



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 556 CULVERT AT STA 10+119 (TOWNSHIP OF DEROCHE)
REHABILITATION OF HIGHWAYS 556 & 532
DISTRICT OF ALGOMA, ONTARIO
ASSIGNMENT NO.: 5020-E-0020
G.W.P. 5221-18-00

GEOCRES Number: 41K-127**

Report

to

AECOM Canada Ltd.

Date: April 24, 2023
File: 31719



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PART A: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) at the site of the proposed dewatering to facilitate replacement of a non-structural culvert, located at STA 10+119 on Highway 556, in the Township of Deroche, District of Algoma, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the culvert site and, based on the data obtained, to provide a borehole location plan, stratigraphic profile, records of boreholes, laboratory test results, and a written description of the subsurface conditions.

Thurber carried out the investigation as a subconsultant to AECOM Canada Ltd. (AECOM), under the Ministry of Transportation, Ontario (MTO) Assignment No. 5020-E-0020.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

2. SITE DESCRIPTION

The existing culvert is located on Highway 556, approximately 14.5 km west of the intersection with Highway 532 near Searchmont, Ontario. For project orientation purposes, Highway 556 is herein described as oriented east-west, and the culvert is described as oriented north-south. Details of the existing culvert are as follows:



Township and Station	Culvert Size and Type	Length of Culvert (m)	Invert Elevation at Inlet ¹ (m)	Invert Elevation at Outlet ¹ (m)
Deroche 10+119	2740 mm dia. SPCSP	A 18.5 m long section and a 16.0 m long extension joined at an angle of 148 degrees ²	318.86 (south)	318.92 (north)

Note 1: Invert elevation is calculated from the surveyed obvert minus the diameter of the culvert.

2: Refer to the plan on the Borehole Location and Soil Strata Drawing in Appendix D.

Despite the outlet invert being at a slightly higher elevation than the inlet, the existing culvert allows flow in a south to north direction under the approximately 1.6 m high embankment (above the culvert obvert). The highway pavement surface is at approximate Elev. 323.1 m. In the area of the culvert, the south-facing slope is generally inclined at approximately 2H:1V, except immediately at the culvert inlet where slope is inclined at approximately 1H:1V. The north-facing slope is inclined at approximately 2H:1V.

Based on visual observations, no signs of slope instability of the embankment were noted near the outlet of the culvert site. Ponded water was observed at the culvert outlet. The embankment side slopes are lightly vegetated with some visible cobbles. Site photographs can be found in Appendix A.

Highway 556 consists of two, 3.25 m wide, paved lanes and narrow shoulders. The alignment in the immediate vicinity of the culvert is a local low point (vertical curve) and relatively straight, with horizontal curves beginning approximately 90 m and 240 m further east and west, respectively. The unpaved shoulders are narrow with no guardrails or guiderails. Overhead utility lines are present on the south side of the highway, with overhead lines crossing the highway approximately 17 m west of the culvert. It is understood that the projected 2023 AADT for Highway 556 is 540. Entrances to rural properties are located approximately 7 m and 60 m to the east and west of the culvert, respectively.

Based on Northern Ontario Engineering Geology Terrain Study (NOEGTS) mapping, the site lies in an outwash plain and valley train and the primary materials are sandy and gravelly soils, and bedrock knobs and outcrops. The site topography in the immediate vicinity of the culvert is of low relief consisting of plains and gullies and the surrounding area is generally described as moderate relief of a clifty volcanic rock signature.

Based on the OGS Map MRD126 titled “Bedrock Geology of Ontario”, dated 2011, the underlying bedrock at the site consists of mafic to intermediate metavolcanic rocks.



3. INVESTIGATION PROCEDURES

The field investigation and testing for this project was carried out between November 28 and December 12, 2022, and consisted of drilling and sampling two boreholes, designated as Boreholes 10119-01 and 10119-02, to depths of 5.0 m and 7.1 m, respectively (corresponding to Elev. 315.9 m and 313.0 m). Boreholes 10119-01 and 10119-02 were advanced near the toe of the embankment near the existing culvert outlet and inlet, respectively.

The Record of Borehole sheets for the boreholes are included in Appendix B.

Utility clearances were obtained prior to mobilization to the site. The ground surface elevations of the as-drilled borehole locations were surveyed in the field relative to known site features (i.e., obvert of existing culvert). The borehole co-ordinates were determined through off-set measurement from the highway centerline and existing culvert. The coordinate system MTM NAD 83, Zone 13 was used for the boreholes.

Boreholes 10119-01 and 10119-02 were advanced with a portable drilling equipment also using wash boring technique with BW casing and AW rock coring methods. Soil samples were obtained at selected intervals using a split-spoon sampler in conjunction with Standard Penetration Testing (SPT) in general accordance with ASTM D1586. Soil sampling in both boreholes employed a third-weight hammer lifted manually and as such, a correction factor has been applied for the reported SPT N-values and thus, they are less reliable. AW coring methods with were used to core through cobbles in Borehole 10119-01.

The drilling and sampling operations were supervised on a full-time basis by a member of Thurber's technical staff, who logged the boreholes and processed the recovered soil and core samples for transport to Thurber's laboratory for further examination and testing.

Monitoring wells were installed in Boreholes 10119-01 and 10119-02. Each well consists of a 32 mm Schedule 40 PVC pipe with a 1.5 m long slotted screen, enclosed in a column of filter sand to permit groundwater level monitoring. Well installation details, groundwater level observations and water level readings are shown on the Record of Borehole sheets.

A Single Well Response Test (SWRT), or "slug" test, was carried out in 32 mm diameter wells installed in Boreholes 10119-01 and 10119-02, which were screened across native silty sand deposit.



Prior to conducting the “slug” tests, the monitoring wells were developed and purged to remove excess sediments that may have entered the well during installation, improve the transmissivity of the sand pack and well screen, and increase the representativeness of the natural groundwater of the soil deposit within the well. Following the development of the well, slug tests were conducted by inserting a datalogger into the well to monitor the recovery of the water level in the well. The dataloggers were set to record water levels every 0.125 to 0.5 seconds, based on the anticipated rate of recovery of the well. During the test, both electronic measurements from the datalogger and manual measurements were recorded until the water level in the well has recovered sufficiently. The electronic and manual measurements were then compared to each other for quality control.

The borehole completion details are summarized below:

Borehole	Depth and Elevation of Borehole Base (m)	Depth and Elevation of Well Tip (m)	Northing and Easting MTM NAD83 Zone 13	Completion Details
10119-01	5.0 / 315.9	5.0 / 315.9	N 5 173 959.6 E 287 838.8	32 mm diameter PVC pipe with a 1.5 m slotted screen.
10119-02	7.1 / 313.0	7.1 / 313.0	N 5 173 922.2 E 287 850.0	32 mm diameter PVC pipe with a 1.5 m slotted screen.

4. LABORATORY TESTING

All recovered soil samples were subjected to visual identification (VI) and natural moisture content determination. Selected samples were subjected to grain size distribution analyses (sieve and/or hydrometer). The results of this testing program are summarized on the Record of Borehole sheets in Appendix B and are shown on the figures included in Appendix C.

Testing was carried out on a sample of the gravelly sand fill to assess the potential for sulphate attack on buried concrete structures, as well as the potential for corrosion associated with buried steel elements of the structures. To assess the quality of the groundwater for disposal purposes, a groundwater sample was collected. The results of the analytical testing are summarized in this report and presented in Appendix C.



5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix B. Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and on the Borehole Locations and Soil Strata Drawing included in Appendix D. A description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be used for interpretation of the site conditions. It must be recognized and expected that soil conditions may vary between and beyond the borehole locations.

In general, the subsurface conditions encountered consisted of gravelly sand to gravelly silty sand embankment fill, underlain by native deposit of silty sand. Coarse gravel (up to 75 mm in diameter) and cobbles were encountered throughout the embankment fill, and native deposit. A boulder was encountered within the silty sand deposit.

