Appendix B

Geotechnical Data Report

GEOTECHNICAL ENGINEERS

CITY OF WINNIPEG, WATER AND WASTE DEPARTMENT

FERRY ROAD AND RIVERBEND CSR PROJECT

CONTRACT 6 – RUTLAND TRUNK SEWER

GEOTECHNICAL DATA REPORT

WINNIPEG, MANITOBA

Prepared for:

Tetra Tech Canada Inc.
Winnipeg, Manitoba

May 2022

File #143691.7

GEOTECHNICAL
ENGINEERS

May 4, 2022

File No. 143691.7

Tetra Tech Canada Inc.
161 Portage Avenue East, Suite 400
Winnipeg, MB R3B 0Y4

Attn: Kirby McRae, P.Eng.

RE: City of Winnipeg Ferry Road and Riverbend CSR Project – Contract 6 Rutland Trunk Sewer Geotechnical Investigation

Dyregrov Robinson Inc. is pleased to submit our final geotechnical data report from the geotechnical investigation that has been completed for the proposed Rutland Trunk Sewer in Winnipeg, Manitoba.

If we can be of further assistance, please contact the undersigned directly.

Sincerely,

DYREGROV ROBINSON INC.

per

Gil Robinson, M.Sc., P.Eng
President

Distribution List

# of Hard Copies	PDF Required	Association / Company Name
0	Yes	Tetra Tech Canada Inc.

DYREGROV ROBINSON INC.

Report Prepared By:

per

Gil Robinson, M.Sc., P.Eng.
Senior Geotechnical Engineer

PROVINCE OF MANITOBA
G.G.B.
ROBINSON
4 May 2022
REGISTERED PROFESSIONAL ENGINEER

APEGM
Certificate of Authorization
Dyregrov Robinson Inc.
No. 86 Date: 4 May 2022

Table of Contents

1.0 INTRODUCTION

Dyregrov Robinson Inc. (DRI) was retained by Tetra Tech Inc. to perform a geotechnical investigation for the proposed Rutland Trunk Sewer which will be installed as part of the Ferry Road and Riverbend Combined Sewer Relief (CSR) Project in Winnipeg, Manitoba.

The purpose of the geotechnical investigation was to explore the subsurface conditions (i.e. soil and groundwater) along the general route of the proposed trunk sewer. This geotechnical data report describes the geotechnical investigation program and presents the field and laboratory testing results from the investigation.

2.0 PROJECT UNDERSTANDING

It is our understanding the trunk sewer pipe will be approximately 2400 mm in diameter and will be about 1600 m long with preliminary (estimated) pipe invert depths that are about 8 to 9 m below ground surface. Much of the pipe alignment will be located in the right-of-way along Rutland Street from Silver Avenue to Portage Avenue. The pipe will extend approximately 345 m north of Silver Avenue across the grounds of the Rods Football Club. South of Portage Avenue the pipe alignment will run through the St. James Collegiate property and the Bourkevale Community Centre site down to the Assiniboine River where an outfall structure will be constructed.

3.0 BACKGROUND INFORMATION

3.1 Regional Geology

Winnipeg is centered around the confluence of the Red and Assiniboine Rivers in the Red River Valley.

3.1.1 Bedrock Geology

The overburden stratigraphy is underlain by an extensive regional fractured bedrock aquifer consisting of limestones and dolomites of the Stony Mountain and Red River Formations. Due to pre-glacial erosion and subsequent deposition, the bedrock surface may include features such as infilled caverns, sinkholes and crevasses. These features may be infilled with clays, sands and glacial till materials.

3.1.2 Surficial Geology

The general soil stratigraphy in Winnipeg includes an upper complex zone overlying a thick deposit of glaciolacustrine clay. Glacial till is typically present beneath the clay deposit. In some locations, alluvial deposits are also present along the riverbanks and can overlay the clay and/or glacial till deposits.

The upper complex zone is generally about 1.5 to 3 m thick and can extend to depths of 4.5 m. The soils often encountered in the complex zone include black clays with trace organics, silt and silty clays. The silt and silty clays may have a laminated structure. The silt layers vary significantly in thickness (a few mm to 3 m) and lateral extent and may be water bearing (i.e. perched water table).

Glaciolacustrine silty clays are present beneath the upper complex zone and can vary in thickness from a few metres to 15 m (approx.). The clay is generally found to be brown and/or mottled brown / grey to depths of 5 to 7 m below grade and is grey below. The brown and mottled brown / grey clays usually have a stiff consistency, and the grey clays are usually firm to stiff. In some areas of Winnipeg, the consistency of the clay can be relatively soft. The clay is known to have high plasticity and is expansive. Although infrequent, boulders have been encountered within the clay layer. Towards the bottom of the clay deposit, the composition may change including higher silt content and an increasing number of glacial till inclusions; this is sometimes referred to as a clay – till transition zone. (Teller, 1976 and Department of Geologic Engineering, 1983)

Glacial till is typically present beneath the silty clay deposit. The thickness of the till deposit is variable ranging from nothing to more than 9 m; it is often found to be 3 to 6 m thick. The glacial till deposit in the Winnipeg area is typically a heterogeneous mixture of sand, gravel, cobble and boulder size materials within a predominantly silt matrix that has a low but variable clay content. The boulders can range in size from 300 mm to 1500 mm, or more. Pockets of non-combustible gas are sometimes encountered and may be under pressure. The nature of the gas does not appear to be well documented, but the author is aware that at least one person died in the 1960's while working in a caisson shaft in downtown Winnipeg.

Alluvial soil deposits occur along various stretches of the banks of the Red and Assiniboine Rivers. The alluvium is a non-homogeneous combination fine grained soils including clay, silt and sand. The gradation of the soil can vary significantly over short distances (horizontally and vertically). Deposits with lower clay content are often saturated with a loose compactness condition. Deposits with higher clay contents are known to have water bearing layers of sand within the clay.

3.1.3 Hydrogeology

The overburden stratigraphy is underlain by an extensive regional fractured bedrock aquifer consisting of limestones and dolomites of the Stony Mountain and Red River Formations. The upper portion of the bedrock is highly fractured and forms an extensive aquifer referred to as the Carbonate Aquifer which underlies the City of Winnipeg. Published information (Render, 1970 and Department of Geologic Engineering, 1983) indicate that the regional transmissivity of this aquifer typically ranges from 1.4×10^{-3} to 7.1×10^{-3} m^2/s (8,100 to 41,000 Igpd/ft). However, it is known that transmissivities can vary substantially over very short distances depending on the degree and interconnectivity of the fracturing.

3.2 Previous Geotechnical Investigations

In 2011 / 2012, a Phase 1 geotechnical investigation was undertaken by Dyregrov Robinson Inc. for the Ferry Road and Riverbend Combined Sewer Relief Works project in the City of Winnipeg. The purpose of the 2011/2012 geotechnical investigation was to provide preliminary geotechnical data relative to the design and installation of storm relief sewers within the Ferry Road and Riverbend areas. The area extends west from St. James Street to the Winnipeg James Armstrong Richardson International Airport and Winchester Street and from the Assiniboine River north to approximately Saskatchewan Avenue. Test holes were drilled to provide subsurface stratigraphy and groundwater conditions at representative locations within the general study area and to obtain soil samples for laboratory testing. Three test holes were drilled along Rutland Street (Test Holes 12-11, 12-12 and 12-13, see Appendix B).

3.3 Site Conditions

The route of the Rutland Trunk Sewer follows Rutland Street from a point about 345 m North of Silver Avenue to the Assiniboine River south of Portage Avenue.

North of Silver Avenue, the proposed route of the trunk sewer crosses an undeveloped area that includes the St. James Rods Football Club property. The property is relatively flat lying, vegetated with grass and has some playing fields, paved parking and a clubhouse structure.

The stretch between Silver Avenue and Portage Avenue is an older residential area that is relatively flat lying and has several existing underground utility lines in the right-of-way along Rutland Street and across Portage Avenue. There are a number of mature trees along the boulevards.

South of Portage Avenue, the proposed route of the trunk sewer crosses the St. James Collegiate property, which owned by the St. James Assiniboia School Division. The school property is relatively flat lying and contains some paved areas and outdoor facilities (e.g. paved running track).

South of the school property is the Bourkevale Community Centre (BCC) property where there is a sharp change in site grade (+/- 1.5 m) from the school's running track down to the BCC outdoor soccer fields. From the soccer fields to the riverbank there is a gradual grade down to the river.

The total height of the riverbank about 6.5 m and the average slope angle is about 5H:1V. The riverbank has three general areas, the lower bank area along the river, a relatively flat mid-bank area and the upper bank area that blends into prairie level behind the riverbank. The lower bank area is about 2.5 m tall and has a slope that is about 3.5H:1V. The flatter mid-bank area is about 1.2 m tall and 11 m long yielding a slope angle of about 9H:1V. The upper bank is about 3 m tall with a slope angle around 4.75H:1V. The bank is well vegetated with grass and there are no obvious signs of deep-seated movements of the riverbank. The lower bank area along the river may have some shallow localized slip surfaces which are likely affected by erosion along the river's edge. There is an existing outfall located about 150 m downstream of the proposed trunk sewer outfall location.

It is not known if any areas along the route of the proposed trunk sewer were previously developed. If some areas were previously developed it is possible that some features of the former buildings, for example, were not removed (e.g. footings, piles, basement walls and floor slabs etc.) and the backfill used may not have been well compacted and may contain some demolition debris (e.g. bricks, wood).

4.0 FIELD INVESTIGATION

Twenty-nine test holes (Test Holes 19-147 to 19-173 and 19-239 and 19-240) were drilled along the trunk sewer route (from the Assiniboine River to Silver Avenue) between July 26th and August 21st, 2019. In December 2020, five additional test holes (Test Holes 20-244 to 20-248) were drilled north of Silver Avenue. The test hole depths were targeted to be about 3 m below the expected invert of the proposed trunk sewer pipe. The test hole locations and pipe invert depths were provided by Tetra Tech. The final test hole locations were adjusted to avoid buried utilities amongst other considerations (e.g. drill rig access). The test holes were not drilled directly on the proposed tunnel alignment to avoid potential construction issues that can arise when tunnel boring machines pass through test holes backfilled with auger cuttings and bentonite. A summary of the test hole locations and survey information is provided on Table A1 (Appendix A) and illustrated on the Test Hole Location drawing in Appendix A.

