DRAFT REPORT

March 17, 2016

DRAFT DETAIL FOUNDATION INVESTIGATION AND DESIGN REPORT

DOG RIVER CULVERT - SITE NO. 48C-218/C
HIGHWAY 527, DISTRICT OF THUNDER BAY
UNSURVEYED TERRITORY
MINISTRY OF TRANSPORTATION, ONTARIO
G.W.P 6302-14-00, W.P. 6300-14-01

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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 Dog River culvert (Site No. 48C-218/C). The Dog River culvert is located in the District of Thunder Bay on Highway 527 at STA 21+844, approximately 40 km north of Highway 11/17. The key plan showing the general location of this section of Highway 527 and the location of the investigated area are shown on Drawing 1.

2.0 SITE DESCRIPTION

The Dog River Culvert is located on Highway 527 at STA 21+844, approximately 40 km north of the junction of Highway 11/17 (see the key plan on Drawing 1). The existing culvert consists of twin Steel Plate Corrugated Steel Pipe (SPCSP), 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 this area consists of rolling terrain to the north of the culvert location to relatively flat in all other directions. The dog river borders the site on the east and west side of the roadway and has areas of standing water, organic terrain consisting of tall grasses, cattails and small shrubs and the river drains westerly. Beyond the right-of-way and the bordering the edges of the Dog River, the area has moderate to heavy coniferous tree cover. At the culvert location, the highway grade is at Elevation 461.7 m and the invert is at about Elevation 458.7 m. The water level measured by others on April 30, 2012 was Elevation 459.05 m. Ground Surface conditions at the culvert inlet (east end) and outlet (west end) areas are shown on Photographs 1 to 3, attached.

3.0 INVESTIGATION PROCEDURES

The field work for this subsurface investigation was carried out on December 5 and 6 2014, during which time five (5) boreholes (Boreholes DG-1, DG-2, DG-2A, DG-3 and DG-4) were advanced. Boreholes DG-1 and DG-4 were advanced using track-mounted CME-55 drill rig whereas Boreholes DG-2, DG-2A and DG-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.

All boreholes were advanced through the overburden using NW casing, wash boring and where required NQ coring 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). The groundwater levels in the open boreholes were observed during the drilling operations as described on the Record of Borehole sheets in Appendix A. All 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 and rock 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. In addition, unconfined compressive strength (UCS) tests were carried out on selected specimens of the bedrock core recovered from the boreholes. The geotechnical laboratory testing was completed according to MTO LS standards.

A sample of the river water was obtained during the field investigation at the Dog River Culvert location on February 3, 2015, 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 member 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 in January 2015 (drawing BC4848905275.dwg). The MTM NAD83 northing and easting coordinates, ground surface elevations referenced to geodetic datum and borehole depths at each borehole locations 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)
DG-1	5408291.8	370262.2	458.8	4.1
DG-2	5408306.9	370269.4	461.9	1.8
DG-2A	5408308.7	370268.3	462.0	7.1
DG-3	5408300.0	370279.0	461.5	4.5
DG-4	5408320.6	370284.3	459.2	3.2

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 Dog River culvert site generally consist of ground moraine deposits, comprised of mainly sandy till subsoils. Bordering the culvert to the north, the landform of the area is considered to be an undulating bedrock plain.

Based on geological mapping by the Ministry of Northern Development and Mines (Map 2542)[2], the site is underlain by bedrocks of the Archean area, comprised of metasedimentary rocks consisting of mainly paragneisses and migmatites.

[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.

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 contained in Appendix B. The results of the in situ field tests (i.e., SPT 'N' values) 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 between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

In summary, the subsoil conditions encountered at the site consist of asphalt and granular fill (for holes through the embankment) overlying cohesionless deposits of silty sand to sand and gravel and cobbles, which is underlain by bedrock. A more detailed description of the soil deposits and groundwater conditions encountered in the boreholes is provided below.

Deposit/Layer Description	Boreholes	Thickness (m)	Elevation (m)	N Values (blows) / Consistency or Relative Density	Laboratory Testing
Asphalt	DG-2; DG-2A DG-3	0.030 – 0.050	462.0 – 461.5	n/a	n/a
(FILL)[1] gravelly sand to sandy gravel, trace to some silt, brown, frozen to wet	DG-2; DG-2A DG-3	1.8; 3.5 – 4.5	462.0 – 461.4	N = 11 – 100 [2] **Compact to Very Dense**	w = 9% – 15 % 1 – MH and 2 – M (Fig. B1)
Silty Sand to Sand and Gravel to Gravel and Cobbles[3]**,** trace silt, trace organics, brown to dark brown, wet	DG-1 DG-2A DG-3 DG-4	0.7 – 3.2	459.2 – 458.4	N = 4 - 41 [4] **Loose to Dense**	w = 9 % - 39% 3 – MH (Fig. B2)

Where:

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

w = Natural Moisture Content (%)

MH = Combined Sieve and Hydrometer analysis

M = Sieve analysis for particle size

Notes:

[1] Refusal was encountered in Borehole DG-2 at 1.8 m and an additional borehole DG-2A was advanced through the deposit to a depth of 3.6 m, indicative of the presence of cobbles and/or boulders within the deposit. In Borehole DG-3, a 90 mm cobble was encountered at 2.2 m depth, requiring NW casing and NQ coring techniques to advance the borehole through the fill.

[2]Two SPT 'N'-values of 102 blows and 142 blows per 0.3 m of penetration were recorded, however these values are inferred to be indicative of the frozen state of the material and are not representative. One split spoon did not penetrate the full sample depth inferred indicative of the presence of cobbles and/or boulders within the fill.

[3]In Borehole DG-1, cobbles were recovered from 0.5 m to 0.8 m depth, requiring the use of NW casing and NQ coring techniques to advance the borehole through this deposit. In Borehole DG-4 cobbles ranging from 75 mm to 225 mm diameter were recovered from NW casing and NQ coring through this deposit.

