



March 18, 2016

DRAFT DETAIL FOUNDATION INVESTIGATION AND DESIGN REPORT

MCINTYRE RIVER CULVERT
SITE NO. 48C-36/C
HIGHWAY 589, DISTRICT OF THUNDER BAY
TOWNSHIP OF GORHAM
MINISTRY OF TRANSPORTATION, ONTARIO
G.W.P 6301-14-00, W.P. 6301-14-01

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DRAFT REPORT





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PART A

**DETAIL FOUNDATION INVESTIGATION REPORT
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Hatch Mott MacDonald (HMM), on behalf of the Ministry of Transportation, Ontario (MTO) to provide detail foundation engineering services for the replacement of the McIntyre River culvert (Site No. 48C-36/C). The McIntyre River culvert is located in the District of Thunder Bay on Highway 589 at STA 17+459 in the Township of Gorham, approximately 11.4 km north of Highway 102. The key plan showing the general location of this section of Highway 589 and the location of the investigated area are shown on Drawing 1.

2.0 SITE DESCRIPTION

The existing culvert consists of a Steel Plate Corrugated Steel Pipe Arch (SPCSPA), the details of which (i.e., width, height, length, etc.) are summarized in Table 1 following the text of the report.

In general, the topography in the area of the culvert is relatively flat with moderate to dense tree cover bordering the Highway right-of-way and McIntyre River. At the culvert location, the highway grade is at Elevation 418.6 m, the invert is at about Elevation 413.3 m and the river flows in an easterly direction.

Surface conditions in the culvert area from the inspection report dated February 2014 and from the field investigation in December 2014 are shown on Photographs 1 to 4, attached.

3.0 INVESTIGATION PROCEDURES

The field work for this subsurface investigation was carried out on December 5 and 6, 2014, during which time a total of five boreholes (Boreholes MR-1 to MR-5) were advanced. Boreholes MR-1, MR-4 and MR-5 were advanced using a track-mounted CME-55 drill rig and Boreholes MR-2 and MR-3 were advanced using a truck-mounted CME 55 drill rig. Both drill rigs were supplied by and operated by George Downing Estate Drilling Ltd. of Grenville-Sur-La-Rouge, Quebec.

Boreholes MR-1, MR-4 and MR-5 were advanced at the toe of slope near the culvert inlet/outlet using 108 mm inside diameter hollow stem augers. Boreholes MR-2 and MR-3 were advanced from the existing highway platform using 108 mm inside diameter hollow stem augers and/or NW casing and wash boring techniques. Soil samples were obtained in the boreholes at 0.75 m and 1.5 m intervals of depth using 50 mm outer diameter split-spoon samplers driven by an automatic hammer, in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586). Field vane shear tests were conducted in cohesive soils for determination of undrained shear strengths (ASTM D2573) using MTO Standard 'N' size vanes. The groundwater levels in the open boreholes were observed during the drilling operations as described on the Record of Borehole sheets in Appendix A. The boreholes were backfilled upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The field work was supervised on a full-time basis by a member of Golder's technical staff who located the boreholes in the field, arranged for the clearance of underground services; supervised the drilling and sampling operations, logged the boreholes; and examined and cared for the soil samples. The soil samples were identified in the field, placed in labelled containers and transported to Golder's geotechnical laboratory in Sudbury for further examination and laboratory testing. Index and classification testing consisting of water content determinations, grain size distributions, and Atterberg limits tests were carried out on selected soil samples. The geotechnical laboratory testing was completed according to MTO LS standards.



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A sample of the river water was obtained during the field investigation, using appropriate sampling protocols and submitted to a specialist analytical laboratory under chain of custody procedures for testing for a suite of parameters, including pH, resistivity, conductivity, sulphates and chlorides. The results of the analytical testing are presented in Table B1 in Appendix B.

The as-drilled borehole locations and ground surface elevations were measured and surveyed by members of our technical staff, referenced to the highway centerline and existing culvert and converted into Northing/Easting on the plan drawing. The ground surface elevation of the highway centerline was obtained from the profile drawing provided by MTO (BC7355895.dwg). The MTM NAD83 northing and easting coordinates, ground surface elevations referenced to Geodetic datum and borehole depths at each borehole location are presented on the Record of Borehole sheets in Appendix A and summarized below.

Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
MR-1	5382090.6	352310.3	416.1	9.0
MR-2	5382088.0	352323.5	418.6	11.6
MR-3	5382099.5	352329.0	418.5	14.4
MR-4	5382094.6	352337.1	417.3	1.5
MR-5	5382107.7	352339.8	415.3	10.2

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on the Northern Ontario Engineering Geology Terrain (NOEGTS)¹ mapping, the subsoils in the vicinity of the McIntyre River culvert site generally consist of glaciolacustrine plain deposits, comprised primarily of clayey subsoils.

Based on geological mapping by the Ministry of Northern Development and Mines (Map 2542)², the site is underlain by bedrock of the Archean Era, comprised of mafic to intermediate metavolcanic rocks, consisting of basaltic and andesitic flows, tuffs and breccia's, chert, iron formation, minor metasedimentary and intrusive rocks, related migmatites.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the Record of Borehole sheets contained in Appendix A. The results of geotechnical laboratory testing are contained in Appendix B. The results of the in situ field tests (i.e., SPT 'N' values and undrained shear strengths from field vanes) as presented on the Record of Borehole sheets and in Section 4 are uncorrected. The stratigraphic boundaries shown on the boreholes records and on the interpreted stratigraphic section on Drawing 1 are inferred from non-continuous sampling and, therefore, represent transitions

¹ Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 52ANW

² Ministry of Northern Development of Mines. Bedrock Geology of Ontario – West Central Sheet, Ontario Geological Survey – Map 2542.



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between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

Subsoil Conditions

In summary, the subsoil conditions encountered at the site consist of asphalt and granular fill (for boreholes through the embankment), or cohesive silty clay fill underlain by an organic silt to organic silty clay deposit (for the boreholes advanced at the toe of the embankment). The fill or organic deposits are underlain by a cohesive deposit of clayey silt to clay, which is underlain in one instance by a deposit of sand and gravel. A more detailed description of the soil deposits and groundwater conditions encountered in the boreholes is provided in the following table and sections.

Deposit/Layer Description	Boreholes	Thickness (m)	Elevation (m)	N Values (blows) / Shear Strength (kPa)	Laboratory Testing
				Consistency or Relative Density	
Asphalt	MR-2, MR-3	0.065 – 0.075	418.6 – 418.5	n/a	n/a
(FILL)¹ sand to sand and gravel, some cobbles, trace to some silt, trace clay, brown, frozen to wet	MR-2, MR-3	5.5	418.5 – 418.4	N = 9 – 25 ² Loose to Compact	w = 9% – 33 % 1 – MH and 2 – M (Fig. B1)
(FILL) silty clay, trace organics, some gravel, some sand, reddish brown to dark brown, frozen	MR-1, MR-5	0.8	416.1 – 415.3	N = 17 – 24 Frozen	w = 20 %
Organic Silt to Organic Silty Clay , trace to some sand, dark brown, wet	MR-1, MR-5	1.6 – 2.6	415.3 – 414.5	N = 2 – 6 S _u = 40 Soft to Firm	w = 33% – 39% 2 – MH (Fig. B2) 2 – AL (Fig. B3) w _p = 26% – 31% w _l = 47% – 54% I _p = 21% – 23% 2- OC = 5% - 7%
Clayey Silt to Clay³ , trace sand, trace organics, reddish brown, wet	MR-1, MR-2, MR-3 and MR-5	MR-3 = 8.0, All other boreholes terminated in this deposit	413.0 – 412.7	N = 2 – 11 S _u = 38 – >100 ⁴ Firm to Very Stiff	w = 30% – 67%; 31% ³ 8 – MH (Fig. B4) 8 – AL (Fig. B5) w _p = 16% – 29%; 16% ³ w _l = 32% – 79%; 22% ³ I _p = 16% – 50%; 5% ³ 2 - OC = 1%
Sand and Gravel, trace to some silt , grey, wet	MR-3	0.8	404.9	N = 37 Dense	w = 10% 1 – M (Fig. B6)



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Where:

N = SPT 'N'-value; number of blows for 0.3 m of penetration

s_u = Undrained Shear Strength from in situ field 'N'-vane (kPa)

w = Natural Moisture Content (%)

MH = Combined Sieve and Hydrometer analysis

M = Sieve analysis

AL = Atterberg Limits Test

w_p = Plastic Limit (%)

w_l = Liquid Limit (%)

I_p = Plasticity Index (%)

OC = Organic Content (%)

Notes:

¹ Cobbles were encountered throughout the fill deposit in Boreholes MR-2 and MR-3 ranging from 120 mm to 225 mm diameter, requiring NW casing and NQ coring techniques to advance the boreholes through this deposit.

Borehole MR-4 was terminated at Elevation 415.8 m within the fill deposit likely due to the presence of cobbles and/or boulders, and an additional Borehole, MR-5, was advanced on the opposite side of the river.