The test holes were drilled by Paddock Drilling Ltd. using a track mounted Acker SS drill rig or a truck mounted Acker MP8 drill rig equipped with 125 mm solid stem augers, 200 mm hollow stem augers and an HQ coring system with casing advancer tools.

General site supervision and logging of the test holes was performed by DRI. Representative disturbed (auger cuttings, split barrel sampler) and undisturbed (Shelby tube) soil samples were collected. In Test Holes 19-166 to 19-173, auger refusal occurred before the target test hole depth was achieved. These eight test holes, and Test Holes 20-244 to 20-248, were finished by coring below the depth of auger refusal. Test Holes 19-173 and 20-248 were cored into bedrock to determine the depth to bedrock. The HQ core samples (65 mm diameter) of the glacial till and bedrock were recovered and placed in core boxes. Standard Penetration Tests (SPT's) were performed in the glacial till by driving a split barrel sampler 450 mm into the base of the test hole using an automatic slide hammer weighing 63.5 kg and dropped from a height of 760 mm. The number of blows for every 150 mm of penetration was recorded. The SPT N values are the number of hammer blows required to drive the split barrel sampler 300 mm deep after the initial 150 mm of penetration. The test holes were backfilled to grade with auger cuttings and bentonite chips. Excess auger cuttings were bagged and removed from site. Twelve holes were drilled through a core hole in the sidewalk, these core holes were repaired with concrete.

The soil samples and coring samples (glacial till and bedrock) were returned to our Soils Testing Laboratory for testing including additional visual classification and determination of moisture contents on all soil samples. Representative samples of the soils encountered along the route of the trunk sewer were tested to determine the plasticity characteristics (Atterberg Limits), gradation (hydrometer analysis), soil chemistry and swelling characteristics. Bulk densities and undrained shear strengths of the clay soil were measured from the Shelby tube samples. Fourteen samples from the Shelby tubes were preserved with wax and can be used for additional testing, if required. Three of the waxed samples from the Shelby tubes were submitted for swell testing. The glacial till and bedrock core samples were photographed and the bedrock core samples were logged.

In addition to the above testing, some soil and rock samples were submitted to the Colorado School of Mines in Denver, Colorado, USA for specialized testing relating to abrasion characteristics of the soil that the tunnelling equipment will have to work through. Two composite samples of the clay soil and two composite samples of the glacial till (one of each soil type from test holes south of Silver Avenue and one of each soil type from the test holes north of Silver Avenue) and one sample of alluvial sand were submitted for SINTEF Soil Abrasion Testing (SAT). The alluvial sand was collected from a tunnel shaft that was drilled on Ferry Road in early 2021 and was also tested for petrographic analysis. Three samples of the cobbles and boulders recovered during coring in the glacial till were submitted for Cerchar Abrasivity Index (CAI) testing, thin section petrographic analysis and uniaxial compressive strength (UCS) testing.

The test hole logs are provided in Appendix B and include a description of the soil and bedrock conditions encountered, laboratory testing results and comments on the subsurface conditions observed at the time of drilling. Appendix C includes photographs of the glacial till and bedrock core samples (Figures C1 to C13) and a summary of the bedrock core samples (Table C1). The laboratory testing results are provided in Appendix D and charts of the test results are provided on Figures E1 to E18 in Appendix E. The standard penetration testing results are provided on Table F1 and Figures F1 to F3 in Appendix F. The test results for the soil and rock samples tested for abrasion characteristics, unconfined compressive strength and petrographic analysis are provided in Appendix G.

A geophysical survey was conducted by Tetra Tech Canada Inc. along the trunk alignment in the summer of 2020. The final report prepared by Tetra Tech Canada Inc. is attached in Appendix H and includes seismic profiles that illustrate the interpreted / inferred glacial till interface.

5.0 SUBSURFACE CONDITIONS

The general stratigraphy encountered in the test holes from grade includes topsoil, fill and pavement materials, alluvial soils, silt, silty clay, glacial silt till and bedrock. A general description of the stratigraphic units is provided below and is based on the test hole logs (Test Holes 19-147 to 19-173, 19-239, 19-240 and Test Holes 20-244 to 20-248) in Appendix B. Refer to the test hole logs and laboratory testing results for additional information.

5.1 Pavement, Topsoil and Fill Materials

Topsoil was encountered in several test holes and is about 50 to 100 mm thick.

Test Holes 19-155 to 19-162 and Test Hole 19-239 were drilled through the sidewalk on the west side of Rutland Street. The sidewalk concrete ranged in thickness from 100 to 125 mm and was supported on clay soil or sand and gravel.

No significant fill layers were encountered in the test holes. The fill materials were typically encountered directly below the concrete sidewalk and were less than 300 mm thick.

5.2 Alluvium

Alluvial soil deposits were encountered in Test Holes 19-147 to 19-151, which are closest to the Assiniboine River. No alluvial deposits were encountered in the other test holes. The alluvium is a non-homogeneous combination fine grained soils including clay, silt and sand. The composition of the soils changed with depth in the test holes and between the test holes. The alluvial soil encountered in the test holes was mainly clay with intermittent layers of silt and a few layers of sand.

The clay contains variable amounts of silt (some silt to silty) and is brown in color, dry to moist with a firm to stiff consistency in the upper portion of the test holes. With depth, the clay trended towards being moist to wet and soft to firm. A few thin layers of sand were observed within the clay zones and the sand was saturated. The various clay layers encountered in the test holes range in thickness from 0.6 m to 6.5 m and the moisture contents ranged from about 15 to 41 percent with an average of 29 percent. The moisture content profiles with depth and elevation are provided on Figures E1 and E2 (Appendix E). Undrained shear strengths of the clay from the Shelby tube samples were measured using Torvane, penetrometer, and unconfined compressive strength methods. The strengths ranged from about 20 to 50 kPa with an average value around 30 kPa. The bulk unit weight of the clay is about 17.5 kN/m^3. The undrained shear strength profile with depth and elevation are provided on Figures E3 and E4 (Appendix E).

The silt layers contain variable amounts of clay (trace to some) and traces of sand. It is brown to grey in color and moist becoming wet with depth. The silt has low to medium plasticity, depending on the clay content, and it has a loose (soft) condition. The moisture contents ranged from about 12 to 33 percent with an average of 26 percent. The moisture content profiles with depth and elevation are provided on Figures E5 and E6 (Appendix E).

Five samples of the clay alluvium (TH 19-148 - sample T296, TH 19-149 – sample G289, TH 19-150 – sample G277, TH 19-151 samples T269 and G272) were tested to evaluate the plasticity characteristics of the soil. The clay has intermediate plasticity with plastic limits ranging from 15 to 23, liquid limits ranging from 33 to 46 percent and plasticity indices of 13 to 26. The liquidity indices range from 0.3 to 1.1. The results are summarized in Table D1 along with the laboratory test reports (Appendix D).

Five samples of the clay alluvium (TH 19-148 - sample T296, TH 19-149 – sample G289, TH 19-150 – sample G277, TH 19-151 samples T269 and G272) were tested to evaluate the particle size distribution of the soil. The samples contained 46 to 53 percent clay sized particles, 40 to 53 percent silt sized particles and 0.7 to 6.4 percent sand sized particles. The results are summarized in Table D2 along with the laboratory test reports (Appendix D).

Two samples of the alluvium soil (TH 19-149 - sample G286 and TH 19-151 – sample G267) were submitted for testing to determine soil chemistry properties including; sulphate (SO4), chloride, conductivity / resistivity and pH. The results are summarized in Table D3 along with the laboratory test report from Bureau Veritas Laboratories (see Appendix D).

Sand layers were encountered in Test Holes 19-148 and 19-150 at depths of 6.4 m and 8.2 m, respectively. The sand was 300 to 600 mm thick and is brown, wet (saturated), coarse grained and has a loose compactness condition. The moisture contents from two samples were 12.1 percent and 14.6 percent. The moisture contents with depth and elevation are provided on Figures E7 and E8 (Appendix E).

A composite sample of sand alluvium, collected from a tunnel shaft that was drilled south of Portage Avenue on Ferry Road, in early 2021, was submitted for SINTEF-SAT testing and petrographic analysis at the Colorado School of Mines in the USA. The SAT test resulted in an SAT value of 11.1. The Abrasivity Classification in the testing report is noted as being medium for SAT values between 7 and 22. The laboratory test report is provided in Appendix G. The petrographic analysis report indicates the sand grains were fine in size and comprised of quartz, feldspar and rock fragments with a coating of clay minerals. Refer to the petrographic analysis report in Appendix G for detailed information.

5.3 Silt

Silt was encountered in 13 test holes (in the area from Test Holes 19-152 to 19-168). It was typically encountered within 1 m of ground level and was generally around 600 mm thick but ranges in thickness from 600 mm to 2100 mm. It is light brown in color and dry to moist with a loose compactness condition. The moisture contents of the silt ranged from about 11 to 26 percent with an average of 18 percent. The moisture content profiles with depth and elevation are provided on Figures E9 and E10 (Appendix E).

One sample of the silt (TH 19-240 - sample G427) was tested to evaluate the plasticity characteristics of the soil. The silt has low plasticity with a plastic limit of 17 percent, a liquid limit of 22 percent and a plasticity index 5. The liquidity index is 1. The results are summarized in Table D1 along with the laboratory test report (see Appendix D).

5.4 Silty Clay (Glaciolacustrine)

Lake Agassiz glaciolacustrine silty clay was encountered in all test holes north of Test Hole 19-151 (i.e. Test Holes 19-152 to 19-168, 19-239 and 19-240 and 20-244 to 20-248)). In Test Hole 19-148, a 900 mm thick layer of glaciolacustrine clay was encountered beneath the alluvium at a depth of 7 m, glacial till was present below the clay layer.