5.1 Embankment Fill

Granular embankment fill consisting of gravelly sand, trace non-plastic fines to gravelly silty sand was encountered at ground surface at both borehole locations. Rootlets and wood fragments were noted in samples from Borehole 10119-02. Given that wood fragments were encountered at/near the bottom of the embankment, they could be from timber mats used as part of construction of the existing culvert (see Photograph #6 in Appendix C).

The embankment fill extended to depths of between 2.6 m and 2.9 m (Elev. 318.3 m and 317.2 m).

SPT 'N' values in the embankment fill ranged from 2 blows to 27 blows per 0.3 m penetration indicating a very loose to compact condition. Measured moisture contents in the gravelly sand fill in Borehole 10119-01 ranged from 6 percent to 11 percent, while moisture contents on samples of the gravelly silty sand fill in Borehole 10119-02, containing rootlets and wood fragments, ranged from 44 percent to 68 percent.

The results of grain size analyses conducted on selected samples of the embankment fill are provided on the Record of Borehole sheets in Appendix B and presented on Figure C-1 of Appendix C. The results are summarized as follows:



Soil Particle	Percentage (%)
Gravel	23 to 33
Sand	40 to 64
Silt and Clay	3 to 37

5.2 Silty Sand

A deposit of silty sand, some gravel, containing silt pockets, cobbles, and boulders was encountered beneath the embankment fill at depths of 2.6 m and 2.9 m (Elev. 318.3 m and 317.2 m) in Boreholes 10119-01 and 10119-02, respectively. Both boreholes were terminated within the silty sand deposit at a depth of 5.0 m and 7.1 m (Elev. 315.9 m and 313.0 m) in Boreholes 10119-01 and 10119-02, respectively. Coring was required to advance through this deposit in Borehole 10119-01.

SPT 'N' values in the silty sand deposit ranged from 6 blows per 0.3 m penetration to 32 blows per 0.076 m penetration, with typical 'N' values between 11 blows and 46 blows per 0.3 m penetration indicating a loose to very dense condition. The high SPT 'N' values are generally attributed to spoon refusal on a probable coarse gravel and/or cobbles. Measured moisture contents in the silty sand ranged from 5 percent to 14 percent.

The results of grain size analyses conducted on selected samples of the silty sand are presented on Figure C-2 in Appendix C and summarized as follows:

Soil Particle	Percentage (%)
Gravel	19 to 20
Sand	55 to 56
Silt	24
Clay	1

5.3 Groundwater Conditions

Groundwater levels in the monitoring wells were measured using a water level tape/dip meter and are presented below:

Borehole	Date of Measurement	Groundwater Level (m)		Remark
		Depth	Elevation	
10119-01	December 11, 2022	1.3	319.6	In monitoring well
	December 12, 2022	1.3	319.6	



Borehole	Date of Measurement	Groundwater Level (m)		Remark
		Depth	Elevation	
	December 13, 2022	1.3	319.6	
	December 14, 2022	1.3	319.6	
10119-02	December 14, 2022	1.2	318.9	In monitoring well
	December 15, 2022	1.2	318.9	

These groundwater levels are short-term observations and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation during spring and after periods of significant or prolonged precipitation.

6. ANALYTICAL LABORATORY TESTING

A sample of the native silty sand was submitted for analytical testing for corrosivity analysis and sulphide content. The analytical test results for the soil are presented in Appendix C and are summarized below.

Borehole	10119-01
Sample	SS3
Depth (m)	2.0 to 2.6
Elevation (m)	318.6
Sulphide (Na_2CO_3) %	<0.04
Chloride ($\mu\text{g/g}$)	19
Sulphate ($\mu\text{g/g}$)	79
pH	7.38
Conductivity ($\mu\text{S/cm}$)	145
Resistivity (Ohm-cm)	6,880

7. SINGLE WELL RESPONSE TEST RESULTS

7.1 Hydraulic Conductivity

The SWRT results were analyzed using the Hvorslev method. The SWRT analysis plots are included in Appendix B. The hydraulic conductivity values calculated from the in-situ SWRTs are summarized in the following table:



Monitoring Well	Screen Interval (m bgs)	Screened Geology	Hydraulic Conductivity (m/s)
10119-01	3.4 – 4.9	Silty Sand, some gravel	1.8×10^{-5}
10119-02	5.6 – 7.1	Silty Sand, some gravel	6.2×10^{-7}

In addition to slug test analysis, the hydraulic conductivity of the subsurface soils was estimated using grain-size hydraulic conductivity correlations. In general, the accuracy of hydraulic conductivity values derived from grain size correlations is low in comparison to those from slug tests. Grain size distributions were obtained for samples of fill materials and silty sand at Boreholes 10119-1 and 10119-2 and are shown on Figures C-1 and C-2 in Appendix C. The hydraulic conductivity ranges estimated from the Hazen, and Kozeny-Carman grain size correlations are shown in the following table:

Geologic Material	Correlation Reference	Relevant Grain Size Information	Hydraulic Conductivity Range (m/s)
Fill Materials	Hazen	D10: 0.009 – 0.22 mm	8.1×10^{-7} to 4.8×10^{-4}
	Kozeny-Carman	D10: 0.009 – 0.22 mm	2.4×10^{-7} to 1.5×10^{-4}
Silty Sand, some gravel	Hazen	D10: 0.025 – 0.03 mm	6.3×10^{-6} to 9.0×10^{-6}
	Kozeny-Carman	D10: 0.025 – 0.03 mm	1.9×10^{-6} to 2.7×10^{-6}
Overall Hydraulic Conductivity Range for Fill Materials:			8.1×10^{-7} to 4.8×10^{-4}
Overall Hydraulic Conductivity Range for Silty Sand:			1.9×10^{-6} to 9.0×10^{-6}

8. MISCELLANEOUS

OGS Inc. of Almonte, Ontario supplied and operated the drilling, sampling, and in-situ geotechnical testing equipment for the field investigation. The field investigation was supervised on a full-time basis by Messrs. Arie Simpson and Benoit Coote, EIT. The single well response tests were conducted by Mr. Benoit Coote, EIT. The overall management of the field program was conducted by Ms. Alysha Kobylinski, P.Eng.

Geotechnical laboratory testing on soil samples was carried out in Thurber's geotechnical laboratory. Analytical laboratory testing was carried out by Paracel Laboratories Ltd., a CALA accredited analytical laboratory in Ottawa, Ontario.

Interpretation of the field data and preparation of this report was carried out by

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PART B: ENGINEERING DISCUSSION AND RECOMMENDATIONS

9. GENERAL

This report provides an interpretation of the geotechnical data in the foundation investigation report and presents recommendations for dewatering of the temporary excavation for the proposed culvert replacement at STA 10+119 on Highway 556 in the Township of Deroche, Ontario. Since this is a non-structural culvert, the bedding, cover, and backfill recommendations for the culvert replacement will be provided in the Pavement Design Report.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, Ontario, and its designers, AECOM Canada Ltd. (AECOM), and shall not be used or relied upon for any other purposes or by any other parties including construction or Design-build Contractors. Contractors must make their own interpretation based on the data provided in factual portion of the report (Part A). Where comments are made on construction, they are provided to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction must make their own interpretation of the information provided in Part A of this report as such interpretation may affect equipment selection, proposed construction methods, scheduling, and the like.

The fill cover over the culvert obvert is up to 1.6 m high at the existing culvert location and as such, the proposed replacement culvert pipe is intended to be installed by cut and cover methods with staged construction/replacement. It is understood that the construction will involve three stages consisting of embankment widening (Stages 1, 2, and 3), installation of the replacement culvert (Stages 1 and 2), and removal of the existing culvert and embankment reinstatement (Stages 2 and 3). In addition, the existing culvert will maintain flow of water under the highway embankment until the replacement culvert is fully installed.

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Based on the 30% Design Contract Drawings, dated February 16, 2023, it is understood that the proposed replacement culvert will be approximately 6 m east of the existing culvert. Other details associated with the proposed culvert is not available at the time of reporting; however, it is understood that the diameter, and invert elevations at the inlet and outlet of the proposed culvert will be the similar to those of the existing culvert. Details of the existing culvert are summarized below.

