



FOUNDATION INVESTIGATION AND DESIGN REPORT

Harris Creek Culvert - Site 44X-0289/C0 Highway 124, 11.2 km East of Highway 400 MTO GWP 5119-13-00, WP 5124-13-01

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PART A

**FOUNDATION INVESTIGATION REPORT
HARRIS CREEK CULVERT – SITE 44X-0289/C0,
HIGHWAY 124, 11.2 KM EAST OF HIGHWAY 400
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5119-13-00, WP 5124-13-01
LAT: 45.466967, LONG: -79.992936**

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by GHD, on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services related to a temporary cofferdam protection system for the rehabilitation of the Harris Creek Culvert located on Highway 124 approximately 11.2 km east of Highway 400, in the Township of Ferguson, Ontario. The key plan of the general location of this section of Highway 124 and the location of the investigated area are shown on Drawing 1.

2.0 SITE DESCRIPTION

The existing Harris Creek culvert consists of a 6.1 m wide by 2.4 m high single cell, concrete rigid frame closed box, 32.3 m long, and was constructed in 1969 as part of Contract 69-139. The culvert invert is about Elevation 238.3 m at both the inlet (north end) and outlet (south end) and the embankment is about 5.5 m high relative to the culvert invert.

It should be noted that the orientation (i.e., north, south, east, west) stated in the text of the report is typically referenced to project north and therefore may differ from magnetic north shown on the drawing. For the purpose of this report, Highway 124 is oriented in a west-east direction with the culvert positioned perpendicular to the highway generally in a north-south orientation. At the culvert location Harris Creek flows in a north-south direction.

In general, the topography within the vicinity of the culvert consists of relatively flat terrain, which is heavily forested beyond the highway right-of-way (ROW) with visible bedrock outcrops noted approximately 25 m west and 100 m east of the culvert location on the north side of the road. A driveway located approximately 20 m south of the culvert crosses Harris Creek with a short single span bridge structure. At the culvert location, the highway grade is at approximately Elevation 243.8 m and the embankments are approximately 4.2 m to 4.9 m high relative to the ground surface at the toe of embankments. The creek water level, as surveyed by Golder on February 7, 2018, was about Elevation 238.4 m. The ground surface and embankment conditions at the culvert location are shown on Photographs 1 to 4, the embankments are heavily vegetated with various grasses and show no evidence of sloughing.

3.0 INVESTIGATION PROCEDURES

The field work for this subsurface investigation was carried out between December 12 and 14, 2017, and February 7 to 10, 2018, during which time four boreholes (Boreholes HC-1 to HC-4) were advanced at approximately the locations shown on Drawing 1. All the boreholes were advanced near the toes of the Highway 124 embankment slopes adjacent to the culvert inlet/outlet ends. The boreholes were advanced using portable tripod equipment and hilti coring equipment in two boreholes, supplied and operated by Landcore Drilling Inc, of Chelmsford Ontario. Dynamic Cone Penetration (DCPT) tests were carried out in adjacent to Boreholes HC-1 and HC-2 as noted on the Record of Borehole Sheets to verify the depth to refusal (inferred bedrock) in the vicinity of the boreholes. Traffic control, where required, was performed in accordance with the Ontario Traffic Control Manual Book 7 – Temporary Conditions.

The boreholes were advanced using NW casing with wash boring techniques and rock coring was completed in Boreholes HC-2 and HC-4 using NQ coring equipment. 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 a cathead hammer in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586). Field vane shear tests were

carried out in separate boreholes located immediately adjacent to boreholes HC-1 and HC-3 to determine the undrained shear strength of cohesive strata utilizing standard MTO “N” vanes (ASTM D2573). The groundwater levels in the open boreholes were observed during the drilling operations as described on the borehole records in Appendix A. All boreholes were backfilled upon completion in accordance with Ontario Regulation 903 (*Wells*, as amended).

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; and logged the boreholes. The soil and bedrock core 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, Atterberg limits and organic content, were carried out on selected soil samples. An unconfined compression (UC) test was conducted on a sample of the bedrock core to determine the uniaxial compressive strength (UCS) of the bedrock. The geotechnical laboratory testing was completed according to ASTM and MTO LS standards, as applicable.

A soil sample was obtained during the field investigation at the Harris Creek culvert location on December 14, 2017, 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 as-drilled borehole locations were measured by a member of our technical staff (relative to the existing culvert and roadway centreline) and converted into northing/easting coordinates on the plan drawing. The ground surface elevations at the borehole locations were surveyed relative to a nearby benchmark and the benchmark elevation was obtained from the plate drawing (1043-124/6-0) provided by MTO. The MTM NAD 83 CSRS CBNv6-2010.0 (Zone 10) northing and easting coordinates, geographical coordinates, ground surface elevations referenced to Geodetic datum, and borehole depths at each borehole location are presented on the borehole records in Appendix A and summarized below.

Borehole Number	MTM NAD 83 Northing (m) (Latitude)	MTM NAD 83 Easting (m) (Longitude)	Ground Surface Elevation (m)	Borehole Depth (m)
HC-1	5036476.7 (45.467162)	266244.4 (-79.993069)	239.2	5.4
HC-2	5036479.4 (45.467187)	266259.9 (-79.992871)	239.6	3.5*
HC-3	5036433.4 (45.466772)	266245.1 (-79.993057)	239.2	7.8
HC-4	5036437.1 (45.466807)	266263.0 (-79.992828)	238.9	4.1*

Note: * Includes between 3.0 m and 2.7 m of bedrock coring.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on the Surficial Geology of Southern Ontario mapping by the Ministry of Natural Resources¹, the subsoils in the vicinity of the Harris Creek Culvert site are comprised of organic and glaciolacustrine deposits bordered closely by Precambrian bedrock drift complexes.

Based on geological mapping by the Ministry of Northern Development and Mines², the site is underlain by bedrock of the central gneiss belt, including mafic bedrock comprised of amphibolite, gabbro, diorite and mafic gneisses, bordered closely to the east by migmatitic rocks and gneisses of undetermined protolith, commonly layered biotite gneisses and migmatites; locally including quartzofeldspathic gneisses, orthogneisses and paragneisses.

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 presented on the borehole records contained in Appendix A. The detailed results of geotechnical laboratory testing are contained in Appendix B. The results of the in-situ field tests (i.e., SPT 'N' values and vane shear strengths) as presented on the borehole records and in Section 4 are uncorrected. The stratigraphic boundaries shown on the boreholes records and on the interpreted stratigraphic cross-sections 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 peat or fill underlain by deposits of sandy silt on the eastern side of the site, and sandy silt, clayey silt to clay and silt to silt and sand on the western side of site, underlain by bedrock. A more detailed description of the soil deposits and groundwater conditions encountered in the boreholes is provided below.

4.2.1 Fill

A 0.6 m thick layer of frozen dark brown, clayey silt was encountered from ground surface in borehole HC-3, at Elevation 239.2 m.

4.2.2 Peat

A 0.5 m and 0.3 m thick deposit of black, fibrous peat was encountered at ground surface in Boreholes HC-2 and HC-4 at Elevation 239.6 m and 238.9 m, respectively.

One SPT 'N' value obtained within the peat deposit is 1 blow per 0.3 m of penetration, suggesting a very soft consistency.

4.2.3 Sandy Silt

A 1.3 m and 1.1 m thick deposit of brown to grey, sandy silt, trace to some clay, trace organics was encountered in Boreholes HC-1 from ground surface at Elevation 239.2 m and underlying the peat deposit in Borehole HC-4 at Elevation 238.6 m, respectively.

¹ Ministry of Natural Resources, Surficial Geology of Southern Ontario. Ontario Geological Society Electronic Mapping.

² Ministry of Northern Development of Mines. Bedrock Geology of Ontario – Southern Sheet, Ontario Geological Survey - Map 2544

SPT 'N'-values obtained within the sandy silt deposit range from 1 blow to 4 blows per 0.3 m of penetration, indicating a very loose to loose compactness condition.

The results of the grain size distribution tests completed on two samples of the sandy silt deposit are shown on Figure B-1 in Appendix B. An Atterberg limit test completed on a sample of the sandy silt yielded a non-plastic result.

The moisture content measured on a sample of the sandy silt deposit is 52 per cent.

One organic content completed on a sample of the sandy silt measured an organic content of 4.8 per cent.

4.2.4 Sandy Clayey Silt to Clay

Underlying the sandy silt deposit in Borehole HC-1 and fill layer in Borehole HC-3, a 3.5 and 5.8 m thick, respectively, a deposit of brown to grey sandy clayey silt to clay was encountered at Elevations 237.9 m and 238.6 m, respectively.

SPT 'N'-values measured within the cohesive deposit range from 0 blows (weight of hammer – WH) to 5 blows per 0.3 m of penetration. In situ vane shear tests within the cohesive deposit measured undrained shear strengths ranging from about 26 kPa to 32 kPa, and sensitivities between 2 and 4. The results of the vane shear tests indicate that the deposit is firm consistency.

The results of the grain size distribution tests completed on three samples of the sandy clayey silt to clay deposit are shown on Figure B-2 in Appendix B.