An upper layer of clay was encountered in the test holes having a shallow silt layer. The thickness of the upper clay layer is about 1 m thick but ranges from 0.3 m to 1.8 m. The main clay deposit, below the silt layer, typically begins at depths of 1.2 to 1.5 m below grade.

The main clay deposit (i.e. excluding the upper clay layer) ranges in thickness from 4 to 12 m thick. The clay is on the order of 10 to 12 m thick in Test Holes 19-152 to 19-159 (i.e. south of Bruce Avenue). The clay is on the order of 7 to 9 m thick in Test Holes 19-160 to 19-165, including Test Hole 19-239 (i.e. north of Bruce Avenue to Ness Avenue). North of Ness Avenue (i.e. Test Holes 19-166 to 19-173 and including TH19-240) the clay is about 6.5 m thick and is 5 m thick at Test Hole 19-173. North of Silver Avenue (i.e. Test Holes 20-244 to 20-248) the clay is about 5.5 m thick and is 4 m thick at Test Hole 20-248.

The upper clay layer, and the upper 1.5 m of the main clay deposit where no silt layer is present, is black in color and contains traces of organics. Below the black clay, it is mottled brown and grey to a depth of about 6 to 7 m below which it is grey. It is moist with a stiff consistency to a depth of about 6 m and below it has a firm consistency. The clay typically has high plasticity, contains trace silt inclusions, traces of sand and gravel and trace till inclusions. The till inclusions occur towards the bottom of the clay deposit. Of interest is Test Hole 19-157, where a 1.7 m thick layer of glacial till was encountered in the clay at a depth of 9.9 m and clay was present below the till down to 12.2 m. The first test holes south (Test Hole 19-156) and north (Test Hole 19-158) of Test Hole 19-157 both had clay down to 12.2 m and no till was encountered when the target test hole depth was achieved. Till layers within the clay are not common but may be a result of a large pocket of glacial till falling off the glacial ice sheet after glacial Lake Agassiz formed. Boulders are also occasionally encountered in the clay layer and are likely deposited in a similar manner as this till layer found within the clay. The moisture contents of the clay are in the range of 20 to 40 percent in the upper 2 m of the test holes. Below 2 m, the moisture contents range from 40 to 60 percent with an average 48 percent. Some of the clay samples at depth in the test holes have moisture contents in the range of 20 to 40 percent, which is attributed to the till inclusions observed in the clay at depth. The moisture content profiles with depth and elevation are provided on Figures E11 and E12 (Appendix E).

Undrained shear strengths of the clay from the Shelby tube samples were measured using Torvane, penetrometer, and unconfined compressive strength methods. The strengths range from about 25 to 75 kPa with an average value around 50 kPa to a depth of 6 m. Below this depth the strengths range from about 25 to 50 kPa with an average value around 35 to 40 kPa. The undrained shear strength profile with depth and elevation are provided on Figures E13 and E14 (Appendix E). The bulk unit weight of the clay ranges from 16 to 19 kN/m^3 with an average of 17 kN/m^3. The bulk unit weight profile with depth and elevation are provided on Figures E15 and E16 (Appendix E).

Eight samples of the glaciolacustrine clay (TH19-152 sample G240, TH19-156 sample T326, TH19-157 sample T377, TH19-162 sample T394, TH19-166 sample G439, TH19-173 sample G492, TH20-245 sample G18 and TH20-248 sample T55) were tested to evaluate the plasticity characteristics of the soil. The clay typically has high plasticity with plastic limits ranging from 13 to 32, liquid limits ranging from 43 to 91 percent and plasticity indices of 30 to 59. The liquidity indices range from 0.3 to 0.9. The two samples north of Silver Avenue (i.e. TH's 20-245 and 20-248) have intermediate plasticity. The results are summarized in Table D1 along with the laboratory test reports (Appendix D).

Six samples of the glaciolacustrine clay (TH19-152 sample G240, TH19-156 sample T326, TH19-157 sample T377, TH 19-162 sample T394, TH 19-166 sample G439 and TH 19-173 sample G492) were tested to evaluate the particle size distribution of the soil. The samples contained 52 to 100 percent clay sized particles, 0 to 37 percent silt sized particles and up to 11 percent sand sized particles. The results are summarized in Table D2 along with the laboratory test reports (Appendix D).

Four samples of the clay soil (TH 19-153 sample G248, TH 19-161 sample G383, TH 19-167 sample G456 and TH20-244 sample T5) were submitted for testing to determine soil chemistry properties including; sulphate (SO4), chloride, conductivity / resistivity and pH. The results are summarized in Table D3 and the laboratory test reports from Bureau Veritas Laboratories is provided in Appendix D.

Three samples of the clay soil (TH 19-156 - sample T326, TH 19-162 – sample T394 and TH 19-173 – sample T493) were submitted for testing to evaluate the potential for swelling and the swell pressure. The swell percentages were 1.3, 1.6 and 2.2 percent and the estimated swell pressures were 40, 41 and 68 kPa. The results are summarized in Table D4 and the laboratory test reports from WOOD PLC are provided in Appendix D.

Two composite samples of the clay soil were submitted for SINTEF-SAT testing at the Colorado School of Mines in the USA. One sample was made up of clay samples from the test holes south of Silver Avenue (sample ID ‘Clay-1’) and the other sample (sample ID ‘Clay-2’) was made up from bulk samples of the auger cuttings collected during drilling of the test holes north of Silver Avenue (i.e. TH’s 20-244 to 20-248). The SAT tests resulted in SAT values of 3.45 and 1.4 for samples Clay-1 and Clay-2, respectively. The Abrasivity Classification in the testing report is noted as being low for SAT values less than 7. The laboratory test reports are provided in Appendix G.

5.5 Glacial Silt Till

Glacial till was not encountered in Test Holes 19-151, 19-152, 19-156, 19-158 and 19-159. In the other test holes, glacial silt till was encountered below the alluvial soils or the silty clay deposit. In Test Holes 19-173 and 20-248, which were drilled into bedrock the glacial till is 8 m and 11.3 m thick, respectively. The till contact depth in the four test holes located closest to the Assiniboine River (Test Holes 19-147 to 19-150) ranged from 5 to 10 m. South of Ness Avenue (Test Holes 19-153 to 19-165, including 19-239) the depth to glacial till is about 9 to 12 m. North of Ness Avenue (Test Holes 19-166 to 19-173, including 19-240) the depth to glacial till decreases in a northerly direction from 9 to 5 m. North of Silver Avenue (Test Holes 20-244 to 20-248), the depth to glacial till was about 5.5 m decreasing to 4 m at Test Hole 20-248. The geophysical survey conducted by Tetra Tech Canada Inc. (see report in Appendix H) was used to interpret / infer the interface between the silty clay and glacial till along the route of the trunk sewer. The results are provided on Figures 2 and 3 of the attached geophysical survey report and show that the interface between the silty clay and the glacial till is not flat and generally rises in a northward direction.

The glacial till deposit in the Winnipeg area is typically a heterogeneous mixture of sand, gravel, cobble and boulder size materials within a predominantly silt matrix that has a low but variable clay content. The silt till encountered in the test holes typically contains traces of sand and gravel. No cobbles and boulders were confirmed in the test holes during augering due to the small diameter of augers used for drilling. During coring at Test Holes 19-166 to 19-173 and 20-244 to 20-248, a few cobbles and boulders were recovered from the core barrel (see Figures C1 to C13 in Appendix C). The till is grey or brown in color, moist to wet and loose to compact in the upper 1 to 2 m (variable) and becomes dry to moist and dense to very dense with depth. The moisture content of the till ranges from 3 to 29 percent with an average of 11 percent. The moisture content profiles with depth and elevation are provided on Figures E17 and E18 (Appendix E).

In Test Holes 19-161 and 19-162, a gas pocket was encountered near the bottom of the test holes. There was no odour, the ‘gas’ flowed out of the test holes under pressure for at least 10 to 15 minutes.

Sixty-five standard penetration tests (SPT) were attempted and fifty-eight were successfully completed. The SPT’s ranged from 2 to 154 with an average of 57. The test results are summarized on Table F1 in Appendix F. The SPT profiles with depth and elevation are provided on Figures F1 and F2 (Appendix F). Figure F3 shows the SPT-N values versus moisture content.

Auger refusal was encountered in 19 test holes. In Test Holes 19-147 to 19-149, which are located at the south end of the trunk sewer near the Assiniboine River, auger refusal was encountered in the glacial till at depths of 6.7 m, 9.6 m and 10 m, respectively. These depths correspond to an elevation of 221.5 m (+/- 0.5). In Test Holes 19-160 to 19-165 and 19-239 (approx. from Bruce Avenue to Ness Avenue), the auger refusal depths ranged from 10 to 12.3 m which correspond to elevations of 222.3 m to 224.1 m. The typical elevation at auger refusal was around 223 m. In Test Holes 19-166 to 19-173 and 19-240 (approx. from Ness Avenue to Silver Avenue), the auger refusal depths ranged from 7.5 to 9 m with a trend of shallower refusal occurring from south to north. These refusal depths correspond to elevations of 226 m to 228.5 m with a typical elevation around 227 m. Test Holes 20-244 to 20-248 were not drilled to auger refusal before the drilling method was switched over to the casing advancer and HQ coring.

Nine samples of the glacial till (TH19-148 sample G302, TH19-161 sample G386, TH19-166 sample S443, TH19-173 sample S496, TH20-244 sample G7, TH20-245 sample G20, TH20-246 sample S36, TH20-247 sample S46 and TH20-248 sample S56) were tested to evaluate the particle size distribution of the soil. The samples contained 32 to 49 percent clay sized particles, 47 to 60 percent silt sized particles and 4 to 8 percent sand sized particles. The results are summarized in Table D2 along with the laboratory test report (Appendix D).

Two samples of the glacial till (TH19-172 sample G486 and TH20-248 sample S57) were submitted for testing to determine soil chemistry properties including; sulphate (SO_4), chloride, conductivity / resistivity and pH. The results are summarized in Table D3 and the laboratory test report from Bureau Veritas Laboratories is provided in Appendix D.