Township and Station	Culvert Size and Type	Length of Culvert (m)	Invert Elevation at Inlet ¹ (m)	Invert Elevation at Outlet ¹ (m)
Deroche 10+119	2740 mm dia. SPCSP with 2740 mm dia. SPCSP Extension to the south (Rt)	18.5 m long, with a 16.0 m long extension joined at an angle of 148°	318.86 (south)	318.92 (north)

Note 1: Invert elevation is calculated from the surveyed obvert minus the diameter of the culvert.

Based on survey of the existing culvert, the existing culvert has a negative/adverse slope (i.e., the invert elevation is slightly lower than the invert at the culvert outlet); however, the direction of flow is confirmed to be from south to north. With regards to the proposed replacement culvert, it is understood that it will be designed with a positive slope.

The finished grade of Highway 556 at the culvert location is at approximately Elev. 323.1 m.

The discussion and recommendations presented in this report are based on information provided by AECOM, and on the subsurface information obtained from the foundation investigation and laboratory testing.

10. CONTROL OF SURFACE WATER AND GROUNDWATER

Groundwater observations show the groundwater table at the time of the investigation is above the invert of the proposed culvert, and therefore seepage from the embankment and native soils during installation of the culvert should be anticipated. In addition, dewatering of the temporary excavation will be required to permit construction in the dry. The embankment and native soils consist primarily of silty sand containing, gravels, cobbles, and boulders. These soils are expected to have high hydraulic conductivity and permeability.

The dewatering system is to be designed in accordance with OPSS.PROV 517, as amended by Special Provision 517F01. Considering the excavation in highly permeable soils, a design Engineer and design-checking Engineer with a minimum of 5 years of experience in designing



systems of similar nature and scope to the required work is required, and thus Designer Fill-In for “Design Engineer Requirement” in Special Provision 517F01 should be “Yes”. In addition, a pre-construction survey should be carried out for structures and facilities within 100 m of construction prior to the start of construction and as such, the Designer Fill-In for “Preconstruction Survey Distance” in Special Provision 517F01 should be “100 m”.

Groundwater taking for construction dewatering is governed by the Ontario Water Resources Act (OWRA), Environmental Protection Act (EPA) and the Water Taking and Transfer Regulation 387/04, a regulation under the OWRA.

The use of flow diversions and cofferdams that may be required to allow for the staged construction of the culvert in the dry is provided in the Section 11.

The groundwater level will fluctuate and the minimum groundwater elevation for the site at the time of the proposed works should be taken as the water level from the design storm period defined by the contract documents.

10.1 Construction in Wet Conditions

Since the temporary excavation for installation of the new culvert will be through the cohesionless fill and native soils with a high-water table, full dewatering the subgrade may not be practical although every attempt should be made to pump out as much accumulated water as possible. Consideration may be given to preparing the culvert subgrade and bedding in the wet. An option to consider is the use of 53 mm diameter clear stone meeting the specification of OPSS.PROV 1004, wrapped in geotextile, as subgrade fill. Consideration could also be given to the use of OPSS.PROV 1010 Granular B Type II in place of clear stone should the depth of standing water is less than 0.5 m. However, once the Granular B Type II fill is above the water level, the fill should be placed in lifts not exceeding 200 mm in loose thickness, and compacted in accordance with OPSS.PROV 501, as amended by Special Provision 105S22.

The geotextile should meet the specification for OPSS.PROV 1860 Class II, non-woven geotextile with a maximum fabric opening size (FOS) of 212 µm. Once excavation backfill is above the water level, the remaining bedding should be placed in dry conditions and the culvert constructed in accordance with OPSS.PROV 401, OPSS.PROV 421 or OPSS.PROV 422 (as applicable).

11. TEMPORARY FLOW DIVERSION SYSTEMS AND COFFERDAMS

Temporary flow diversion systems and the use of cofferdams may be required to support the installation and staged construction of the replacement culvert in the dry.

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Since the depth of water in the creek at this site is generally shallow and considering that the excavations for the culvert bedding placement and construction will only penetrate about 0.5 m below the creek bed, it may be possible to divert the creek water by constructing A temporary diversion system using one of the following methods:

- Rows of large sandbags (commonly known as bulk bags or super sacks) lined with an impermeable barrier (poly material);
- Water-filled inflatable dams constructed of industrial grade, impermeable, composite fabrics formed into flexible tubes containing one or more chambers; or,
- Interlocking sheetpiles embedded below the creek bed.

The use of interlocking sheetpiles may not be appropriate at this site due to the extensive cohesionless deposit. As such, the use of sandbags may be preferred as these systems can be installed manually with relative ease. However, the effectiveness of such diversion systems is subject to the levels of the groundwater and creek water at the time of construction and the available space between the diversion structure and the excavation for the replacement culvert. If water levels in the creek are high and/or if the working area is constrained, it may be necessary to install a groundwater cut-off system (comprised of an interlocking steel sheetpiles, in dense sand) to avoid a condition known as sand boil that would loosen and disturb the foundation subgrade within the footprint of the excavation area. The diversion systems could include the use of sumps and pumps for dewatering.

If required, a more robust/watertight system for this site could consist of steel sheet piles driven to a suitable depth. However, the cobbles and boulders in the native soils below the creek bed may damage or impede the installation of sheetpiles. As such, heavier sheetpile sections and/or protection at the tip maybe required to facilitate installation. The temporary cofferdams that may be used at the site should be designed and constructed in accordance with OPSS.PROV 539, as amended by Special Provision 105S09. The lateral movement of temporary cofferdam systems should include an evaluation of base stability and hydraulic uplift as defined in the Canadian Foundation Engineering Manual (CFEM, 2006). The Contractor is responsible for the design and construction of the temporary cofferdam systems and cofferdams, if required.

The temporary cofferdams may be designed using the following parameters:



Stratigraphic Unit	Unit Weight of Material, γ' (kN/m ³)	Angle of Internal Friction, ϕ (kN/m ³)	Coefficient of Static Lateral Earth Pressure ¹		
			At Rest, K_o	Active, K_a	Passive, K_p ²
Very Loose to Compact Gravelly Sand to Gravelly Silty Sand (Fill)	20	30	0.50	0.33	3.00
Loose to Very Dense Silty Sand, some gravel, containing cobbles and boulders	20	32	0.47	0.31	3.30

Note:

1. The lateral earth pressure coefficients presented above are based on static loading conditions and level backfill/ground surface behind cofferdam. Where there is sloping ground behind the cofferdam, the coefficient of lateral earth pressure must be adjusted to account for the slope.
2. The total passive resistance below the base of excavation (i.e., within the cofferdam), may be calculated based on the values of K_p indicated above but reduced by an appropriate factor that considers the allowable wall movement in accordance with Figure C6.27 of the Canadian Highway Bridge Design Code (CHBDC, 2019) to account for the fact that a large strain would be required for mobilization of the full passive resistance.

The cofferdam should be designed and constructed in accordance with OPSS.PROV 539 and designed for Performance Level 2 with a maximum horizontal deflection of 25 mm. Should the cofferdam be left in place after completion of the installation, the top shall be removed to at least 0.6 m below the streambed.

12. TEMPORARY FLOW PASSAGE SYSTEM

It is understood that the existing culvert is being used as the temporary flow passage system to facilitate construction of the new culvert.

13. SCOUR AND EROSION PROTECTION

The Contractor shall provide silt fences and erosion control blankets as per OPSS.PROV 805 and OPSD 219.110 throughout the duration of construction to prevent transport of silt/sediment.

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the earth and granular embankment slopes. A vegetation cover shall be established on exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 803 and OPSS.PROV 804. Surface water shall be prevented from flowing on unprotected slopes. Vegetation shall be established as soon as practical after completion of the embankment fills to limit surficial erosion.



Particle size analysis on samples of the existing embankment fill and native soils indicate that the soils have a low to moderate potential for soil erodibility (Wischmeier Nomograph factor, K ranging from 0.05 to 0.2).

Scour and erosion protection should be provided for the culvert inlet and outlet areas. Effective scour and erosion protection should be provided along the waterline and ditches. Design of the erosion protection measures must consider hydrologic and hydraulic factors and shall be carried out by specialists experienced in this field. Typically, rock protection should be provided over all earth surfaces subjected to flowing water in accordance with OPSS.PROV 511. Treatment at the outlet should be in accordance with OPSD 810.010.

