**MERLEX ENGINEERING LTD.**

CONSULTING GEOTECHNICAL ENGINEERS

# FINAL

## FOUNDATION INVESTIGATION AND DESIGN REPORT

***FOUNDATION AREA 2***

W.P. 309-00-00

Highway 63 Drainage Improvements,
Site 43-42, North River Culvert (South Crossing)
Station 23+483 Widdifield Township
District 54 Sudbury

Merlex Reference No. 00/11/00135

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**GEOCRES 31L-83**

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## 1.0 INTRODUCTION

Merlex Engineering Ltd. (MEL) has been retained by Stantec Consulting Ltd., on behalf of the Ministry of Transportation, to carry out a foundation investigation for Work Project 309-00-00. The work project is located along a section of Highway 63 near the MTO Feronia Station in the Twp. of Widdifield. Highway 63 connects the City of North Bay with the Town of Temiscaming at the Ontario – Quebec border.

This report addresses Foundation Area 2, MTO Site 43-42, North River Culvert (South Crossing) (see Key Location Plan). The investigation was initiated via detailed site reconnaissance by a senior geotechnical engineer from MEL, followed by drilling and sampling boreholes, carrying out Dynamic Cone Penetration Tests (DCPT), and performing a series of laboratory analyses on selected samples from the subject locations. Based on the information recovered from this program and our interpretation of the conditions that were encountered at the subject sites, we have provided recommendations on the geotechnical aspects of the culvert replacement, along with discussions on excavations, fills and embankment design.

The attached Plan and Profile information for Foundation Area 2 is presented on Figure A-2. Stantec Consulting Ltd. provided the base drawings, coordinates, and reference elevations at the borehole locations. Stratigraphic information contained on the above noted figures is based on our evaluation of conditions encountered in the field.

Specific terms of reference for this project are contained in MEL Proposal No. P-00-83, dated August 17, 2000. The work was carried out in compliance with our Quality Control Plan dated November 30, 2000.

## 2.0 SITE DESCRIPTION

The section of Highway 63 addressed within this report commences at approximately Station 23+470 and extends to Station 23+495, Twp. of Widdifield. The actual station of the culvert at highway centreline is Station 23+483.

Within the immediate area of Site 43-42 the topography is quite flat and vegetative cover consists of tag alders, dogwood, and occasional black spruce and tamarack. The topographic setting is a low lying flat swamp area.

## 3.0 INVESTIGATION PROCEDURES

All drilling operations were performed with a Bombardier mounted CME 45 drilling unit under the guidance of experienced staff during the period of April 4th and 5th, 2001. Boreholes were advanced with 150 mm hollow stem continuous flight augers. Samples were retrieved at regular intervals of depth or as deemed necessary by our field staff. Disturbed samples were retrieved with 50 mm OD Split Spoon Samplers and Standard Penetration Test (SPT) "N" values were recorded in conjunction with this sampling technique. Typical sampling depth was to equivalent fill height in fill areas, 2 to 3 times structure height, or auger refusal.

The results of our investigation program for Site 43-42 are presented in the attached Record of Borehole Logs for borings 24, 25 and 26, which also include DCPT results at each borehole. A Summary of Laboratory Testing is presented in Table 1. Specific laboratory test results are presented in Figures L42-1 to L42-4, inclusive.

All samples were identified in the field and placed in airtight sample jars or sealed in their thin walled tubes prior to careful transport to our North Bay laboratory. All samples received a confirmatory inspection in our laboratory and select samples were tested to determine natural water content, Atterberg Limits, Specific Gravity, and grain size distributions.

Where encountered, groundwater conditions have been recorded on the attached Record of Borehole Logs.

## 4.0 SUBSURFACE CONDITIONS

Details of subsurface conditions revealed by our investigation program are presented on the Record of Borehole Logs. Please note that stratigraphic delineations presented on the borehole logs are the result of non-continuous sampling, response to drilling progress, the results of SPTs and values obtained from DCPTs. Typically, such boundaries represent transitions from one zone to another and not an exact demarcation of a specific geological unit. Additional consideration should be given to the fact that subsurface conditions may vary markedly between adjacent boreholes, or beyond any specific boring location.

Plan and Stratigraphic Profiles for Site 43-42 are presented in Figure A–2. A total of three borings were put down at this area during the period April 4$^{th}$ and 5$^{th}$, 2001. Borehole No. 24 is located 1.5 m north of the north side of the culvert inlet, Borehole No. 25 is located 4 m south of the south wall at the outlet and Borehole No. 26 is located on the highway shoulder approximately 2 m north of the culvert wall. The respective ground surface elevation at the boreholes were 274.2 m, 275.9 m and 277.0 m. At Borehole No. 24 and No. 25 the stratigraphic sequence was found to be comprised of a surficial layer of silts and interbedded organic silt to a depth of 300 mm. Natural moisture content values ranged from 30% to 46%, providing general confirmation of silt and organics.