² In the granular fill, two SPT 'N'-values of 41 blows and 87 blows per 0.3 m of penetration were recovered, however these are likely indicative of the frozen state of the material and are not representative. Further, one SPT 'N'-value of 20 blows for 0.05 m of penetration was recovered, likely indicative of the presence of a cobble and/or boulder.

³ A clayey silt to silt seam was encountered in Borehole MR-2 within the clayey silt to clay deposit at approximately 9.1 m depth. The natural moisture content measured on a sample of the clayey silt to silt seam is about 31 per cent. The result of a grain size distribution test completed on the clayey silt to silt seam within the clayey silt to clay deposit is shown on Figure B4. One Atterberg limit test was carried out on a sample of the clayey silt to silt seam within the clayey silt to clay deposit yielded a liquid limit of about 22 per cent, a plastic limit of about 16 per cent and a corresponding plasticity index of about 5 as shown on Figure B5. Based on the results of the Atterberg limit test the material is classified as clayey silt to silt of slight plasticity.

⁴Typically, the deposit is stiff in consistency in the boreholes drilled through the existing embankment.

Refusal

Refusal to further casing and split spoon penetration was encountered in Borehole MR-3, corresponding to Elevation 404.1 m.

Groundwater Conditions

Boreholes MR-1, MR-4 and MR-5 were noted to be dry upon completion of drilling. Boreholes MR-2 and MR-3 caved at depths of 3.8 m and 3.9 m, respectively upon completion of drilling and boreholes were noted to be dry to the caved depths. The river ice level was measured at Elevation 414.6 m on December 4, 2014. Groundwater and river water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.



5.0 CLOSURE

The field drilling program was carried out under the supervision of Mr. Cody Walter and Mr. Mathew Riopelle, under the overall direction of Mr. David Muldowney, P.Eng. This Detail Foundation Investigation Report was prepared by Mr. Adam Core, P.Eng., and Ms. Sarah E. M. Poot, P.Eng., an Associate of Golder provided a technical review of the report. Mr. Jorge M. A. Costa, P.Eng., the Designated MTO Foundations Contact and Principal of Golder conducted an independent quality control review and technical audit of this report.



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Report Signature Page

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PART B

**DETAIL FOUNDATION DESIGN REPORT
MCINTYRE RIVER CULVERT – SITE NO. 48C-36/C
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6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides detail foundation design recommendations for the proposed replacement of the McIntyre River culvert. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during this subsurface investigation. Where comments are made on construction, they are provided to highlight those aspects that could affect the current detail design of the project, and for which special provisions may be required in the Contract Documents. Those requiring information on the aspects of construction should make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.1 General

The existing McIntyre River culvert is located on Highway 589 at STA 17+459, located approximately 11.4 km north of the Highway 102 junction in the Township of Gorham. The highway embankment is constructed of granular fill and is approximately 5.3 m high relative to the invert of the existing culvert (river bottom). The existing culvert consists of a Steel Plate Corrugated Steel Pipe Arch (SPCSPA) the details of which (i.e., width, height, length, etc.) are summarized in Table 1 following the text of the report.

As part of the preliminary design phase of the project, alternative types of culverts were considered for replacement of the existing structure, as reported in the "Preliminary Foundation Investigation and Design Report, McIntyre River Culvert – Site 48C-36/C, Highway 589, District of Thunder Bay, Unsurveyed Territory, G.W.P. 6301-14-00", GEOCRE 52A-198, dated June 5, 2015, by Golder Associates Ltd.

Based on the General Arrangement (GA) drawing provided by HMM on December 15, 2015, the new culvert is to be comprised of a 4.6 m diameter Structural Plate Corrugated Steel Pipe (SP CSP). The proposed invert of the culvert will be Elevations 412.7 m and 412.6 m at the west and east ends, respectively, which is approximately 0.6 m to 0.7 m lower than the invert of the existing culvert. The grade of the highway at the McIntyre River Culvert will remain the same (i.e. at about Elevation 418.6 m) and there will not be any embankment widening in the culvert area.

A revised GA was provided by HMM on March 8, 2016 which includes gabion basket retaining walls at the culvert inlet and outlet. Geotechnical recommendations regarding the geotechnical axial resistance/reaction, global wall stability and potential retaining wall/culvert settlement will be provided to HMM and MTO prior for review and comment prior to submission of the final Foundation Investigation Design Report.

6.2 Foundation Conditions and Frost Protection

The subsoil conditions encountered at the proposed culvert location consist of asphalt and granular fill (for boreholes through the embankment), or cohesive silty clay fill underlain by an organic silt to organic silty clay deposit (for the boreholes advanced at the toe of the embankment). The fill or organic deposits are underlain by a cohesive deposit of clayey silt to clay, which is underlain in one instance by a deposit of sand and gravel. Based on the proposed culvert invert elevation, the replacement pipe culvert will be founded on a layer of granular



bedding overlying the native firm to very stiff clayey silt to clay deposit at Elevation 412.4 m and 412.3 m (to accommodate a 300 mm thick bedding layer).

It is not necessary to found a circular pipe culvert at the standard depth for frost protection purposes, as these structures are tolerant of small magnitudes of movement related to freeze-thaw cycles, should these occur.

6.3 Stability, Settlement and Horizontal Strain

For the subsurface conditions and the reconstructed embankment heights up to about 3.3 m above the existing ground surface (relative to Borehole MR-5) in the culvert area, the granular fill reconstructed embankment at this site will be stable (i.e. Factor of Safety greater than 1.3 m) at side slopes inclined at 2 Horizontal to 1 Vertical (2H:1V) or flatter.

Given that an embankment grade raise or widening is not proposed as part of the culvert replacement and highway embankment reconstruction, the existing native soils will not experience additional load, and therefore settlement of the culvert after embankment reconstruction is estimated to be less than 25 mm and horizontal strain is not expected to occur. As a result, culvert construction concurrent with the embankment reconstruction can be carried out without the need for any foundation mitigation measures or culvert camber.

6.4 Culvert Construction Considerations

6.4.1 Construction Staging and Temporary Roadway Protection

The temporary excavation for the culvert will be made through the existing embankment granular fill and into native soils, which are comprised of soft to firm organic silt and organic silty clay (in places) and an underlying deposit of firm to very stiff clayey silt to clay. All excavations must be carried out in accordance with Ontario Regulation 213, Ontario Occupational Health and Safety Act for Construction Projects (as amended). The granular fills and native soils are considered to be Type 3 soil above the groundwater table and Type 4 soil below. Temporary open-cut excavations in Type 3 soils should remain stable if side slopes are formed no steeper than 1 Horizontal to 1 Vertical (1H:1V). In Type 4 soils, the side slopes should be formed no steeper than 3H:1V.

Based on the GA drawing provided by HMM on March 8, 2016, we understand that the roadway will be closed during construction with traffic being re-routed via a detour, however a temporary protection support system is being proposed between the temporary diversion channel and the excavation for the replacement culvert. At this site, the installation of sheet-piles for culvert construction and/or temporary shoring may be impeded by the presence of cobbles (up to 225 mm in size) within the fill material. It may be necessary to excavate and replace the existing fill material in the areas of sheet-pile installation in a series of limited length and narrow trenches. In general, the narrowest suitable excavator bucket should be used. The replacement fill could consist of excavated fill material or imported granular material provided that 100 per cent of the material passes the 75 mm size. Sieving, sorting or picking of large particles from the excavated spoil pile may be required if the excavated material is re-used. Alternatively, imported Granular 'A' or Granular 'B' Type I, II or III may be used as backfill for the excavated trench. Excavation and replacement should be carried out on the same day to avoid leaving any trench



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open overnight. It is recommended that a Non-Standard Special Provision (NSSP) be included in the Contract to address obstructions; a sample NSSP is included in Appendix C.

As an alternative to sheet-piling, the temporary support systems could consist of soldier piles and lagging where H-piles would be driven to a suitable depth and horizontal lagging installed as the excavation proceeds. Support to the system could be in the form of struts and walers and rakers or anchors. Where required, temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (Temporary Protection Systems). Temporary excavation support systems should be designed to Performance Level 2 for any excavation adjacent to existing roadways. The support systems may be designed using the following parameters:

Soil Type	Unit Weight	Internal Angle of Friction	Undrained Shear Strength	Coefficient of Earth Pressure		
	(γ , kN/m ³)	(ϕ , degrees)	(kPa)	Active, K_a	At Rest, K_o	Passive, K_p
New Granular 'A' or Granular B' Type I, II or III	21	35	-	0.27	0.43	3.69
Existing Sand to Sand and Gravel - Fill (Loose to Compact)	20	32	-	0.31	0.47	3.25
Existing Silty Clay - Fill	18	27	-	0.38	0.55	2.63
Organic Silt to Organic Silty Clay (Soft to Firm)	16	27	25	0.38	0.55	2.63
Clayey Silt to Clay (Firm to Very Stiff)	17	28	50	0.36	0.53	2.77
Sand and Gravel, (Dense)	20	35	-	0.27	0.43	3.69

The temporary shoring design should be assessed for both the drained and undrained cases, based on the more conservative earth pressure conditions.