Atterberg limits tests were carried out on the three samples of the sandy clayey silt to clay deposit measured liquid limits ranging from 35 per cent to 56 per cent, plastic limits ranging from 20 per cent to 26 per cent and plasticity indices ranging from 15 per cent to 30 per cent, indicating the material is classified as clayey silt of low plasticity to clay of high plasticity. The results of the Atterberg limit testing are shown on Figure B-3 in Appendix B.

The moisture content measured on three samples of the sandy clayey silt to clay deposit range from 33 per cent to 74 per cent.

4.2.5 Silt to Silt and Sand

Underlying the cohesive deposit in Boreholes HC-1 and HC-3, a 0.6 m and 1.4 m thick deposit of grey silt to silt and sand was encountered at Elevation 234.4 m and 232.8 m, respectively.

An SPT 'N'-value of 12 blows for 0.15 m of penetration and 30 blows for 0.05 m of penetration was recorded at the bottom of the deposit/top of the underlying bedrock.

The results of grain size distribution tests completed on two samples of the silt to silt and sand deposit are shown on Figure B-4 in Appendix B.

The moisture content measured on two samples of the silt to sandy silt deposit range are 18 per cent and 28 per cent.

4.3 Bedrock/Refusal

Bedrock was cored in Boreholes HC-2 and HC-4 and refusal to split-spoon and/or casing advancement was encountered in HC-1 and HC-3. The bedrock surface elevation as encountered in the cored boreholes and inferred from refusal to further split-spoon and/or casing advancement is presented below.

Borehole No.	Bedrock Surface Elevation / Refusal Depth (m)	Core Length (m)
HC-1*	233.8 / 5.4	n/a
HC-2**	239.1 / 0.5	3.0
HC-3	231.4 / 7.8	n/a
HC-4	237.5 / 1.4 ***	2.7

*A DCPT was completed adjacent to Borehole HC-1 and refusal was encountered at 5.5 m depth.

**Three DCPT's were completed for adjacent to Borehole HC-2 with refusal encountered between 0.6 m and 0.9 m depth.

***Split-spoon refusal was encountered at 1.3 m depth (Elevation 237.6 m), bedrock core obtained from a separate borehole advanced 1.0 m east of Borehole HC-4.

The retrieved bedrock core from Boreholes HC-2 and HC-4 is described as very strong, strongly foliated, fine grained with some medium grained bands, dark grey, mafic gneiss. More detailed descriptions of the bedrock core samples are presented on the Record of Drillhole sheets in Appendix A. Photographs of the bedrock core samples are shown on Figure B-5 in Appendix B and the result of an unconfined compression test is presented on Figure B-6 also in Appendix B. The bedrock properties, as encountered in the boreholes, are summarized below.

Borehole No.	Total Core Recovery (TCR)	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 ³)
HC-2	100%	44% - 71%	36% - 71%	Poor to Fair	102	(R5 – Very Strong)
HC-4	100%	82% - 96%	76% - 93%	Good to Excellent	n/a	-

4.4 Groundwater Conditions

The unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized below. The creek water level, as surveyed by Golder on February 7, 2018, was at about Elevation 238.4 m. Groundwater and creek water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

³ Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, 4th Edition.

Borehole No.	Depth to Unstabilized Groundwater Level (m)	Approximate Groundwater Elevation (m)
HC-1	0.6	238.6
HC-2	0.0	239.6
HC-3	0.9	238.3
HC-4	0.0	238.9

Note: All boreholes were advanced using NW casing and wash boring techniques. As such, these groundwater levels may not be representative of in situ groundwater conditions.

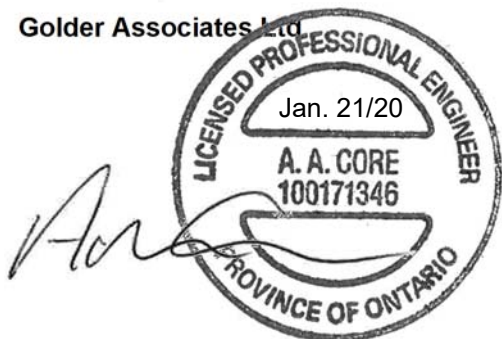
4.5 Analytical Tests Results of Soil Sample

The results of the analytical testing of a soil sample from Borehole HC-1, submitted to Maxxam Analytics Inc. an accredited analytical testing laboratory, are summarized in Table C-1 in Appendix C and the detailed laboratory test report (Certificate of Analysis) is included in Appendix C.

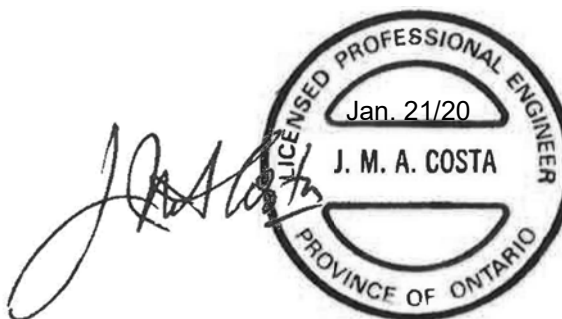
5.0 CLOSURE

The field drilling program was supervised by Messrs. Mat Riopelle and Shane Albert under the direction of Mr. David Muldowney, P.Eng. and Mr. Adam Core, P.Eng.. This Foundation Investigation Report was prepared by Mr. Adam Core, P. Eng. Mr. Jorge M. A. Costa, P. Eng., a MTO Foundations Designated Contact and Senior Consultant for Golder conducted an independent quality control review of this report.

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PART B

**FOUNDATION DESIGN REPORT
HARRIS CREEK CULVERT – SITE 44X-0289/C0
HIGHWAY 124, 11.2 km EAST OF HIGHWAY 400
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5119-13-00, WP 5124-13-01
LAT: 45.466967, LONG: -79.992936**

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides foundation design recommendations related to a temporary cofferdam protection system for the proposed rehabilitation of the Harris Creek Culvert (Site No. 44X-0289/C0) on Highway 124, Township of Ferguson, Ontario. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during this subsurface investigation. The discussion and recommendations presented are intended to provide the designer with sufficient information to assess the feasible cofferdam alternatives and carry out the conceptual design of the cofferdam system, as may be required. The foundation investigation report, discussion and recommendations are intended for the use of the MTO and shall not be used or relied upon for any other purpose or by any other parties, including the construction or design-build contractor. The contractor must make their own interpretation based on the factual data in the Part A (Foundation Investigation) of the report. Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project and for which special provisions may be required in the Contract Documents. Those requiring information on the aspects of construction must 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 Harris Creek culvert consists of a 6.1 m wide by 2.4 m high single cell, closed bottom box and is 32.3 m long, as provided by the MTO structural section December 9, 2019. The culvert invert is about Elevations 238.3 m at both the inlet (north end) and outlet (south end) and the embankment is about 5.5 m high relative to the culvert invert, providing a soil cover of about 3.1 m.

Based on the information provided in the Request for Proposal (RFP), we understand that the proposed rehabilitation consists of localized concrete patching inside the culvert and at the exposed ends. We further understand that the culvert will be rehabilitated while both lanes of the highway are maintained open to traffic during the rehabilitation works.

6.2 Excavations and Temporary Embankment Cut Slopes

Based on discussions with GHD, we understand that the culvert rehabilitation is to consist of concrete repairs to the interior culvert walls. As such, we understand that excavations are not required at this site to allow for repairs to the culvert walls to proceed.

As boreholes were not drilled on the roadway platform at the culvert site, the depth and type of embankment fill is not known; however, a 0.6 m layer of granular fill was encountered at the toe of slope in Borehole HC-3. Further, based on our site reconnaissance/observations and given the relatively limited thickness of fill embankment over the culvert, it is expected that the embankment fill at the site would also consist of granular fill material(s).

In the event that excavations are required to expose sections of the culvert walls below the ground surface or creek bed, all excavations should be carried out in accordance with the latest edition of the Ontario Occupational Health and Safety Act and Regulations for Construction Projects (as amended). Above the groundwater level, the fill materials and native soils at the site can be considered Type 3 soils and the amorphous peat deposit encountered should be considered Type 4 soil. All soils below the groundwater level should be considered Type 4 soils. 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.

6.3 Temporary Protection Systems

In the event that excavations are utilized to facilitate the culvert rehabilitation, a temporary protection system may be required to support the excavation and/or embankment side slopes. Temporary support systems (or cofferdams) for this site could consist of steel sheet piles driven to a suitable depth with horizontal lagging in the form of struts and wales installed as the excavation proceeds, as may be required, notably along the east side of the culvert as the depth to bedrock (at Boreholes HC-2 and HC-4) is 0.6 m and 1.4 m, respectively, which will not allow for adequate embedment to resist the lateral earth pressures. The temporary excavation support system (and/or cofferdams) at the ends of the culvert shall be designed and constructed in accordance with Ontario Provincial Standard Specification (OPSS).PROV 539 (Temporary Protection Systems) as amended by special provision (SP)105S09. The lateral movement of the temporary shoring system shall meet Performance Level 2 as specified in OPSS.PROV 539. Design of the temporary excavation support system and/or cofferdam system should include an evaluation of base stability and hydraulic uplift stability as defined in the Canadian Foundation Engineering Manual (CFEM 2006). The contractor is responsible for the complete detailed design of the temporary protection/cofferdam system.