At Borehole No. 26, the surficial layer was highway fill, consisting of compact brown sand and gravely sand with cobbles and boulders. The stratum was found to extend to a depth of 4.7 m. Natural moisture content values of 4% to 7%, recorded in the course of our testing program,

indicate the presence of a generally clean well drained granular fill. A stratum of fine sand with varying silt content was encountered below the surficial strata at all three boreholes. The stratum was found to range in thickness from 1.4 m in Borehole No. 26 to 4.7 m in Borehole No. 25. Standard Penetration Test "N" values recorded in conjunction with Split Spoon Sampling within this stratum ranged from hammer weight to 7, indicating a very loose to compact (generally very loose to loose) condition. It should be noted that the only compact observation recorded was below the highway fill. Grain size determinations performed on samples retrieved from this stratum were found to contain 1 to 10% gravel sizes, 62 to 92% sand sizes and, 6 to 29% silt sizes. The specific grain size distribution curves are presented on Figure L42-1. Natural moisture content values recorded within this stratum ranged between 20 to 45% indicating variable silt content and occasional inclusions of organics.

A stratum of grey cohesionless silt was found to underlay the silty sand stratum in all boreholes put down at this location. Thicknesses of 2 m to 3.6 m were proven by drilling and sampling operations. However, results from DCPTs, which continued beyond auger depth, suggest a continuance of similar material to lower depths. Incorporating the two methods of observation indicates that total thicknesses of 6.8 to 9.6 m can be expected and the stratum to be located between elevations 270.9 m and 261.6 m. Standard Penetration Testing "N" values within the stratum indicate a very loose to loose condition based on values of hammer weight to 5. Atterberg limits were performed on representative samples from this stratum. The results are shown plotted on the applicable Record of Borehole Logs and on Figure L42-5. Natural

moisture content determinations carried out on samples retrieved from this stratum were found to vary from 30% to 36%, generally confirming the nature of the stratum and its relative

homogeneity. Refusal on the DCPT at Boreholes No. 24, No. 25, and No.26 was encountered at depths of 13.5, 11.9, and 12.9 m respectively (elevations 260.7, 264.0, and 264.1 m).

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## 5.0 DESIGN COMMENTS AND RECOMMENDATIONS

### 5.1 General

Culvert replacement will be carried out at the North River Culvert (South Crossing) in a manner similar to that shown on the General Arrangement Details of Figure P-42. Founding level will be the existing twin box culvert floor slab. The new height (underside of new floor slab to top of roof slab) will be 3360 mm. Preliminary general arrangements indicates the box sections will have a width of 13340 mm, which approximately matches the existing width of the older twin structure. Integral head, cut-off, and wing walls are to be installed at both the inlet and outlet.

Based on our soils exploration program and work done by others in the vicinity of this structure (see Geocres Files in Appendix B), the founding soil is a deep deposit of sandy silt trace to some clay. Its depth below floor slab for design purposes is judged to be in the order of 8 m to 10 m. Normal water level for design purposes coincides with river level (273 m); seasonal fluctuations of some 1.5 m have been observed in the past. Highway fill materials are crushed gravel (fill) overlying compact gravely sand with occasional cobbles and boulders. No significant structural problems, other than aging, have been reported at this culvert system.

During construction operations, unhindered stream flow is to be maintained so that fish passage is not restricted. In situations where creek flows must be stopped or pumped around the construction site on a temporary basis, adequate measures must be put in place to insure maximum fish habitat safety. Consideration may be given to a winter construction program when flows are low, frozen soils aid excavation stability and the fish have moved off to deeper water due to ice encroachment.

### 5.2 Foundations

### ***5.2.1 Culvert Replacement, Head, Cut-Off and Wing Walls***

The upper fluvial deposits are very loose to compact, variable by nature, saturated and water bearing. As such, they are not considered adequate to support both the culvert end walls and wing wall extensions. However, it is judged possible to support these units through structural connections to the culvert barrels. Below the culvert barrels, the cut-off wall zone will have to be sequentially isolated by sand bagging, sheet piling, ground freezing or similar methods, dewatered, excavated, formed and poured with sufficient reinforcement extended to tie into the new section of slab. In order to carry this operation out, it will be necessary to break back some 1400 mm of the existing floor slab (see Figure P-42). Subsequent to this operation, the make up portion and the new floor slab section can be poured over approximately one half of the culvert length along one of the barrel sections. Based on the information presently at hand, and the nature of the construction sequences, it is believed that sheet piling will provide the most effective form of river diversion, groundwater control and installation procedure. The sheet piling for the river diversion would involve driving sheeting down to a depth below the base of the excavation equal to the height of water above the excavation base and incorporate a stick up of at least 1 m above river level at the time of installation. Depending on the actual section properties of the sheeting, braced whalers may be required along the top of the sheet piles. The sheeting will be located in such a manner that there is sufficient room to carry out the work at one complete barrel of the working half of culvert construction, to provide space for sumps for local water control, and to prevent major back seepage from the inner space of the water flow barrel and the underside of the isolated barrel. Downstream, sandbagging would be provided at the culvert outlet in order to prevent flooding and disruption of construction activities as a result of local backwater effects.