The earth pressure coefficients noted above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are present, the coefficient of earth pressure should be adjusted accordingly.

The clayey silt to clay deposit is potentially sensitive to disturbance from vibration and/or driving, which should be considered in the design and installation of the temporary protection systems. Design of the temporary excavation and roadway support system should include an evaluation of base stability ('base heave' or soil squeezing stability) and hydraulic uplift stability as defined in the Canadian Foundation Engineering Manual (CFEM 2006).



6.4.2 Excavation and Replacement Fill Below Culvert

Prior to placement of any bedding material, granular fill or concrete, all organics (including peat, topsoil and mixed organic soil materials such as organic silt and organic silty clay) and any softened soils, should be sub-excavated from below the plan limits of the proposed works.

The culvert subgrade should be inspected following sub-excavation to ensure that all organics and other unsuitable materials have been removed, in accordance with OPSS 421 (Pipe Installation in Open Cut). Following inspection, if further sub-excavation of unsuitable subgrade materials is required, the sub-excavation and backfill placement operations should be carried out in accordance with OPSS.PROV 209 (Embankments over Swamps). The sub-excavated area should be backfilled with granular material meeting the requirements of an OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type I, II or III that is placed and compacted in accordance with OPSS.PROV 501 (Compacting). The use of Granular 'B' Type II is recommended in wet ground conditions or below water.

6.4.3 Culvert Bedding and Backfill

Culvert construction should be in accordance with OPSS 421 (Pipe Culvert Installation in Open Cut). The bedding and backfill for a SP CSP culvert should be in accordance with OPSS 802.010 (Flexible Pipe, Excavation and Backfill – Earth Excavation) and construction should be carried out in accordance with OPSS.PROV 401 (Trenching, Backfilling and Compacting). It is important that the backfill at the haunches be well compacted. Given the potential for surface water flow and some groundwater seepage through the adjacent granular fill and native soils during excavation to the invert and bedding level and the potential for further loosening of the fine grained native soils, it is recommended that a minimum 300 mm thick layer of OPSS.PROV 1010 (Aggregates) Granular 'A' or 'B' Type II material be used for bedding purposes. As the native soils below the bedding are generally fine grained (i.e. clayey silt to clay), it is recommended that a non-woven geotextile be placed between the native soil and the bottom of the bedding. The geotextile should meet the specifications for OPSS 1860 (Geotextiles) Class II, and have a fabric opening size (FOS) not greater than 212 µm. The bedding should be placed in maximum 200 mm thick loose lifts and compacted to at least 95 per cent of the SPMDD of the materials as specified in OPSS.PROV 501 (Compacting).

Backfill above/around the pipe culvert should consist of granular fill meeting the specifications for OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type I, II or III. The existing fill materials may be suitable as backfill for embankment reconstruction above the granular cover material over the culvert provided that the asphalt layer/pieces are removed and the material is available at a suitable moisture content for compaction. The backfill should be placed in maximum 200 mm thick loose lifts and be compacted to at least 95 per cent of the SPMDD of the materials in accordance with OPSS.PROV 501 (Compacting).

Backfill placement for reconstruction of the roadway embankments along and over the culvert should be carried out as per OPSS 208.010 (Benching of Earth Slopes) to integrate the existing embankment fill and new fill along the cut faces.



At this site, given that the existing sand and gravel embankment fill, which extends below the frost penetration depth, is classified as having a low susceptibility to frost heaving (i.e. soil has less than about 13 per cent fine particles between 5 μm and 75 μm); a frost taper is not required at this site.

Inspection and field density testing should be carried out by qualified geotechnical personnel during all engineered fill placement operations to ensure that appropriate materials are used and that adequate levels of compaction have been achieved.

6.4.4 Subgrade Protection

The native soils will be susceptible to disturbance from construction traffic and/or ponded water. To limit the effect of this disturbance, the 300 mm thick granular bedding layer should be placed in a timely manner. The foundation subgrade should be inspected immediately prior to placement of the bedding layer to confirm that the subgrade has been properly prepared for placement of the bedding/pipe. Consideration should be given to include an NSSP in the contract to address subgrade protection at this site. An example NSSPs for subgrade protection to be included in the Contract is presented in Appendix C.

6.4.5 Erosion Protection

Provision should be made for scour and erosion protection at all culvert locations. In order to prevent surface water from flowing either beneath the culvert (potentially causing undermining and scouring) or around the culvert (creating seepage through the embankment fill, and potentially causing erosion and loss of fine soil particles), a clay seal or concrete cut-off wall should be provided at the upstream end of the culvert. If a clay seal is adopted, the clay material should meet the requirements of OPSS 1205 (Clay Seal), and the seal should be a minimum thickness of 1 m, if constructed of natural clay or soil bentonite mix. The clay seal should extend from a depth of 1 m below the scour level to a minimum vertical height equivalent to the high water level. The seal should also extend a minimum horizontal distance of 2 m on either side of the culvert inlet opening.

The requirements for and design of erosion protection measures for the inlet and outlet of the culvert should be assessed by the hydraulics design engineer. As a minimum, rip rap treatment for the outlet of the culvert should be consistent with the standard presented in OPSD 810.010 (Rip Rap Treatment). Erosion protection for the inlet of the culverts should also follow the standard presented in OPSD 810.010 (Rip Rap Treatment) similar to the outlet but with the rip rap placed up to the toe of slope level, in combination with the cut off measures noted above.

The requirements for and design of erosion protection measures for the temporary diversion channel should be assessed by the hydraulics design engineer. Consideration could be given to providing rip rap the base of the channel and the excavation side slopes extending vertically up to the high water level similar to that shown in OPSD 810.010 (Rip Rap Treatment) for the culvert outlet. A geotextile is not considered to be required on the temporary diversion channel bottom.



6.4.6 Control of Groundwater and Surface Water

Excavation along the culvert alignment will be required to remove the existing embankment fill and organic materials, where present, and extend into the native clayey silt to clay deposit to achieve the required invert/bedding level, followed by placement of bedding, the actual culvert, backfill and roadway pavement structure. Groundwater flow into the excavation can be expected due to the depth of the excavations. Therefore, control of groundwater will be necessary to allow construction to be carried out in dry conditions, where required. Surface water should be directed away from the excavation areas to prevent ponding of water that could result in disturbance and weakening of the foundation subgrade.

Based on the GA drawing provided by HMM on March 8, 2016, we understand that the creek flows will be diverted via a temporary bypass channel to be installed approximately 15 m south of the existing/replacement culvert. A temporary sheet-pile cut-off wall or cofferdam will be required to divert the creek water to the temporary bypass. To reduce the potential for surface/groundwater from the temporary channel diversion discharging/seeping into the excavation area of the permanent culvert.

Although a SP CSP culvert can be placed in wet conditions, given the presence of relatively permeable embankment fills it is anticipated that unwatering within the excavation will be required to allow for preparation of the subgrade soils and proper placement and compaction of the bedding material. Temporary shoring and groundwater control could be in the form of a sheet-pile cut off wall or cofferdam advanced to an appropriate depth to control groundwater inflow from the creek and to prevent base heaving of the foundation subgrade.

The subsurface soils at this site are potentially sensitive to disturbance from vibration and/or driving, which should be considered in the design and installation of the unwatering system.

Dewatering of all excavations should be carried out in accordance with OPSS 517 (Dewatering). An NSSP should be included in the Contract to address unwatering at this site; a sample NSSP is included in Appendix C.

Provided that the creek flow is diverted and the unwatering system is installed to a suitable depth to mitigate groundwater inflows, pumping volumes are not anticipated to exceed 50 m³/day. However, an application for a Permit to Take Water (PTTW) should be submitted in the event that the pumping volumes exceed this amount.

6.4.7 Obstructions

The Contractor should be alerted to the presence of cobble size materials and potential boulders within the granular fill at this site. A sample NSSP is included in Appendix C.

6.4.8 Analytical Testing for Construction Materials

The results of an analytical test on a sample of river water taken at the culvert site are shown on Table B1 in Appendix B. The suite of parameters tested is intended to allow the design engineer to assess the requirements for the appropriate type of cement to be used in construction and the need for corrosion protection of steel reinforcing elements.



7.0 CLOSURE

This Detail Foundation Design Report was prepared by Mr. Adam Core, P.Eng. and the technical aspects were reviewed by Ms. Sarah E. M. Poot P.Eng., Associate. Mr. Jorge M. A. Costa P.Eng., the Designated MTO Foundations Contact and Principal of Golder conducted an independent review of this report.



Report Signature Page

GOLDER ASSOCIATES LTD.

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Designated MTO Foundations Contact, Principal

AC/SEMP/JMAC/kp

n:\active\2014\1190 sudbury\1191\1411523 - hmm 26 culverts thunder bay\reporting\detail design\d7 - mcintyre river\draft\1411523 dft rpt d7 16ma18 mcintyre river fdr.docx



REFERENCES

Canadian Standards Association (CSA), 2006. *Canadian Highway Bridge Design Code and Commentary on CAN/CSA S6 06*. CSA Special Publication, S6.1 06.