The temporary protection system (or cofferdam) may be designed using the flowing parameters:

Soil Type	Unit Weight (γ , kN/m ³)	Internal Angle of Friction (ϕ , degrees)	Undrained Shear Strength (S_u , kPa)	Coefficients of Earth Pressure		
				Active, K_a	At Rest, K_o	Passive, K_p
Clayey Silt (FILL)	17	27	15	0.38	0.55	2.64
Fibrous Peat (Very Soft)	12	27	1	0.38	0.55	2.64
Clayey Silt to Clay (Firm)	17	29	25	0.35	0.52	2.85
Sandy Silt (Very Loose to Loose)	18	28	-	0.36	0.53	2.77
Silt to Silt and Sand (Compact)	19	29	-	0.35	0.52	2.85

Due to the relatively shallow and variable depth to bedrock, a temporary protection system comprised of sheet piling alone will likely not be feasible at the ends of the culvert on the east side, depending on the required depth of excavation and required depth of sheet piling installation to resist lateral earth pressures at this site. While soldier piles and lagging (with the piles socketed into bedrock and supported by tiebacks or rakers) could be considered for the sections of protection system at the ends of the culvert on the east side, the excavation(s) would likely extend to below the groundwater (and creek water) level, precluding the installation of the lagging boards. The temporary protection system design should be assessed for both the drained (ϕ) and undrained (S_u) cases and should be 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.

Consideration could be given to either partial or full removal of the temporary protection system upon completion of construction or each stage of construction (as required). At this site, full removal of the protection system should be required to mitigate potential impediments to future reconstruction work; an NSSP amending OPSS.PROV 539 should be included in the Contract to address full removal of the protection system, and an example NSSP is included in Appendix D. Vibration and noise controls during extraction of any temporary systems should meet the same tolerable limits used for installation.

The native soil (i.e., sandy silt, sandy clayey silt to clay soils) at this site is sensitive to disturbance from vibration and/or driving operations for pile installation, which should be considered in the design, installation and removal of the temporary protection system.

6.4 Control of Groundwater and Surface Water

If excavations are required and will/extend below the creek/groundwater level, groundwater flows into the excavations should be expected given the presence of the relatively permeable native soils (i.e., peat, sandy silt) and adjacent inferred granular embankment fill. In this case, control of groundwater would be necessary to allow for construction to be carried out in “dry” conditions, if 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.

Although not anticipated to be required given the proposed rehabilitation works at the Harris Creek site, should active dewatering be required to draw down the groundwater level, it shall be designed/carried out in accordance with OPSS.PROV 517 (Dewatering), as amended by SP517F01. The return period flow estimates in Table A of SP517F01 should be filled in by the hydraulic design engineer. Given the variable subgrade conditions and the potential sensitive nature of the subgrade soils at this site, the Designer fill in for Note 1 in Table A should indicate “YES”. Further, given the potential presence of infrastructure (i.e. an adjacent hydro sub-station and houses) in the vicinity of the culvert, a 150 m radius preconstruction survey distance would be considered appropriate for the fill-in in SP519F01. The recommended preconstruction survey distance should, however, be reviewed by the project hydrogeologist. A copy of SP517F01 filled in by the foundation service provided for the fill-in sections noted above is included in Appendix D.

A dewatering system at this site could consist of a steel 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. Near the ends of the culvert on the east side, where bedrock was encountered at shallow depth (i.e. in the areas of Boreholes HC-2 and HC-4), a sandbag or bladder system may need to be used in lieu of or in combination with a sheet pile cut-off wall or be placed against the wall to provide additional lateral support.

Depending on the creek flow conditions and groundwater levels at the time of construction, water flow and seepage water will likely have to be diverted (i.e. pumped) from behind the temporary cofferdam either around the work area or channelized via a pipe through (along) the inside of the culvert to provide for as “dry” a condition as possible within the work area or a sandbag cofferdam may be installed along the interior of the culvert barrel although such a system would reduce the opening in the culvert and restrict water flow.

6.5 Backfill Materials

Although not anticipated,, if excavations are required immediately behind the culvert walls near the ends, backfill behind the culvert walls (and/or on top of the culvert) for reconstruction of the embankment side slopes should consist of free draining granular fill meeting the specifications for OPSS.PROV 1010 (Aggregates) Granular ‘A’ in

dry conditions or Granular 'B' Type II material in wet conditions. For backfilling below the water level, it is recommended that only Granular 'B' Type II material be utilized.

The granular backfill should be placed in maximum 200 mm thick loose lifts and compacted to not less than 95 per cent of the material's standard Proctor maximum dry density (SPMDD) in accordance with OPSS.PROV 501 (Compacting) where placed in dry conditions. The fill should also be placed concurrently on both sides of the culvert, ensuring that the backfill depth on one side does not exceed the other side by more than 400 mm. Backfill placement for reconstruction of the roadway embankments at the toes and 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.

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.

6.6 Analytical Testing for Construction Materials

The results of an analytical test on a soil sample taken from a borehole at the Harris Creek culvert site are presented in Table C-1 in Appendix C. 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.

For potential sulphate attack on concrete, the results of the soil analysis (i.e. sulphate concentrations < 20 µg/g) were compared to Table 3 in CSA A23-1-09, which indicate that the relative degree of sulphate attack is low. However, given that the culvert location is on Highway 124 and will be exposed to de-icing salts, it is recommended that C-1 class exposure concrete be used for the repairs/rehabilitation of damaged culvert areas. Further, the resistivity results (i.e. 5,100 ohm-cm) indicate that the soil has a low corrosiveness potential based on the Transportation Research Board Guidelines (Transportation Research Board, National Research Council, 1998 as referenced in the MTO Gravity Pipe Manual, 2014). It should be noted that the creek water levels in the area are subject to seasonal fluctuations and variations due to precipitation events and the soil chemistry could also be variable. These recommendations are provided as guidance only; the structural designer should take the results of the laboratory testing, the potential for corrosion and the ultimate selection of materials into consideration.

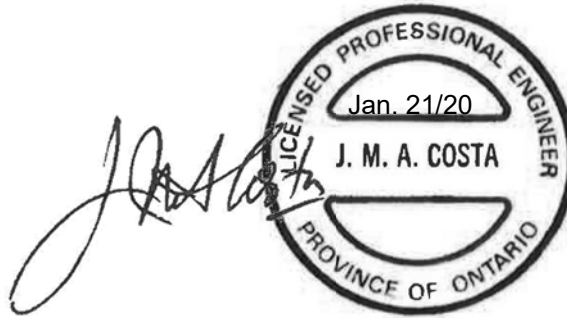
7.0 CLOSURE

This Detail Foundation Design Report was prepared by Mr. Adam Core, P. Eng. Mr. Jorge M. A. Costa, P.Eng., a MTO Foundations Designated Contact and Senior Consultant for Golder, conducted an independent quality control review and technical audit of this report.

Golder Associates Ltd.



Adam Core, P.Eng.
Geotechnical Engineer



Jorge M. A. Costa, P.Eng.
MTO Foundations Designated Contact, Senior Consultant

AC/DAM/JMAC/cr

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[https://golderassociates.sharepoint.com/sites/13313g/deliverables/foundations/2_reporting/r02_harris_creek_culvert/final-rev1/1776446-r02-rev1_jan_21_2019_\(final\)_fidr_ghd_harris_creek_hwy_124.docx](https://golderassociates.sharepoint.com/sites/13313g/deliverables/foundations/2_reporting/r02_harris_creek_culvert/final-rev1/1776446-r02-rev1_jan_21_2019_(final)_fidr_ghd_harris_creek_hwy_124.docx)

REFERENCES

Canadian Geotechnical Society. 2006. Canadian Foundation Engineering Manual (CFEM), 4th Edition. The Canadian Geotechnical Society c/o BiTech Publisher Ltd, British Columbia.

Canadian Standards Association (CSA), 2014. CSA A23.1-09 Concrete Materials and Methods of Construction (R2014)

Ministry of Natural Resources, *Surficial Geology of Southern Ontario*. Ontario Geological Society Electronic Mapping. Accessed April 30, 2018.

Ministry of Northern Development of Mines. *Bedrock Geology of Ontario – Southern Sheet*, Ontario Geological Survey – Map 2544.

Ministry of Transportation, Ontario, MTO Gravity Pipe Design Guidelines, April 2014

Occupational Health and Safety Act and Regulation for Construction Projects (as amended).

Transportation Research Board, National Research Council, 1998. Service Life of Drainage Pipe, National Cooperative Highway Research Program (NCHRP) Synthesis 254.

