passive pressures from soils above the culvert (Case 2). The polystyrene has a specified (Special Provision C3-00211) compressive strength of 110 kPa, and a maximum permanent stress capability of 30% of this (33 kPa).

The initial conservative analyses of the culvert configuration indicated that the soils at this site, at the design configuration, do not have sufficient shear strength (factor of safety <1) to resist the driving forces induced by the weight of the embankment. Therefore the lightweight fill used over the culvert should be extended on both sides of the culvert along the road alignment, to decrease the driving forces in the embankment. Extending the polystyrene 8.6 m beyond both walls of the culvert will reduce the driving forces such that satisfactory factors of safety (> 1.3) are attained (Case 1). A graphical summary of the length of LWF (beyond the culvert) versus theoretical factor of safety is provided in Appendix D.

Based on the second analyses, incorporating the compressive strength capacity of the LWF, and the assumption of risk by the Ministry, the longitudinal extent of the lightweight fill may be reduced to a length extending 4.0 beyond each wall of the culvert (Case 2). A graphical summary of the length of LWF (beyond the culvert) versus theoretical factor of safety is provided in Appendix D.

Polystyrene lightweight fill should be specified and placed in accordance with Special Provision C3-00211.

The lightweight fill is buoyant and subject to uplift when submerged. However at this site the polystyrene will be entirely above the high water mark (444.68 m).

All fill soils used to restore the embankment should consist of Granular A, Granular B, Type III or rock fill. Embankment fill must be placed and compacted in accordance with OPSS requirements.

5.7 Embankments

The horizontal highway alignment is to remain essentially unchanged. A vertical revision of approximately 1.5 m is anticipated. As a result the embankment section will be widened and the culvert length increased.

Where rock fill is used, fore-slopes should be constructed to an inclination of 1.5h:1v or flatter. Where granular fill is used, slopes should be not steeper than 2h:1v.

Settlements of the embankment due to the additional weight of the fill will be small, less than 25 mm, and will occur as the fill is placed. The new fill thickness and resulting settlements will be approximately equal over the length of the culvert. No camber of the culvert profile is required.

The face of the slope that borders on the creek should be provided with a 0.6 m thickness of rock protection (OPSS 1004.05.06.02) to the high water level. Elsewhere, exposed granular slopes should be seeded to provide protection from erosion and surficial sloughing.

The embankment fill used to restore the roadway to the pavement sub-grade level should consist of Granular A, Granular B, Type III or rock fill. Above this the pavement fill structure should be placed as per the Geotechnical Design Report.

In general, temporary cuts in the existing embankment fills may be trimmed to 1.5h:1v or flatter. Isolated areas of soft or loose materials should be anticipated, and the temporary slopes flattened in these areas.

Granular soils are present near the proposed foundation level. Below the water level, these materials can be very porous and the granular materials subject to sloughing and erosion. Temporary support of the existing embankment and base materials will be required. The design of the temporary support must include the effects of the existing embankment.

5.8 Lateral Loadings - Headwalls

Culvert headwalls (if utilized) should be designed to resist lateral loadings induced by backfill adjacent to the walls at appropriate deformation conditions. Backfill should consist of free draining granular materials such as Granular B. Earth pressures may be calculated using the methods provided in Canadian Highway Bridge Design Code, or using a triangular pressure distribution as provided in the Canadian Foundation Engineering Manual and the parameters provided in Table 5. Active soil loadings are appropriate where sufficient deformation of the headwall can occur. For rigid designs, the at-rest condition should be used.

Table 5 - Embankment Soil Parameters (unfactored) Level Backfill

Soil	Active Earth Pressure Coefficient (Ka)	At-Rest Earth Pressure Coefficient (Ko)	Passive Earth Pressure Coefficient (Kp)	Unit Weight (KN/m^3)	Phi (Degrees)
Granular A	0.27	0.43	3.7	22	35
Granular B	0.30	0.46	3.4	21	33

Weeping tile and/or weep holes should be provided to prevent development of hydrostatic pressures behind the abutments. The weep holes should be protected with a granular filter or non-woven geotextile to prevent migration of fines. Positive drainage of the weeping tiles should be provided.

5.9 Temporary Shoring - De-watering

Temporary shoring, where required, should be designed to resist lateral loadings and to minimise deformations. The soils encountered are coarse grained with frequent cobbles and boulders present. Zones of materials consisting almost entirely of cobbles and boulders were encountered at some test locations.

Temporary shoring may be designed using the methods provided in the Canadian Foundation Engineering Manual. The loading configurations will depend on the type of shoring system used. In general, temporary shoring may be designed using the following parameters:

Table 6 - Embankment Soil Parameters (unfactored)

Soil	Active Earth Pressure Co-efficient (Ka)	Passive Earth Pressure Co-efficient (Kp)	Unit Weight ($KN/m^{3)}$	Phi (Degrees)
Granular A	0.27	3.7	22	35
Granular B	0.30	3.4	21	33
Sand & Gravel	0.30	3.4	21	33

The estimated permeabilities of the soils below the groundwater table vary from 10^{-5} cm/sec in the silt to more than 10 cm/sec in the rock fill. Because of the high permeability values in the coarser soils, conventional de-watering of excavations below the water table using only sumps and pumps is expected to be difficult, particularly where zones of coarse cobbles and boulders are present below the water table. Alternate forms of ground water control, which may include such methods as large diameter wells, sand bagging, and/or other in situ cofferdams will likely be required.

5.10 Temporary Road Protection

Depending on the construction sequence and configurations used temporary road protection may be required for support of the parts of the embankment and/or pavement structure. Details of the temporary road protection are normally the responsibility of the contractor. Special provisions for Temporary Road Protection (539S01) and RSS (599S22) should be reviewed for inclusion in contract documents.

The coarse fill and the shallow bedrock limit the use of conventional sheet piling. Better success may be possible with soldier piles and lagging although the contractor should be prepared for the anticipated difficult drilling conditions. Gravity wall designs are not expected to be applicable due to the limited space available. Reinforced earth structures may be applicable for fill sections.

There may be some use for trench box type retaining systems for some areas of this project, depending on the configurations used. Site-specific design is required.

These temporary road protection systems may be designed using the methods provided in the Canadian Highway Bridge Design Code. Lateral loads should include active or at-rest pressures as appropriate for the soil support systems and traffic loadings, embankment configuration and the applicable compaction surcharge. Active loads are appropriate for yielding conditions while at-rest pressures should be used for non-yielding cases. Soil pressure coefficients are provided in Table 7.

Table 7 - Embankment Soil Parameters (unfactored), Level Backfill

Soil	Active Earth Pressure Coefficient (Ka)	At-Rest Earth Pressure Coefficient (Ko)	Unit Weight (KN/m^3)	Phi (Degrees)
Sand and Gravel	0.30	0.45	21	33
Granular A	0.27	0.43	22	35
Granular B	0.30	0.45	21	33

5.11 Red Flag Issues

Specific attention should be paid to un-conventional aspects of this project, as previously discussed. Excavations below the water table will be complicated by the presence of coarse, highly permeable materials. The coarse fill and till materials will also prohibit conventional driving of sheet piling. The contractor should be aware of the potential hard driving/drilling anticipated during installation of shoring.

The above comments are not intended to include all critical issues that may become apparent during the construction of this project. The responsibility to deliver acceptable construction quality remains with the contractor.

6 Limitations

Conclusions and recommendations presented in this report are based on the information determined at the test hole locations. Subsurface and groundwater conditions between and beyond these locations may differ from those encountered. Conditions may become apparent during construction that were not detected and could not be anticipated at the time of the site investigation.

The design recommendations provided in this report are based on the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments given in this report on potential construction problems and possible methods of construction are intended only for the guidance of the designer.

Benchmarks and elevations referred to in this report are used primarily to establish relative elevation differences between the test hole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

Groundwater levels indicated are based on the information described within the report. The presence of all conditions that could affect the type and scope of dewatering procedures which may be considered cannot be readily be determined from boreholes. These include local and seasonal fluctuations of the groundwater level, changes in soil conditions between test locations, thin and/or discontinuous layers of highly permeable soils, etc.

The information contained within this report in no way reflects any environmental aspect of the site or soil.

7 Closure

We trust the above addresses your project requirements at this time. Should you have any questions or comments, please do not hesitate the contact us at your convenience.