It is recommended that a clay seal be used for an open cut culvert replacement to minimize the potential for piping and erosion around the inlet of the culvert. The clay seal must have a minimum thickness of 500 mm, constructed to approximately 300 mm above the high-water level and extend laterally for the width of the granular material. The material requirements should be in accordance with OPSS.PROV 1205. A geosynthetic clay liner could be considered for use as a clay seal.

14. TEMPORARY EXCAVATIONS AND ABANDONMENT OF EXISTING CULVERT

All temporary excavations must be carried out in accordance with the current Occupational Health and Safety Act (OHSA) of Ontario and local regulations. If an excavation penetrates more than one soil type, the entire excavation must be completed in accordance with the more stringent requirement. The embankment fill, and native soils above the water table at this site are classified as Type 3 soils under OHSA. Below the water table they are classified as Type 4 soils; an open cut excavation extending below the water table will require 3H:1V side slopes. Given the depth of the anticipated cut and cover excavation at this site, it is recommended that temporary cut slopes in Type 3 soils be sloped at 1H:1V or flatter. Should excavations extend into the Type 4 soils, the entire cut slope should be at 3H:1V or flatter. Alternatively, excavation slopes should be supported with a temporary protections system.

Excavation should occur in a dewatered environment (see Section 10). Excavations must be planned and carried out in a manner that does not impact on the stability of existing roadway. The temporary cut slopes may have to be protected from precipitation and runoff to avoid surficial instabilities. The duration of temporary open excavations and cut slopes should be minimized to reduce the likelihood of causing instability concerns. Embankment and temporary excavation slope stability is the responsibility of the Contractor.



Material stockpiling is a temporary construction measure and the associated stability implications are the responsibility of the Contractor. The selection and placement of construction equipment (such as cranes) and construction of temporary construction access roads are also the Contractor's responsibility. Placement of the crane or temporary stockpiling must not destabilize the embankment.

In general, the existing side slopes is inclined at approximately 2H:1V and did not show any visible signs of global instability at the time of the investigation.

As indicated in Section 9, it is understood the existing culvert will be removed during staged construction/replacement. Embankment reinstatement after removal of the existing culvert/staged construction should be carried out in accordance with OPSS.PROV 206 with embankment side slopes constructed to 2H:1V or flatter provided the reinstatement is completed with OPSS.PROV 1010 Granular B Type II. Embankment reinstatement with side slopes steeper than 2H:1V and as steep as 1.25H:1V must be constructed using rock fill. The fill placement and compaction should be carried out in accordance with OPSS.PROV 501, as amended by Special Provision 105S22.

Where newly placed embankment fill is placed against existing embankment slopes or on a sloping ground surface steeper than 3H:1V, benching of the existing slope should be carried out in accordance with OPSD 208.010.

If the permanent embankment envelope remains unchanged, foundation settlement is also expected to be negligible.

The magnitude of the embankment self-compression constructed with granular materials is in the order of 0.5% of the newly reconstructed embankment height and is expected to occur predominantly during fill placement.

If the existing culvert is to be abandoned in place, the abandonment should be carried out in accordance with OPSS.PROV 510. If the existing culvert is to be removed, the placement of backfill should be carried out with the procedure, material, and slopes as described above. Settlement of the native soils is estimated to be less than 10 mm upon completion of grouting or replacement with embankment fill.

15. CORROSION POTENTIAL

Based on results of corrosivity testing on a sample of native silty sand, the following statements can be made in reference to the MTO Gravity Pipe Design Guideline. However, the effects of



road de-icing salts/chemicals should be considered when selecting pipe material and/or corrosion mitigation measures.

- The resistivity of the silty sand was measured to be 6,880 ohm-cm, which indicates the soil is of moderate corrosion potential ($2,000 \text{ ohm-cm} < R < 4,500 \text{ ohm-cm}$) according to Table 3.2 of the MTO Gravity Pipe Design Guideline.
- The sulphate concentration of the silty sand was measured to be 79 µg/g, which is considered to have a negligible degree of sulphate attack on concrete according to Table 7.2 of the MTO Gravity Pipe Design Guideline.
- The pH level of the silty sand was measured to be 7.38, and according to Section 7.1.1 of the MTO Gravity Pipe Design Guideline, pH levels between 5.5 and 8.5 in soil or water are not considered detrimental to the durability of the culvert.

16. OBSTRUCTIONS

The existing highway embankment fill, and the native soils contain wood fragments, cobbles, and boulders. The Contractor's equipment and methodology must be selected to handle such obstructions and successfully remove them without jeopardizing the performance or operation of the highway.

17. CLOSURE

Engineering analysis and preparation of this report was carried out by Ms. Alysha Kobylinski, P.Eng., and Mr. Christopher Ng, P.Eng. The report was reviewed by Mr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects at Thurber.



Thurber Engineering Ltd.

Alysha Kobylinski

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Geotechnical Engineer



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Review Principal,
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STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

- a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.
- b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.
- c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.
- d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.



Appendix A

Site Photographs



Photograph #1 – North highway embankment at culvert outlet, facing west (October 2022)



Photograph #2 – North highway embankment at culvert outlet, facing north (October 2022)



Photograph #3 – South highway embankment at culvert inlet, facing east.



Photograph #4 – South highway embankment at culvert inlet, facing southwest. (October 2022)



Photograph #5 – South highway embankment at culvert inlet, facing northeast (December 2022)



Appendix B

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$


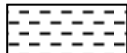



 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

<u>ROCK WEATHERING CLASSIFICATION</u>		<u>SYMBOLS</u>	
Fresh (FR)	No visible signs of weathering.		
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.		CLAYSTONE
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Very thinly bedded	20 to 60mm				
Laminated	6 to 20mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Thinly Laminated	Less than 6mm				



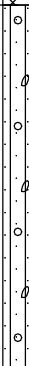
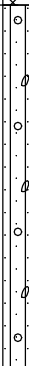

<u>TERMS</u>		Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.				
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.				
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.				
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen				
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.				

RECORD OF BOREHOLE No 10119-01

1 OF 1

METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 173 959.6 E 287 838.8 ORIGINATED BY BC
DIST Algoma HWY 556 BOREHOLE TYPE Portable Drilling, Washboring, BW Casing Advance, AW Coring COMPILED BY AK
DATUM Geodetic DATE 2022.11.28 - 2022.11.28 LATITUDE 46.705006 LONGITUDE -84.221814 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)	
320.9	GROUND SURFACE							20	40	60	80	100							
0.0	Gravelly SAND , trace non-plastic fines Compact Brown Wet Coring from a depth of 1.5 m to 2.0 m		1	AS	-		320										33 64 3 (SI+CL)		
			2	SS	27														
			1	AW	-														
318.3			3	SS	17	319											19 56 24 1		
2.6	SILTY SAND some gravel, containing silt pockets, cobbles, and boulders Dense to Very Dense Light Brown Wet Coring from a depth of 2.7 m to 3.3 m		2	AW	-	318													
315.9	No sample recovery from a depth of 4.9 to 5.1 m.		4	SS	46	317													
316			5	SS	32/0.15	316													
5.0	END OF BOREHOLE AT 5.0 m Monitoring well installation consists of 31.8 mm diameter schedule 40 PVC pipe with 1.5 m slotted screen NOTES: 1. A third-weight hammer was used to advance the split-spoon sampler. The "N" values presented above have been adjusted to provide an estimate of the "N" value that would have been obtained with a standard hammer. 2. The cored depth intervals and particle sizes of recovered cobbles and boulders are summarized as follows: Depth (m) Recovered 1.5 - 2.0 coarse gravels, and cobbles up to 100 mm 2.7 - 3.3 1 x 150 mm, 1 x 355 mm 3. Borehole terminated at a depth of 5.0 m after multiple attempts to clear blowback in casing. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2022.12.11 1.3 319.6 2022.12.12 1.3 319.6 2022.12.13 1.3 319.6 2022.12.14 1.3 319.6																		