Two composite samples of the glacial till soil were submitted for SINTEF-SAT testing at the Colorado School of Mines in the USA. One sample was made up of till samples from the test holes south of Silver Avenue (sample ID ‘Till-1’) and the other sample (sample ID ‘Till-2’) was a bulk sample made from the auger cuttings collected during drilling of the test holes (i.e. TH’s 20-244 to 20-248) north of Silver Avenue. The SAT tests resulted in SAT values of 6.25 and 8.2 for samples Till-1 and Till-2, respectively. The Abrasivity Classification in the testing report is noted as being low for SAT values less than 7 and medium for SAT values of 7 to 22. The laboratory test reports are provided in Appendix G.

Three samples of the cobbles and boulders recovered during coring in the glacial till were submitted for Cerchar Abrasivity Index (CAI) testing, thin section petrographic analysis and uniaxial compressive strength (UCS) testing. The samples were taken from Test Hole 19-168 (core sample C550), Test Hole 19-173 (Core sample C518) and Test Hole 20-244 (core sample C8). The samples submitted for testing are identified on Figures C3, C8 and C9 in Appendix C. The Cerchar CAI, petrographic and UCS results are summarized in Table 5.1:

Table 5.1 – Rock Type, CAI and UCS Results

Test Hole	Sample ID	Depth (m / ft)	Rock Type	Cerchar Abrasivity Index (CAI)	Uniaxial Compressive Strength (UCS) (MPa)
TH 19-168	C550	8.2 / 27	Alkali-Feldspar Granite	3.24	n/a sample too short
TH 19-173	C518	7.9 / 26	Limestone (Crystalline Carbonate/Sparstone)	3.29	99.5
TH 20-244	C8	7.3 / 24	Tonalite	3.36	205.7

5.6 Bedrock

Test Holes 19-173 and 20-248 were drilled into bedrock using HQ size coring tools. Bedrock was encountered beneath the glacial silt till at a depths of 13.2 m (elevation 221.9 m) and 15.3 m (elevation 220.8 m) in Test Holes 19-173 and 20-248, respectively. The bedrock geology maps in this area of Winnipeg (Manitoba Geological Survey's Geologic Scientific Report GR2002-1) classify the bedrock as a dolomite mudstone belonging to the Upper Fort Garry Member of the Red River Formation. The geology map suggests that Test Hole 19-173 is on the boundary between the Upper Fort Garry Member of the Red River Formation to the east and Gunn Member of the Stony Mountain Formation to the west and south.

The colour of the bedrock is generally whitish grey color and has horizontal and vertical joints with some evidence of water flow. The length of bedrock core recovered from each core run was typically greater than about 90 percent of the cored length and the Rock Quality Designation (RQD) for the bedrock ranged from about 30 to 90 percent, indicating poor to good quality. The bedrock recovered from the test holes is strong and has close to moderately close discontinuity spacing and gapped to open joint apertures. Appendix C includes photographs of the bedrock core samples recovered (see Figure C8 and C13) and a tabular summary (Table C1) of the core samples.

5.7 Test Hole Stability and Groundwater Conditions

In Winnipeg, groundwater usually occurs in shallow perched water tables within fill layers and silt deposits that are quite permeable and underlain by the relatively impermeable Lake Agassiz clays. A groundwater table is not apparent during drilling within the clay soil due to its low permeability.

Sloughing and seepage conditions were observed in Test Holes 19-147 to 19-151 which were drilled into the alluvial soils. No significant seepage and sloughing were observed from the remaining test holes, which were not drilled into alluvial soils. Some minor seepage and sloughing were encountered from the shallow silt layer in Test Hole 19-239 and from the glacial till in Test Holes 19-160, 19-161, 19-164, 19-168 and 19-240. Refer to the notes on each test hole log for additional information.

Standpipe piezometers were installed in Test Holes 19-147, 19-148, 19-155, 19-173, 19-239, 19-240 and 20-248. The piezometer installation details and measured ground water levels are provided on the test hole logs and summarized in Table 5.2 below. The initial water levels were taken on September 23, 2019 (January 7, 2021 for TH20-248) and the second set of water levels were taken on November 13, 2019. After a dry summer, the months of September and October 2019 had a lot of precipitation, and the river levels were high. The water levels from November 13, 2019 are relatively high compared to September 23, 2019 and are attributed to the wet weather in the fall of 2019. The water levels on June 11, 2021 were taken following a dry fall (2020) and winter (2020/2021) but also after some recent rain events.

In May 2020, hydraulic conductivity testing was performed by Tetra Tech Canada Inc. using the standpipe piezometers installed in Test Holes 19-147, 19-148, 19-155, 19-173, 19-239 and 19-240. The testing procedures and results are presented in Tetra Tech's final report (Appendix H). The results indicate that the hydraulic conductivities are consistent with the soil types (alluvial clay, silt till) and the dolomite bedrock encountered in the test holes (refer to Table 1 of the report in Appendix H).

In general, the water level in the limestone bedrock aquifer below the glacial till has been rising since the early 1970's. In some areas of the City of Winnipeg (e.g. downtown area) the bedrock water levels have risen by about 3 m since that time to around elevation 225 to 226 m with local spikes approaching 227 m. The local spikes are assumed to be associated with spring freshet and flooding events. The rise in the bedrock aquifer levels has been attributed, by others, to the reduced demand for groundwater by industrial users in the greater Winnipeg area.

Groundwater conditions should be expected to vary seasonally, from year to year and possibly as a result of construction activities.

Table 5.2 – Standpipe Piezometer Monitoring Results

Test Hole	19-147	19-148	19-155	19-173	19-239	19-240	19-248
Ground Elev. (m)	228.62	230.57	233.63	235.16	234.08	235.11	236.03
Tip Elevation (m)	221.90	221.00	221.30	219.60	223.00	225.70	225.3
Monitoring Zone	Alluvium / Till	Alluvium / Till	Till	Bedrock	Till	Till	Till
Date	**Piezometric Elevation (m)**						
23 Sept 2019	225.60	226.39	226.29	226.68	226.37	226.61	n/a
13 Nov 2019	226.83	227.00	228.46	228.67	228.53	227.26	n/a
25 May 2020	226.28	226.99	226.97	227.46	227.09	228.61	n/a
7 January 2021	n/a	n/a	n/a	n/a	n/a	n/a	228.63
11 June 2021	225.33	226.80	226.00	226.53	226.08	227.76	228.64

6.0 REFERENCES

1. Department of Geological Engineering, University of Manitoba (1983). Geological Engineering Report for Urban Development of Winnipeg.
2. Dyregrov Robinson Inc., Phase 1 Geotechnical Investigation Ferry Road and Riverbend Combined Sewer Relief Works, August 2012.
3. Render, F.W., 1970, Geohydrology of the Metropolitan Winnipeg Area as Relates to Groundwater Supply and Construction, Canadian Geotechnical Journal, 7, pp 243-274.
4. Teller, J.T., 1976, Lake Agassiz Deposits in the Main Offshore Basin of Southern Manitoba, Canadian Journal of Earth Sciences, 134, pp. 27-43.
5. Manitoba Geological Survey's Geologic Scientific Report GR2002-1, Bedrock mineral resources of Manitoba's capital region.

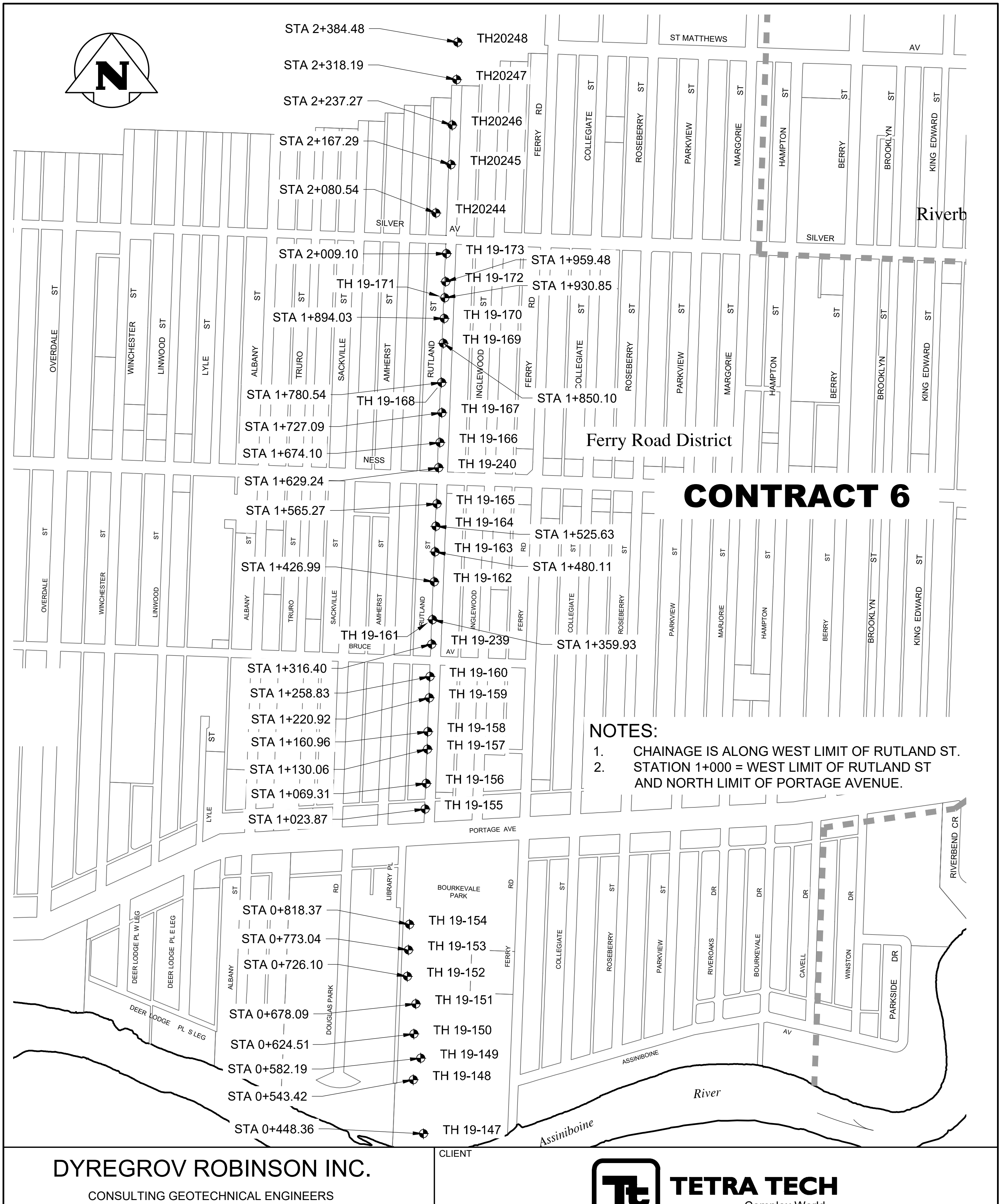
7.0 CLOSURE

This report and its findings were prepared based on the subsurface conditions encountered in the random representative sample of test holes drilled in July and August of 2019 and December 2020 for the sole purpose of this geotechnical investigation and our understanding of the proposed Rutland Trunk Sewer at the time of this report. Subsurface conditions are inherently variable and should be expected to vary along the route of the trunk sewer.