Yours truly,
For TBT ENGINEERING

Prepared by:

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APPENDIX A

BOREHOLE LOGS

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS $\bar{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	>200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	>3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL
e	1,%	VOID RATIO
n	1,%	POROSITY
w	1,%	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX = $w_L - w_P$
I_L	1	LIQUIDITY INDEX = $\frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_P}$
e_{max}	1,%	VOID RATIO IN LOOSEST STATE
e_{min}	1,%	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

TBT Engineering

RECORD OF BOREHOLE No 1

1 OF 1 **METRIC**

W.P. **70-97-00** PROJECT **Lachappelle Creek Culvert Replacement** SITE NO. **SITE 48C-224C** ORIGINATED BY **JM**

DIST **103** HWY **527** LOCATION **Sta 19+927 - 20.0m Rt, Dist. Thunder Bay** TBTE JOB# **J02-134** COMPILED BY **SP**

DATE **23 July 2003** BOREHOLE TYPE **Hollow Stem Auger - 100mm ID** DATUM **Geodetic** CHECKED BY **WH**

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ■ SPT (N), × FIELD VANE, ★ LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
444.5								20 40 60 80 100	20 40 60		
0.0	GRAVEL - sandy, silty, frequent cobbles, dense, brown/grey (till)						444				Organics present at surface. 'N' Casing used to advance BH. rock fragment in SS tip
			1	SS	36						45 29 (26)
			2	SS	21		443				
			3	SS	28						
441.4							442				52 36 (13)
3.1	SILT - sandy, with gravel, trace clay, grey, moist, very dense (till)		4	SS	70						
440.9			5	SS	100		441				
3.6	BEDROCK - coarse grained Granite, pink, massive, closely to moderatly jointed		6	RC			440				SPT refusal -SS bouncing on bedrock. N size drill core. RQD = 55 %
			7	RC			439				RQD = 68 %
437.9							438				
6.6	End of hole at 6.6 m in bedrock										Standpipe piezometer installed July 25/03. Water level at 0.8 m below grade at 1400 hrs - July 25/03.

$\times^3$, $\star^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 2

1 OF 1 **METRIC**

TBT Engineering

W.P. **70-97-00** PROJECT **Lachappelle Creek Culvert Replacement** SITE NO. **SITE 48C-224C** ORIGINATED BY **JM**

DIST **103** HWY **527** LOCATION **Sta 19+900 - 20.0m Lt. Dist. Thunder Bay** TBTE JOB# **J02-134** COMPILED BY **SP**

DATE **29 July 2003** BOREHOLE TYPE **Hollow Stem Auger - 100mm ID** DATUM **Geodetic** CHECKED BY **WH**

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (O UNCONFINED, ■ SPT (N), × FIELD VANE, ★ LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
443.9											
443.7 / 0.2	FILL - boulders, cobbles (shotrock)										
	SAND & GRAVEL - silty, frequent cobbles, compact to very dense, grey/brown (till)		1	SS	25						
			2	SS	15						
			3	SS	23						
440.3			4	SS	60						28 39 (33)
3.6 / 439.8	SILT - sandy, with gravel, trace clay, grey, moist, very dense (till)		5	SS	100						Rock fragments in tip of SS. SPT refusal - SS bouncing on bedrock.
4.1	BEDROCK - coarse grained Granite, pink, massive, closely to moderately spaced joints, potassium alterations at surface		6	RC							RQD = 53 % N size drill core.
436.8			7	RC							RQD = 72 %
7.1	End of hole at 7.1 m in bedrock										

Elevation scale: 443, 442, 441, 440, 439, 438, 437

Dynamic cone penetration resistance plot: 20 40 60 80 100

Shear strength kPa: 20 40 60 80 100

Water content (%): 20 40 60

$\times^3$, $\star^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

ON_MOT_BH LOG 02-134.GPJ ON_MOT.GDT 30/7/04

TBT Engineering

RECORD OF BOREHOLE No 3

1 OF 1 **METRIC**

W.P. **70-97-00** PROJECT **Lachappelle Creek Culvert Replacement** SITE NO. **SITE 48C-224C** ORIGINATED BY **JM**

DIST **103** HWY **527** LOCATION **Sta 19+825 - 9.0m Lt, Dist. Thunder Bay** TBTE JOB# **J02-134** COMPILED BY **SP**

DATE **5 August 2003** BOREHOLE TYPE **Hollow Stem Auger - 100mm ID** DATUM **Geodetic** CHECKED BY **WH**

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, ✖ FIELD VANE, ■ SPT (N), ★ 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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
450.2											
0.0 / 449.9	Angular rock fill						450				4 attempts made, NFP
0.3	Auger refusal - NFP										

✖³, ★³: Numbers refer to Sensitivity O³% STRAIN AT FAILURE

TBT Engineering

RECORD OF BOREHOLE No 4

1 OF 1 **METRIC**

W.P. **70-97-00** PROJECT **Lachappelle Creek Culvert Replacement** SITE NO. **SITE 48C-224C** ORIGINATED BY **JM**

DIST **103** HWY **527** LOCATION **Sta 19+979 - 9.0m Lt, Dist. Thunder Bay** TBTE JOB# **J02-134** COMPILED BY **SP**

DATE **5 August 2003** BOREHOLE TYPE **Hollow Stem Auger - 100mm ID** DATUM **Geodetic** CHECKED BY **WH**

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
452.0								20 40 60 80 100	W_P W W_L	γ	GR SA SI CL
								O UNCONFINED ✕ FIELD VANE	WATER CONTENT (%)	kN/m³	
								■ SPT (N) ★ LAB VANE	20 40 60		
0.0	SAND - gravelly, silty, brown, moist (till)							20 40 60 80 100			
			1	SS	100			■	●		24 52 (24)
451.1											
0.9	Auger refusal @ 0.9 m on inferred bedrock End of hole at 0.9 m										SPT refusal at 0.75 m - SS bouncing

$\times^{3}$, $\star^{3}$ Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

ON_MOT_BH LOG 02-134.GPJ ON_MOT.GDT 30/7/04

TBT Engineering

RECORD OF BOREHOLE No 5

1 OF 1 **METRIC**

W.P. **70-97-00** PROJECT **Lachappelle Creek Culvert Replacement** SITE NO. **SITE 48C-224C** ORIGINATED BY **JM**

DIST **103** HWY **527** LOCATION **Sta 20+005 - 4.5m Lt, Dist. Thunder Bay** TBTE JOB# **J02-134** COMPILED BY **SP**

DATE **5 August 2003** BOREHOLE TYPE **Hollow Stem Auger - 100mm ID** DATUM **Geodetic** CHECKED BY **WH**

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, ■ SPT (N), × 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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
453.3											
0.0	FILL - sand, with gravel, trace silt, brown-grey, dry						453				
452.6											
0.7	SAND and GRAVEL - with silt, brown, dense (till)		1	SS	34						Stone in tip of SS
							452				
451.5			2	SS	37						41 43 (16)
1.8	End of hole at 1.8 m Auger refusal @ 1.5 m on rock fill/fractured bedrock		3	SS	100						SS deflected on angular rock SS bouncing

×³, ★³: Numbers refer to Sensitivity O³% STRAIN AT FAILURE

ON_MOT_BH LOG 02-134.GPJ ON_MOT.GDT 30/7/04

TBT Engineering

RECORD OF BOREHOLE No 6

1 OF 1 **METRIC**

W.P. **70-97-00** PROJECT **Lachappelle Creek Culvert Replacement** SITE NO. **SITE 48C-224C** ORIGINATED BY **JM**

DIST **103** HWY **527** LOCATION **Sta 19+965 - 4.5m Lt, Dist. Thunder Bay** TBTE JOB# **J02-134** COMPILED BY **SP**

DATE **5 August 2003** BOREHOLE TYPE **Hollow Stem Auger - 100mm ID** DATUM **Geodetic** CHECKED BY **WH**

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			O UNCONFINED ■ SPT (N) ✕ FIELD VANE ★ LAB VANE			GR SA SI CL
451.7											
0.0 451.1	FILL - sand & gravel, trace silt										Granular fill - shoulder of hwy
0.6 450.5	SAND - silty, with gravel, brown		1	SS	35		451				
			2	SS	100						11 60 (30)
1.2	Auger refusal @ 1.2 m on rock fragments End of hole at 1.85 m										felsic volcanic rock in tip of SS SPT refusal at 1.2 m - SS bouncing

$\times^3, \star^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

ON_MOT_BH LOG 02-134.GPJ ON_MOT.GDT 30/7/04

TBT Engineering

RECORD OF BOREHOLE No 7

1 OF 1 **METRIC**

W.P. **70-97-00** PROJECT **Lachappelle Creek Culvert Replacement** SITE NO. **SITE 48C-224C** ORIGINATED BY **JM**

DIST **103** HWY **527** LOCATION **Sta 19+885 - 4.5m Lt, Dist. Thunder Bay** TBTE JOB# **J02-134** COMPILED BY **SP**

DATE **5 August 2003** BOREHOLE TYPE **Hollow Stem Auger - 100mm ID** DATUM **Geodetic** CHECKED BY **WH**

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, ■ SPT (N), × 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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
449.8											
0.0 / 449.1	FILL - sand & gravel, trace silt										Granular fill - shoulder of hwy 3 70 (27)
0.8	FILL - sand, gravelly, with silt, numerous cobbles & boulders (angular), brown, dry Gravel/Cobble fraction increases with depth grey-brown, Wet Auger refusal at 1.5m (cobbles)		1	SS	10		449				
447.5			2	SS	24		448				Rock fragments in SS tip
2.3	End of hole at 2.3 m		3	SS	34						