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 Drawings (OPSD)

OPSD 208.010 Benching of Earth Slopes

Ontario Provincial Standard Specifications (OPSS) – Provincial Oriented

OPSS.PROV 501 Construction Specification for Compacting

OPSS.PROV 517 Construction Specification for Dewatering

OPSS.PROV 539 Construction Specification for Temporary Protection Systems

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

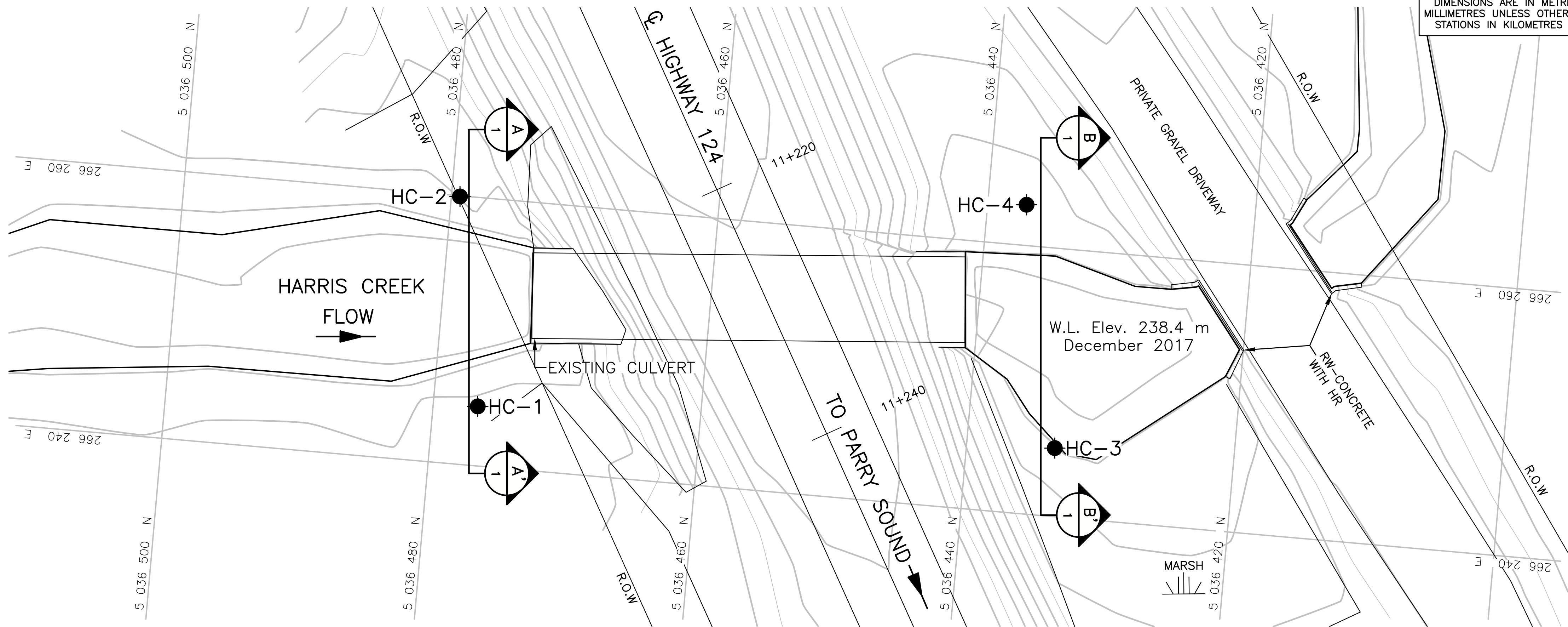
Special Provisions

SP105S09 Amendment to OPSS 539

SP517F01 Dewatering System / Temporary Flow Passage System

Ontario Water Resource Act:

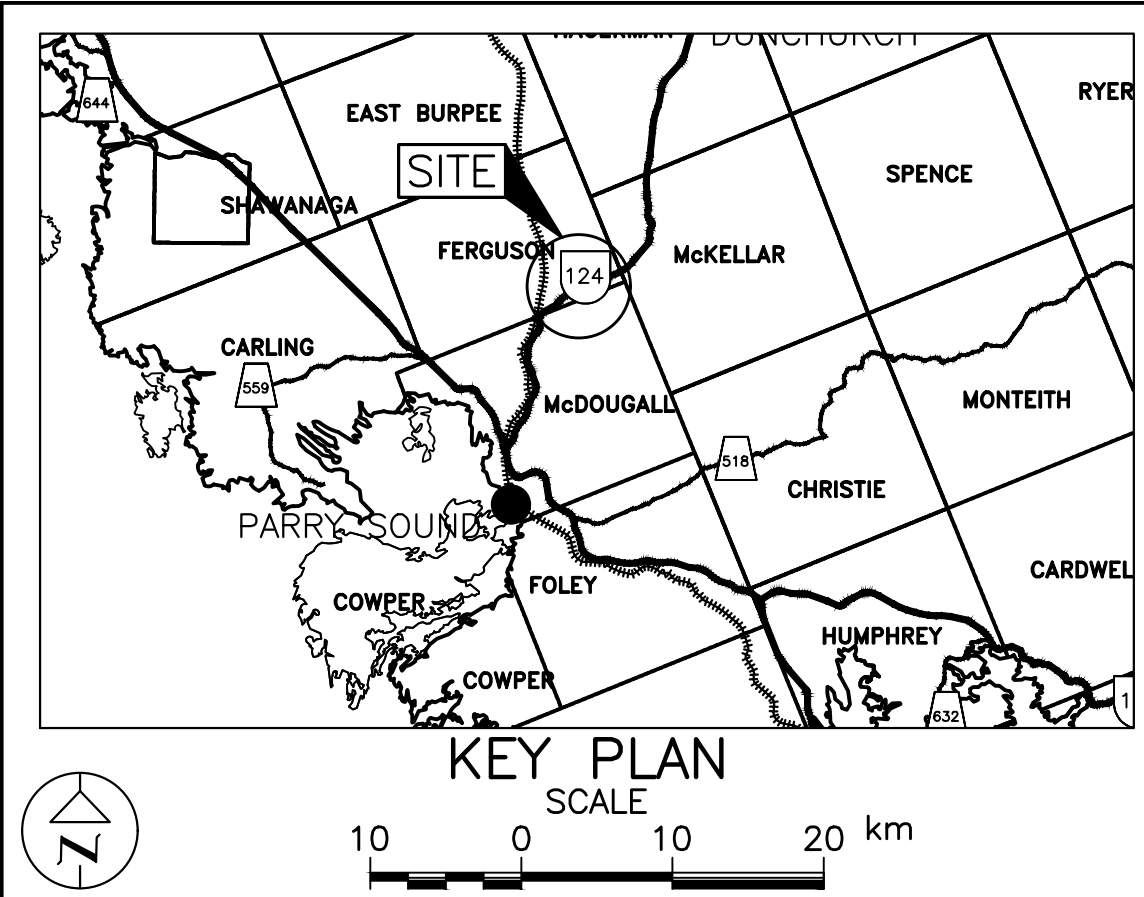
Regulation 903 Wells (as amended)



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

CONT No.
WP No. 5124-13-01

HIGHWAY 124
HARRIS CREEK CULVERT
LAT. 45.466967, LONG. -79.992936
BOREHOLE LOCATIONS AND SOIL STRATA



LEGEND

- Borehole
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 93% Rock Quality Designation (RQD)
- R Refusal
- WL upon completion of drilling

BOREHOLE CO-ORDINATES (NAD 83 MTM ZONE 10)

No.	ELEVATION	NORTHING	EASTING
HC-1	239.2	5036476.7	266244.4
HC-2	239.6	5036479.4	266259.9
HC-3	239.2	5036433.4	266245.1
HC-4	238.9	5036437.1	266263.0

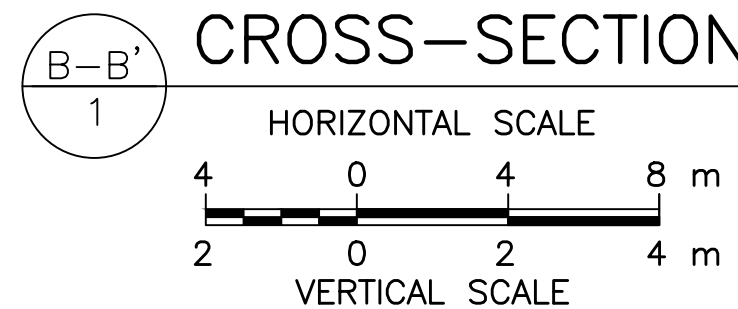
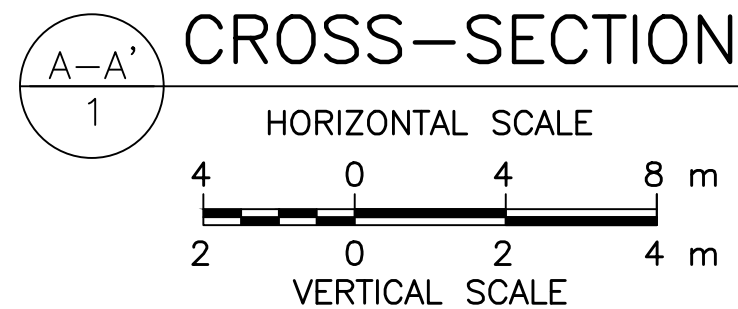
NOTES

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.