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+³, ×³: Numbers refer to Sensitivity 20 15 10 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 10119-02

1 OF 1

METRIC

W.P. 5221-18-00 LOCATION MTM Zone 13: N 5 173 922.2 E 287 850.0 ORIGINATED BY BC
DIST Algoma HWY 556 BOREHOLE TYPE Portable Drilling, Washboring, BW Casing Advance, AW Coring COMPILED BY AK
DATUM Geodetic DATE 2022.12.10 - 2022.12.12 LATITUDE 46.704670 LONGITUDE -84.221667 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa												
								20 40 60 80 100												
								20 40 60 80 100												
320.1	GROUND SURFACE																			
0.0	Gravelly SILTY SAND Very Loose to Loose Brown Wet (FILL) Trace rootlets to a depth of 0.2 m Trace organics from a depth of 1.5 to 2.1 m BW casing grinding at a depth of 2.0 m Wood fragments in cuttings from a depth of about 2.1 to 2.9 m		1	AS	-		320													
			1	SS	2		319													23 40 33 4
			2	SS	5															
317.2							318													
			1	AW	-															
2.9	SILTY SAND some gravel Loose to Very Dense Grey Wet 																			

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE



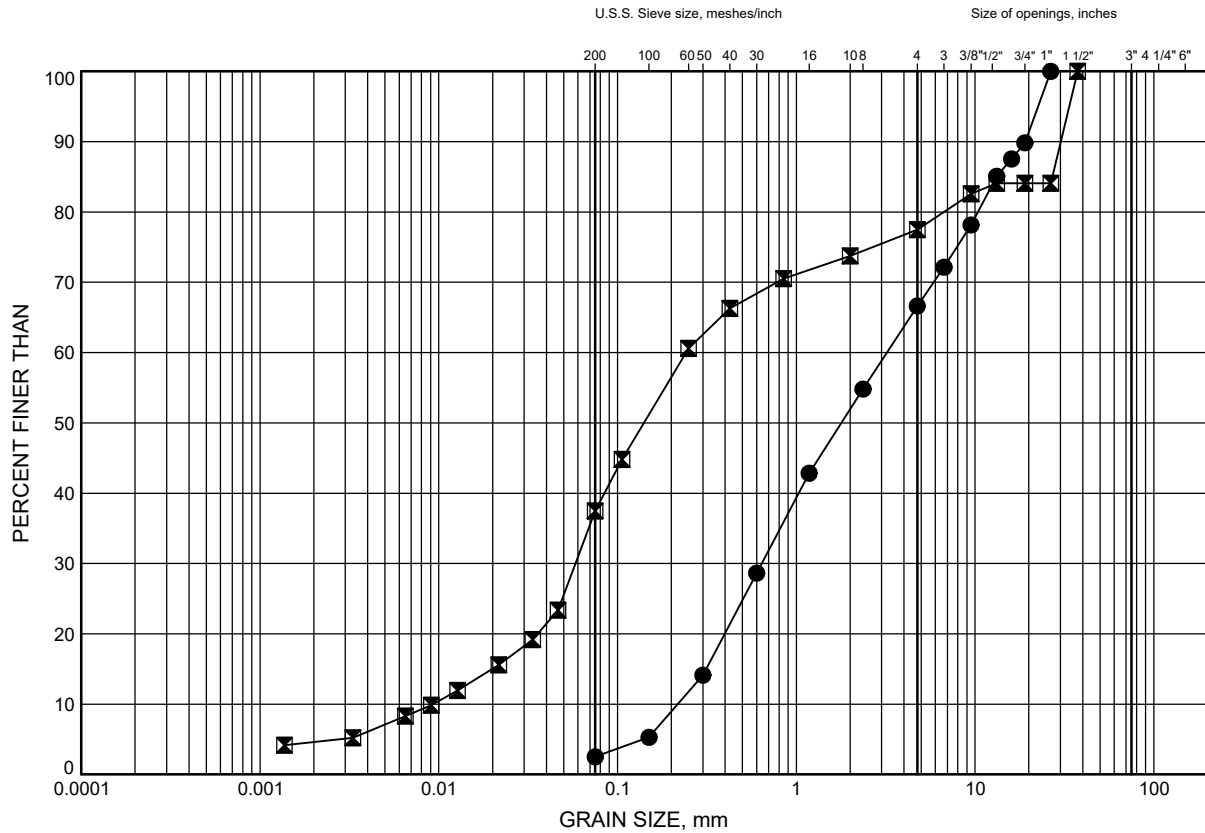
Appendix C

Geotechnical and Analytical Laboratory Test Results, Single Well Response Test Results and Sample Photographs

Culvert Replacement at Sta. 10+119
GRAIN SIZE DISTRIBUTION

FIGURE C1

Gravelly SAND to Gravelly SILTY SAND (FILL)



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	10119-01	0.3	320.6
⊠	10119-02	1.2	318.9

Date February 2023
W.P. 5221-18-00

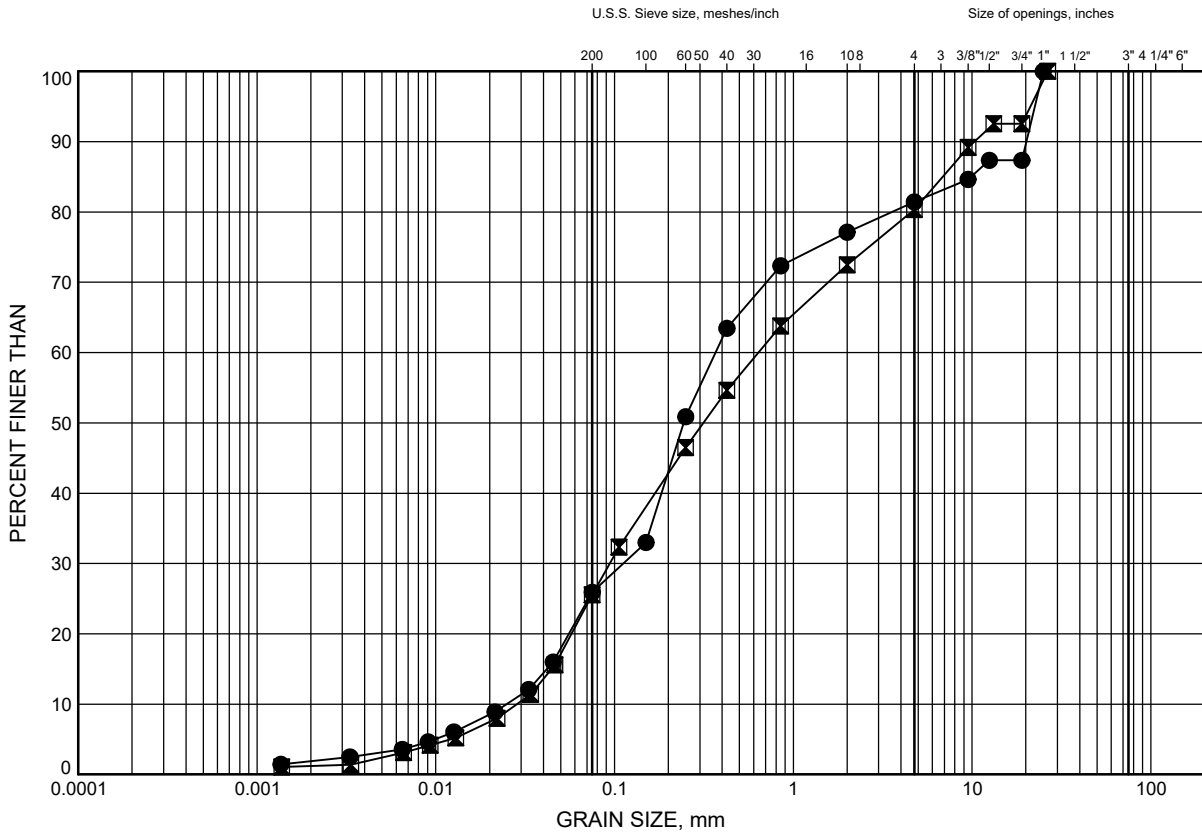


Prep'd AN
Chkd. AK

Culvert Replacement at Sta. 10+119
GRAIN SIZE DISTRIBUTION

FIGURE C2

SILTY SAND to Gravelly SILTY SAND



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	10119-01	4.3	316.6
⊠	10119-02	4.8	315.3

Date February 2023
W.P. 5221-18-00



Prep'd AN
Chkd. AK



Photograph #6 – Wood fragments recovered in Borehole 10119-02 (December 2022)

Certificate of Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104
Ottawa, ON K1B4S5
Attn: Anderson de Oliveira

Client PO:
Project:
Custody:

Report Date: 5-Jan-2023
Order Date: 22-Dec-2022

Order #: 2252371

This Certificate of Analysis contains analytical data applicable to the following samples as submitted :

Paracel ID
2252371-01

Client ID
10119-01 SS#3 (6'6"-8'6")

Approved By:



Dale Robertson, BSc
Laboratory Director

Certificate of Analysis

Client: Thurber Engineering Ltd.