× 3 ★ 3 Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

TBT Engineering

RECORD OF BOREHOLE No 8

1 OF 1 **METRIC**

W.P. **70-97-00** PROJECT **Lachappelle Creek Culvert Replacement** SITE NO. **SITE 48C-224C** ORIGINATED BY **JM**

DIST **103** HWY **527** LOCATION **Sta 19+850 - 4.5m Lt, Dist. Thunder Bay** TBTE JOB# **J02-134** COMPILED BY **SP**

DATE **5 August 2003** BOREHOLE TYPE **Hollow Stem Auger - 100mm ID** DATUM **Geodetic** CHECKED BY **WH**

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, ■ SPT (N), × 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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
450.2											
0.0	FILL - sand & gravel, trace silt						450				Granular fill - shoulder of hwy
449.5											13 67 (20)
0.8	SAND - silty, with gravel, brown, compact		1	SS	15						
448.7	Auger refusal at 1.5 m						449				
1.5	End of hole at 1.5 m		2	SS	100						SPT refusal - SS bouncing

$\times^3$, $\star^3$ Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

TBT Engineering

RECORD OF BOREHOLE No 9

1 OF 2 **METRIC**

W.P. **70-97-00** PROJECT **Lachappelle Creek Culvert Replacement** SITE NO. **SITE 48C-224C** ORIGINATED BY **JM**

DIST **103** HWY **527** LOCATION **Sta 19+913 - 4.5m Lt, Dist. Thunder Bay** TBTE JOB# **J02-134** COMPILED BY **SP**

DATE **25 August 2003** BOREHOLE TYPE **Hollow Stem Auger - 100mm ID** DATUM **Geodetic** CHECKED BY **WH**

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
449.8							
0.0 / 449.0	FILL - sand and gravel, with silt, brown, compact						449
0.8	FILL - sand and gravel, with silt, occasional cobble, brown, dry, compact						448
	sandy, numerous cobbles and boulders (rock fill), compact to dense						447
							446
							445
							444
442.8						▼	443
7.0	Gravel - sandy, numerous cobbles, occasional boulder, wet, compact to very dense (till)						442
			1	SS	100		
			2	SS	100		441
440.5							
9.3	BEDROCK - Granite, coarse grained, pink, closely spaced joints		3	RC			440
			4	RC			439
							438

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED ■ SPT (N) × 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

Water well rig used to advance BH.

200mm casing installed to 8m below grade.

N casing from 8m

N size drill core used to advance BH.

RQD = 10%

Continued Next Page

×³, ★³. Numbers refer to Sensitivity O³% STRAIN AT FAILURE

TBT Engineering

RECORD OF BOREHOLE No 9 2 OF 2 METRIC

W.P. 70-97-00 PROJECT Lachappelle Creek Culvert Replacement SITE NO. SITE 48C-224C ORIGINATED BY JM

DIST 103 HWY 527 LOCATION Sta 19+913 - 4.5m Lt, Dist. Thunder Bay TBTE JOB# J02-134 COMPILED BY SP

DATE 25 August 2003 BOREHOLE TYPE Hollow Stem Auger - 100mm ID DATUM Geodetic CHECKED BY WH

ELEV / DEPTH	DESCRIPTION	STRAT 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 (O UNCONFINED, ■ SPT (N), × 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
			5	RC			437				RQD = 0
			6	RC			436				RQD = 12%
			7	RC							RQD = 0
			8	RC			435				RQD = 50%
			9	RC			434				RQD = 56%
432.8 17.0							433				

× 3, ★ 3. Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

ON_MOT_BH LOG 02-134.GPJ ON_MOT.GDT 30/7/04

TBT Engineering

RECORD OF TESTPIT No TP01

1 OF 1 **METRIC**

W.P. **70-97-00** PROJECT **Lachappelle Creek Culvert Replacement** SITE NO. **SITE 48C-224C** ORIGINATED BY **SP**

DIST **103** HWY **527** LOCATION **Sta 19+967 - 21.0m Rt, Dist. Thunder Bay** TBTE JOB# **J02-134** COMPILED BY **SP**

DATE **18 September 2003** BOREHOLE TYPE **Caterpillar 219 LC Trackhoe** DATUM **Geodetic** CHECKED BY **WH**

ELEV / DEPTH	DESCRIPTION	STRAT 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 (20 40 60 80 100): O UNCONFINED, ■ SPT (N), ✖ FIELD VANE, ★ LAB VANE	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
445.0											
444.9 / 0.1	TOPSOIL - organics (rootmat)										
	FILL - sand, gravelly, silty, numerous cobbles, occasional boulders, grey/brown, dry, dense						444				
443.6 / 1.4	ORGANICS - rootmat, topsoil (200 mm thick)										
443.4 / 1.6	GRAVEL - sandy, with silt, numerous cobbles, occ. boulder, grey/brown, moist (till)						443				
							442				Water seeping into exc. at 3.0 m b.g.
			1	BS							54 30 (17)
441.0 / 4.0	End of hole at 4.0 m, backhoe refusal on bedrock Bedrock - Granite, pink						441				

✖³, ★³: Numbers refer to Sensitivity O^3% STRAIN AT FAILURE

ON_MOT_TESTPIT 02-134.GPJ ON_MOT.GDT 18/10/04

TBT Engineering

RECORD OF TESTPIT No TP02 1 OF 1 METRIC

W.P. 70-97-00 PROJECT Lachappelle Creek Culvert Replacement SITE NO. SITE 48C-224C ORIGINATED BY SP

DIST 103 HWY 527 LOCATION Sta 19+990 - 18.0m Rt, Dist. Thunder Bay TBTE JOB# J02-134 COMPILED BY SP

DATE 18 September 2003 BOREHOLE TYPE Caterpillar 219 LC Trackhoe DATUM Geodetic CHECKED BY WH

ELEV / DEPTH	DESCRIPTION	STRAT 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 (20 40 60 80 100): O UNCONFINED, ■ SPT (N), × FIELD VANE, ★ LAB VANE	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
451.2											
451.0 / 0.1	TOPSOIL - rootlets, organics (100 mm)						451				
	FILL - sand, gravelly, silty, numerous cobbles, dry, brown		1	BS							26 42 (22)
450.2							450				
1.0	GRAVEL - sandy, with silt, numerous cobbles, occ. boulder, grey/brown, moist (till)										
449.4											
1.8	End of hole at 1.8 m, backhoe refusal on bedrock Bedrock - Granite, pink, surface fractured										

×3, ★3. Numbers refer to Sensitivity O3% STRAIN AT FAILURE

TBT Engineering

RECORD OF TESTPIT No TP03

1 OF 1 **METRIC**

W.P. 70-97-00 PROJECT Lachappelle Creek Culvert Replacement SITE NO. SITE 48C-224C ORIGINATED BY SP

DIST 103 HWY 527 LOCATION Sta 19+988 - 5.0m Rt, Dist. Thunder Bay TBTE JOB# J02-134 COMPILED BY SP

DATE 18 September 2003 BOREHOLE TYPE Caterpillar 219 LC Trackhoe DATUM Geodetic CHECKED BY WH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, x FIELD VANE, ■ SPT (N), ★ LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT (w_P, w, w_L); WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
453.2											
0.0 452.4	FILL - sand and gravel, with silt, brown, dry, compact						453				Upper 300 mm of fill contained crushed aggregate.
0.8 450.5	FILL - sand, gravelly, with silt, numerous cobbles & boulders (angular), brown, dry						452				Excavation starting at shoulder rounding
2.7	End of hole at 2.7 m						451				

$\times^3$, $\star^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

TBT Engineering

RECORD OF TESTPIT No TP04

1 OF 1 **METRIC**

W.P. 70-97-00 PROJECT Lachappelle Creek Culvert Replacement SITE NO. SITE 48C-224C ORIGINATED BY SP

DIST 103 HWY 527 LOCATION Sta 19+961 - 11.0m Lt, Dist. Thunder Bay TBTE JOB# J02-134 COMPILED BY SP

DATE 18 September 2003 BOREHOLE TYPE Caterpillar 219 LC Trackhoe DATUM Geodetic CHECKED BY WH

ELEV / DEPTH	DESCRIPTION	STRAT 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: O UNCONFINED, ■ SPT (N), × 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
450.6 / 0.0	TOPSOIL - rootlets, organics										
0.1 / 450.1	FILL - sand & gravel, with silt, numerous cobbles, occ. boulder, brown, dry, compact										
0.5 / 449.8	GRAVEL - sandy, with silt, fractured bedrock pieces (till)						450				
0.8	End of Hole at 0.8 m, backhoe refusal on bedrock Bedrock - Granite, pink, surface fractured										