REFERENCE

Base plans provided in digital format by Tulloch, drawing file noBC10431241.dwg, received MAY 7, 2018.



NO.	DATE	BY	REVISION
Geocres No. 31E-402			
HWY. 124	PROJECT NO. 1776446		DIST.
SUBM'D.	CHKD. DAM	DATE: 1/16/2020	SITE: 44-289/C
DRAWN: TR	CHKD. AC	APPD. JMAC	DWG. 1



Photograph 1: Harris Creek Culvert – Hwy 124 – Looking West from South (Outlet) End of Culvert (November 2017)



Photograph 2: Harris Creek Culvert – Hwy 124 – Looking at South (Outlet) End of Culvert (November 2017)



Photograph 3: Harris Creek Culvert – Highway 124, Looking West at North (Inlet) End of Culvert (November 2017)



Photograph 4: Harris Creek Culvert – Highway 124, Looking South from Outlet End of Culvert (November 2017)

APPENDIX A

Record of Boreholes and Drillholes

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

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

Compactness	N
Condition	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

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° 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	

PROJECT 1776446		RECORD OF BOREHOLE No HC-1		1 OF 1 METRIC																			
W.P. 5124-13-01		LOCATION N 5036476.7; E 266244.4 NAD83 MTM ZONE 10 (LAT. 45.467162; LONG. -79.993069)		ORIGINATED BY SA																			
DIST _____ HWY 124		BOREHOLE TYPE Portable Tripod, NW Casing and Wash Boring		COMPILED BY AC																			
DATUM GEODETIC		DATE December 14, 2017		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																		
239.2	GROUND SURFACE																						
0.0	Sandy SILT, some clay, trace organics Very loose to loose Brown to grey Moist		1	SS	1																		
			2	SS	4																		
237.9	SILTY CLAY, trace sand, trace organics Firm Reddish grey Wet		3	SS	1																		
1.3			4	SS	WH																		
			5	SS	WH																		
234.4	SILT, some clay, trace to some sand, trace gravel Loose Red, grey Wet		6	SS	2																		
4.8			7	SS	4																		
233.8	END OF BOREHOLE REFUSAL TO SPLIT-SPOON PENETRATION		8	SS	30/0.05																		
5.4	Notes: 1. Water level at a depth of 0.6 m below ground surface (Elev. 238.6 m) upon completion of drilling 2. Additional borehole advanced 1.0 m northeast to obtain field vains at 1.9 m and 3.4 m depths (Elev. 237.3 m and 235.8 m). a DCPT was carried out starting at 3.4 m depth and encountered refusal at 5.4 m.																						

PROJECT <u>1776446</u>		RECORD OF BOREHOLE No HC-2				1 OF 1 METRIC											
W.P. <u>5124-13-01</u>		LOCATION <u>N 5036479.4; E 266259.9 NAD83 MTM ZONE 10 (LAT. 45.467187; LONG. -79.992871)</u>				ORIGINATED BY <u>SAMR</u>											
DIST <u> </u> HWY <u>124</u>		BOREHOLE TYPE <u>Portable Equipment; Hilti NQ Coring</u>				COMPILED BY <u>AC</u>											
DATUM <u>GEODETIC</u>		DATE <u>December 14, 2017 and February 7, 2018</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/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
239.6	GROUND SURFACE																
0.0	PEAT (Fibrous) Very soft Black Wet		1	SS	1												
239.1	0.5	MAFIC GNEISS (BEDROCK)															
	Bedrock cored from 0.5 m depth to 3.5 m depth.		1	RC	REC 100%											RQD = 38%	
	For coring details see record of drillhole HC-2.		2	RC	REC 100%											RQD = 36%	
			3	RC	REC 100%											RQD = 71%	
236.1	3.5	END OF BOREHOLE															
	Notes: 1. Water level at ground surface (Elev. 239.6 m) upon completion of drilling. 2. Additional DCPT's advanced as follows: - DCPT-1 (2.8 m northwest), refusal at 0.6 m depth. - DCPT-2 (adjacent to HC-2), refusal at 0.9 m depth. - DCPT-3 (2.8 m southwest), refusal at 0.6 m depth. 3. Sample No. 1 obtained from a separate borehole advanced 2.0 m west of borehole HC-2.																

SUD-MTO 001 S:\CLIENTS\MT\TOHWY_124_400_518\02_DATA\GINT\1776446.GPJ GAL-MISS.GDT 1-15-20 TR

SHEET 1 OF 1

DATUM: GEODETIC

DRILLING CONTRACTOR: Landcore Drilling

CHECKED: DAM

SUD-MTO-RCK S:\CLIENTS\MTO\HWY 124 400 518\02 DATA\GINT\1776446.GPJ GAL-MISS.GDT 1-10-20 TR

S:\CLIENTS\IMTO\HWY 124 400 518\02 DATA\GIN\1776446.GPJ GAL-MISS.GDT 1-15-20 TR

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

PROJECT <u>1776446</u>		RECORD OF BOREHOLE No HC-4				1 OF 1 METRIC										
W.P. <u>5124-13-01</u>		LOCATION <u>N 5036437.1; E 266263.0 NAD83 MTM ZONE 10 (LAT. 45.466807; LONG. -79.992828)</u>				ORIGINATED BY <u>SA</u>										
DIST <u> </u> HWY <u>124</u>		BOREHOLE TYPE <u>Portable Equipment; Hilti NQ Coring</u>				COMPILED BY <u>AC</u>										
DATUM <u>GEODETIC</u>		DATE <u>December 12, 2017</u>				CHECKED BY <u>AC/DAM</u>										
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								
238.9	GROUND SURFACE															
0.0	PEAT (Fibrous)															
238.6	Black															
0.3	Wet		1	SS	2											
	Sandy SILT, trace organics, trace to some clay															
	Very loose to dense															
	Brown to grey		2	SS	1											
	Wet															
237.5	Split-spoon refusal (i.e. spoon bouncing) at 1.3 m depth															
1.4	MAFIC GNEISS (BEDROCK)															
	Bedrock cored from 1.4 m depth to 4.1 m depth.		1	RC	REC 100%											
	For coring details see record of drillhole HC-4.															
			2	RC	REC 100%											
234.8	END OF BOREHOLE															
4.1	Note:															
	1. Water level at ground surface (Elev. 238.9 m) upon completion of drilling.															
	2. Bedrock core obtained from a separate borehole advanced 1.0 m east of borehole HC-4.															

SUD-MTO 001 S:\CLIENTS\MT\TOHWY_124_400_518\02_DATA\GINT\1776446.GPJ GAL-MISS.GDT 1-15-20 TR

PROJECT: 1776446

RECORD OF DRILLHOLE: HC-4

SHEET 1 OF 1

LOCATION: N 5036437.1; E 266263.0

DRILLING DATE: December 12, 2017

DATUM: GEODETIC

NAD83 MTM ZONE 10 (LAT. 45.466807; LONG. -79.992828)

DRILL RIG: Hilti Coring Machine

INCLINATION: -90° AZIMUTH: —

DRILLING CONTRACTOR: Landcore Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	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.																		Diametral Point Load Index (MPa)	RMC -Q AVG																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
							FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	B Angle	DIP w.r.t. CORE AXIS	DISCONTINUITY DATA			HYDRAULIC CONDUCTIVITY			Point Load Index (MPa)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
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DEPTH SCALE