[4]In three instances, the split spoon did not penetrate the full sample depth, inferred to be indicative of the presence of cobbles and/or boulders within the deposit. .

Refusal/Bedrock

Refusal to further split spoon or casing penetration was encountered in Boreholes DG-2 (inferred to be on cobbles/boulder) and DG-3, corresponding to Elevation 460.1 m and 457.0 m, respectively. Bedrock was cored in Boreholes DG-1 and DG-2 and the depth to the bedrock surface and bedrock surface elevations are presented below.

Borehole No.	Depth to Bedrock (below ground surface) (m)	Bedrock Surface Elevation (m)	Core Length (m)
DG-1	2.4	456.4	1.7
DG-2A	5.5	456.5	1.6

The retrieved bedrock core is described as grey-black, fine grained, fresh, basalt, with areas of white, medium grained inclusions and dykes, as presented on the Record of Drillhole sheets in Appendix A. Photographs of the retrieved bedrock core samples are shown on Figure B3. A more detailed description of the bedrock properties encountered in the boreholes is provided below.

Borehole No.	Depth/ Elevation (m)	Solid Core Recovery (SCR)	Rock Quality Designation (RQD)	Quality Classification Table 3.10 of CFEM 2006[3]	UCS (MPa)	Strength Classification Table 3.5 of CFEM 2006
DG-1	2.4/456.4	72% and 100%	72% and 100%	Fair to Good	72	(R4) Strong
DG-2A	5.5/456.5	50%	61%	Fair	100	(R4) Strong

Groundwater Conditions

Unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized below. The river ice level was measured at Elevation 458.8 m on December 6, 2014. The water level measured

[3] Canadian Geological Society, 2006. Canadian Foundation Engineering Manual, 4th Edition.

by others on April 30, 2012 was Elevation 459.05 m. Groundwater and river water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

Borehole No.	Depth to Groundwater Level (m)	Groundwater Elevation (m)
DG-1	0.3	458.5
DG-2	1.2	460.7
DG-2A	1.8	460.2
DG-3	0.9	460.6
DG-4	0.2	459.0

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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PART B

DETAIL FOUNDATION DESIGN REPORT
DOG RIVER CULVERT – SITE NO. 48C-218/C
HIGHWAY 527, DISTRICT OF THUNDER BAY
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6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides detailed foundation design recommendations for the proposed replacement of the Dog 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 Dog River culvert is located on Highway 527 at STA 21+844 located approximately 40 km north of the Highway 11/17 junction. The highway embankment is construction of granular fill material and is approximately 3.0 m high relative to the existing culvert invert. The existing culvert consists of twin SPCSP the details of which (i.e. width, height, length, etc.) are summarized in Table 1.

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, Dog River Culvert – Site 48C-218/C, Highway 527, District of Thunder Bay, Unsurveyed Territory, G.W.P. 6300-14-00, GEOCRES No. 52A-197, dated March 30, 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 three 3.3 m diameter Corrugated Steel Pipes (CSP). The proposed invert of the culvert is Elevation 457.7 m and Elevation 457.6 m at the inlet (east) and outlet (west) ends, respectively, which is approximately 1.2 m lower than the existing culvert inverts. The grade of the highway at the Dog River Culvert will remain the same (i.e. at about Elevation 461.7 m).

6.2 Founding Conditions and Frost Protection

The subsoil conditions encountered at the proposed culvert location consist of asphalt and granular fill (for boreholes drilled through the embankment), underlain by cohesionless deposits of silty sand to sand and gravel and cobbles, which are underlain by basalt bedrock. Based on the proposed invert elevations, the replacement pipe culvert will be founded on a granular bedding layer to be placed on native compact to very dense silty sand to sand and gravel and cobbles subgrade excavated at Elevation 457.4 m and 457.3 m (taking into account invert Elevations and a 300 mm thick bedding layer).

It is not necessary to found the culvert pipes below the standard depth of frost penetration, as these are tolerant to 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 proposed reconstructed embankment height up to about 4 m relative to the proposed culvert invert, or about 3 m high relative to the ground surface adjacent to the new culvert, the granular fill reconstructed embankments at this site will be stable (i.e., Factor of Safety greater than 1.3) at side slopes of 2 Horizontal to 1 Vertical (2H:1V) or flatter, assuming that there is no grade raise or platform widening at the culvert site.

Given that embankment grade raise or widening is not proposed as part of the culvert replacement and highway embankment, the existing native soils will not experience additional load, and therefore, settlement of the culvert will be less than 25 mm.

Horizontal Strain is not expected to occur as we understand that the permanent embankment geometry is not changing from the current (existing) geometry. As a result, culvert construction concurrent with the embankment reconstruction can be carried out without the need for any foundation mitigation measures of culvert camber.

6.4 Culvert Construction Considerations

6.4.1 Construction Staging and Temporary Roadway Protection

The temporary excavation for the culvert replacement will be made through the existing embankment granular fill and into native soil deposits, which are comprised of compact to very dense sand to sand and gravel and cobbles. 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 fill and native soils are considered to be Type 3 soil above the groundwater table and Type 4 soil below the groundwater table. Temporary open-cut excavations in Type 3 soils should remain stable if side slopes are formed no stepper than 1 Horizontal to 1 Vertical (1H:1V). In Type 4 soils, the side sloes should be formed no steeper than 3H:1V.

Based on the GA drawing provided by HMM, a temporary protection system is being proposed along the centreline of the highway to facilitate construction staging and maintain traffic during culvert replacement work. At this site, due to the relatively shallow depth to bedrock and the presence of cobbles as encountered within the native soils in the boreholes, a temporary support system comprised of sheet piling will not be feasible at this site. Soldier piles and lagging (with the piles socketted into bedrock and supported by tiebacks or rakers) are considered an appropriate system to support the excavation along the culvert, as well as along the roadway. 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.

Where required, the temporary protection system 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 Fill	21	35	-	0.27	0.43	3.69
Existing Gravelly Sand to Sandy Gravel Fill (Compact to Very Dense)	20	32	-	0.31	0.47	3.25
Silt and Sand to Sand and Gravel, Cobbles (Loose to Dense)	20	35	-	0.27	0.43	3.69

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.