$\times^3, \star^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

ON_MOT_TESTPIT 02-134.GPJ ON_MOT.GDT 18/10/04

TBT Engineering

RECORD OF TESTPIT No TP05

1 OF 1 **METRIC**

W.P. 70-97-00 PROJECT Lachappelle Creek Culvert Replacement SITE NO. SITE 48C-224C ORIGINATED BY SP

DIST 103 HWY 527 LOCATION Sta 19+872 - 24.0m Lt, Dist. Thunder Bay TBTE JOB# J02-134 COMPILED BY SP

DATE 18 September 2003 BOREHOLE TYPE Caterpillar 219 LC Trackhoe DATUM Geodetic CHECKED BY WH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (O UNCONFINED, ■ SPT (N), × FIELD VANE, ★ LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
444.0 0.0	FILL - rock fill (max dia. 800 mm)						443				Average rock fill diameter - 300 mm
442.8 1.2	SILT - sandy, with gravel, trace clay, grey, moist, very dense (till)		1	BS							11 33 46 10
442.3 1.7	End of hole at 1.7 m, backhoe refusal on bedrock Bedrock - Granite, pink										

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: 20 40 60 80 100

WATER CONTENT (%): 20 40 60

$\times^3, \star^3$: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

TBT Engineering

RECORD OF TESTPIT No TP06 1 OF 1 METRIC

W.P. 70-97-00 PROJECT Lachappelle Creek Culvert Replacement SITE NO. SITE 48C-224C ORIGINATED BY SP

DIST 103 HWY 527 LOCATION Sta 19+849 - 12.5m Lt, Dist. Thunder Bay TBTE JOB# J02-134 COMPILED BY SP

DATE 18 September 2003 BOREHOLE TYPE Caterpillar 219 LC Trackhoe DATUM Geodetic CHECKED BY WH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, ■ SPT (N), × 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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
448.8											
448.7	TOPSOIL - rootlets, organics										
0.1	GRAVEL & SAND - with silt, numerous cobbles & boulders, grey brown, dry, dense (till)		1	BS			448				38 38 (12)
446.6							447				
2.2	End of hole at 2.2 m, backhoe refusal on bedrock										

ON_MOT_TESTPIT 02-134.GPJ ON_MOT.GDT 18/10/04

×³, ★³: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

TBT Engineering

RECORD OF TESTPIT No TP07

1 OF 1 **METRIC**

W.P. 70-97-00 PROJECT Lachappelle Creek Culvert Replacement SITE NO. SITE 48C-224C ORIGINATED BY SP

DIST 103 HWY 527 LOCATION Sta 19+875 - 5.5m Lt, Dist. Thunder Bay TBTE JOB# J02-134 COMPILED BY SP

DATE 18 September 2003 BOREHOLE TYPE Caterpillar 219 LC Trackhoe DATUM Geodetic CHECKED BY WH

ELEV / DEPTH	DESCRIPTION	STRAT 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: O UNCONFINED, ■ SPT (N), ✖ 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
449.8											
0.0	FILL - sand and gravel, with silt, brown, compact										Excavation starting at shoulder rounding
449.0							449				
0.8	FILL - sand, gravelly, with silt, numerous cobbles & boulders (angular), brown, dry										Upper 300 mm of fill contained crushed aggregate.
							448				
446.8							447				
3.0	End of hole at 3.0 m										

✖³, ★³: Numbers refer to Sensitivity O³% STRAIN AT FAILURE

TBT Engineering

RECORD OF TESTPIT No TP08 1 OF 1 METRIC

W.P. 70-97-00 PROJECT Lachappelle Creek Culvert Replacement SITE NO. SITE 48C-224C ORIGINATED BY SP

DIST 103 HWY 527 LOCATION Sta 19+790 - 9.0m Lt, Dist. Thunder Bay TBTE JOB# J02-134 COMPILED BY SP

DATE 18 September 2003 BOREHOLE TYPE Caterpillar 219 LC Trackhoe DATUM Geodetic CHECKED BY WH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ✕ FIELD VANE ■ SPT (N) ★ 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
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
451.6											
451.5 0.1	TOPSOIL - rootlets, organics (100 mm)										
	GRAVEL - sandy, with silt, numerous cobbles & boulders, grey.brown, dry, dense (till)						451				
450.7 0.9	End of hole at 0.9 m, backhoe refusal on bedrock										
	Bedrock - Mafic Intrusive, med. grained, dark grey										

✕³, ★³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ON_MOT_TESTPIT_02-134.GPJ ON_MOT.GDT 18/10/04

TBT Engineering

RECORD OF TESTPIT No TP09

1 OF 1 **METRIC**

W.P. **70-97-00** PROJECT **Lachappelle Creek Culvert Replacement** SITE NO. **SITE 48C-224C** ORIGINATED BY **SP**

DIST **103** HWY **527** LOCATION **Sta 19+860 - 9.0m Rt, Dist. Thunder Bay** TBTE JOB# **J02-134** COMPILED BY **SP**

DATE **18 September 2003** BOREHOLE TYPE **Caterpillar 219 LC Trackhoe** DATUM **Geodetic** CHECKED BY **WH**

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, ■ SPT (N), × 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
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
449.2											
~~449.0~~	TOPSOIL - rootlets, organics										
0.1	GRAVEL - sandy, with silt, numerous cobbles & boulders, grey.brown, dry, dense (till)						449				
448.0											
1.2	End of hole at 1.2 m, backhoe refusal on bedrock Bedrock - Mafic Intrusive, med. grained, dark grey						448				

$\times^3$, $\star^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

ON_MOT_TESTPIT 02-134.GPJ ON_MOT.GDT 18/10/04

TBT Engineering

RECORD OF TESTPIT No TP10

1 OF 1 **METRIC**

W.P. 70-97-00 PROJECT Lachappelle Creek Culvert Replacement SITE NO. SITE 48C-224C ORIGINATED BY SP

DIST 103 HWY 527 LOCATION Sta 19+914 - 18.0m Rt, Dist. Thunder Bay TBTE JOB# J02-134 COMPILED BY SP

DATE 18 September 2003 BOREHOLE TYPE Caterpillar 219 LC Trackhoe DATUM Geodetic CHECKED BY WH

ELEV / DEPTH	DESCRIPTION	STRAT 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 (O UNCONFINED, ■ SPT (N), × 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
444.6											
444.6	TOPSOIL - rootlets, organics (100 mm)										
0.1	FILL - sand, gravelly, with silt, brown, dry										
	Rock fill (angular), to 300 mm dia, little fines					▼	444				Water table at 0.9 m below grade
							443				
441.8							442				
2.8	SILT - sandy, traces gravel & clay, grey, wet, very dense (till)										
441.3											
3.3	End of hole at 3.3 m, backhoe refusal on bedrock										

$\times^3, \star^3$: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

ON_MOT_TESTPIT 02-134.GPJ ON_MOT.GDT 18/10/04

TBT Engineering

RECORD OF TESTPIT No TP11

1 OF 1 **METRIC**

W.P. **70-97-00** PROJECT **Lachappelle Creek Culvert Replacement** SITE NO. **SITE 48C-224C** ORIGINATED BY **SP**

DIST **103** HWY **527** LOCATION **Sta 19+893 - 6.0m Rt, Dist. Thunder Bay** TBTE JOB# **J02-134** COMPILED BY **SP**

DATE **18 September 2003** BOREHOLE TYPE **Caterpillar 219 LC Trackhoe** DATUM **Geodetic** CHECKED BY **WH**