Occupational Health and Safety Act and Regulation for Construction Projects, January 2006.

Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 52ANW

Ministry of Northern Development of Mines. Bedrock Geology of Ontario – West Central Sheet, Ontario Geological Survey – Map 2542.

ASTM International:

ASTM D1586 Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils

ASTM D2573 Standard Test Method for Field Vane Shear Test in Cohesive Soil

Ontario Provincial Standard Specifications (OPSS)

OPSS 517 Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation

OPSS 1205 Material Specification for Clay Seal

OPSS 1860 Material Specification for Geotextiles

Ontario Provincial Standard Specifications (OPSS) – Provincial Oriented

OPSS.PROV 209 Construction Specification for Embankments over Swamps and Compressible Soils

OPSS.PROV 401 Construction Specification for Trenching, Backfilling, and Compacting

OPSS.PROV 421 Construction Specification for Pipe Culvert Installation in Open Cut

OPSS.PROV 501 Construction Specification for Compacting

OPSS.PROV 539 Construction Specification for Temporary Protection Systems

OPSS.PROV 1010 Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material

Ontario Provincial Standard Drawings (OPSD)

OPSD 208.010 Benching of Earth Slopes

OPSD 802.010 Flexible Pipe, Excavation and Backfill; Earth Excavation

OPSD 803.031 Frost Treatment – Pipe Culverts, Frost Penetration Line between Top of Pipe and Bedding Grade

OPSD 810.010 Rip-Rap Treatment for Sewer and Culvert Outlets

Ontario Water Resource Act:

Regulation 903 Wells (as amended)



DRAFT DETAIL FOUNDATION REPORT
MCINTYRE RIVER CULVERT - SITE NO. 48C-36/C

Table 1: Summary Details of Existing Culvert

Culvert Location (Township)	Site #	Approximate Height of Embankment ¹ (m)	Existing Culvert			Approximate Invert Elevation ² (m)
			Type	Approximate Dimension ² (m)	Approximate Length (m)	
Hwy 589 STA 17+459 (Township of Gorham)	48C-36/C	5.3	Steel Plate Corrugated Steel Pipe Arch (SPCSPA)	4.3 m x 2.7 m	21	413.3

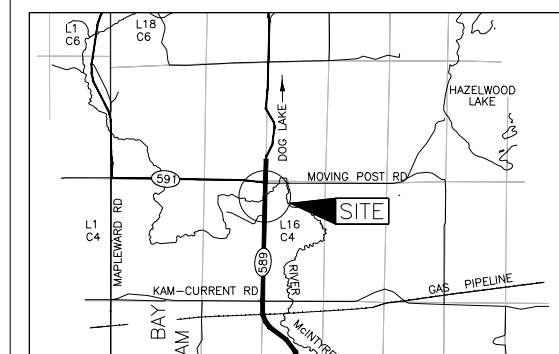
- Notes:
1. Embankment height is relative to existing ground surface at the centreline of the roadway and the invert elevation of the culvert.
 2. Culvert dimensions are based on the RFP and invert elevation are based on the plan and profile drawing provided by MTO on drawing BC7355895.dwg.

Prepared by: AC
Checked by: SEMP
Reviewed by: FJH/JMAC

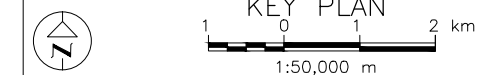


SHEET


HIGHWAY 589
MCINTYRE RIVER CULVERT STA 17+459
BOREHOLE LOCATIONS AND SOIL
STRATA



KEY PLAN



LEGEND

- | | |
|-------------------------------------------------------------------------------------|--------------------------------------------------------------------|
|  | Borehole |
| N | Standard Penetration Test Value |
| 16 | Blows/0.3m unless otherwise stated
(Std. Pen. Test, 475 j/blow) |
| R | Refusal |

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
MR-1	416.1	5382090.6	352310.3
MR-2	418.6	5382088.0	352323.5
MR-3	418.5	5382099.5	352329.0
MR-4	417.3	5382094.6	352337.1
MR-5	415.3	5382107.7	352339.8

NOTES

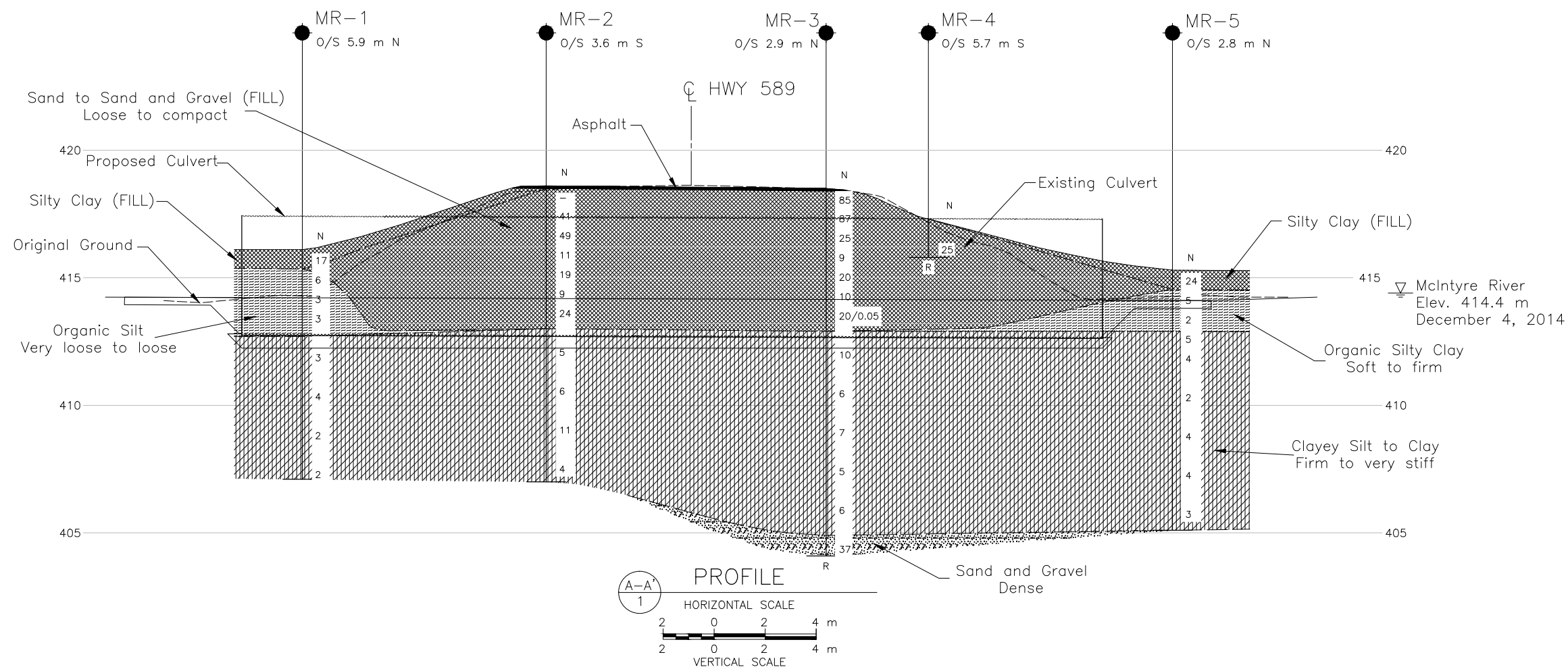
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by Hatch Mott MacDonald, drawing file no. ST-343033-MCINTYRE RIVER ARCH CULVERT-01-GENERAL ARRANGEMENT.dwg, dated MAR 2016, received MAR 8 2016.



DRAFT

NO.	DATE	BY	REVISION

Geocres No.,

HWY. 589	PROJECT NO. 1411523	DIST. .
SUBM'D. AC	CHKD. DAM	DATE: 3/15/2016
DRAWN: JVL	CHKD. SEMP	APPD. JMAC
		DWG. 1



PHOTOGRAPHS

**Photograph 1: McIntyre River Culvert
West Side - Inlet (Taken from MTO, OSIM 10-Feb-14)**



**Photograph 2: McIntyre River Culvert
East Side - Outlet (Taken from MTO, OSIM 10-Feb-14)**





PHOTOGRAPHS

**Photograph 3: McIntyre River Culvert
Looking West at Culvert (Golder – 3-Dec-14)**



**Photograph 4: McIntyre River Culvert
Looking West at Culvert (Golder – 3-Dec-14)**





APPENDIX A

RECORD OF BOREHOLES



LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
$\ln x$,	natural logarithm of x
\log_{10}	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a)	Index Properties
$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
C_v	coefficient of consolidation (vertical direction)
C_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = $\tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

* Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

Notes: 1
2

$$\tau = c' + \sigma' \tan \phi'$$

$$\text{shear strength} = (\text{compressive strength})/2$$



LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Density Index	N
Relative Density	Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils Consistency

	C_u, S_u	
	kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000




IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

PROJECT 1411523			RECORD OF BOREHOLE No MR-1			1 OF 1 METRIC							
G.W.P. 6301-14-00			LOCATION N 5382090.6; E 352310.3			ORIGINATED BY CW							
DIST _____ HWY 589			BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers			COMPILED BY SEMP							
DATUM GEODETIC			DATE December 3, 2014			CHECKED BY DAM							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT <div style="display: flex; justify-content: space-around; font-size: small;"> 20 40 60 80 100 </div>	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES								
416.1	GROUND SURFACE						416						
0.0	Silty clay with organics (FILL) Reddish-brown Frozen		1	SS	17		416						
415.3							415						
0.8	ORGANIC SILT, trace to some sand Soft to firm Reddish-brown Wet		2	SS	6		415						
			3	SS	3		414						
			4	SS	3		414						
412.7							413						
3.4	SILTY CLAY to CLAY, trace sand, trace organics Firm to stiff Reddish-brown Wet		5	SS	3		412						
							411						
			6	SS	4		410						
							409						
			7	SS	2		408						
407.1			8	SS	2								
9.0	END OF BOREHOLE												
	Note: 1. Borehole dry upon completion of drilling.												