Although the subsurface (native) soils are granular in gradation and considered to be relatively free-draining, nevertheless the 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 below Culvert

Prior to placement of any bedding material or engineered fill as backfill for sub-excavation of unsuitable soils if required, the existing embankment fill, organics (if encountered) and any loosened 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 Culvert Installation in Open Cut). Following inspection, the sub-excavated area should be backfilled with granular material meeting the requirements of an OPSS.PROV 1010 Granular 'A' or Granular 'B' Type I or II that is placed and compacted in accordance with OPSS.PROV 501 (Compacting). The use of Granular "B" Type II fill is recommended in wet conditions or below water.

6.4.3 Culvert Bedding and Backfill

Culvert construction should be in accordance with OPSS.PROV 421 (Pipe Culvert Installation in Open Cut). The bedding/cover and backfill for the CSP culverts should be in accordance with OPSD 802.010 (Flexible Pipe, Embedment and Backfill) and construction should be carried out in accordance with OPSS.PROV 401 (Trenching, Backfilling and Compacting). It is important that 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.

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 asphalt layer and cobbles/boulders greater than 75 mm 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 OPSD 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 fill and native soils are can generally be classed as low frost susceptible and has low potential to heaving soils as the content of particle sizes between 5 µm and 75 µm is less than 40 per cent (MTO Northern Region Pavement Design Practices and Guidelines); 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 silty native soils will be susceptible to disturbance from construction traffic and/or ponded water. To limit the effect of this disturbance a 300 mm compacted bedding layer should be placed in a timely manner. The bedding layer should be placed immediately after the subgrade has been inspected and approved. An NSSP should be included in the Contract to address subgrade protection at this site; a sample NSSP has been included in Appendix C.

6.4.5 Erosion Protection

Provision should be made for scour and erosion protection at the culvert location. 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 of 1 m, thick 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 culvert 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. Similarly, rip rap should be provided over the full extent of the clay blanket, including the river side slopes and fill slope over the culvert if this clay seal is adopted.

6.4.6 Control of Groundwater and Surface Water

Excavation at the culvert alignment will be required to remove embankment fill and overburden soils prior to placement of engineered fill, bedding material and the actual culvert structure, backfill and the roadway pavement structure.

River flows through the existing culvert will need to be diverted/pumped away from the excavation areas during the construction period. As a result of the excavation, groundwater flow into the excavation can be expected due to the permeable nature of the native granular soils. Therefore, control of groundwater will be necessary to allow for construction to be carried out in dry conditions. 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, we understand the river flows will be diverted through one of the existing CSPs culverts during the first stage of construction and then through the new CSP culvert during the second stage of construction. Although a CSP culvert can be placed in wet conditions, given the presence of relatively permeable embankment fill and native soils, it is anticipated that unwatering within the excavation will be required to allow for inspection and approval of the subgrade soils and proper placement/compaction of the bedding material.

Given that cobbles were encountered in most of the boreholes and that the depth to bedrock is relatively shallow at this site it may not be feasible/practical to install a sheet-pile cut-off system. Alternatively, a cofferdam could be considered, however, it should be noted that pumping from the excavation will be required as water will still flow under the base of the cofferdam. If a sheet-pile cut-off wall or cofferdam is used for unwatering purposes the sheeting will need to be installed to a suitable depth to control groundwater inflows and prevent basal heaving of the unwatered area.

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.

An accurate prediction of the groundwater pumping volumes cannot be made, as the flow rate would be dependent on construction methods adopted by the contractor. However, it is considered that groundwater pumping volumes could exceed 50 m^3/day during initial drawdown stages and/or during periods of heavy precipitation. For this pumping volume, a Permit to Take Water (PTTW) would be required. We understand that HMM has already submitted a PTTW for this project site.

6.4.7 Obstructions

The contractor should be alerted to the presence of cobbles within the existing embankment fill and native soils, as encountered in the boreholes advanced at this site. An NSSP should be included in the Contract; 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 presented in Table B1 included 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., and Associate of Golder. 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

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REFERENCES

Canadian Geotechnical Society, 2006. *Canadian Foundation Engineering Manual*, 4th Edition. The Canadian Geotechnical Society, BiTech Publisher Ltd., British Columbia.

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

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.

Ministry of Transportation. Northern Region Pavement Design Practices and Guidelines, 1997

ASTM International:

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

Ontario Provincial Standard Specifications (OPSS) – Provincial Oriented

OPSS 517	Construction Specification for Dewatering of Pipeline, Utility and Associated Structure Excavation
OPSS.PROV 401	Construction Specification for Trenching, Backfilling, and Compacting
OPSS.PROV 421	Construction Specification for Pipe Sewer 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
OPSS.PROV 1205	Material Specification for Clay Seal

Ontario Provincial Standard Drawings (OPSD)

OPSD 208.010	Benching of Earth Slopes
OPSD 802.010	Flexible Pipe, Embedment and Backfill: Earth Excavation
OPSD 803.031	Frost Treatment – Pipe Culverts, Frost Penetration Line between Top of Pipe and Bedding Grade
OPSD 810.010	General Rip-Rap Layout for Sewer and Culvert Outlets

Ontario Water Resource Act:

Regulation 903	Wells (as amended)

Table 1: Summary Details of Existing Culvert

Culvert Location	Site #	Approximate Height of Embankment [1]	Existing Culvert			Approximate Invert Elevation[2]	
			Type	Approximate Dimension[2]	Approximate Length	West End of Culvert	East End of Culvert
Hwy 527 STA 21+844	48C-218/C	3.0 m	Twin Steel Plate Corrugated Steel Pipe (SPCSP)	2.6 m x 1.5 m (each SP CSP)	26 m	458.7 m	458.9 m

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 and invert elevations are based on the plan and profile drawings provided by MTO (Drawing BC4848905275.dwg).