1 : 60

**GOLDER**

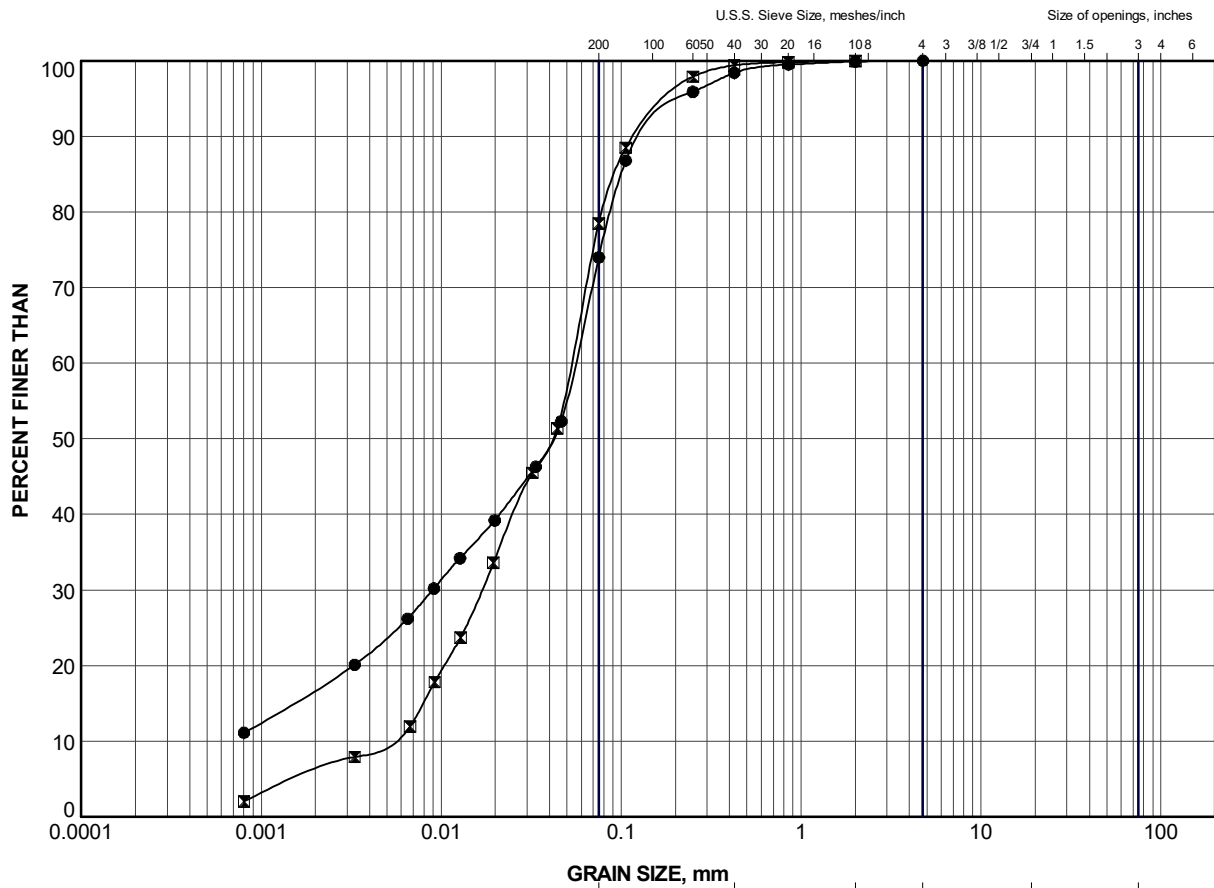
LOGGED: SA

CHECKED: AC/DAM

SUD-MTO-RCK S:\CLIENTS\IMTOHWY_124_400_518\02_DATA\GINT\1776446.GPJ GAL-MISS.GDT 1-10-20 TR

APPENDIX B


Laboratory Test Results

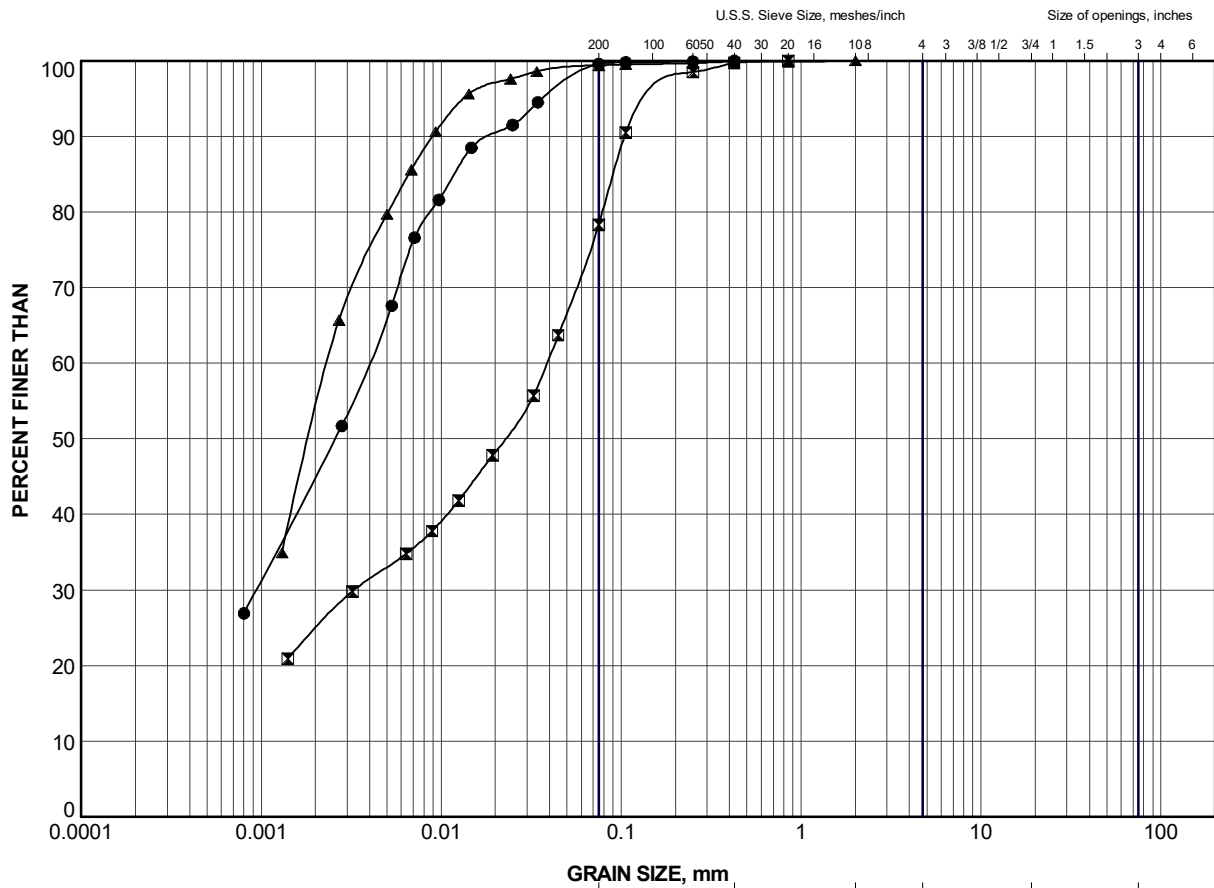


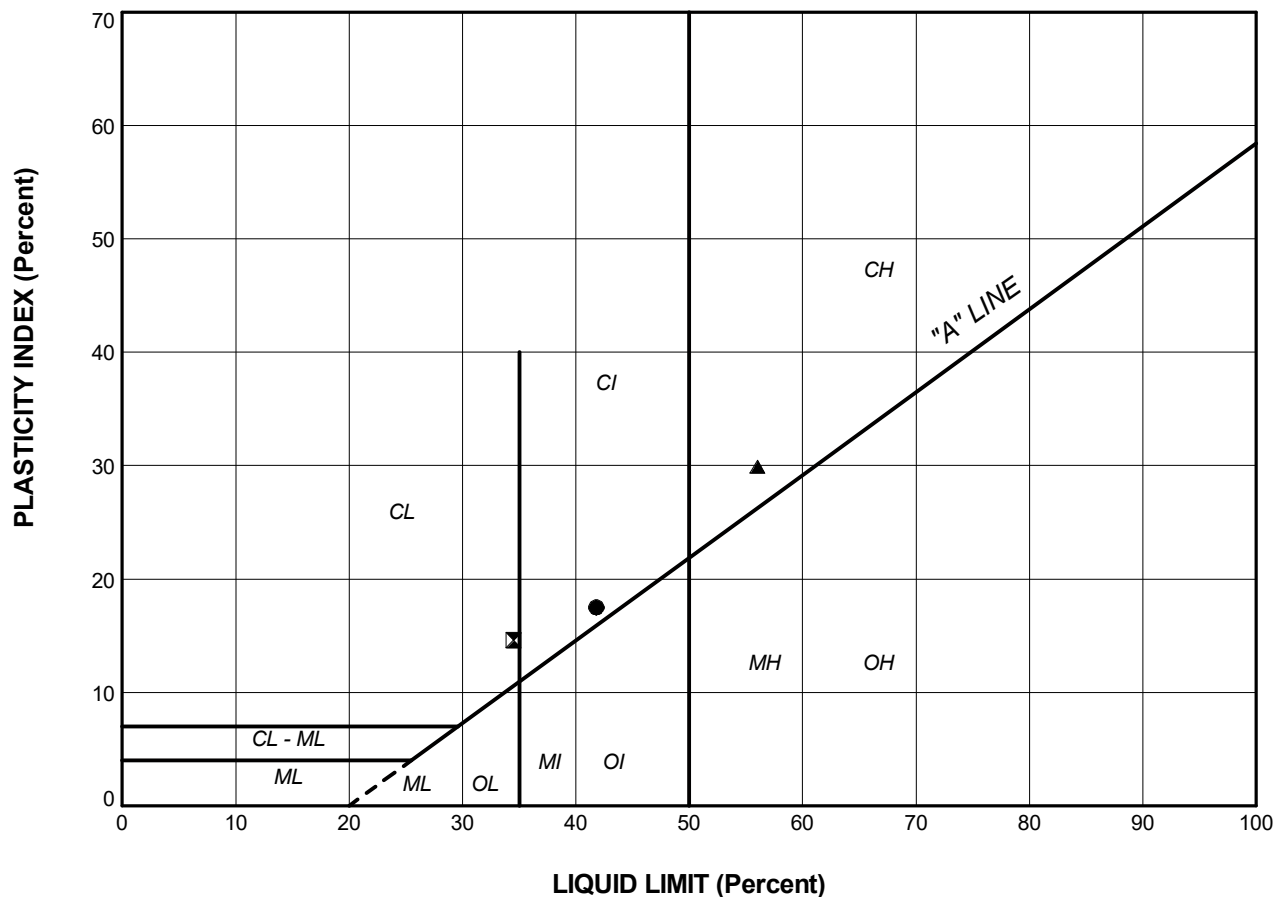
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	HC-1	2	238.3
×	HC-4	2	237.8