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 09/03/15 DATA INPUT:

PROJECT 1411523		RECORD OF BOREHOLE No MR-2				1 OF 1 METRIC											
G.W.P. 6301-14-00		LOCATION N 5382088.0; E 352323.5				ORIGINATED BY MR											
DIST _____ HWY 589		BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers, NW Casing, Wash Boring				COMPILED BY SEMP											
DATUM GEODETIC		DATE December 3, 2014				CHECKED BY DAM											
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	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
418.6	GROUND SURFACE						20	40	60	80	100						
0.0	ASPHALT (75 mm)		1	AS	-												14 74 10 2
	Sand, some gravel, trace to some silt, trace clay (FILL)		2	SS	41												
	Loose to compact																
	Brown																
	Frozen / wet																
	Upper 1.4 m frozen.																
	225 mm cobble at 1.7 m depth.		3	SS	49												
	150 mm cobble at 2.1 m depth.																
	175 mm cobble at 2.9 m depth.		4	SS	11												
			5	SS	19												
			6	SS	9												
			7	SS	24												
413.0	SILTY CLAY, trace sand																
5.6	Stiff to very stiff		8	SS	5												
	Reddish-brown																
	Wet																
			9	SS	6												
	Clayey silt to silt seam encountered at 9.1 m depth.		10	SS	11												
			11	SS	4												
407.0	END OF BOREHOLE																
11.6	Note:																
	1. Refusal on cobble at 1.7 m depth. Samples 4 through 11 obtained from additional borehole advanced 1.2 m north of MR-2.																
	2. Borehole caved at 3.8 m depth upon completion of drilling. Borehole dry to 3.8 m depth upon completion of drilling.																

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 09/03/15 DATA INPUT:

PROJECT 1411523		RECORD OF BOREHOLE No MR-3		1 OF 2 METRIC																				
G.W.P. 6301-14-00		LOCATION N 5382099.5; E 352329.0		ORIGINATED BY MR																				
DIST _____ HWY 589		BOREHOLE TYPE NW Casing, Wash Boring		COMPILED BY SEMP																				
DATUM GEODETIC		DATE December 4 and 5, 2014		CHECKED BY DAM																				
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			ELEVATION SCALE			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES																			
418.5	GROUND SURFACE																							
0.0	ASPHALT (65 mm)		1	SS	85																			
0.1	Sand and gravel, some silt (FILL) Loose to compact Brown Frozen / wet		2	SS	87																			
	Upper 1.4 m frozen.																							
	120 mm cobble at 1.4 m depth.																							
	180 mm cobble at 2.0 m depth.		3	SS	25																			
			4	SS	9																			
			5	SS	20																			
			6	SS	10																			
			7	SS	20/0.05																			
	200 mm cobble at 5.1 m depth.																							
412.9	CLAYEY SILT, trace to some sand Stiff to very stiff Reddish-brown Wet		8	SS	10																			
5.6																								
			9	SS	6																			
			10	SS	7																			
			11	SS	5																			
			12	SS	6																			
404.9	SAND and GRAVEL, trace to some silt Dense Grey Wet		13	SS	37																			
13.6																								
404.1																								
14.4																								

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 09/03/15 DATA INPUT:

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>1411523</u>	RECORD OF BOREHOLE No MR-3	2 OF 2	METRIC
G.W.P. <u>6301-14-00</u>	LOCATION <u>N 5382099.5; E 352329.0</u>	ORIGINATED BY <u>MR</u>	
DIST <u></u> HWY <u>589</u>	BOREHOLE TYPE <u>NW Casing, Wash Boring</u>	COMPILED BY <u>SEMP</u>	
DATUM <u>GEODETIC</u>	DATE <u>December 4 and 5, 2014</u>	CHECKED BY <u>DAM</u>	

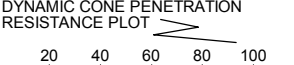






SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					w _p	w	w _L		GR	SA	SI	CL
								○ UNCONFINED	● QUICK TRIAXIAL	+	×	FIELD VANE	REMOULDED	WATER CONTENT (%)						
	<div>END OF BOREHOLE CASING AND SPLIT-SPOON REFUSAL (HAMMER BOUNCING)</div> <div>Note: 1. Borehole caved at 3.9 m depth upon completion of drilling. Borehole dry to 3.9 m depth upon completion of drilling.</div>																			

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 09/03/15 DATA INPUT:

PROJECT 1411523		RECORD OF BOREHOLE No MR-4		1 OF 1 METRIC	
G.W.P. 6301-14-00		LOCATION N 5382094.6; E 352337.1		ORIGINATED BY CW	
DIST _____ HWY 589		BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers		COMPILED BY SEMP	
DATUM GEODETIC		DATE December 3 and 4, 2014		CHECKED BY DAM	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								○ UNCONFINED	+	FIELD VANE	● QUICK TRIAXIAL	×	REMOULDED	w _p	w		w _L			
417.3	GROUND SURFACE																			
0.0	ROCK FILL																			
416.5																				
0.8	Sand and gravel, some silt, some rock fragments (FILL) Compact Brown Moist		1	SS	25							○								
415.8																				
1.5	END OF BOREHOLE AUGER REFUSAL																			
<div>Note:</div> <div>1. Borehole dry upon completion of drilling.</div>																				

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 09/03/15 DATA INPUT:

PROJECT 1411523			RECORD OF BOREHOLE No MR-5			1 OF 1 METRIC					
G.W.P. 6301-14-00			LOCATION N 5382107.7; E 352339.8			ORIGINATED BY CW					
DIST _____ HWY 589			BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers			COMPILED BY SEMP					
DATUM GEODETIC			DATE December 4, 2014			CHECKED BY DAM					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT  SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
415.3	GROUND SURFACE										
0.0	Silty clay some organics, some sand (FILL) Dark brown Frozen		1	SS	24		415				
414.5											
0.8	ORGANIC SILTY CLAY, trace to some sand Soft to firm Dark brown Wet		2	SS	5		414			OC=5.2%	0 10 67 23
			3	SS	2						
			4a				413				
412.9			4b	SS	5						
2.4	SILTY CLAY to CLAY, trace sand, trace organics Firm to very stiff Reddish-brown Wet										
			5	SS	4		412			OC=1.0%	0 3 67 30
							411	2 +			
			6	SS	2		410	2 +			
			7	SS	4		409				
							408	2 +			
			8	SS	4		407				
							406	3 + 2 +			
			9	SS	3						0 0 37 63
405.1											
10.2	END OF BOREHOLE										
	Note: 1. Borehole caved at 6.0 m depth upon completion of drilling. Borehole dry upon completion of drilling.										