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

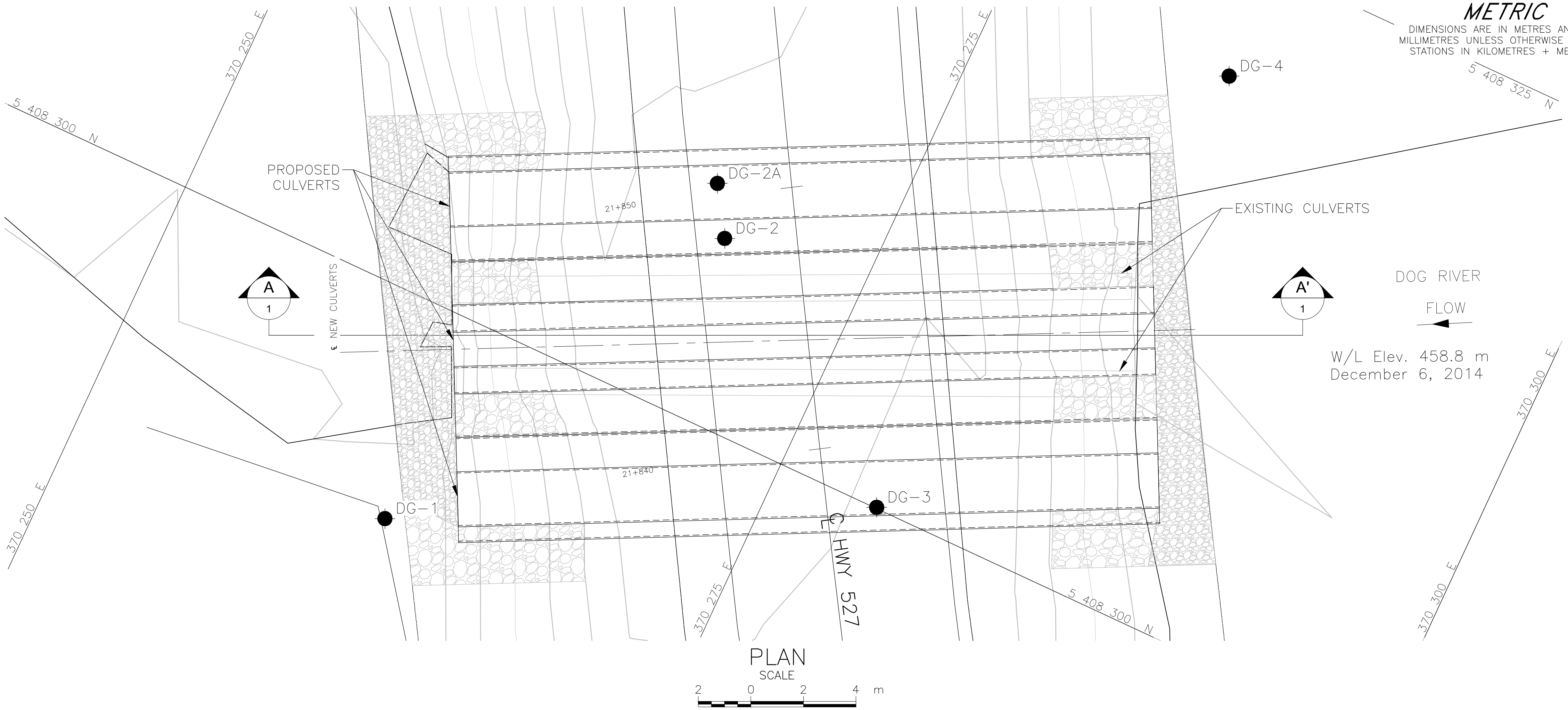
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

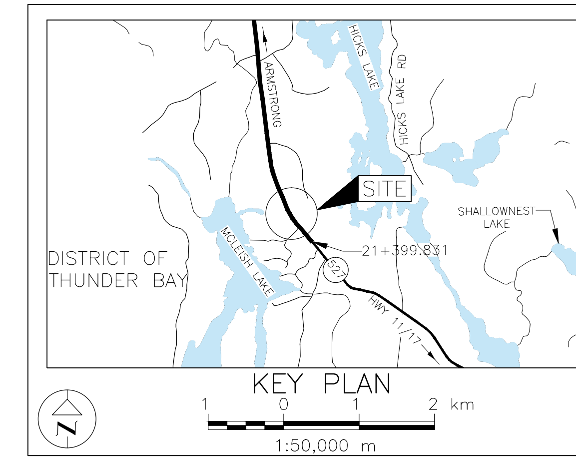
CONT No.
WP No. 6300-14-01

SHEET

HIGHWAY 527
DOG RIVER CULVERT STA 21+844
BOREHOLE LOCATIONS AND SOIL STRATA

Golder Associates





LEGEND

●	Borehole
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
100%	Rock Quality Designation (RQD)
REC	Recovery
R	Refusal
▽	WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
DG-1	458.8	5408291.8	370262.2
DG-2	461.9	5408306.9	370269.4
DG-2A	462.0	5408308.7	370268.3
DG-3	461.5	5408300.0	370279.0
DG-4	459.2	5408320.6	370284.3