Client PO:

Report Date: 05-Jan-2023

Order Date: 22-Dec-2022

Project Description:

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	28-Dec-22	28-Dec-22
Conductivity	MOE E3138 - probe @25 °C, water ext	28-Dec-22	28-Dec-22
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	28-Dec-22	28-Dec-22
Resistivity	EPA 120.1 - probe, water extraction	28-Dec-22	28-Dec-22
Solids, %	CWS Tier 1 - Gravimetric	23-Dec-22	23-Dec-22

Certificate of Analysis

Report Date: 05-Jan-2023

Client: Thurber Engineering Ltd.

Order Date: 22-Dec-2022

Client PO:

Project Description:

Client ID:	10119-01 SS#3 (6'6"-8'6")	-	-	-
Sample Date:	28-Nov-22 09:00	-	-	-
Sample ID:	2252371-01	-	-	-
MDL/Units	Soil	-	-	-

Physical Characteristics

% Solids	0.1 % by Wt.	89.2	-	-	-
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General Inorganics

Conductivity	5 uS/cm	145	-	-	-
pH	0.05 pH Units	7.38	-	-	-
Resistivity	0.10 Ohm.m	68.8	-	-	-

Anions

Chloride	10 ug/g dry	19	-	-	-
Sulphate	10 ug/g dry	79	-	-	-

Certificate of Analysis

Report Date: 05-Jan-2023

Client: Thurber Engineering Ltd.

Order Date: 22-Dec-2022

Client PO:

Project Description:

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	10	ug/g						
Sulphate	ND	10	ug/g						
General Inorganics									
Conductivity	ND	5	uS/cm						
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis

Report Date: 05-Jan-2023

Client: Thurber Engineering Ltd.

Order Date: 22-Dec-2022

Client PO:

Project Description:

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	18.8	10	ug/g	19.3			2.3	35	
Sulphate	78.2	10	ug/g	78.5			0.4	35	
General Inorganics									
Conductivity	137	5	uS/cm	134			2.3	5	
pH	7.36	0.05	pH Units	7.37			0.1	2.3	
Resistivity	72.9	0.10	Ohm.m	74.5			2.3	20	
Physical Characteristics									
% Solids	96.7	0.1	% by Wt.	97.1			0.5	25	

Certificate of Analysis

Client: Thurber Engineering Ltd.

Client PO:

Report Date: 05-Jan-2023

Order Date: 22-Dec-2022

Project Description:

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	122	10	ug/g	19.3	103	82-118			
Sulphate	184	10	ug/g	78.5	105	80-120			

Certificate of Analysis

Client: Thurber Engineering Ltd.

Client PO:

Report Date: 05-Jan-2023

Order Date: 22-Dec-2022

Project Description:

Qualifier Notes:

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable

ND: Not Detected

MDL: Method Detection Limit

Source Result: Data used as source for matrix and duplicate samples

%REC: Percent recovery.

RPD: Relative percent difference.

NC: Not Calculated

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.

Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.



OTTAWA • KINGSTON • NIAGARA

Client Name: <u>Thurber Engineering</u>	Project Reference:	TAT: <input checked="" type="checkbox"/> Regular [] 3 Day [] 2 Day [] 1 Day Date Required: _____
Contact Name: <u>Anderson</u>	Quote #	
Address: <u>2460 Lancaster Rd</u>	PO #	
Telephone: <u>613-770-7957</u>	Email Address: <u>Adeoliveira@thurber.ca</u>	

Criteria: [] O. Reg. 153/04 Table [] O. Reg. 153/11 (Current) Table [] RSC Filing [] O. Reg. 558/00 [] PWQO [] CCME [] SUB (Storm) [] SUB (Sanitary) Municipality: _____ [] Other: _____

Matrix Type: S (Soil/Sed.) GW (Ground Water) SW (Surface Water) SS (Storm/Sanitary Sewer) P (Paint) A (Air) O (Other)

Required Analyses

Parcel Order Number:		Matrix	Air Volume	# of Containers	Sample Taken		pH	Resistivity	Conductivity	Chloride	Sulphate	Sulfide						
Sample ID/Location Name					Date	Time												
1	10119-01 SS#3 (6'6"-8'6")				20/11/22	-												
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		

Comments: Please e-mail results to Adeoliveira@thurber.ca ~~Disregard~~ Hold time Method of Delivery: Walking

Relinquished By (Print & Sign): <u>Richard Howarth</u>	Received by Driver/Depot:	Received at Lab:	Verified By:
Date/Time: <u>2022/12/22 3:01 PM</u>	Date/Time:	Date/Time: <u>2022-12-22 2:45 PM</u>	Date/Time: <u>DEC 22 2022 15:46</u>
Temperature: _____ °C	Temperature: <u>20.4</u> °C	pH Verified []	By:

Subcontracted Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104

Ottawa, ON K1B4S5

Attn: Anderson de Oliveira

Paracel Report No. **2252371**

Client Project(s):

Client PO:

Reference: **Standing Offer**

CoC Number:

Order Date: 22-Dec-22

Report Date: 23-Jan-23

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor's report is attached

Paracel ID	Client ID	Analysis
2252371-01	10119-01 SS#3 (6'6"-8'6")	Sulphide, solid

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

Paracel Laboratories

Attn : Dale Robertson

300-2319 St.Laurent Blvd.
Ottawa, ON
K1G 4K6, Canada

Phone: 613-731-9577
Fax:613-731-9064

19-January-2023

Date Rec. : 30 December 2022
LR Report: CA13967-DEC22
Reference: Project#: 2252371

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Sulphide (Na ₂ CO ₃) %
1: Analysis Start Date		17-Jan-23
2: Analysis Start Time		15:25
3: Analysis Completed Date		19-Jan-23
4: Analysis Completed Time		09:27
5: QC - Blank		< 0.04
6: QC - STD % Recovery		103%
7: QC - DUP % RPD		6%
8: RL		0.02
9: 10119-01 SS#3 (6'6"-8'6")	28-Nov-22	< 0.04

RL - SGS Reporting Limit

Note: Sample was past the 28 day holding time for Sulphide analysis when received; result may be unreliable. Processed past holding time as per client's standing instructions.

Kimberley Didsbury
Project Specialist,
Environment, Health & Safety



THURBER ENGINEERING LTD.

Slug Test Analysis Report

Project: Highway 556 & 532 Rehabilitation Design

Number: 31719

Client: AECOM Canada Ltd.