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 10/03/15 DATA INPUT:



APPENDIX B

LABORATORY TEST RESULTS



DRAFT DETAIL FOUNDATION REPORT MCINTYRE RIVER CULVERT - SITE NO. 48C-36/C

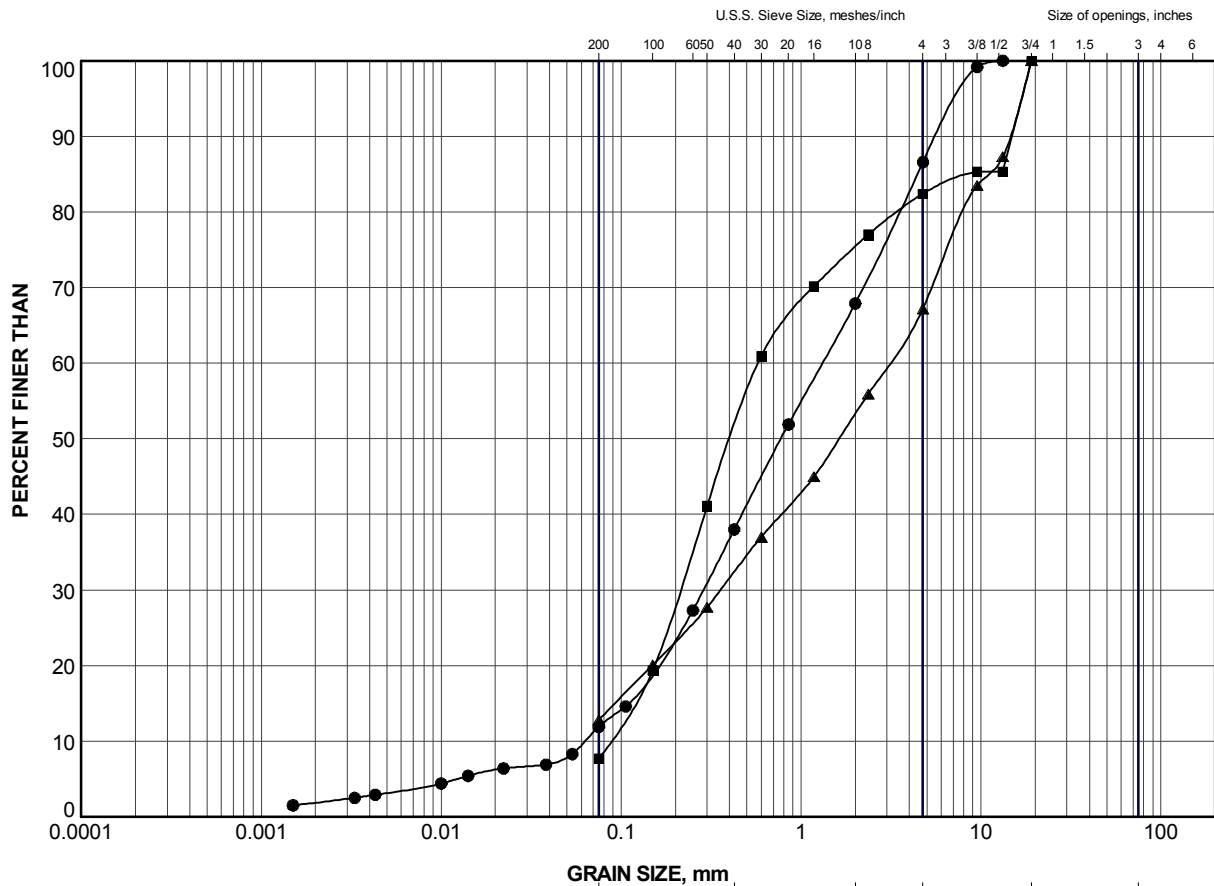
Table B1: Summary of Analytical Testing of McIntyre River Water Sample

Parameter	Units	Result
Chloride (CL)	mg/L	6.41
Sulphate (SO4)	mg/L	6.63
Conductivity (EC)	µS/cm	129
Resistivity	ohms*cm	7752
pH	n/a	7.10

Notes:

1. Sample obtained on February 9, 2015.
2. Analytical testing carried out by ALS Canada Ltd.


Prepared by: AC
Checked by: SEMP
Reviewed by: JMAC

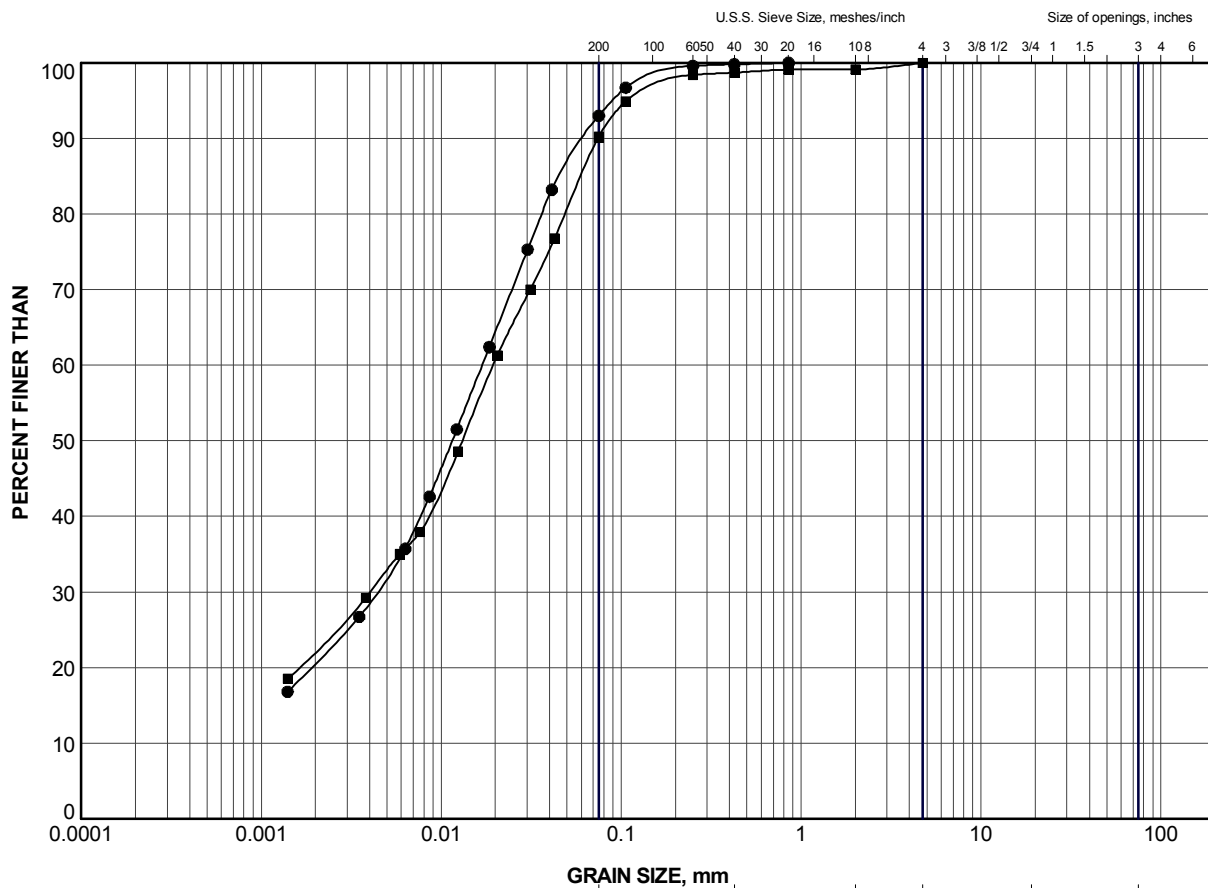


GRAVEL SIZE, mm							Cobble Size
CLAY AND SILT	fine	medium	coarse	fine	coarse		
	SAND SIZE			GRAVEL SIZE			

LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	MR-2	1	418.3
■	MR-2	6	414.5
▲	MR-3	2	417.4

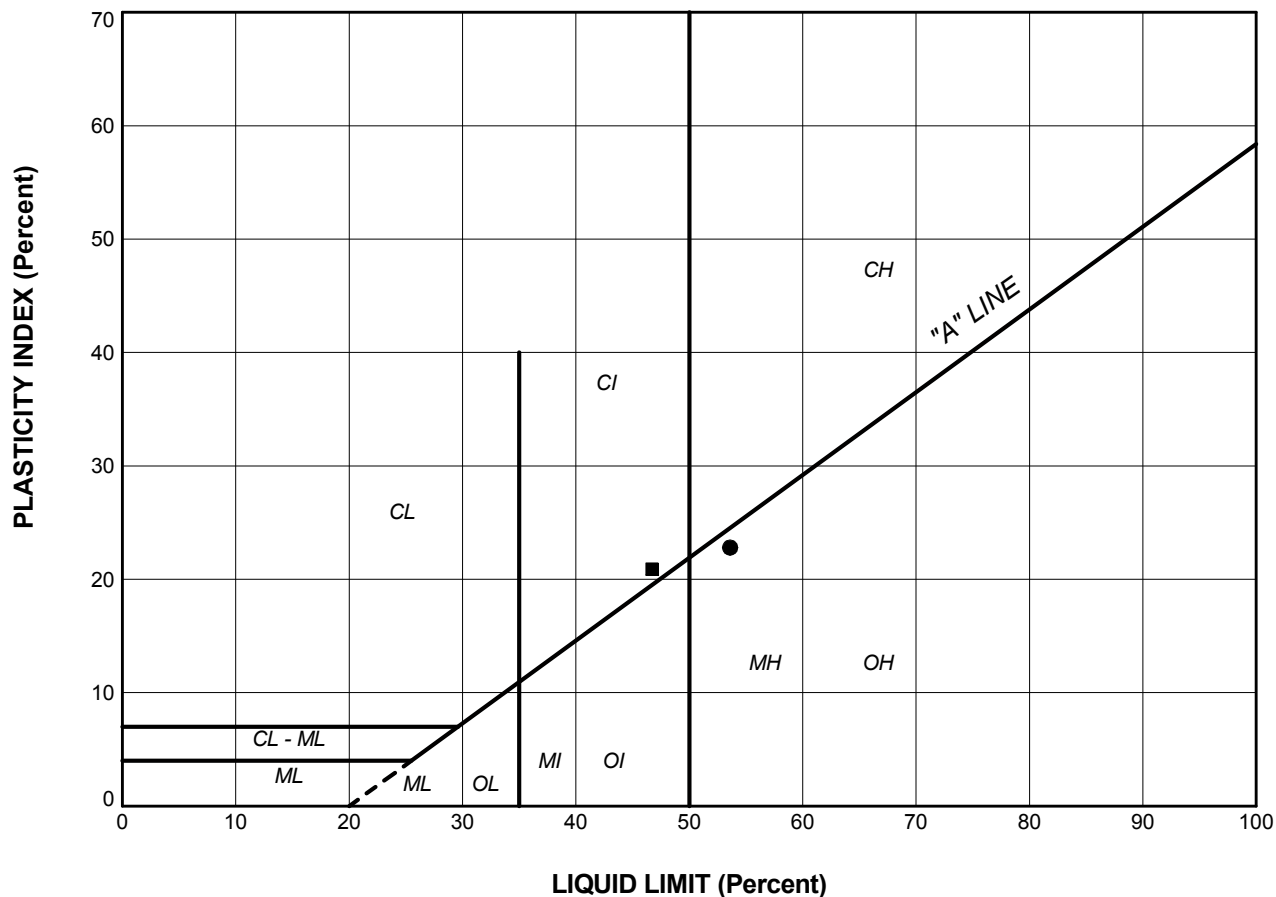
PROJECT					HIGHWAY 589 MCINTYRE RIVER CULVERT STA 17+459				
TITLE					GRAIN SIZE DISTRIBUTION SAND to SAND and GRAVEL (FILL)				
PROJECT No.			1411523		FILE No.			1411523.GPJ	
DRAWN	JJL	Mar 2015	SCALE	N/A	REV.				
CHECK	DAM	Mar 2015							
APPR	FJH	Mar 2015							
 Golder Associates SUDBURY, ONTARIO			FIGURE B1						