NOTES

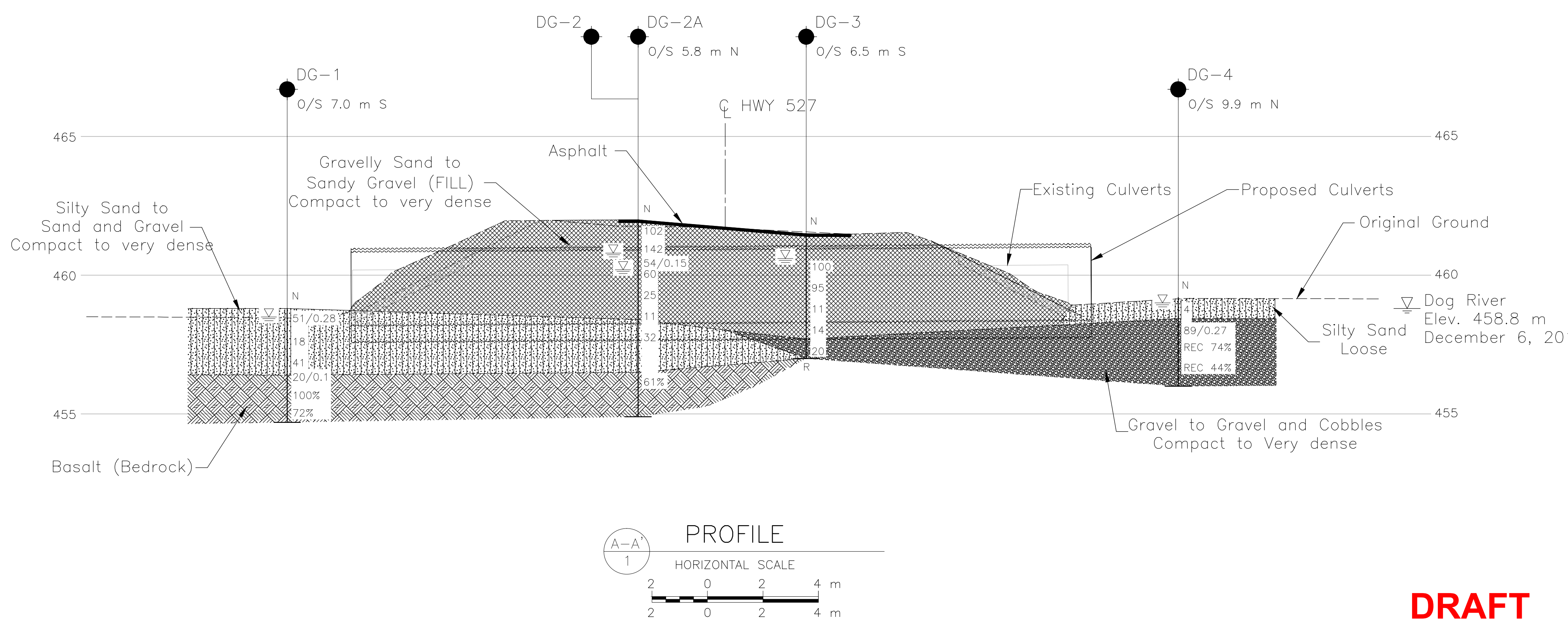
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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 MTO, drawing file no. BC4848905275, dated MAY 2012, received FEB 2, 2015. Culvert GA drawing no. ST-343033-DOG RIVER CULVERTS-01-GA-CSP.dwg, received DEC 15, 2015.



NO.	DATE	BY	REVISION
.	.	.	.

Geocres No.

HWY. 527		PROJECT NO. 1411523	DIST.
SUBM'D. AC	CHKD. DAM	DATE: 3/10/2016	SITE:48C-218/C
DRAWN: TB	CHKD. SEMP	APPD. JMAC	DWG. 1

DRAFT

Photograph 1: Dog River Culvert
East Side - Inlet (Taken from MTO, OSIM_08-27-2013)

Photograph 2: Dog River Culvert
West Side - Outlet (Taken from MTO, OSIM_08-27-2013)

Photograph 3: Dog River Culvert
East Side - Inlet (Golder – December 5, 2014)

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
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_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

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

(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 $= \sigma'_p / \sigma'_{vo}$

(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 δ
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

Notes:
1. $\tau = c' + \sigma' \tan \phi'$
2. shear strength = (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, 60º 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 cm^2 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 Relative Density	N 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

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	Less than 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90^{o} angle is horizontal.

Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

JN	Joint	PL	Planar
FLT	Fault	CU	Curved
SH	Shear	UN	Undulating
VN	Vein	IR	Irregular
FR	Fracture	K	Slickensided
SY	Stylolite	PO	Polished
BD	Bedding	SM	Smooth
FO	Foliation	SR	Slightly Rough
CO	Contact	RO	Rough
AXJ	Axial Joint	VR	Very Rough
KV	Karstic Void		
MB	Mechanical Break		

Golder Associates

RECORD OF BOREHOLE No DG-1

 METRIC

PROJECT 1411523
G.W.P. 6302-14-00
LOCATION N 5408291.8; E 370262.2
ORIGINATED BY CW
DIST HWY 527
BOREHOLE TYPE NW Casing, Wash Boring
COMPILED BY SEMP
DATUM GEODETIC
DATE December 5, 2014
CHECKED BY DAM

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
458.8	GROUND SURFACE								
0.0	Silty SAND to SAND and GRAVEL, trace clay Compact to very dense Brown to grey Frozen to wet Cobbles encountered between 0.5 m and 0.8 m depth.	1	SS	51/0.28	▽	458			
		2	SS	18			○		OC=0.9% 7 59 30 4
		3	SS	41		457	○		40 45 14 1
456.4		4	SS	20/0.1			○		
2.4	BASALT BEDROCK Bedrock cored from 2.4 m depth to 4.1 m depth. For coring details see Record of Drillhole DG-1.	1	RC	REC 100%		456			RQD = 100%
454.7		2	RC	REC 98%		455			RQD = 72%
4.1	END OF BOREHOLE Note: 1. Water level at a depth of 0.3 m below ground surface (Elev. 458.5 m) upon completion of drilling.								