This report was prepared for the sole and exclusive use of Tetra Tech Canada Inc. and The City of Winnipeg for the Rutland Trunk Sewer which will be installed as part of the Ferry Road and Riverbend Combined Sewer Relief Project in Winnipeg, Manitoba. The information and recommendations contained in this report are for the benefit of Tetra Tech Canada Inc. and The City of Winnipeg only and no other party or entity shall have any claim against Dyregrov Robinson Inc., or the author, nor may this report be used for any other projects, including but not limited to changes in the proposed Rutland Trunk Sewer Project without the consent of Dyregrov Robinson Inc. The findings and recommendations in this report have been prepared in accordance with generally accepted geotechnical engineering principles and practises. No other warranty, expressed or implied, is provided.

APPENDIX A

Test Hole Location Plan
and
Test Hole Location and Survey (Table A1)



X:\A-G\CITY OF WINNIPEG - WATER & WASTE DEPARTMENT - 0012\10001203.00 - FERRY ROAD\CONTRACT 6\GEOTECH\CONTRACT 6 THS_STATIONS_2.DWG 21.05.03 9:21 AM

DYREGROV ROBINSON INC.

CONSULTING GEOTECHNICAL ENGINEERS

AUTHORIZED BY: AUTHORIZED	CLIENT DRAWING NO.
DATE: 19.09.17	

CLIENT

TETRA TECH
Complex World
Clear Solutions

DRAWING DESCRIPTION

TEST HOLE LOCATION FOR FERRY ROAD CSR WORKS CONTRACT 6

DESIGNED BY:	DRAWN BY: NL	DRAWING NO.	REV.
REVIEWED BY:	SCALE: NTS		

Ferry Road & Riverbend CSR - Rutland Trunk Sewer

Table A1) Test Hole Location and Survey

Test Hole ID	General Location	*UTM Coordinates		*Geodetic
		Northing (m)	Easting (m)	Elevation (m)
TH 19-147	Bourkevale Park	5,526,115.1	627,781.6	228.62
TH 19-148	Bourkevale Park	5,526,210.9	627,763.6	230.57
TH 19-149	Bourkevale Park	5,526,249.2	627,776.8	231.01
TH 19-150	Bourkevale Park	5,526,292.0	627,764.9	231.91
TH 19-151	Bourkevale Park	5,526,345.5	627,768.0	231.04
TH 19-152	Bourkevale Park	5,526,394.1	627,753.1	232.70
TH 19-153	Bourkevale Park	5,526,441.0	627,755.0	232.56
TH 19-154	Bourkevale Park	5,526,486.3	627,756.8	232.64
TH 19-155	Between Portage Ave. & Bruce Ave.	5,526,690.9	627,784.7	233.63
TH 19-156	Between Portage Ave. & Bruce Ave.	5,526,736.3	627,786.6	233.70
TH 19-157	Between Portage Ave. & Bruce Ave.	5,526,797.0	627,788.9	233.79
TH 19-158	Between Portage Ave. & Bruce Ave.	5,526,827.9	627,789.6	233.73
TH 19-159	Between Portage Ave. & Bruce Ave.	5,526,887.8	627,792.2	233.82
TH 19-160	Between Portage Ave. & Bruce Ave.	5,526,925.7	627,793.2	233.93
TH 19-161	Between Bruce Ave. & Ness Ave.	5,527,026.7	627,797.8	234.20
TH 19-162	Between Bruce Ave. & Ness Ave.	5,527,093.7	627,800.6	234.34
TH 19-163	Between Bruce Ave. & Ness Ave.	5,527,146.8	627,802.2	234.62
TH 19-164	Between Bruce Ave. & Ness Ave.	5,527,192.3	627,803.7	234.64
TH 19-165	Between Bruce Ave. & Ness Ave.	5,527,231.9	627,805.5	234.67
TH 19-166	Between Ness Ave. & Silver Ave.	5,527,340.6	627,810.9	234.94
TH 19-167	Between Ness Ave. & Silver Ave.	5,527,393.5	627,814.3	234.59
TH 19-168	Between Ness Ave. & Silver Ave.	5,527,447.0	627,814.0	234.97
TH 19-169	Between Ness Ave. & Silver Ave.	5,527,516.5	627,816.8	234.92
TH 19-170	Between Ness Ave. & Silver Ave.	5,527,560.4	627,818.5	235.01
TH 19-171	Between Ness Ave. & Silver Ave.	5,527,597.2	627,819.6	234.99
TH 19-172	Between Ness Ave. & Silver Ave.	5,527,625.8	627,821.1	235.07
TH 19-173	Between Ness Ave. & Silver Ave.	5,527,675.4	627,822.5	235.16
TH 19-239	Between Bruce Ave. & Ness Ave.	5,526,983.2	627,796.2	234.09
TH 19-240	Between Ness Ave. & Silver Ave.	5,527,295.8	627,808.6	235.11
TH 20-244	North of Silver Ave.	5,527,747.6	627,803.8	235.22
TH 20-245	North of Silver Ave.	5,527,833.4	627,830.3	235.31
TH 20-246	North of Silver Ave.	5,527,903.4	627,832.4	235.43
TH 20-247	North of Silver Ave.	5,527,984.0	627,840.4	235.64
TH 20-247	North of Silver Ave.	5,528,050.3	627,842.2	236.03

*** Test hole survey by Tetra Tech**

DRI GEOTECHNICAL ENGINEERS

APPENDIX B

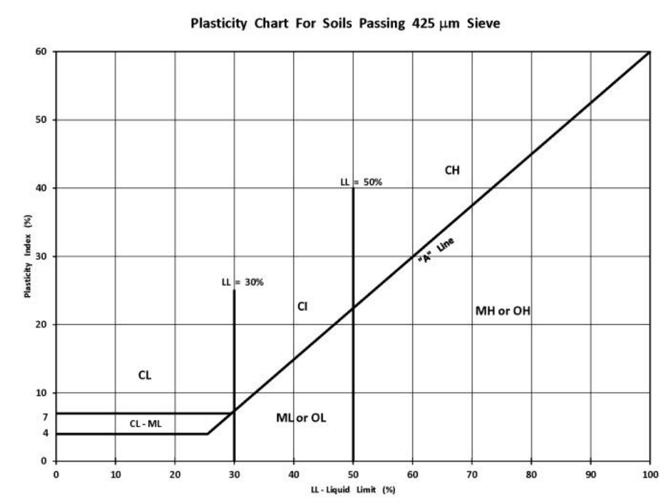
2019 / 2020 Test Hole Logs
&
2012 Test Hole Logs

EXPLANATION OF TERMS & SYMBOLS

Description				TH Log Symbols	USCS Classification	Laboratory Classification Criteria			
						Fines (%)	Grading	Plasticity	Notes
COARSE GRAINED SOILS	GRAVELS (More than 50% of coarse fraction of gravel size)	CLEAN GRAVELS (Little or no fines)	Well graded gravels, sandy gravels, with little or no fines		GW	0-5	$C_U > 4$ $1 < C_C < 3$		Dual symbols if 5-12% fines. Dual symbols if above "A" line and $4 < W_P < 7$ $C_U = \frac{D_{60}}{D_{10}}$ $C_C = \frac{(D_{30})^2}{D_{10} x D_{60}}$
			Poorly graded gravels, sandy gravels, with little or no fines		GP	0-5	Not satisfying GW requirements		
		DIRTY GRAVELS (With some fines)	Silty gravels, silty sandy gravels		GM	> 12		Atterberg limits below "A" line or $W_P < 4$	
			Clayey gravels, clayey sandy gravels		GC	> 12		Atterberg limits above "A" line or $W_P < 7$	
	SANDS (More than 50% of coarse fraction of sand size)	CLEAN SANDS (Little or no fines)	Well graded sands, gravelly sands, with little or no fines		SW	0-5	$C_U > 6$ $1 < C_C < 3$		
			Poorly graded sands, gravelly sands, with little or no fines		SP	0-5	Not satisfying SW requirements		
		DIRTY SANDS (With some fines)	Silty sands, sand-silt mixtures		SM	> 12		Atterberg limits below "A" line or $W_P < 4$	
			Clayey sands, sand-clay mixtures		SC	> 12		Atterberg limits above "A" line or $W_P < 7$	
FINE GRAINED SOILS	SILTS (Below 'A' line negligible organic content)	$W_L < 50$	Inorganic silts, silty or clayey fine sands, with slight plasticity		ML			Classification is Based upon Plasticity Chart	
		$W_L > 50$	Inorganic silts of high plasticity		MH				
	CLAYS (Above 'A' line negligible organic content)	$W_L < 30$	Inorganic clays, silty clays, sandy clays of low plasticity, lean clays		CL				
		$30 < W_L < 50$	Inorganic clays and silty clays of medium plasticity		CI				
		$W_L > 50$	Inorganic clays of high plasticity, fat clays		CH				
	ORGANIC SILTS & CLAYS (Below 'A' line)	$W_L < 50$	Organic silts and organic silty clays of low plasticity		OL				
		$W_L > 50$	Organic clays of high plasticity		OH				
HIGHLY ORGANIC SOILS			Peat and other highly organic soils		Pt	Von Post Classification Limit		Strong colour or odour, and often fibrous texture	

	Asphalt		Glacial Till		Bedrock (Igneous)
	Concrete		Clay Shale		Bedrock (Limestone)
	Fill				Bedrock (Undifferentiated)

DYREGROV ROBINSON INC.
CONSULTING GEOTECHNICAL ENGINEERS



FRACTION		PARTICLE SIZE (mm) Min.	Max.
Boulders		>300	
Cobbles		75	300
Gravel	Coarse	19	75
	Fine	4.75	19
Sand	Coarse	2.0	4.75
	Medium	0.425	2.0
	Fine	0.075	0.425
Silt (non-plastic) or Clay (plastic)		< 0.075 mm	

RELATIVE PROPORTIONS (by weight) Percent	Descriptor
>35%	main fraction
35 - 50	"and"
20 – 35	Adjective e.g. silty, clayey
10 – 20	"some"
1 - 10	"trace"

Soil Classification Example

Clay 50% (main fraction), Silt 25%, Sand 17%, Gravel 8%

Clay – silty, some sand, trace gravel

TERMS and SYMBOLS

Laboratory and field tests are identified as follows:

Unconfined Comp.: undrained shear strength (kPa or psf) derived from unconfined compression testing.