Location: Deroche, Ontario

Slug Test: 10119-01

Test Well: 10119-01

Test Conducted by: BC

Test Date: 2022-12-15

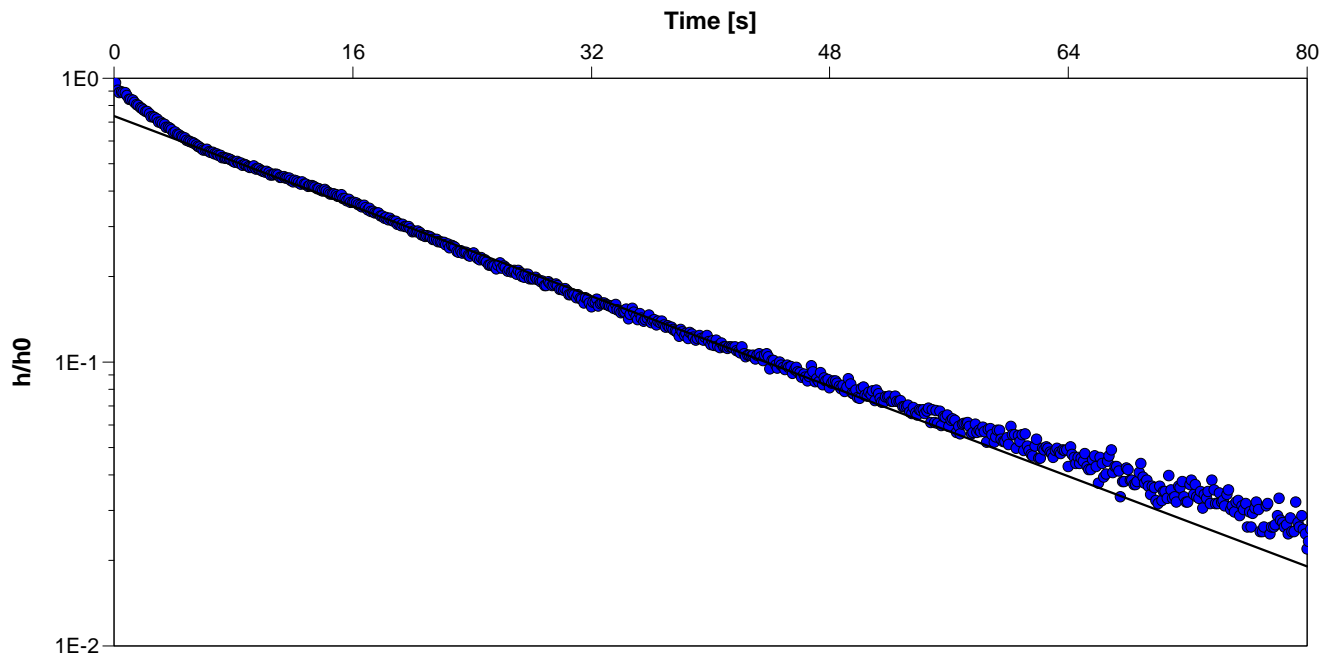
Analysis Performed by: SM

SWRT Analysis

Analysis Date: 2022-12-21

Aquifer Thickness:

Checked by: DH



Calculation using Hvorslev

Observation Well

Hydraulic Conductivity
[m/s]

10119-01

1.8×10^{-5}



THURBER ENGINEERING LTD.

Slug Test Analysis Report

Project: Highway 556 & 532 Rehabilitation Design

Number: 31719

Client: AECOM Canada Ltd.

Location: Deroche, Ontario

Slug Test: 10119-02

Test Well: 10119-02

Test Conducted by: BC

Test Date: 2022-12-15

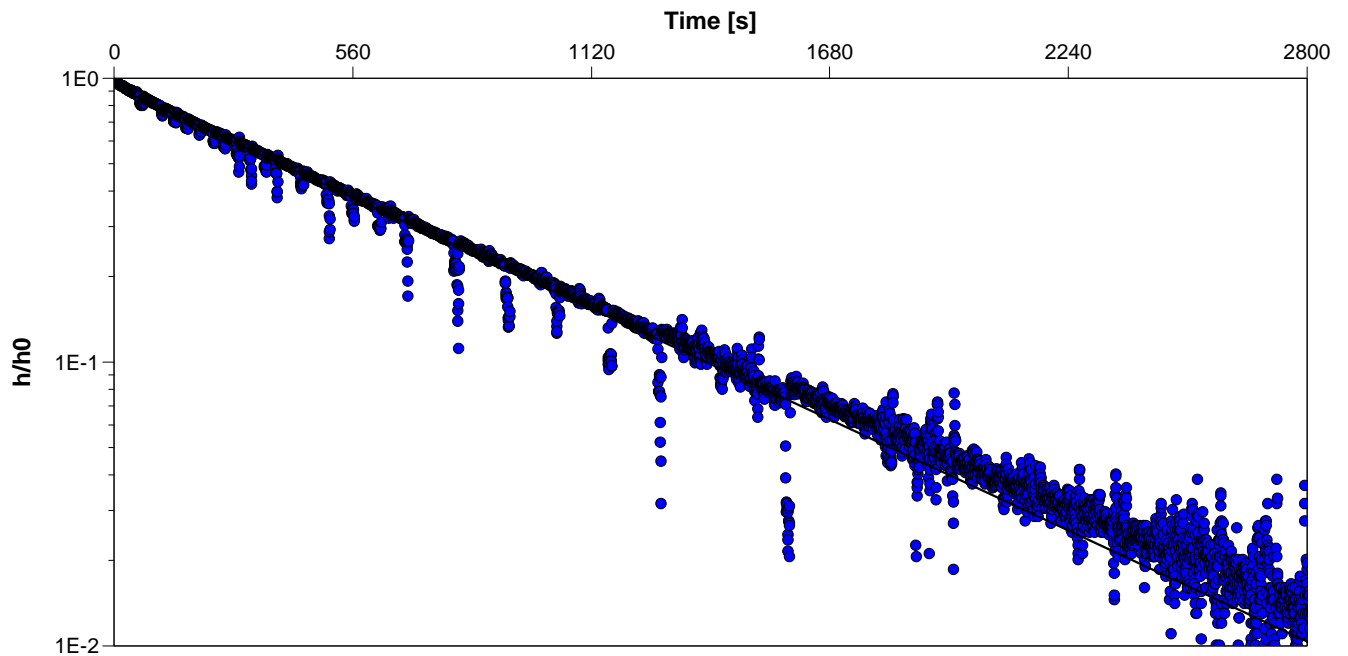
Analysis Performed by: SM

SWRT Analysis

Analysis Date: 2022-12-21

Aquifer Thickness:

Checked by: DH



Calculation using Hvorslev

Observation Well

Hydraulic Conductivity
[m/s]