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	MR-1	3	414.3
■	MR-5	2	414.2

PROJECT						HIGHWAY 589 MCINTYRE RIVER CULVERT STA 17+459					
TITLE						GRAIN SIZE DISTRIBUTION ORGANIC SILT to ORGANIC SILTY CLAY					
PROJECT No.				1411523		FILE No.				1411523.GPJ	
DRAWN		J.J.L.		Mar 2015		SCALE		N/A		REV.	
CHECK		DAM		Mar 2015							
APPR		F.J.H.		Mar 2015							
 Golder Associates SUDBURY, ONTARIO						FIGURE B2					



SOIL TYPE

C = Clay

M = Silt

O = Organic

PLASTICITY

L = Low

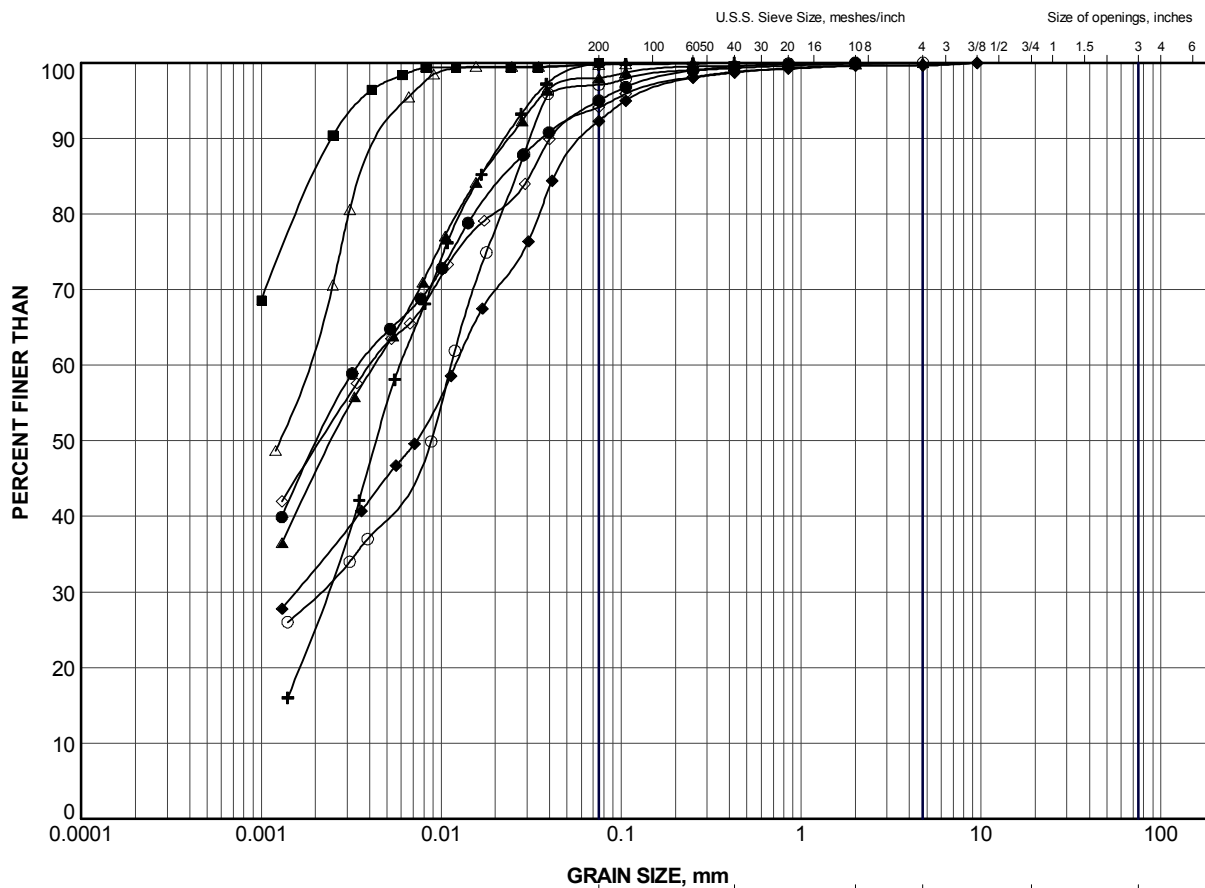
I = Intermediate

H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	MR-1	3	53.6	30.8	22.8
■	MR-5	2	46.7	25.8	20.9


PROJECT					
HIGHWAY 589 MCINTYRE RIVER CULVERT STA 17+459					
TITLE					
PLASTICITY CHART ORGANIC SILT to ORGANIC SILTY CLAY					
PROJECT No.		1411523		FILE No.	
DRAWN		J.J.L.		Mar 2015	
CHECK		DAM		Mar 2015	
APPR		F.J.H.		Mar 2015	
SCALE		N/A		REV.	
Golder Associates SUDBURY, ONTARIO		FIGURE B3			