Torvane: undrained shear strength (kPa or psf) measured using a Torvane

Pocket Pen.: undrained shear strength (kPa or psf) measured using a pocket penetrometer.

Unit Weight bulk unit weight of soil or rock (kN/m^3 or pcf).

SPT – N Standard Penetration Test: The number of blows (N) required to drive a 51 mm O.D. split barrel sampler 300 mm into the soil using a 63.5 kg hammer with a free fall drop height of 760 mm.

DCPT Dynamic Cone Penetration Test. The number of blows (N) required to drive a 50 mm diameter cone 300 mm into the soil using a 63.5 kg hammer with a free fall drop height of 760 mm.

M/C insitu soil moisture content in percent

PL Plastic limit, moisture content in percent

LL Liquid limit, moisture content in percent

The undrained shear strength (Su) of cohesive soil is related to its consistency as follows:

Su (kPa)	Su (psf)	CONSISTENCY
<12	250	very soft
12 – 25	250 – 525	soft
25 – 50	525 – 1050	firm
50 – 100	1050 – 2100	stiff
100 – 200	2100 – 4200	very stiff
200	4200	hard

The SPT - N of non-cohesive soil is related to compactness condition as follows:

N – Blows / 300 mm	COMPACTNESS
0 - 4	very loose
4 - 10	loose
10 - 30	compact
30 - 50	dense
50 +	very dense

References:

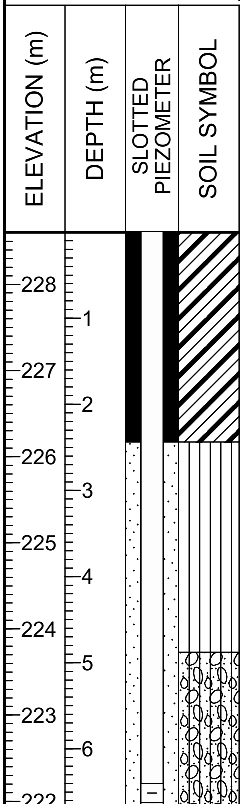
ASTM D2487 – Classification of Soils For Engineering Purposes (Unified Soil Classification System)

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

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-147**
LOCATION: UTM 14U: 5526115 m N, 627782 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS & 200mm HS Augers	ELEVATION (m): 228.619

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND



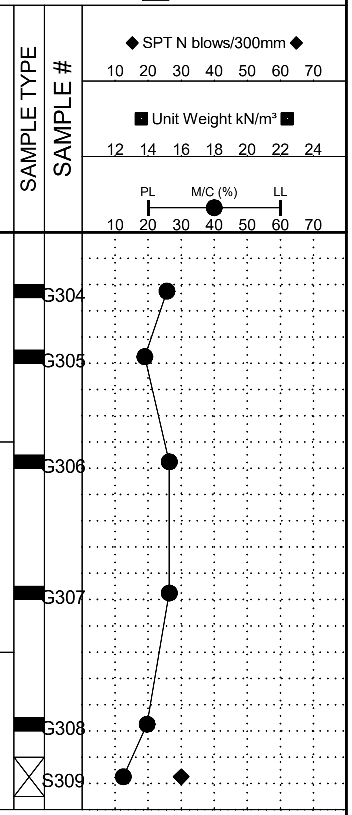
SOIL DESCRIPTION

CLAY (Alluvium) - some silt to silty, trace sand
- brown
- dry to moist
- intermediate plasticity

SILT (Alluvium) - some clay, some sand
- brown
- moist, loose
- low plasticity

- grey and wet below 4 m

SILT (TILL) - trace to some clay, trace sand, trace gravel
- grey, wet, loose
- compact and moist below 5.5 m
- dense below 6 m



END OF TEST HOLE AT 6.7 m IN SILT(TILL) (AUGER REFUSAL)
NOTES:
1. Some sloughing and seepage observed at 4 m.
2. After drilling to 5.8 m, hole caved to 4 m.
Switched to hollow stem (HS) augers at 5.8 m.
3. 25 mm PVC Standpipe piezometer w/ Cassagrande tip installed 6.7 m b/l grade.
Top of pipe (T.O.P) 0.91 m above grade.

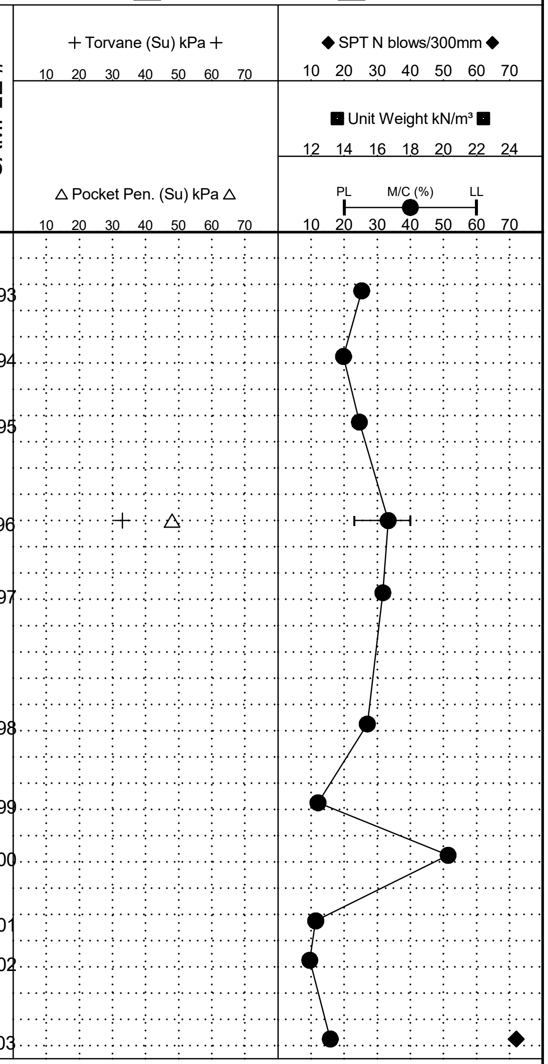
Water levels:
Sept 23, 2019: 3.93 m below T.O.P. - Ground water elevation - 225.60 m
Nov 13, 2019: 2.70 m below T.O.P. - Ground water elevation - 226.83 m
May 25, 2020: 3.25 m below T.O.P. - Ground water elevation - 226.28 m

DYREGROV ROBINSON INC. Consulting Geotechnical Engineers	LOGGED BY: CR	COMPLETION DEPTH: 6.71 m
	REVIEWED BY: GR	COMPLETION DATE: 30/7/19
	PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-148**
LOCATION: UTM 14U: 5526211 m N, 627764 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS & 200mm HS Augers	ELEVATION (m): 230.568

SAMPLE TYPE	GRAB	SHELBY TUBE	SPLIT SPOON	BULK	NO RECOVERY	CORE
BACKFILL TYPE	BENTONITE	GRAVEL	SLOUGH	GROUT	CUTTINGS	SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE #
230.568–230.4	0–0.15	TOPSOIL (150 mm thick) - black, dry	
230.4–224.4	0.15–6.2	CLAY (Alluvium) - some silt to AND SILT (variable silt) - trace sand - black with trace organics to 1.5 m - dry to moist - brown below 1.5 m - moist, stiff becoming firm below 3 m - intermediate plasticity T296: PL 23, LL 40, Liquidity Index 0.6 52.7% silt, 46.1% clay, 1.2% sand - wet sand lense at 5.2 m - grey, wet, soft below 5.2 m	G293, G294, G295, T296, G297, G298
		SAND (Alluvium) - brown, wet, loose, coarse grained	G299
		CLAY (Glaciolacustrine) - silty - grey - moist, firm, high plasticity	G300
		SILT (TILL) - some clay to clayey, trace sand, trace gravel - grey, wet, loose becoming moist and dense to very dense at 9 m G302: 60.2% silt, 33.7% clay, 5.8% sand	G301, G302, S303



END OF TEST HOLE AT 9.6 m IN SILT(TILL) (AUGER REFUSAL)

NOTES:
1. Some sloughing and seepage observed.
2. After drilling to 8.8 m, hole caved to 5 m.
   Switched to hollow stem (HS) augers at 8.8 m.
4. 25 mm PVC Standpipe piezometer w/ Cassagrande tip installed 6.4 m b/l grade.
Top of pipe (T.O.P) 0.05 m below grade.
Water levels:
Sept 23, 2019: 4.13 m below T.O.P. - Ground water elevation - 226.39 m
Nov 13, 2019: 3.52 m below T.O.P. - Ground water elevation - 227.00 m
May 25, 2020: 3.53 m below T.O.P. - Ground water elevation - 226.99 m