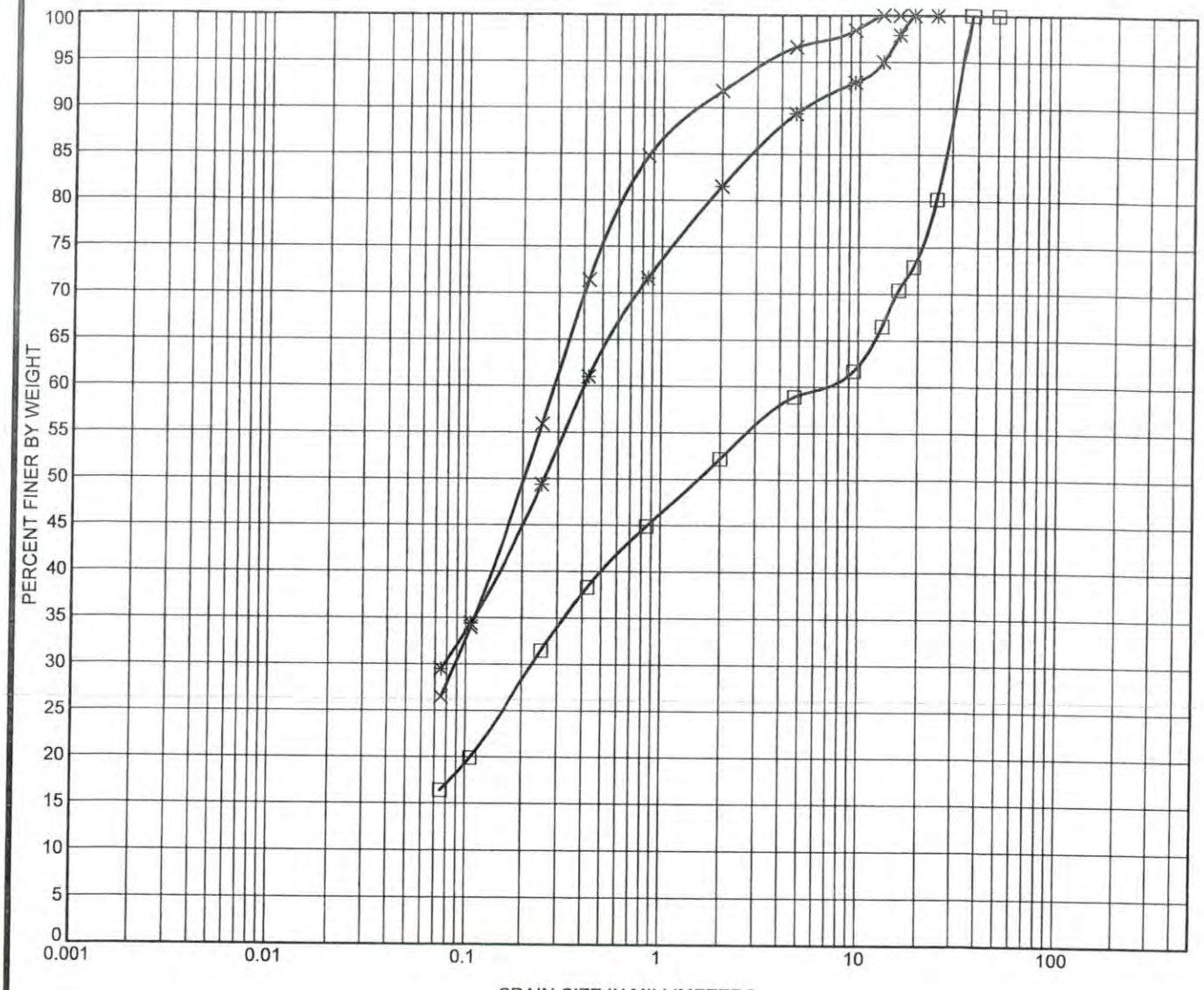
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, ■ SPT (N), ✖ FIELD VANE, ★ LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL 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
449.8 / 0.0	FILL - sand and gravel, with silt, dry, brown, compact										Upper 300 mm of fill contained crushed aggregate.
449.0 / 0.8	FILL - sandy, gravelly, with silt, numerous cobbles & boulders (angular), max dia. 300 mm		1	BS			449 448				22 29 (12)
446.8 / 3.0	End of hole at 3.0 m						447				Excavation starting at shoulder rounding

✖³, ★³: Numbers refer to Sensitivity O³% STRAIN AT FAILURE

ON_MOT_TESTPIT 02-134.GPJ ON_MOT.GDT 18/10/04

APPENDIX B

Laboratory Test Data



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Material:

FILL

	Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□	**5**	**1.50**	**50**	**6.237**	**0.224**		**41.1**	**42.5**	**16.4**	
✳	**6**	**1.05**	**25**	**0.406**	**0.078**		**10.6**	**59.9**	**29.5**	
×	**7**	**0.75**	**16**	**0.288**	**0.088**		**3.4**	**70.1**	**26.5**	

TBT Engineering
Suite 314-101 Syndicate Ave. N
Thunder Bay, ON P7C 3V4
Telephone: (807) 624-5160
Fax: (807) 624-5161

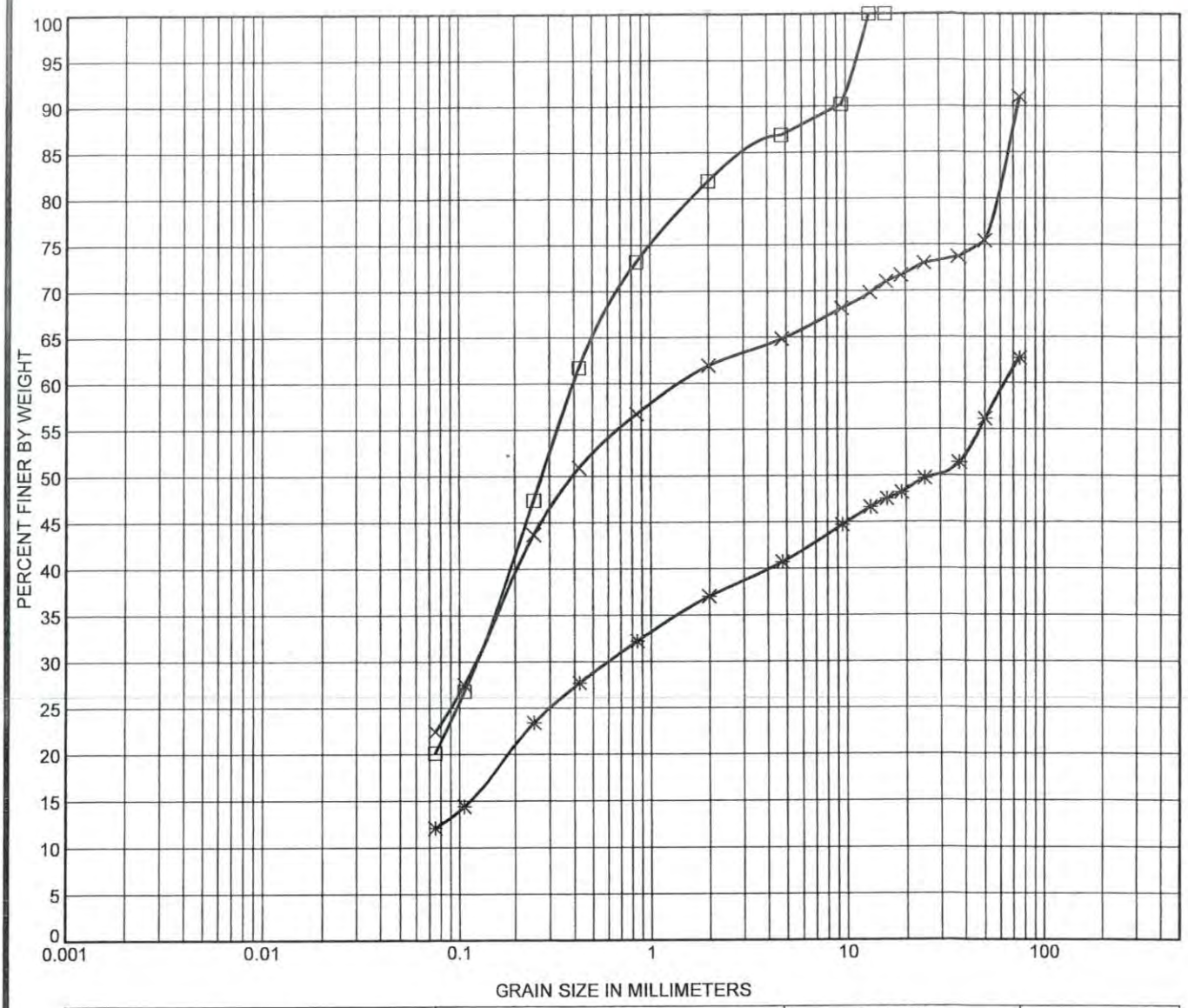
GRAIN SIZE DISTRIBUTION

Project: Hwy 527 - Culvert Replacement

Location: 527

Number: 70-97-00

FIGURE 1



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Material:
FILL

Test Hole		Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□	**8**	**0.75**	**16**	**0.399**	**0.121**		**13.1**	**66.8**	**20.1**	
✳	**TP11**	**1.50**	**75**	**63.537**	**0.606**		**22.0**	**28.6**	**12.1**	
×	**TP2**	**0.60**	**75**	**1.463**	**0.121**		**26.2**	**42.4**	**22.4**	