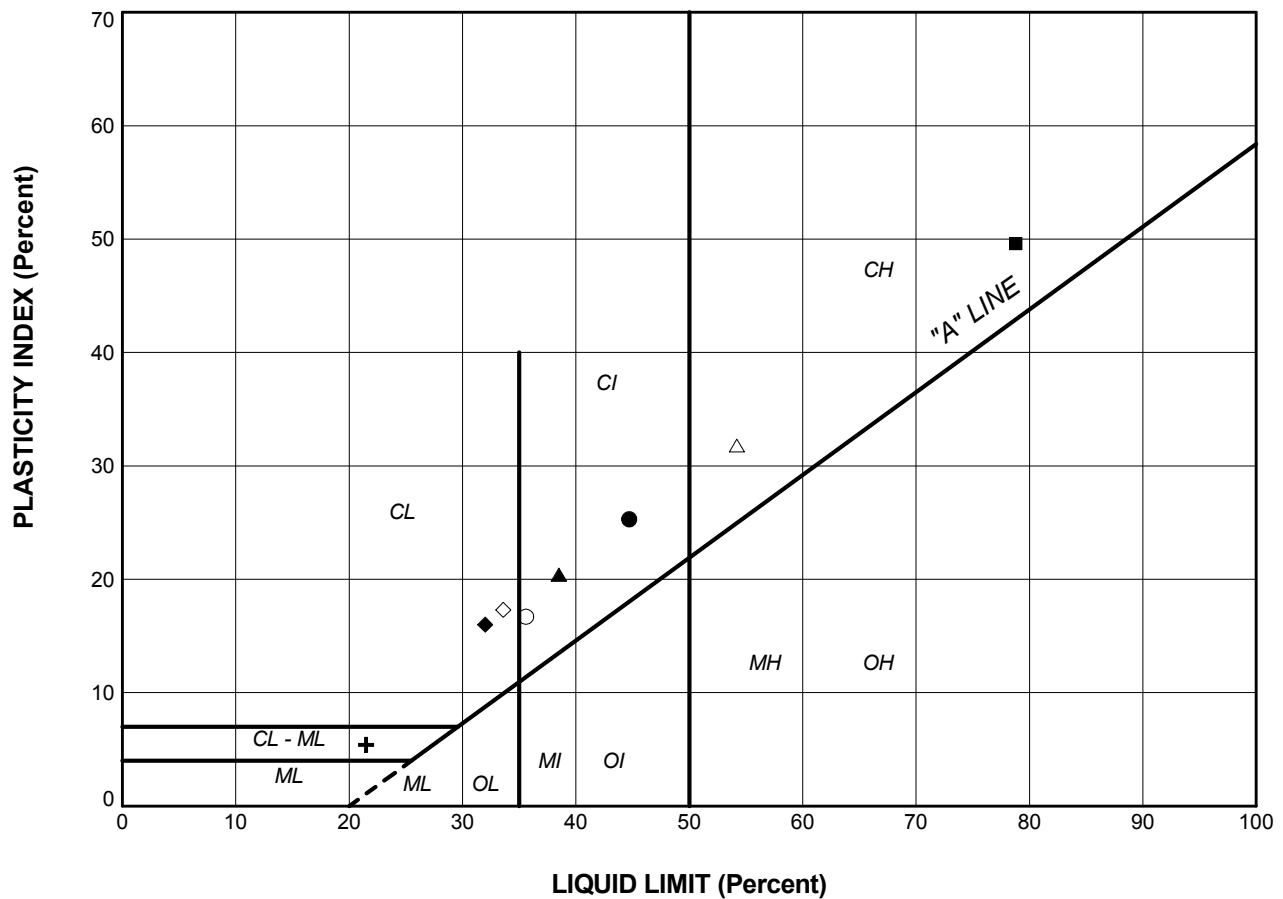


GRAVEL SIZE, mm						Cobble Size
CLAY AND SILT	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)	
●	MR-1	5	412.0	
■	MR-1	8	407.4	
▲	MR-2	9	410.7	
+	MR-2	10	409.2	Clayey Silt to Silt seam
◆	MR-3	9	410.6	
◇	MR-3	11	407.5	
○	MR-5	5	411.9	
△	MR-5	9	405.9	

PROJECT					
HIGHWAY 589 MCINTYRE RIVER CULVERT STA 17+459					
TITLE					
GRAIN SIZE DISTRIBUTION CLAYEY SILT to CLAY					
PROJECT No.		1411523		FILE No. 1411523.GPJ	
DRAWN	JJL	Mar 2015	SCALE	N/A	REV.
CHECK	DAM	Mar 2015			
APPR	FJH	Mar 2015			
 Golder Associates SUDBURY, ONTARIO			FIGURE B4		



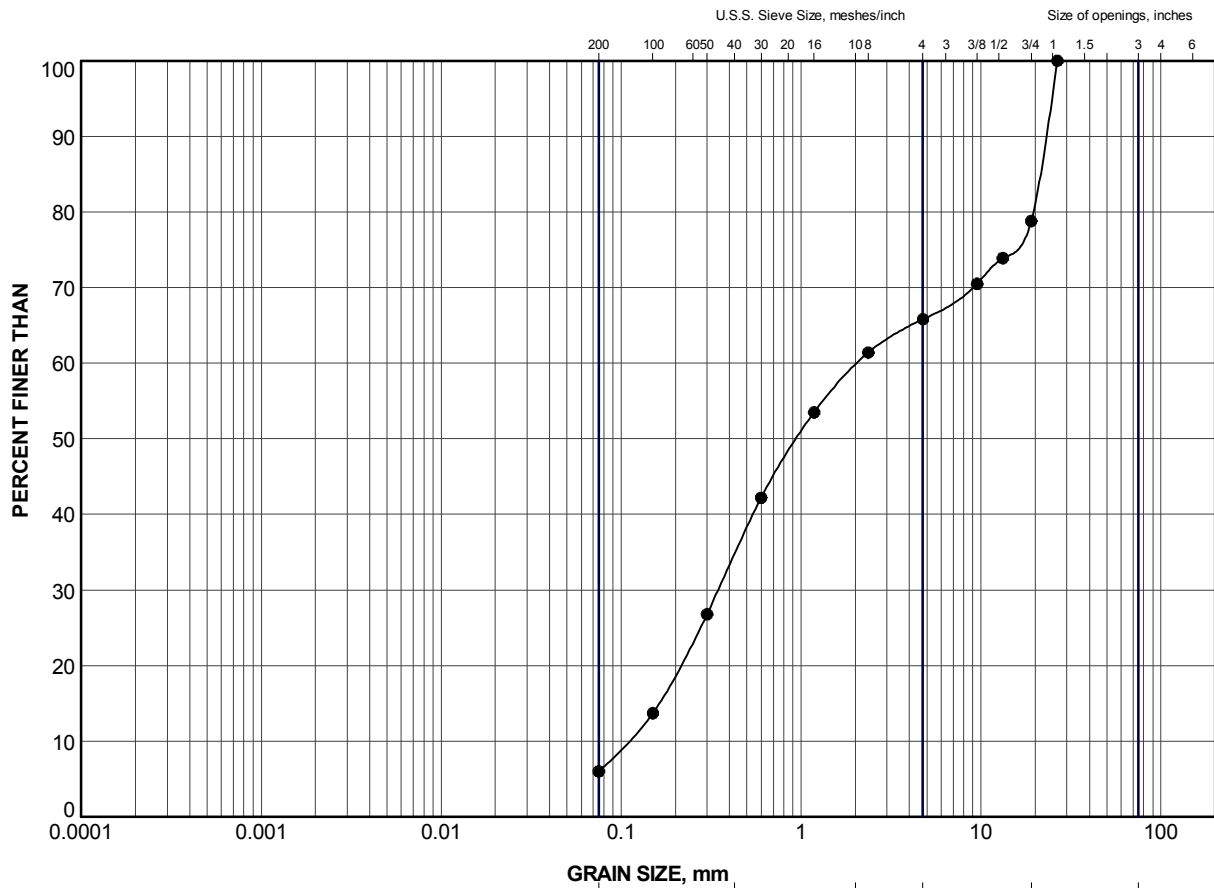
LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	MR-1	5	44.7	19.4	25.3
■	MR-1	8	78.8	29.2	49.6
▲	MR-2	9	38.5	18.1	20.4
+	MR-2	10	21.5	16.1	5.4
◆	MR-3	9	32.0	16.0	16.0
◇	MR-3	11	33.6	16.3	17.3
○	MR-5	5	35.6	18.9	16.7
△	MR-5	9	54.2	22.4	31.8

Clayey Silt to Silt seam

PROJECT				
HIGHWAY 589 MCINTYRE RIVER CULVERT STA 17+459				
TITLE				
PLASTICITY CHART CLAYEY SILT to CLAY				
PROJECT No.		1411523		FILE No.
DRAWN		J.J.L.		Mar 2015
CHECK		DAM		Mar 2015
APPR		F.J.H.		Mar 2015
SCALE		N/A		REV.
FIGURE B5				






CLAY AND SILT	GRAIN SIZE, mm					Cobble Size
	fine		medium	coarse		
	SAND SIZE		GRAVEL SIZE			

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	MR-3	13	404.5

PROJECT					HIGHWAY 589 MCINTYRE RIVER CULVERT STA 17+459				
TITLE					GRAIN SIZE DISTRIBUTION SAND and GRAVEL				
PROJECT No.			1411523		FILE No.			1411523.GPJ	
DRAWN	JJL	Mar 2015	SCALE	N/A	REV.				
CHECK	DAM	Mar 2015							
APPR	FJH	Mar 2015							
 Golder Associates SUDBURY, ONTARIO			FIGURE B6						



APPENDIX C

Non-Standard Special Provisions

OBSTRUCTIONS

Non-Standard Special Provision

The Contactor shall be alerted to the presence of cobbles and potential boulders within the embankment fill at this site as encountered during borehole advancement. Considerations of the presence of these obstructions must be made in the selection of appropriate equipment and procedures for sub-excavation and installation of the temporary shoring and roadway protection system, if required.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION

UNWATERING OF STRUCTURE EXCAVATION - Item No.

Non-Standard Special Provision

Construction of the culvert will require excavations to extend below the groundwater level and the adjacent river water level on both ends of the culvert. The embankment sand fill and adjacent organic silt/organic silty clay deposits if encountered within the excavation area, as may be present below the groundwater table will slough, run, boil or cave into the excavation unless appropriate groundwater controls are in place. The Contractor is to design and install an appropriate excavation protection and unwatering system to enable construction and prevent disturbance to the founding soils.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION

SUBGRADE PROTECTION – Item No.

Non-Standard Special Provision

Scope of Work

The silty sand stratum of the subgrade at this site is susceptible to disturbance and loosening from construction traffic and ponded water. Any loosened or disturbed soils below the plan limits of the proposed works should be sub-excavated and replaced with compacted engineered fill. A 300 mm thick protection layer, or bedding layer, comprised of Granular A or Granular B Type II material should be placed in a timely manner after inspection and approval of the subgrade condition. The subgrade should be inspected and approved immediately before placing the bedding layer to confirm the subgrade conditions are suitable for the construction of the culvert.

Basis of Payment

Payment at the lump sum contract price for the above tender item includes full compensation for all labour, equipment and material for completion of the work.

END OF SECTION

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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