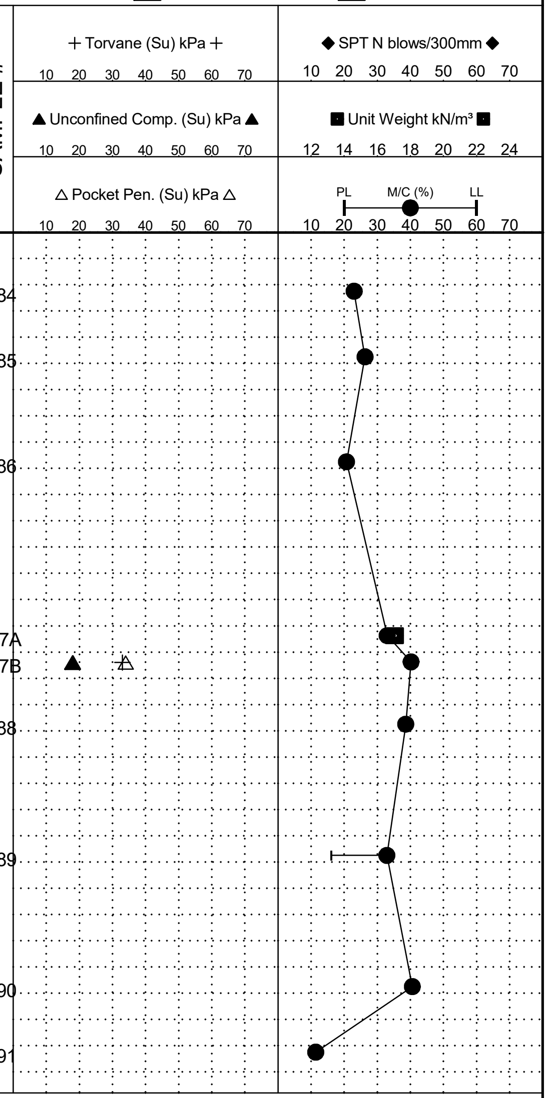
DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

LOGGED BY: CR	COMPLETION DEPTH: 9.60 m
REVIEWED BY: GR	COMPLETION DATE: 29/7/19
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-149**
LOCATION: UTM 14U: 5526249 m N, 627777 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS & 200mm HS Augers	ELEVATION (m): 231.011

SAMPLE TYPE	GRAB	SHELBY TUBE	SPLIT SPOON	BULK	NO RECOVERY	CORE
BACKFILL TYPE	BENTONITE	GRAVEL	SLOUGH	GROUT	CUTTINGS	SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
		TOPSOIL (100 mm thick) - black, moist		
		CLAY (Alluvium) - silty, trace organics - black with trace organics to 1.5 m - brown below 1.5 m - moist, stiff - intermediate plasticity	GRAB	G284
230	1		GRAB	G285
229	2			
228	3	Below 3 m: moist to wet, soft to firm	GRAB	G286
227	4	SILT (Alluvium) - trace to some clay - brown to grey, moist to wet, loose - low plasticity	SHELBY TUBE	T287A
226	5	CLAY (Alluvium) - some silt to AND SILT (variable) - trace sand - brown / grey - moist to wet, soft to firm - intermediate plasticity - sand lensing in the clay below 6 m - variable amounts of sand	SHELBY TUBE	T287B
225	6		GRAB	G288
224	7	G289: PL 16, LL 34, Liquidity Index 0.9 50.1% silt, 44.2% clay, 5.6% sand	GRAB	G289
223	8			
222	9		GRAB	G290
		SILT (Till) - trace to some clay, trace sand, trace gravel - brown, moist, compact - attempted SPT after auger refusal, no penetration, split spoon bouncing	GRAB	G291



END OF TEST HOLE AT 10 m IN SILT (TILL) (AUGER REFUSAL)

NOTES:

1. Seepage observed at 4.6 m.
2. Hole open to 5.5 m after drilling to 6m
3. Hole open to 4.3 m after drilling to 9 m
4. Switch to hollow stem augers at 9 m
5. Upon completion of drilling, test hole open to 4.3 m, water level 3.7 m b/l grade.
6. Test hole backfilled with auger cuttings and bentonite chips.

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

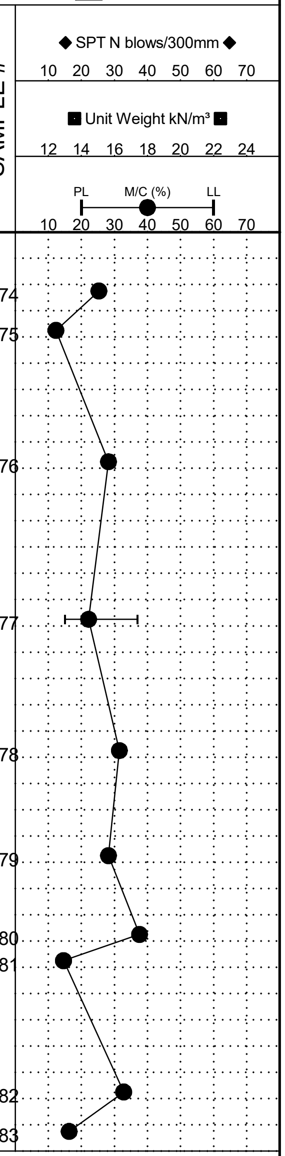
LOGGED BY: CR	COMPLETION DEPTH: 10.00 m
REVIEWED BY: GR	COMPLETION DATE: 29/7/19
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-150**
LOCATION: UTM 14U: 5526292 m N, 627765 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS Augers	ELEVATION (m): 231.907

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE #
		TOPSOIL (100 mm thick) - black, dry	
231	1	SILT (Alluvium) - trace to some clay, friable black to brown, dry to moist, loose	G274 G275
230	2	CLAY (Alluvium) - silty - brown - moist, stiff - intermediate plasticity	
229	3		G276
228	4	CLAY (Alluvium) - some silt to AND SILT - trace sand - brown / grey, wet, soft to firm - intermediate plasticity G277: PL 15, LL 37, Liquidity Index 0.3 53.3% clay, 40.3% silt, 6.4% sand	G277
227	5		
226	6	SILT (Alluvium) - trace sand - brown - loose, wet - low plasticity	G278
225	7		G279
224	8	CLAY (Alluvium) - silty - grey, moist, firm, intermediate plasticity	G280
		SAND (Alluvium) - brown, wet, loose, coarse	G281
223	9	SILT (Alluvium) - trace sand - brown - loose, wet - low plasticity	
222	10		G282
		SILT (TILL) - trace to some clay, trace sand, trace gravel, grey, wet, loose	G283



END OF TEST HOLE AT 10.7 m IN SILT (TILL)
Notes:
1. Sloughing and seepage observed below 6 m.
2. Upon completion of drilling test hole open to 6 m, water level 5.2 m b/l grade.
3. Test hole backfilled with auger cuttings and bentonite chips.

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

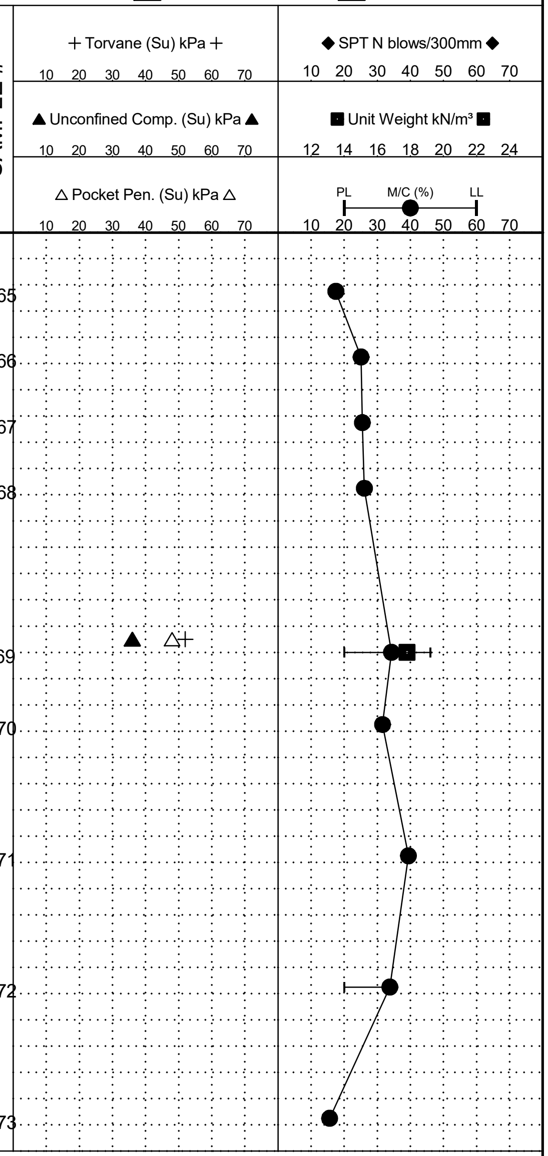
LOGGED BY: CR	COMPLETION DEPTH: 10.67 m
REVIEWED BY: GR	COMPLETION DATE: 29/7/19
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-151**
LOCATION: UTM 14U: 5526346 m N, 627768 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS Augers	ELEVATION (m): 231.04

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
			TOPSOIL (50 mm thick) - black, moist		
230	1		CLAY (Alluvium) - silty - brown - moist, stiff, intermediate plasticity	Grab	G265
				Grab	G266
229	2		SILT (Alluvium) - some clay, trace sand - brown - moist to wet, loose - low plasticity	Grab	G267
228	3			Grab	G268
227	4		CLAY (Alluvium) - silty - brown - moist, firm - intermediate plasticity - 100 mm of sand at top of tube sample (T269) T269: PL 20, LL 46, Liquidity Index 0.5 50.0% clay, 49.3% silt, 0.7% sand		
226	5			Shelby Tube	T269
225	6			Grab	G270
224	7		- grey, soft below 7 m	Grab	G271
223	8				
222	9		G272: PL 20, LL 33, Liquidity Index 1.1 50.0% silt, 47.7% clay, 2.3% sand	Grab	G272
221	10		- trace till inclusions below 10 m	Grab	G273



END OF TEST HOLE AT 10.7 m IN CLAY

NOTES:

1. Sloughing and seepage observed below 4.6 m.
2. Upon completion of drilling, test hole open to 4.9 m, water level 4.6 m b/l grade.
3. Test hole backfilled with auger cuttings and bentonite chips.