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Fax: (807) 624-5161

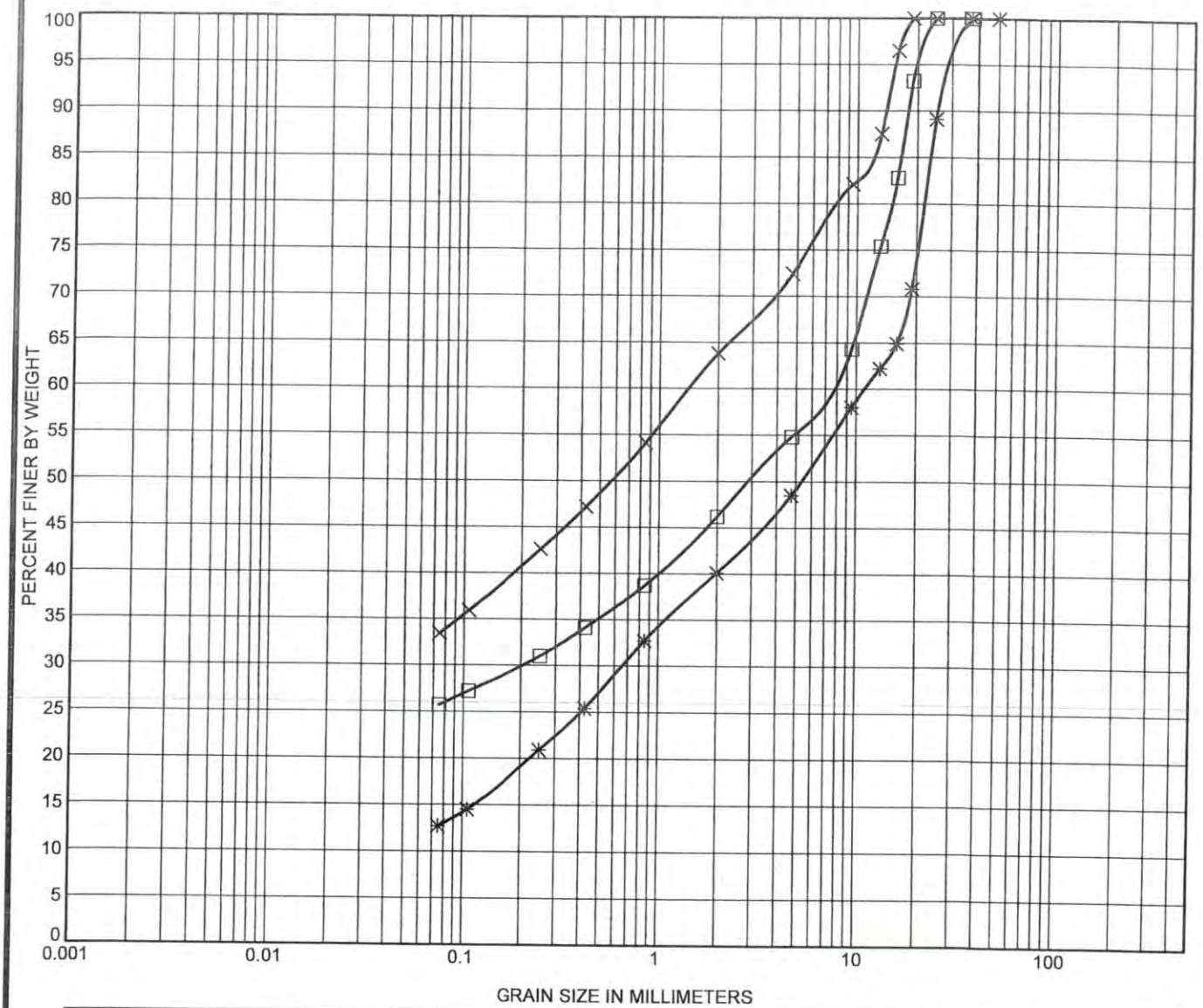
GRAIN SIZE DISTRIBUTION

Project: Hwy 527 - Culvert Replacement

Location: 527

Number: 70-97-00

FIGURE 2



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Material:

Sand and Gravel (till)

	Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□	1	2.00	37.5	6.942	0.199		45.2	29.1	25.7	
✳	1	3.00	50	11.111	0.658		51.5	35.8	12.7	
×	2	3.00	25	1.43			27.6	39.0	33.4	

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Thunder Bay, ON P7C 3V4
Telephone: (807) 624-5160
Fax: (807) 624-5161

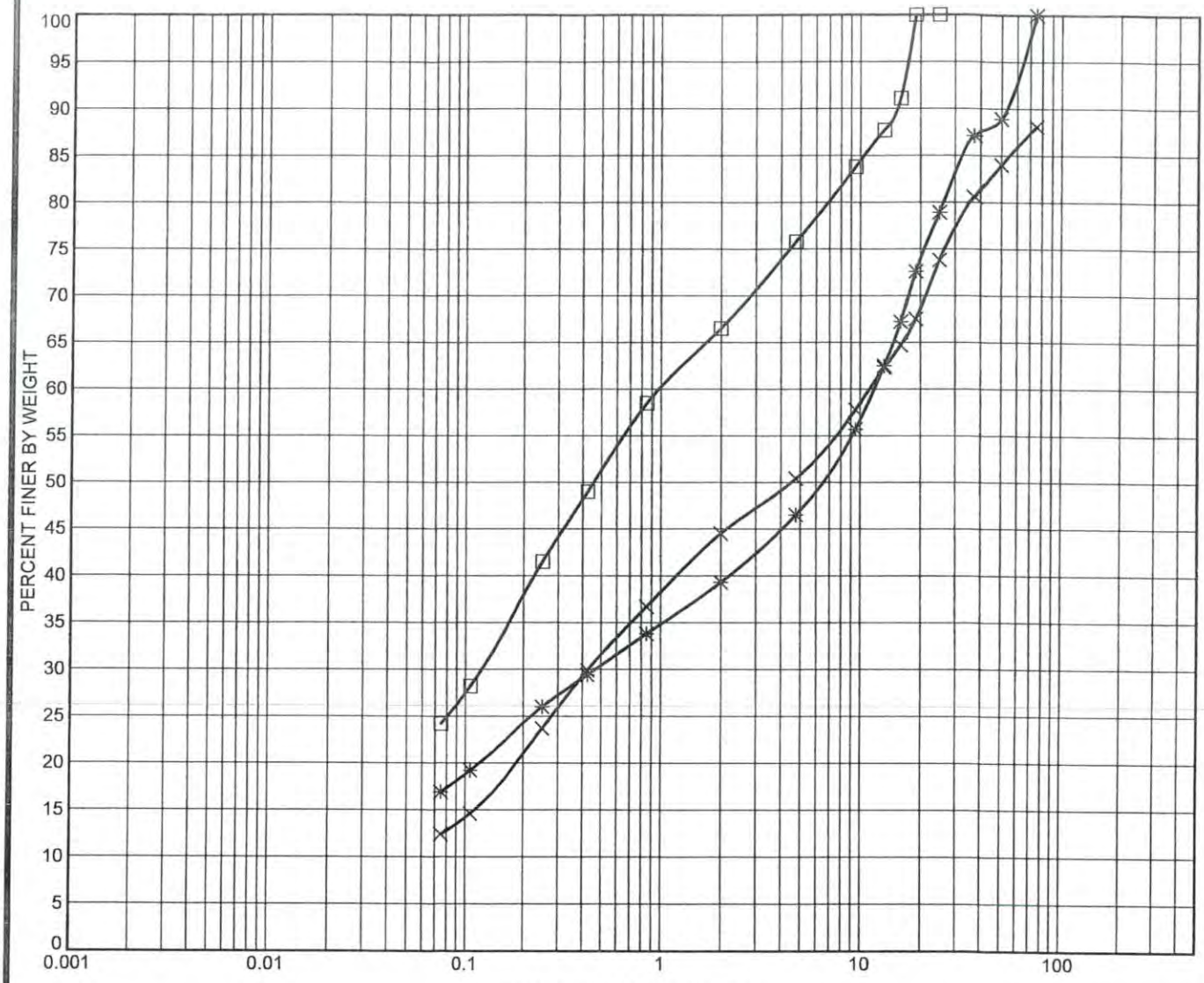
GRAIN SIZE DISTRIBUTION

Project: Hwy 527 - Culvert Replacement

Location: 527

Number: 70-97-00

FIGURE 3



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Material:

Sand and Gravel (till)

	Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□	**4**	**0.60**	**25**	**0.998**	**0.119**		**24.2**	**51.6**	**24.2**	
✳	**TP1**	**3.60**	**75**	**11.696**	**0.467**		**53.5**	**29.6**	**16.9**	
×	**TP6**	**1.20**	**75**	**11.157**	**0.429**		**37.7**	**38.0**	**12.4**	