PROJECT						HIGHWAY 124 HARRIS CREEK CULVERT					
TITLE						GRAIN SIZE DISTRIBUTION Sandy SILT					
PROJECT No.			1776446			FILE No.			1776446.GPJ		
DRAWN	TR	Dec 2019	SCALE	N/A	REV.	FIGURE B-1					
CHECK	AC	Dec 2019									
APPR	JMAC	Dec 2019									
 GOLDER SUDBURY, ONTARIO											

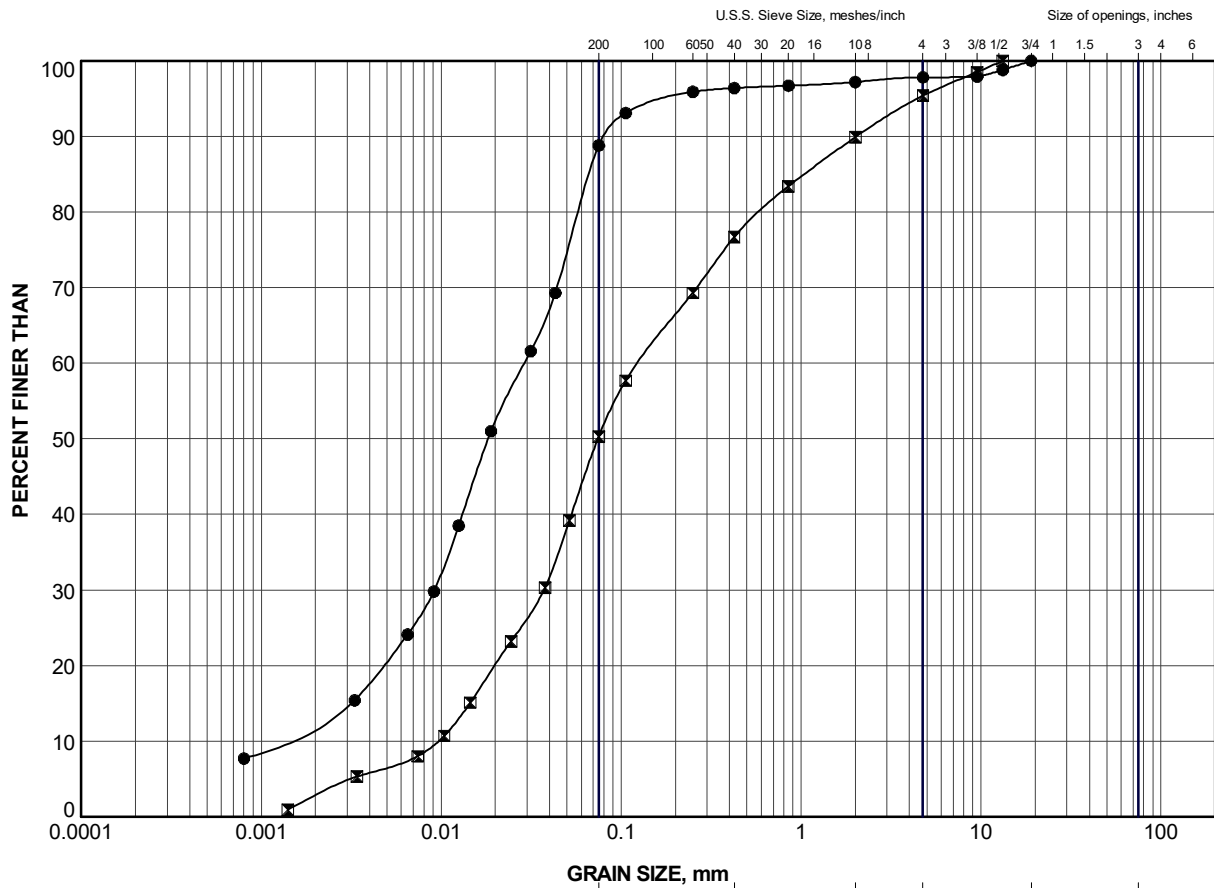




LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	HC-1	5	41.8	24.3	17.5
⊠	HC-3	1	34.5	19.9	14.6
▲	HC-3	4	56.0	26.1	29.9

PROJECT						HIGHWAY 124 HARRIS CREEK CULVERT					
TITLE						PLASTICITY CHART CLAYEY SILT to CLAY					
PROJECT No.			1776446			FILE No.			1776446.GPJ		
DRAWN	TR	Dec 2019	SCALE	N/A	REV.	FIGURE B-3					
CHECK	AC	Dec 2019									
APPR	JMAC	Dec 2019									
GOLDER						SUDBURY, ONTARIO					



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	HC-1	7	234.3
⊠	HC-3	6	231.5

PROJECT						HIGHWAY 124 HARRIS CREEK CULVERT					
TITLE						GRAIN SIZE DISTRIBUTION SILT to SILT and SAND					
PROJECT No.			1776446			FILE No.			1776446.GPJ		
DRAWN	TR	Dec 2019	SCALE	N/A	REV.	FIGURE B-4					
CHECK	AC	Dec 2019									
APPR	JMAC	Dec 2019									
GOLDER						SUDBURY, ONTARIO					

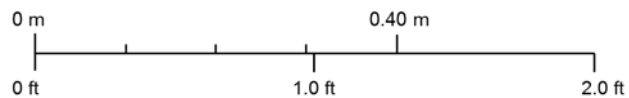



Borehole HC-2: Elevation 239.1 m to 236.1 m



Borehole HC-4: Elevation 237.5 m to 234.8 m







Scale



PROJECT		Harris Creek Culvert Site No. 44-289/C Highway 124			
TITLE		BEDROCK CORE PHOTOGRAPHS BOREHOLES HC-2 and HC-4			
	PROJECT No. 1776446		FILE No. ----		
	DESIGN	AC	Aug 2018	SCALE	NTS
	CADD	--		FIGURE B-5	
	CHECK	JMAC	Aug 2018		
	REVIEW				
				VER. 1.	



PROJECT NO.: 1776446/2300
PROJECT NAME: MTO/5016-E-0037/Hwys 124,400,518
TYPE OF UNIT: Rock Core
TESTED BY: JM
DATE TESTED: March 13, 2018

GOLDER LAB NUMBER	S169								
BOREHOLE NUMBER:	HC-2								
SAMPLE NUMBER:	N/A								
DEPTH OF TESTED CORE (ft)	8'11"								
LENGTH AS CUT (mm)	101.4								
DIAMETER (mm)	43.2								
DENSITY (kg/m ³)	2821								
COMPRESSIVE STRENGTH (KN)	149.1								
CORRECTED STRENGTH (MPa)	101.6								
TYPE OF FRACTURE	3								
Type of Fracture									
		1	2	3	4	5	6		
COMMENTS:									


Input by: SM
Reviewed by: 

Figure B-6

APPENDIX C

**Maxxam Certificate of Analysis -
Analytical Testing**

Table C-1 - Summary of Analytical Testing of Harris Creek Culvert Soil Sample

Parameter	Units	Results
Resistivity	ohm-cm	5,100
Conductivity	µmho/cm	197
pH	pH	7.44
Sulphate	µg/g	Not Detected (RDL=20)
Chloride	µg/g	56

Notes:

1. Sample obtained December 14, 2017 (Borehole HC-1, Sample 3)
2. Analytical testing carried out by Maxxam Analytics Inc.

Prepared by: AC
Reviewed by: JMAC

Your Project #: 1776446 T2200/MTP/GHD HWY124/5
Site Location: HWY 124 HARRIS CREEK
Your C.O.C. #: 641586-01-01

Attention: David Muldowney

Golder Associates Ltd
33 Mackenzie Street
Suite 100
Sudbury, ON
Canada P3C 4Y1

Report Date: 2018/01/03
Report #: R4927509
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B7S5485

Received: 2017/12/15, 14:01

Sample Matrix: Soil
Samples Received: 3

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride (20:1 extract)	3	N/A	2017/12/27	CAM SOP-00463	EPA 325.2 m
Conductivity	3	N/A	2017/12/27	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl ₂ EXTRACT	3	2017/12/28	2017/12/28	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	3	2017/12/20	2017/12/27	CAM SOP-00414	SM 22 2510 m
Sulphate (20:1 Extract)	3	N/A	2017/12/27	CAM SOP-00464	EPA 375.4 m

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.

Results relate to samples tested.