### ***5.2.2 Design Bearing Resistance***

Based on the above noted soil conditions and the founding elevations shown on the General Arrangement Details (Figure P-42) we have determined a factored bearing capacity value at

ULS of 150 kPa. A SLS bearing capacity of 80 kPa reflects settlement considerations of the preloaded zone of soil below the existing floor slab. The above noted design values can be used by the design team to carry out final section choice and optimization. However, the final design would require review and/or adjustment if founding elevation or structural configuration is changed.

### ***5.2.3 Lateral Earth Pressure***

A free draining Granular B Type I, as per OPSS, is recommended as appropriate backfill to the culvert and wing walls in order to insure the prevention of hydrostatic pressure build-up. The embankment fill placement should be carried out in a balanced manner with the fill on the outer side of the walls in order to prevent the development of unequal lateral pressures.

Lateral earth pressures should be computed in accordance with the OHBDC.
The design parameters are as follows:

| | **Granular A** | **Granular B Type I** | **Rock Fill** |
|---|---|---|---|
| Angle of Internal Friction (degrees) | 35 | 30 | 43 |
| Unit weight ($kN/m^3$) | 22 | 20 | 18.5 |
| Active earth pressure (Ka) | 0.27 | 0.33 | 0.19 |
| At-rest earth pressure (Ko) | 0.43 | 0.50 | 0.32 |

An active condition (Ka) may be assumed to apply for a yielding structure, which will require an outward deflection of up to 0.5 percent of the wall height, measured from passive support line to the top of the wall. For rigid structures such deflection cannot occur, so the “at rest” condition (Ko) applies.

The actual magnitude of force and location of application will be controlled by final structure geometry and siting. The relevant lateral pressure calculations involved in an assessment of the force will incorporate surcharge loading whether line, point or area, hydrostatic effects, and the proper evaluation of such general formulae as:

**$Pa = Ka (\gamma' H^2 / 2 + q)$** Where: Ka = active earth pressure

$\gamma'$ = unit weight ($kN/m^3$)

H = total height of supported soils

q = the effect of any form of surcharge loading

Cohesive soils and soils that exhibit both cohesion and friction require different evaluation, as do assessments of at rest and passive earth pressure.

### ***5.2.4 Embankment Fills***

Embankment widening in the vicinity of the structure, is in the order of 3 m of widening with attendant depths of 1 to 3 m in the immediate vicinity of the culvert barrels.

Prior to placing the fill, the existing embankment slopes and affected native soils should be sub-excavated to at least 300 mm within the plan limits of the culvert work area in order to provide a uniform and stable base free of organics and other deleterious materials. Beyond the immediate culvert area, the benching requirements of OPSD 208.010 shall be met with a height of 500 mm and a width of 900 mm. The sub-excavated material will be replaced with a granular fill of the same nature as the highway widening material. Temporary excavations should be inclined at 2:1 (horizontal to vertical) or flatter in the vicinity of saturated zones or flowing water. The embankment widening fill can be placed at 2:1 (horizontal to vertical) provided it meets OPSS 1010 for Granular B Type I grading requirements.

### ***5.2.5 Rock Fill***

As a minimum creek side backfill to structures should consist of rock fill which meets hydraulic and fish habitat requirements.

### ***5.2.6 Roadway Protection***

Sheet piling is recommended for roadway protection during construction. Over the actual culvert locations, the sheeting would be carried down to top of slab grade behind a suitably sized and connected anchorage system. A suitably sized whaler should be provided and tied into the full depth piling and bracing at the edge of the culvert barrel, in order to provide support at the top of the sheeting over the culvert barrels. The full depth piling sections would extend to a depth of 2 m to 3 m below underside of the existing culvert slab and extend up above highway surface. Depending on the section properties of the sheeting, whalers and bracing struts or ground anchor support systems may be required. Minimum sheeting penetration adjacent to the culvert barrel will be 3 m and this depth of embedment will be maintained relative to the excavation profile. Across the top of the two barrels, a similar arrangement of anchors, clip angle(s) and support whaler can be installed. Once one half of the culvert barrel construction is complete, a system of dead man type anchors can be installed, as the highway fill is brought up to grade to tie back the sheeting.

## 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.

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