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 04/03/16 DATA INPUT:

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

RECORD OF DRILLHOLE: DG-1

PROJECT: 1411523

SHEET 1 OF 1

LOCATION: N 5408291.8 ;E 370262.2

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: December 5, 2014

DRILL RIG: CME 55-Track

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

DATUM: GEODETIC

JN - Joint, FLT - Fault, SHR- Shear, VN - Vein, CJ - Conjugate, BD- Bedding, FO- Foliation, CO- Contact, OR- Orthogonal, CL - Cleavage, PL - Planar, CU- Curved, UN- Undulating, ST - Stepped, IR - Irregular, PO- Polished, K - Slickensided, SM- Smooth, Ro - Rough, MB- Mechanical Break, BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	DISCONTINUITY TYPE AND SURFACE DESCRIPTION	NOTES WATER LEVELS INSTRUMENTATION
		Refer to Previous Page					
	CME 55-Track, NW Casing	BASALT Fine grained Grey-black Fresh Strong		456.4 2.4	1		
3		White medium grained inclusion at 2.7 m, 3.0 m and 3.7 m depths.			2	JNIRRO	UCS = 72 MPa
						JNIRRO	
4				454.7 4.1		JNIRRO	
		END OF DRILLHOLE					
5							
6							
7							
8							
9							
10							
11							
12							

Other column headings: COLOUR % RETURN; FLUSH; RECOVERY (TOTAL CORE %, SOLID CORE %) 80 60 40 20; R.Q.D. % 80 60 40 20; FRACT. INDEX METRES 5 10 15 20; DISCONTINUITY DATA (B Angle 0 90 180 270; DIP w.r.t. CORE AXIS 0 30 60 90; Jr, Ja, Jn); HYDRAULIC CONDUCTIVITY k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3}; Diametral Point Load Index (MPa) 2 4 6; RMC -Q' AVG.

SUD-RCK 1411523.GPJ GAL-MISS.GDT 04/03/16 DATA INPUT:

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: CW

CHECKED: DAM

Golder Associates

RECORD OF BOREHOLE No DG-2

 METRIC

PROJECT 1411523
G.W.P. 6302-14-00
LOCATION N 5408306.9; E 370269.4
ORIGINATED BY MR
DIST HWY 527
BOREHOLE TYPE NW Casing, Wash Boring
COMPILED BY SEMP
DATUM GEODETIC
DATE December 5, 2014
CHECKED BY DAM

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED) 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
461.9	GROUND SURFACE										
0.0	ASPHALT (30 mm)										
	Gravelly sand, some silt, trace clay (FILL) Very dense Brown Frozen to wet		1	SS	102				○		
							461				
			2	SS	142	▽			○		23 61 14 2
460.1			3	SS	54/0.15						
1.8	END OF BOREHOLE REFUSAL TO FURTHER CASING ADVANCEMENT Note: 1. Water level at a depth of 1.2 m below ground surface (Elev. 460.7 m) upon completion of drilling.										

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

Golder Associates

RECORD OF BOREHOLE No DG-2A

 METRIC

PROJECT 1411523
G.W.P. 6302-14-00
LOCATION N 5408308.7; E 370268.3
ORIGINATED BY MR
DIST HWY 527
BOREHOLE TYPE NW Casing, Wash Boring
COMPILED BY SEMP
DATUM GEODETIC
DATE December 6, 2014
CHECKED BY DAM

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
462.0	GROUND SURFACE									
0.0	ASPHALT (30 mm)									
0.0	Gravelly sand, trace to some silt (FILL) Compact to very dense Brown Frozen to wet						461			
			1	SS	60	∇	460	○		26 63 (11)
			2	SS	25			○		
			3A / 3B	SS	11		459			
458.4 / 3.6	SAND and GRAVEL some silt, trace organics, trace broken rock fragments Dense Grey Wet		4	SS	32		458			
							457			
456.5 / 5.5	BASALT BEDROCK Bedrock cored from 5.5 m depth to 7.1 m depth. For coring details see Record of Drillhole DG-2A.		1	RC	REC 100%		456			RQD = 61%
454.9 / 7.1	END OF BOREHOLE Note: 1. Water level at a depth of 1.8 m below ground surface (Elev. 460.2 m) upon completion of drilling.						455			

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

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

RECORD OF DRILLHOLE: DG-2A

PROJECT: 1411523

SHEET 1 OF 1

LOCATION: N 5408308.7 ;E 370268.3

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: December 6, 2014

DRILL RIG: CME 55-Track

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

JN - Joint, FLT - Fault, SHR- Shear, VN - Vein, CJ - Conjugate, BD- Bedding, FO- Foliation, CO- Contact, OR- Orthogonal, CL - Cleavage, PL - Planar, CU- Curved, UN- Undulating, ST - Stepped, IR - Irregular, PO- Polished, K - Slickensided, SM- Smooth, Ro - Rough, MB- Mechanical Break, BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. / DEPTH (m)	RUN No.	FLUSH COLOUR / % RETURN	DISCONTINUITY TYPE AND SURFACE DESCRIPTION	NOTES WATER LEVELS INSTRUMENTATION
		Refer to Previous Page	456.5				
6 7	CME 55-Track; NW; NQ Coring	BASALT Fine grained Dark grey/black Fresh Strong Broken rock and multiple vertical fractures between 5.5 m and 5.8 m depth. White medium grained inclusion vertically from 5.5 m to 8.8 m depth.	5.5	1	GREY 100	BR JNCURO JNIRRO JNIRRO JNIRRO	UCS = 100 MPa
		END OF DRILLHOLE	454.9 7.1				
8, 9, 10, 11, 12, 13, 14, 15							

SUD-RCK 1411523.GPJ GAL-MISS.GDT 04/03/16 DATA INPUT:

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MR

CHECKED: DAM

Golder Associates

RECORD OF BOREHOLE No DG-3

 METRIC

PROJECT 1411523
G.W.P. 6302-14-00
LOCATION N 5408300.0; E 370279.0
ORIGINATED BY MR
DIST HWY 527
BOREHOLE TYPE NW Casing, Wash Boring
COMPILED BY SEMP
DATUM GEODETIC
DATE December 6, 2014
CHECKED BY DAM

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
461.5	GROUND SURFACE							
0.0	ASPHALT (50 mm)					461		
0.1	Sandy gravel, trace silt (FILL) Compact to very dense Brown Frozen to wet	1	SS	100	∇			
		2	SS	95		460	○	
	90 mm cobble at 2.2 m depth.	3	SS	11		459		
		4	SS	14		458	○	75 23 (2)
457.7 3.8	GRAVEL, trace sand Compact Grey Wet	5	SS	20				
457.0 4.5	END OF BOREHOLE SPLIT SPOON REFUSAL (HAMMER BOUNCING)					457		