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Fax: (807) 624-5161

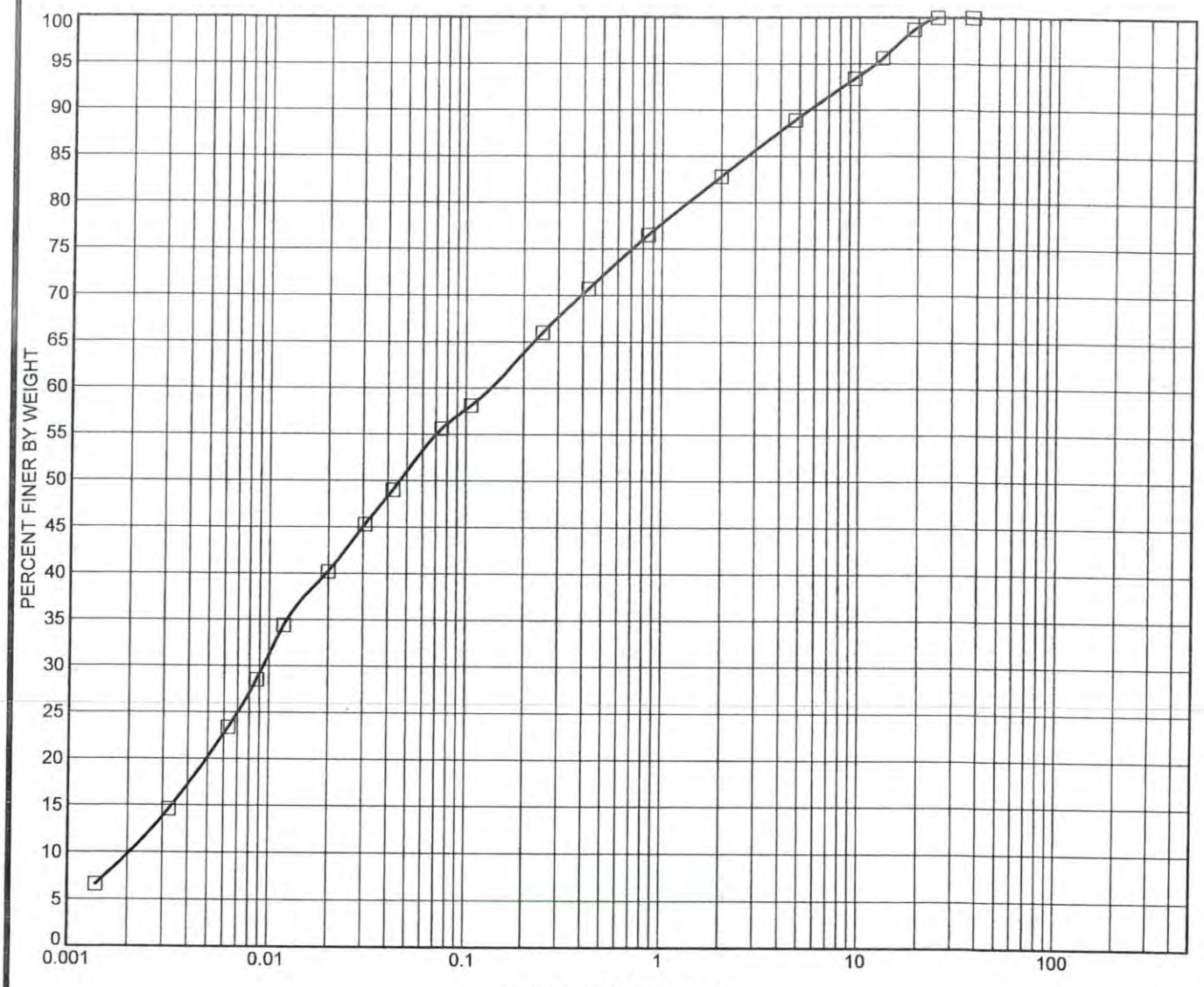
GRAIN SIZE DISTRIBUTION

Project: Hwy 527 - Culvert Replacement

Location: 527

Number: 70-97-00

FIGURE 4



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Material:
Silt (till)

	Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
☐	**TP5**	**1.30**	**37.5**	**0.13**	**0.009**	**0.002**	**11.1**	**33.3**	**45.5**	**10.1**

TBT Engineering
Suite 314-101 Syndicate Ave. N
Thunder Bay, ON P7C 3V4
Telephone: (807) 624-5160
Fax: (807) 624-5161