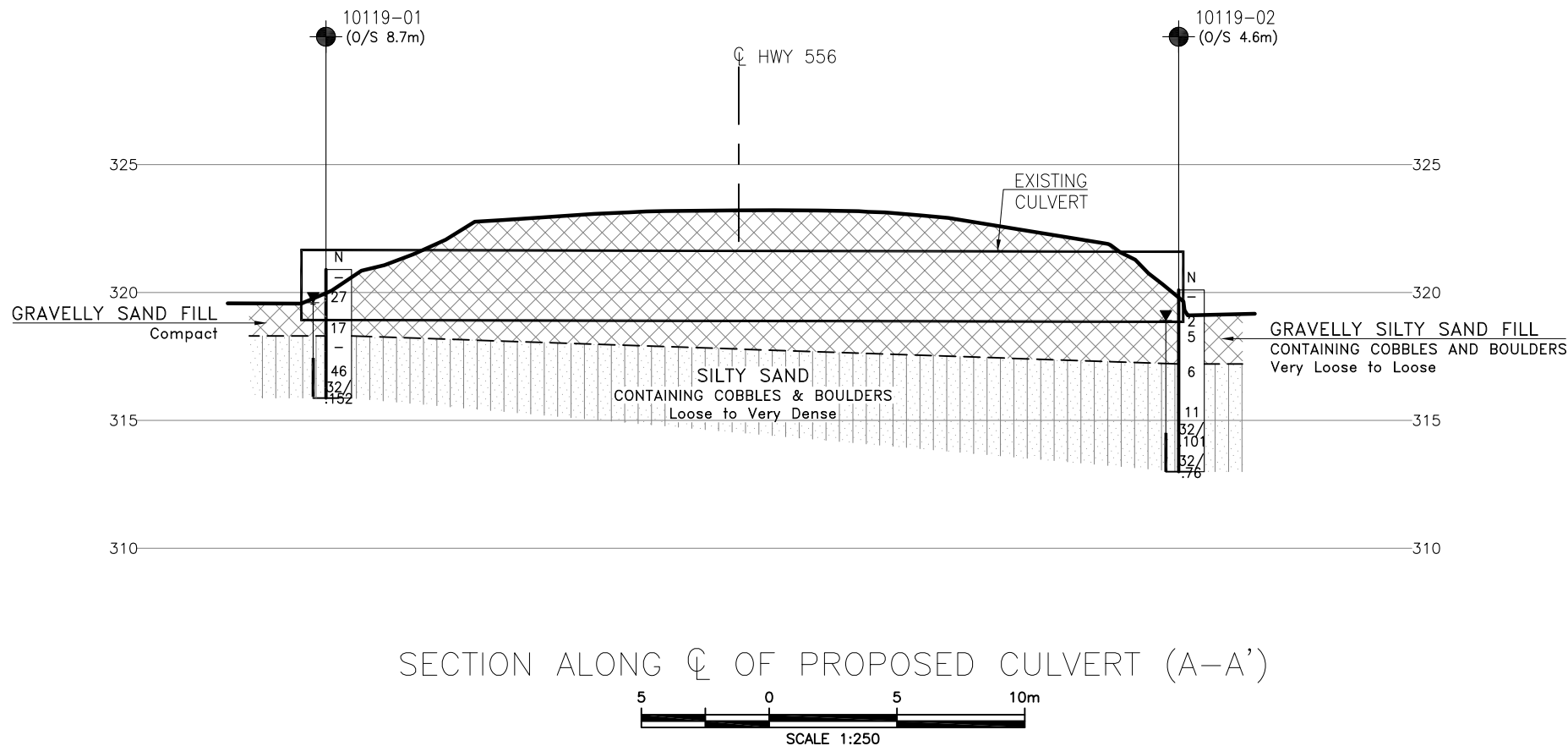
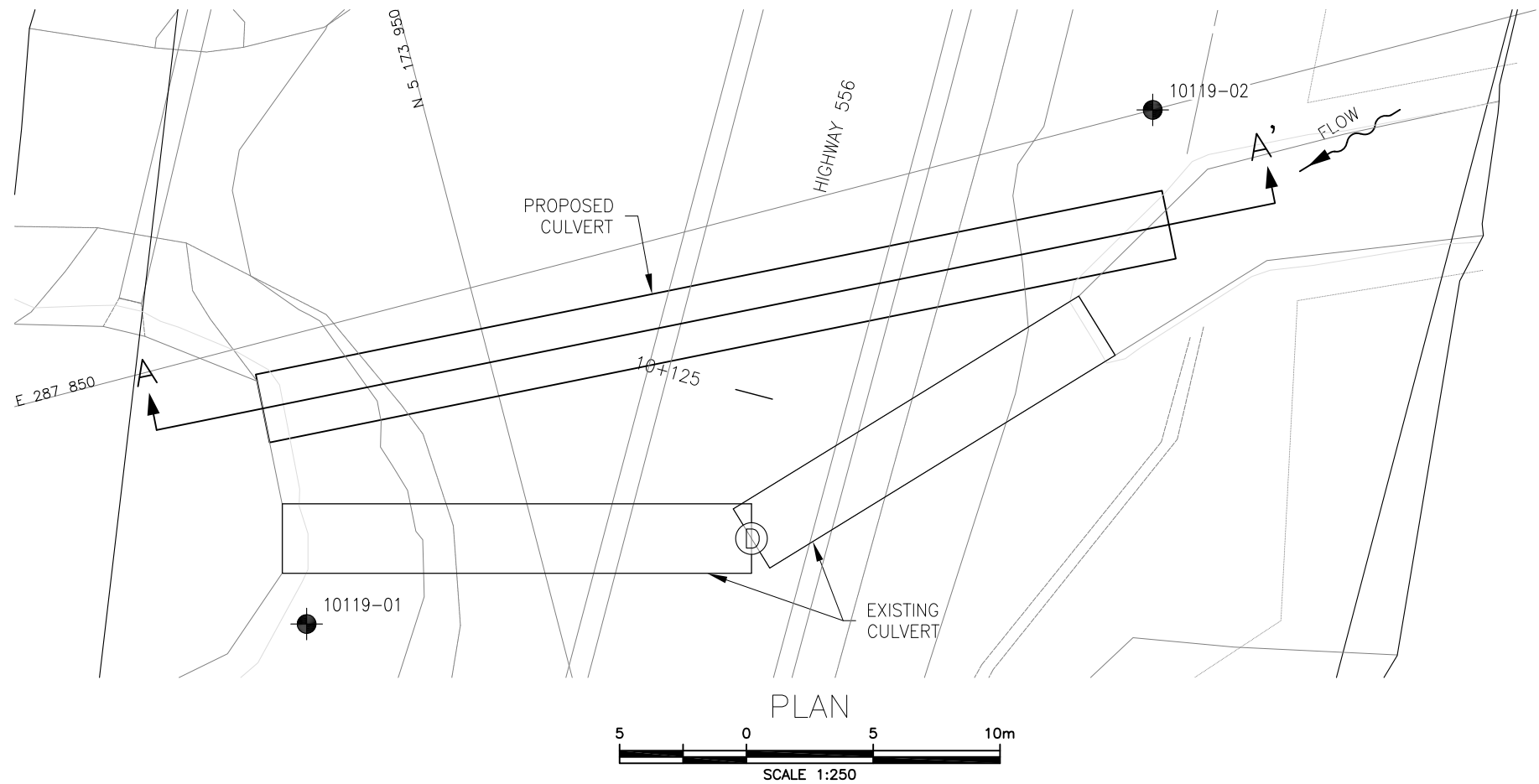
10119-02

6.2×10^{-7}



Appendix D

Borehole Locations and Soil Strata Drawing



METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 5221-18-00

HIGHWAY 556
STATION 10+119
CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
10119-01	320.9	5 173 959.6	287 838.8
10119-02	320.1	5 173 922.2	287 850.0

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 13.

GEOCRES No. 41K-127



REVISIONS	DATE	BY	DESCRIPTION

DESIGN	AK	CHK	PKC	CODE	LOAD	DATE	APR 2023
DRAWN	AN	CHK	AK	SITE	STRUCT	DWG	1



Appendix E

List of OPSDs, OPSSs, and Special Provisions



1. List of OPSDs, OPSSs, and Special Provisions referenced in this report

- OPSD 208.010 (Benching of Earth Slopes)
- OPSD 219.110 (Light-Duty, Silt Fence Barrier)
- OPSD 810.010 (General Rip-Rap Layout for Sewer and Culvert Outlets)
- OPSS.PROV 206 (Construction Specification for Grading)
- OPSS.PROV 401 (Construction Specification for Trenching, Backfilling, and Compacting)
- OPSS.PROV 421 (Construction Specification for Pipe Culvert Installation in Open Cut)
- OPSS.PROV 422 (Construction Specification for Installation of Precast Reinforced Concrete Box Culverts with Span 3 m or Less in Open Cut)
- OPSS.PROV 501 (Construction Specification for Compacting)
- OPSS.PROV 510 (Construction Specification for Removal)
- OPSS.PROV 511 (Construction Specification for Rip-Rap, Rock Protection, and Granular Sheeting)
- OPSS.PROV 517 (Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation)
- OPSS.PROV 539 (Construction Specification for Temporary Protection Systems)
- OPSS.PROV 803 (Construction Specification for Vegetative Cover)
- OPSS.PROV 804 (Construction Specification for Temporary Erosion Control)
- OPSS.PROV 805 (Construction Specification for Temporary Sediment Control)
- OPSS.PROV 1004 (Material Specification for Aggregates – Miscellaneous)
- OPSS.PROV 1010 (Material Specification for Aggregates, Base, Subbase, Select Subgrade, and Backfill Material)
- OPSS.PROV 1205 (Material Specification for Clay Seal)
- OPSS.PROV 1860 (Material Specification for Geotextiles)
- Special Provision 105S09 (Amendment to OPSS 539)
- Special Provision 105S22 (Amendment to OPSS 501)
- Special Provision 517F01 (Amendment to OPSS 517)