Note:

1. Water level at a depth of 0.9 m below ground surface (Elev. 460.6 m) upon completion of drilling.

2. Poor recovery in all split-spoons, mostly gravel recovered.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED — 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

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

RECORD OF BOREHOLE No DG-4

 METRIC

PROJECT 1411523
G.W.P. 6302-14-00
LOCATION N 5408320.6; E 370284.3
ORIGINATED BY CW
DIST HWY 527
BOREHOLE TYPE NW Casing, Wash Boring
COMPILED BY SEMP
DATUM GEODETIC
DATE December 5, 2014
CHECKED BY DAM

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
459.2	GROUND SURFACE													
0.0	Silty SAND, some clay, trace to some gravel, some organics Loose Brown Frozen to wet		1	SS	4	▽	459		○ (~38)		6	51	29	14
458.4 0.8	GRAVEL and COBBLES (rock fragments) Very dense Grey Wet Cobbles ranging from 75 mm to 225 mm diameter encountered between 0.8 m and 3.2 m depths.		2	SS	89/0.27		458		○ (~9)					
			3	RC	REC 74%									
			4	RC	REC 44%		457							
456.0 3.2	END OF BOREHOLE Note: 1. Water level at a depth of 0.2 m below ground surface (Elev. 459.0 m) upon completion of drilling.						456							

Legend: SHEAR STRENGTH kPa: ○ UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × REMOULDED. PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

APPENDIX B

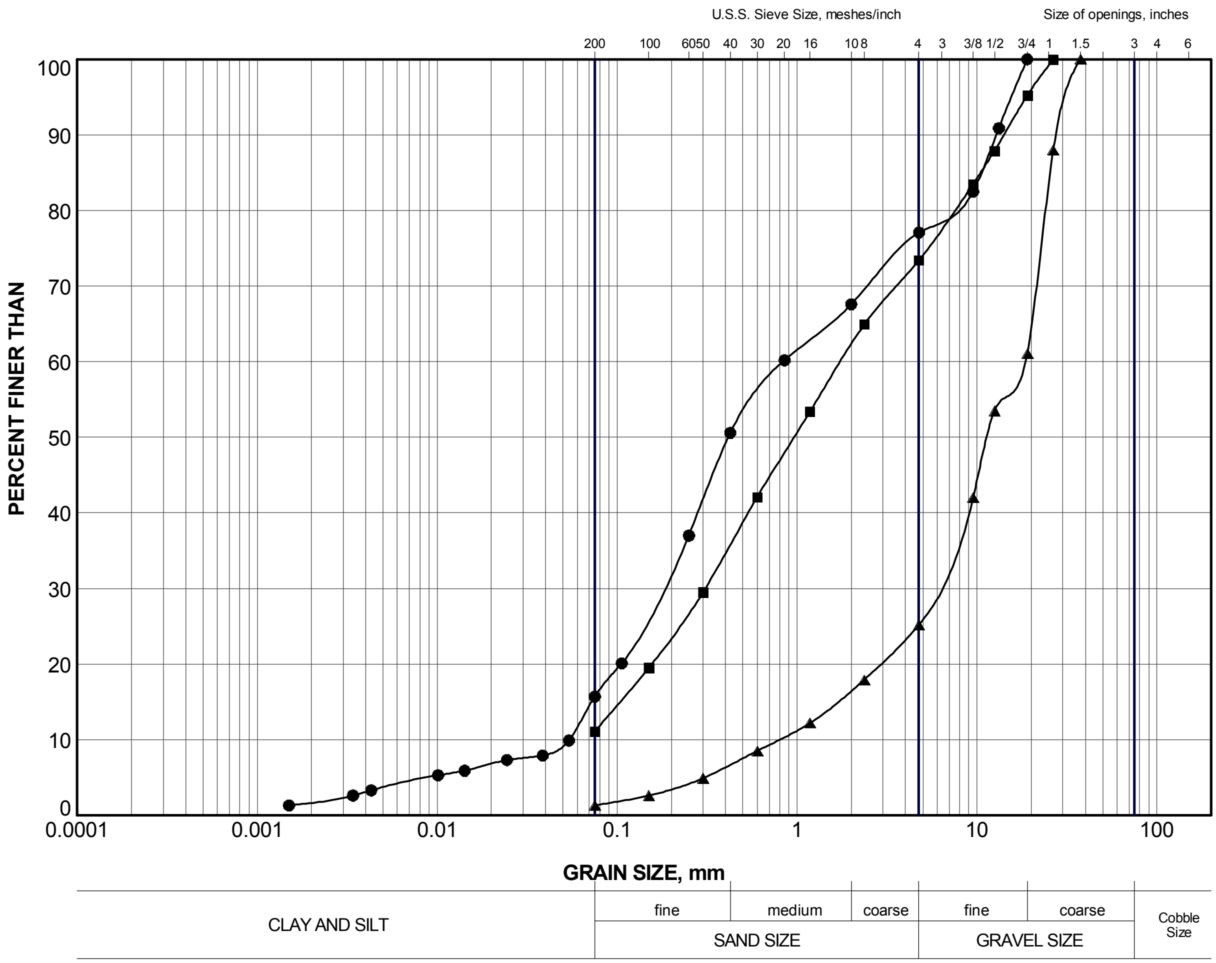
Laboratory Testing

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

Parameter	Units	Result
Chloride (CL)	mg/L	5.02
Sulphate (SO4)	mg/L	1.62
Conductivity (EC)	µS/cm	57.2
Resistivity	ohms*cm	17483
pH	n/a	7.04

Notes:
1. Sample obtained on February 3, 2015.
2. Analytical testing carried out by ALS Canada Ltd.