GRAIN SIZE DISTRIBUTION

Project: Hwy 527 - Culvert Replacement

Location: 527

Number: 70-97-00

FIGURE 5

APPENDIX C

Photographs

Photo: Test Pit 1

Photo: Test Pit 3
Embankment Fill

MINISTRY OF TRANSPORTATION - NORTHWEST REGION

LaChappelle Creek Culvert Replacement - Site No.: 48C-224C

TBT ENGINEERING

TBTE Ref. No. 02-1347
Agreement No.: 6005-A-000171

Photo: Test Pit 5 Rock Fill over Silt

Photo: Test Pit 7 Embankment Fill

MINISTRY OF TRANSPORTATION - NORTHWEST REGION

LaChappelle Creek Culvert Replacement - Site No.: 48C-224C

TBT ENGINEERING

TBTE Ref. No. 02-1347

Agreement No.: 6005-A-000171

Photos: Test Pit 10 **(both photos)**

MINISTRY OF TRANSPORTATION - NORTHWEST REGION

LaChappelle Creek Culvert Replacement - Site No.: 48C-224C

TBT ENGINEERING

TBTE Ref. No. 02-1347

Agreement No.: 6005-A-000171

Photo: South side of Culvert

Photo: Exposed Boulders South West of Culvert

MINISTRY OF TRANSPORTATION - NORTHWEST REGION

LaChappelle Creek Culvert Replacement - Site No.: 48C-224C

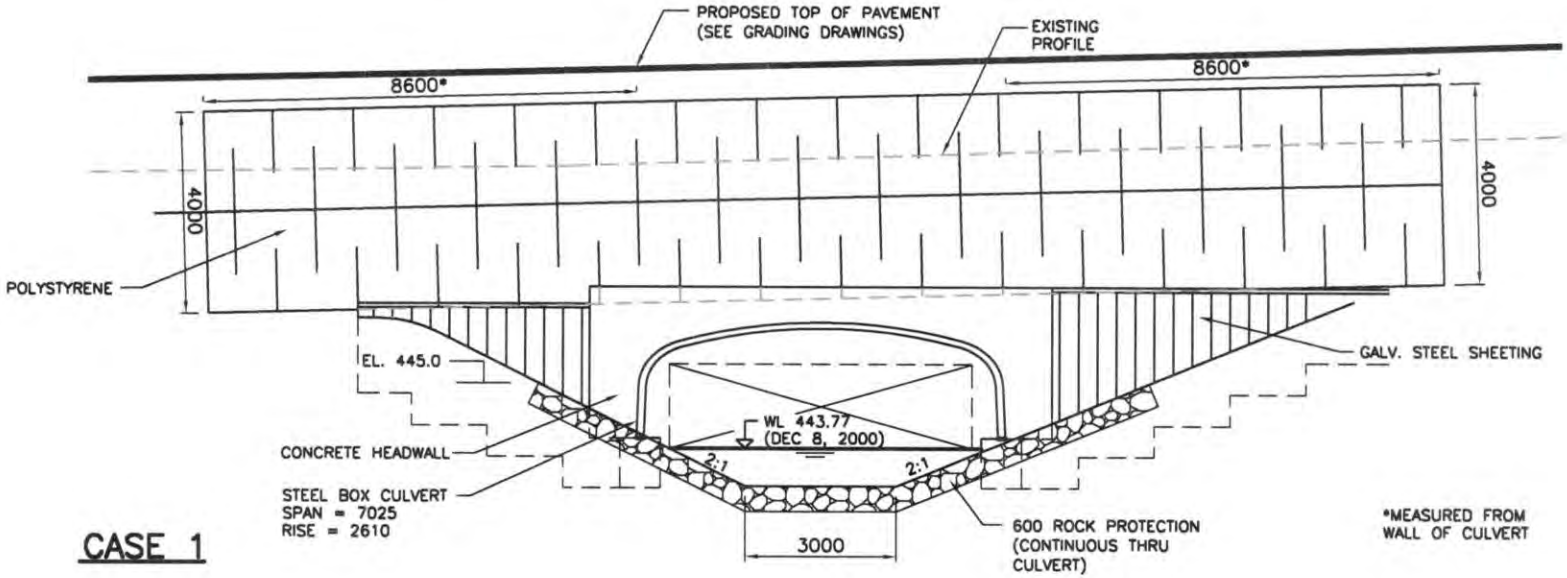
TBT ENGINEERING

TBTE Ref. No. 02-1347

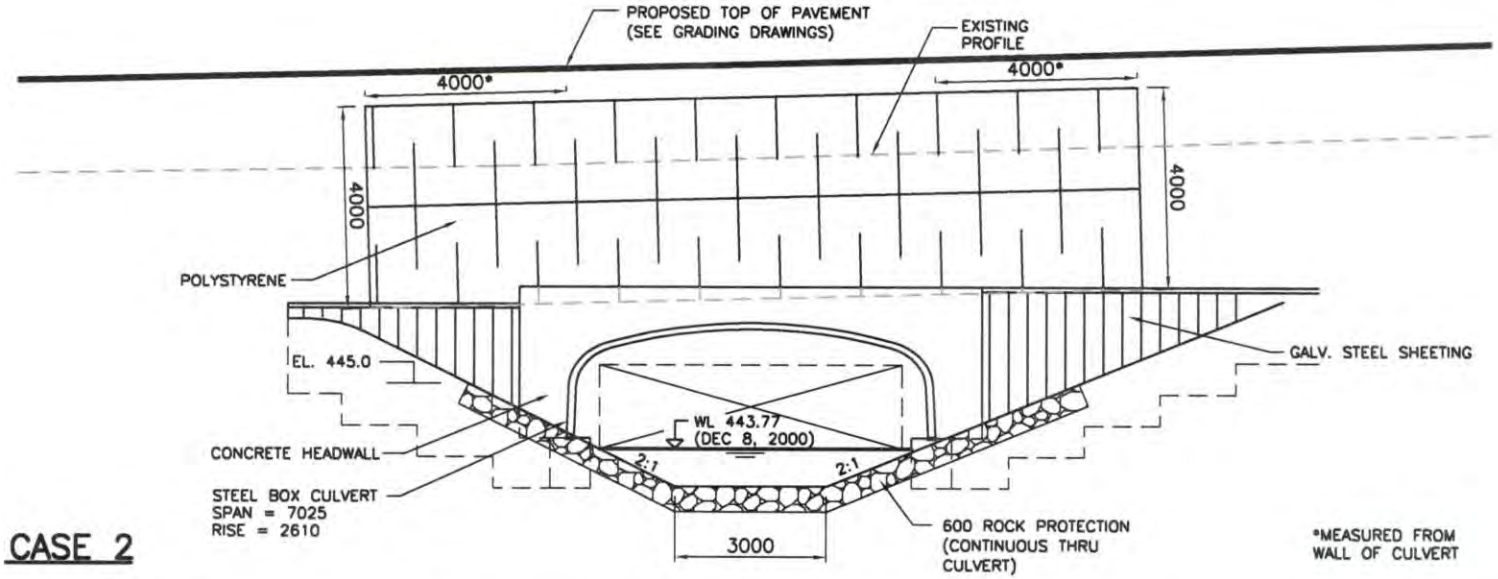
Agreement No.: 6005-A-000171

APPENDIX D

DRAWINGS

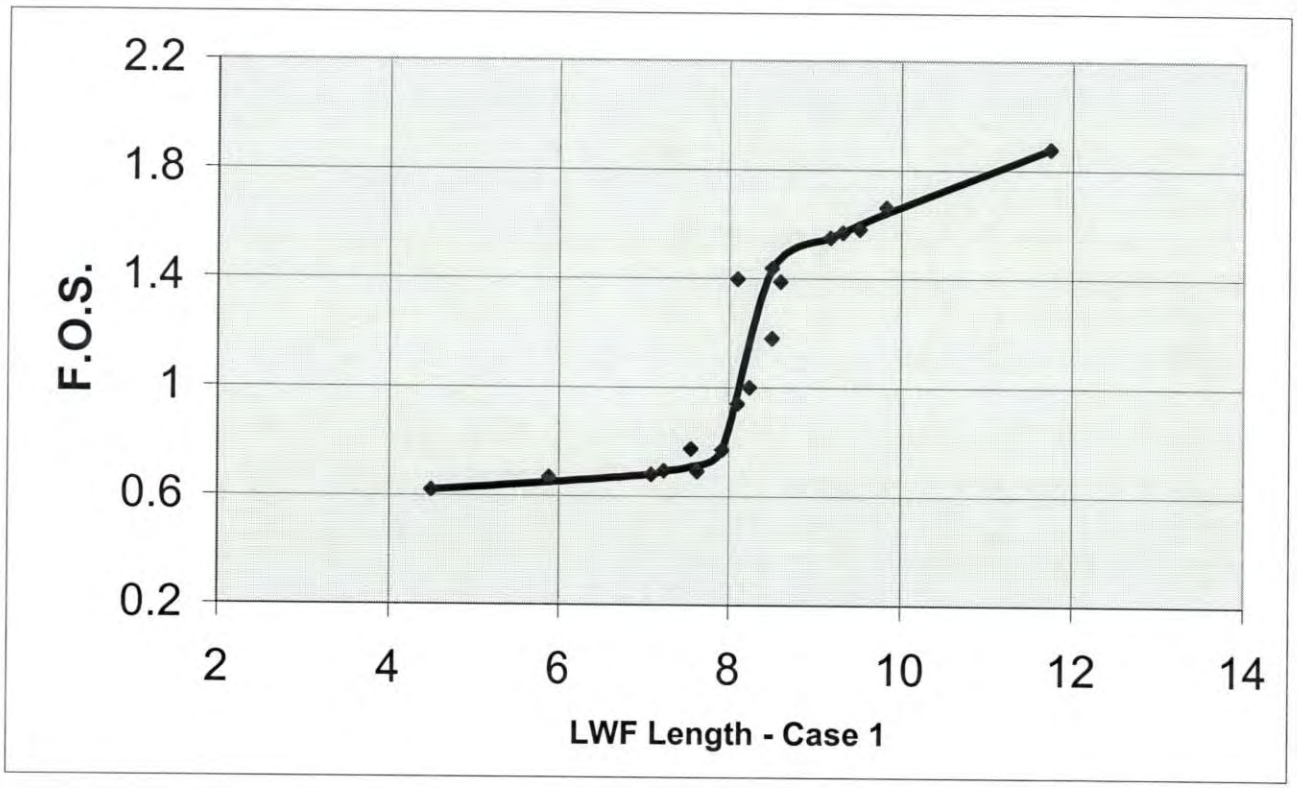


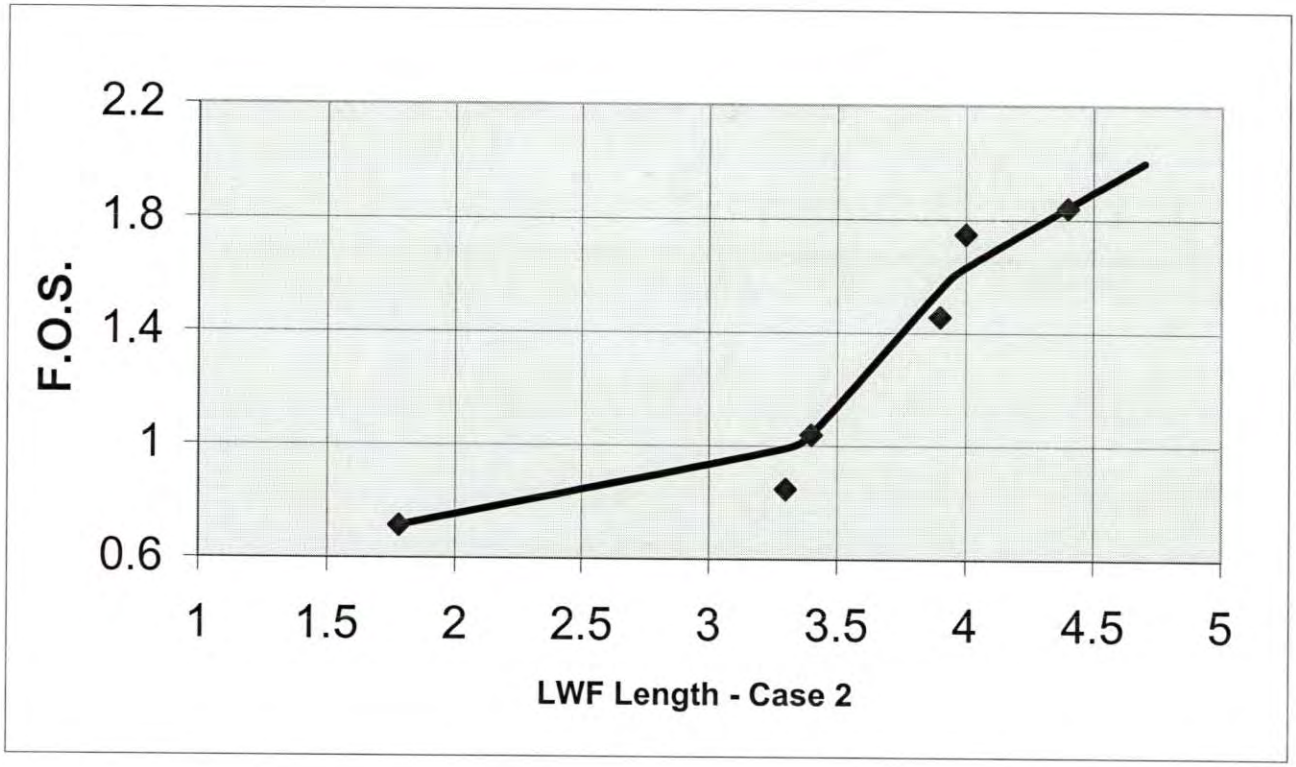
CASE 1



CASE 2

CLIENT: MINISTRY OF TRANSPORTATION	DWG TITLE: LIGHT WEIGHT FILL		DATE: OCT 2004	PROJECT NO. J02-134
CAD REF. NO.: BASE.DWG	PROJECT: HIGHWAY 527 LaCHAPPELLE CREEK ONTARIO		SCALE: 1 : 150	ENCLOSURE





Highway 527 - Lachapelle Creek

Lightweight Fill Length vs. Safety Factor

GWP 70-97-00
Site No.:48C-224C
TBTE No. 02-134