This Certificate shall not be reproduced except in full, without the written approval of the laboratory.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

Your Project #: 1776446 T2200/MTP/GHD HWY124/5
Site Location: HWY 124 HARRIS CREEK
Your C.O.C. #: 641586-01-01

Attention: David Muldowney

Golder Associates Ltd
33 Mackenzie Street
Suite 100
Sudbury, ON
Canada P3C 4Y1

Report Date: 2018/01/03
Report #: R4927509
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B7S5485
Received: 2017/12/15, 14:01

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Fatemeh Habibagahi, Project Manager Assistant
Email: FHabibagahi@maxxam.ca
Phone# (905) 817-5700

=====

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

RESULTS OF ANALYSES OF SOIL

Maxxam ID		FTW859	FUN106	FUN107		
Sampling Date		2017/12/14 13:00	2017/12/05 12:00	2017/12/07 13:30		
COC Number		641586-01-01	641586-01-01	641586-01-01		
	UNITS	HC-1(HARRIS CREEK CULVERT HWY 121)	BC-3(BEWR CREEK HWY 518)	C27-2(CULVERT27 HWY124)	RDL	QC Batch

Calculated Parameters						
Resistivity	ohm-cm	5100	11000	2300		5325054
Inorganics						
Soluble (20:1) Chloride (Cl)	ug/g	56	35	210	20	5329429
Conductivity	umho/cm	197	91	444	2	5330818
Available (CaCl2) pH	pH	7.44	6.59	6.66		5333167
Soluble (20:1) Sulphate (SO4)	ug/g	ND	ND	ND	20	5329488
RDL = Reportable Detection Limit						
QC Batch = Quality Control Batch						
ND = Not detected						

Maxxam ID		FUN107		
Sampling Date		2017/12/07 13:30		
COC Number		641586-01-01		
	UNITS	C27-2(CULVERT27 HWY124) Lab-Dup	RDL	QC Batch
Inorganics				
Available (CaCl2) pH	pH	6.71		5333167
Soluble (20:1) Sulphate (SO4)	ug/g	ND	20	5329488
RDL = Reportable Detection Limit				
QC Batch = Quality Control Batch				
Lab-Dup = Laboratory Initiated Duplicate				
ND = Not detected				

Maxxam Job #: B7S5485
Report Date: 2018/01/03

Golder Associates Ltd
Client Project #: 1776446 T2200/MTP/GHD HWY124/5
Site Location: HWY 124 HARRIS CREEK
Sampler Initials: SA

TEST SUMMARY

Maxxam ID: FTW859
Sample ID: HC-1(HARRIS CREEK CULVERT HWY 121)
Matrix: Soil

Collected: 2017/12/14
Shipped:
Received: 2017/12/15

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5329429	N/A	2017/12/27	Deonarine Ramnarine
Conductivity	AT	5330818	N/A	2017/12/27	Tahir Anwar
pH CaCl2 EXTRACT	AT	5333167	2017/12/28	2017/12/28	Tahir Anwar
Resistivity of Soil		5325054	2017/12/27	2017/12/27	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5329488	N/A	2017/12/27	Deonarine Ramnarine

Maxxam ID: FUN106
Sample ID: BC-3(BEWR CREEK HWY 518)
Matrix: Soil

Collected: 2017/12/05
Shipped:
Received: 2017/12/15

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5329429	N/A	2017/12/27	Deonarine Ramnarine
Conductivity	AT	5330818	N/A	2017/12/27	Tahir Anwar
pH CaCl2 EXTRACT	AT	5333167	2017/12/28	2017/12/28	Tahir Anwar
Resistivity of Soil		5325054	2017/12/27	2017/12/27	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5329488	N/A	2017/12/27	Deonarine Ramnarine

Maxxam ID: FUN107
Sample ID: C27-2(CULVERT27 HWY124)
Matrix: Soil

Collected: 2017/12/07
Shipped:
Received: 2017/12/15

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5329429	N/A	2017/12/27	Deonarine Ramnarine
Conductivity	AT	5330818	N/A	2017/12/27	Tahir Anwar
pH CaCl2 EXTRACT	AT	5333167	2017/12/28	2017/12/28	Tahir Anwar
Resistivity of Soil		5325054	2017/12/27	2017/12/27	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5329488	N/A	2017/12/27	Deonarine Ramnarine

Maxxam ID: FUN107 Dup
Sample ID: C27-2(CULVERT27 HWY124)
Matrix: Soil

Collected: 2017/12/07
Shipped:
Received: 2017/12/15

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
pH CaCl2 EXTRACT	AT	5333167	2017/12/28	2017/12/28	Tahir Anwar
Sulphate (20:1 Extract)	KONE/EC	5329488	N/A	2017/12/27	Deonarine Ramnarine

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	6.0°C
Package 2	7.0°C

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1776446 T2200/MTP/GHD HWY124/5
Site Location: HWY 124 HARRIS CREEK
Sampler Initials: SA

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5329429	Soluble (20:1) Chloride (Cl)	2017/12/27	116	70 - 130	104	70 - 130	ND, RDL=20	ug/g	NC	35
5329488	Soluble (20:1) Sulphate (SO4)	2017/12/27	115	70 - 130	110	70 - 130	ND, RDL=20	ug/g	NC	35
5330818	Conductivity	2017/12/27			100	90 - 110	ND,RDL=2	umho/cm	0.40	10
5333167	Available (CaCl2) pH	2017/12/28			100	97 - 103			0.70	N/A

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

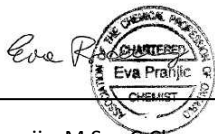
Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference $\leq 2 \times \text{RDL}$).

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).



Ewa Pranjić, M.Sc., C.Chem, Scientific Specialist

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

APPENDIX D

**Non Standard Special Provision
and Special Provisions**

TEMPORARY PROTECTION SYSTEM – Item No.

Non-Standard Special Provision

Amendment to OPSS 539, November 2014

539.07.02 Removal of Protection Systems

Subsection 539.07.02 of OPSS 539 is deleted in its entirety and replaced with the following:

Protection systems shall be removed from the right-of-way unless it is specified in the Contract Documents that the protection system may be left in place.

Where piles are left in place, the top shall be removed to at least 1.2 m below the finishing grade or ground surface.

The method and sequence of removal shall be such that there shall be no damage to the new work, existing work or facility being protected.

All disturbed areas shall be restored to an equivalent to better condition than existing prior to the commencement of construction.

DEWATERING SYSTEM - Item No.
TEMPORARY FLOW PASSAGE SYSTEM - Item No.

Special Provision No. 517F01

July 2017

Amendment to OPSS 517, November 2016

Design Storm Return Period and Preconstruction Survey Distance

517.01 SCOPE

Section 517.01 of OPSS 517 is deleted in its entirety and replaced with the following:

This specification covers the requirements for the design, operation, and removal of a dewatering or temporary flow passage system or both to control water during construction, and the control of the water prior to discharge to the natural environment and sewer systems.

517.04 DESIGN AND SUBMISSION REQUIREMENTS

517.04.01 Design Requirements

Subsection 517.04.01 of OPSS 517 is amended by deleting the first paragraph in its entirety and replacing it with the following:

A dewatering or temporary flow passage system or both shall be designed to control water at the locations specified in the Contract Documents and at any other location where a system is necessary to complete the work. The design of the system shall be sufficient to permit the work at each location to be carried out as specified in the Contract Documents.

Subsection 517.04.01 of OPSS 517 is further amended by deleting the second last paragraph in its entirety and replacing it with the following:

Temporary flow passage systems shall be designed, as a minimum, for a 2 year design storm return period and groundwater discharge, except for the work specified in Table A. For the work specified in Table A, the temporary flow passage system shall be designed, as a minimum, for the design storm return period specified in Table A and groundwater discharge. A longer return period shall be used when determined appropriate for the work.

Intensity-Duration Factor (IDF) curve location, site specific minimum return period, return period flow estimates, and other information is provided in Table A. The IDF information can be accessed through the MTO IDF Curve Look up Tool on the Drainage and Hydrology page of MTO's website. The return period flow estimates do not include flow volumes from groundwater discharge. The Owner specifically excludes these flow estimates from the warranty in the Reliance on Contract Documents subsection of OPSS 100, MTO General Conditions of Contract.

Table A

IDF Curve Location	Latitude: 45.466999°			Longitude: -79.992928°		
Temporary Flow Passage Systems						
Site Name / Station Reference	Minimum Return Period (Years)	Return Period Flow Estimates (m³/s)				Design Engineer Requirements (Note 1)
		2 Year	5 Year	10 Year	25 Year	
Harris Creek - Site 44X-0289/CO	***	****	****	****	****	YES
Dewatering Systems						
Site Name / Station Reference	Preconstruction Survey Distance (Note 2) (m)					Design Engineer Requirements (Note 1)
Harris Creek - Site 44X-0289/CO	150					YES
Note: 1. “Yes” means the design Engineer and design-checking Engineer shall have a minimum of 5 years of experience in designing systems of similar nature and scope to the required work. “No” means a minimum experience level is not required for the design Engineer and design-checking Engineer. 2. “N/A” indicates a preconstruction survey is not required.						



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