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



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	DG-2	2	460.8
■	DG-2A	1	460.2
▲	DG-3	4	458.2

PROJECT

HIGHWAY 527
DOG RIVER CULVERT STA 21+844

TITLE

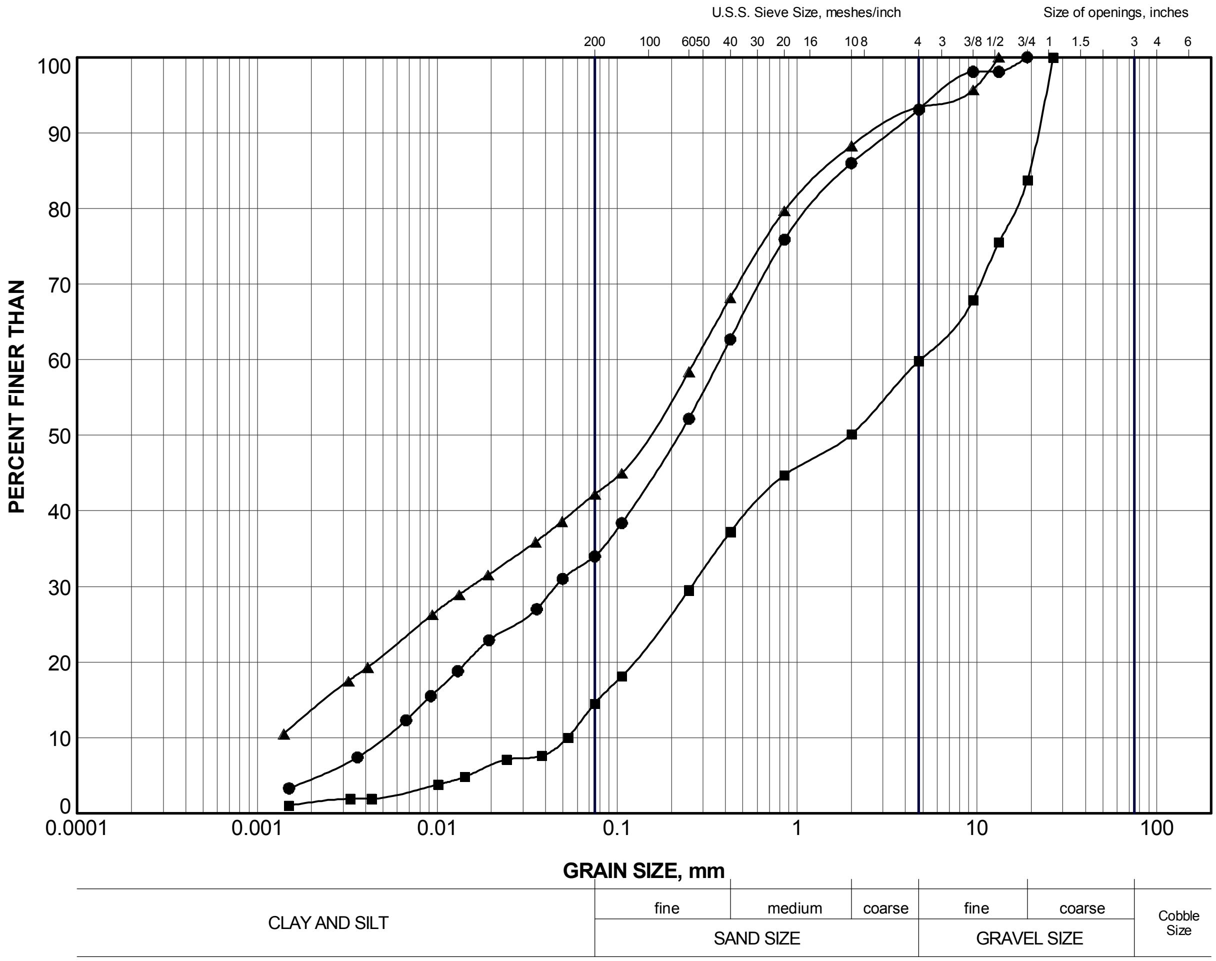
GRAIN SIZE DISTRIBUTION

GRAVELLY SAND to SANDY GRAVEL (FILL)

Golder Associates
SUDBURY, ONTARIO

PROJECT No.		1411523	FILE No.	1411523.GPJ
DRAWN	TB	Feb 2015	SCALE N/A	REV.
CHECK	DAM	Feb 2015		
APPR	FJH	Feb 2015	**FIGURE B1**	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	DG-1	2	457.7
■	DG-1	3	457.0
▲	DG-4	1	458.9

PROJECT

HIGHWAY 527
DOG RIVER CULVERT STA 21+844

TITLE

GRAIN SIZE DISTRIBUTION

SILTY SAND to SAND and GRAVEL

Golder Associates
SUDBURY, ONTARIO

PROJECT No.		1411523	FILE No. 1411523.GPJ
DRAWN	TB	Feb 2015	SCALE N/A REV.
CHECK	DAM	Feb 2015	
APPR	FJH	Feb 2015	FIGURE B2

SUD-MTO GSD (NEW) GLDR_LDN.GDT

<u>Borehole DG-1</u>
Elevation 456.4 m to 454.7 m

<u>Borehole DG-2A</u>
Elevation 456.5 m to 454.9 m

0 m 0.3 m 0.6 m

PROJECT	
HIGHWAY 527 DOG RIVER CULVERT STA 21+844	
TITLE	
BEDROCK CORE PHOTOGRAPHS	

PROJECT No.	1411523		FILE No. ----
DESIGN	AC	Feb. 2015	SCALE AS SHOWN REV.
CADD	--		**FIGURE B3**
CHECK	DAM	Feb. 2015	
REVIEW	FJH	Feb. 2015	

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APPENDIX C

Non-Standard Special Provisions

OBSTRUCTIONS

Non-Standard Special Provision

The Contactor shall be alerted to the presence of a cobbles within the granular embankment fill and native soils as encountered during borehole advancement. Considerations of the presence of such 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

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

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 cohesionless soils that are present below the groundwater table at this site, notably the silty sand and sand strata will slough, run, boil and/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

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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