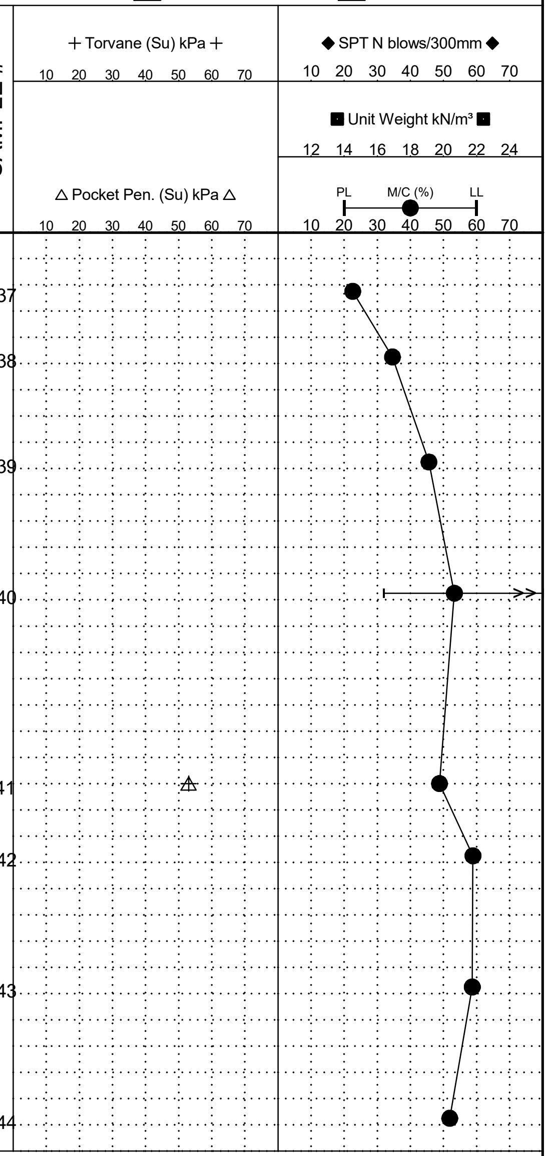
DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

LOGGED BY: CR	COMPLETION DEPTH: 10.67 m
REVIEWED BY: GR	COMPLETION DATE: 26/7/19
PROJECT ENGINEER: Gil Robinson	

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-152**
LOCATION: UTM 14U: 5526394 m N, 627753 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS Augers	ELEVATION (m): 232.695

SAMPLE TYPE	GRAB	SHELBY TUBE	SPLIT SPOON	BULK	NO RECOVERY	CORE
BACKFILL TYPE	BENTONITE	GRAVEL	SLOUGH	GROUT	CUTTINGS	SAND

ELEVATION (m)	DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
232	0–1		TOPSOIL (100 mm thick) - black, dry		
			SILT - light brown, moist, loose	GRAB	G237
231	1–2		CLAY (Glaciolacustrine) - silty - mottled brown and grey - moist, stiff, high plasticity - trace silt inclusions	GRAB	G238
230	3			GRAB	G239
229–228	4–5		G240: PL 32, LL 91, Liquidity Index 0.4 99.9% clay, 0.1% sand	GRAB	G240
227	5–6		- below 5 m; trace sand, trace gravel, grey		
226	7			SHELBY TUBE	T241
225	7–8			GRAB	G242
224	9			GRAB	G243
223	10			GRAB	G244



END OF TEST HOLE AT 10.7 m IN CLAY
NOTES:
1. No sloughing or seepage observed during drilling.
2. Upon completion of drilling, test hole open to 10.7 m, dry.
3. Test hole backfilled with auger cuttings and bentonite chips.

BH GEOTECH PLOTS-AUGUST 2013 143691.7_RUTLAND TRUNK_GINT.GPJ DATA TEMPLATE - AUGUST 2, 2013.GDT 9/8/20

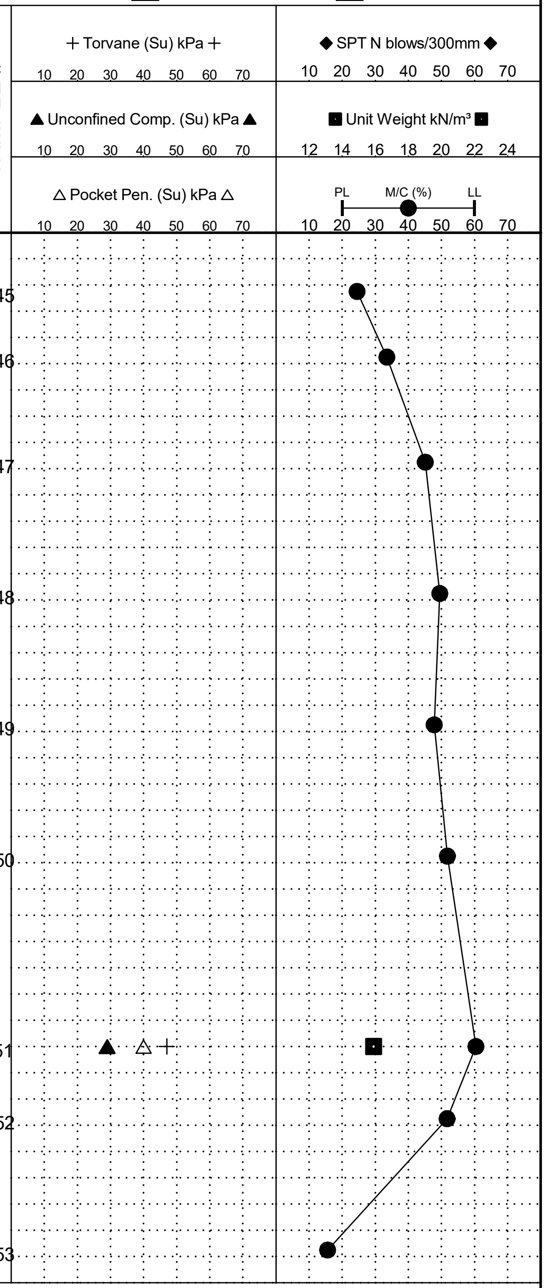
DYREGROV ROBINSON INC. Consulting Geotechnical Engineers	LOGGED BY: CR	COMPLETION DEPTH: 10.67 m
	REVIEWED BY: GR	COMPLETION DATE: 26/7/19
	PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-153**
LOCATION: UTM 14U: 5526441 m N, 627755 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS Augers	ELEVATION (m): 232.555

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
232.555	0	TOPSOIL (100 mm thick) - black, dry		
		CLAY (Glaciolacustrine) - silty - black with trace organics to 1.2 m - mottled brown / grey below 1.2 m - moist, stiff - high plasticity	GRAB	G245
			GRAB	G246
			GRAB	G247
			GRAB	G248
			GRAB	G249
		- grey below 6 m	GRAB	G250
		- below 9 m; trace sand, trace gravel, firm	SHELBY TUBE	T251
			GRAB	G252
		SILT (TILL) - trace to some clay, trace sand, trace gravel - grey - moist to wet, loose	GRAB	G253



END OF TEST HOLE AT 12.2 m IN SILT(TILL)

NOTES:
1. No sloughing or seepage observed during drilling.
2. Upon completion of drilling, test hole open to 12.2 m, dry.
3. Test hole backfilled with auger cuttings and bentonite chips.

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

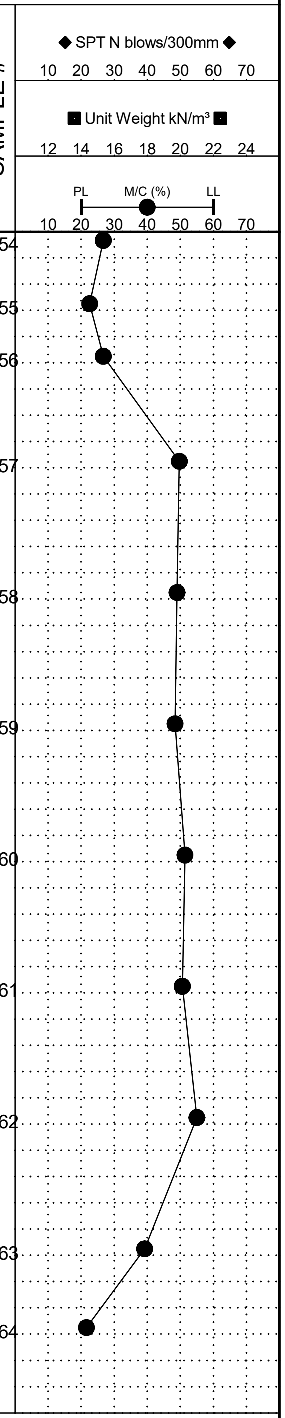
LOGGED BY: CR	COMPLETION DEPTH: 12.19 m
REVIEWED BY: GR	COMPLETION DATE: 26/7/19
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-154**
LOCATION: UTM 14U: 5526486 m N, 627757 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS Augers	ELEVATION (m): 232.638

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
	0.0	TOPSOIL (50 mm thick) - black, dry	GRAB	G254
232		CLAY - silty, trace organics, black, dry to moist, stiff		
	1	SILT - light brown, moist, loose	GRAB	G255
231		CLAY (Glaciolacustrine) - silty - mottled brown and grey - dry to moist becoming moist with depth - stiff - high plasticity	GRAB	G256
230	2–3		GRAB	G257
229–228	4		GRAB	G258
227	5–6		GRAB	G259
226–225	7	- grey below 6.7 m	GRAB	G260
224	8–9		GRAB	G261
223–222	10		GRAB	G262
221	11–12	Below 11.3 m: - trace till inclusions, trace sand, trace gravel	GRAB	G263
220–219	13	SILT (TILL) - trace clay, trace sand, trace gravel - grey, moist to wet, loose	GRAB	G264



END OF TEST HOLE AT 13.7 m IN SILT(TILL)

NOTES:

1. No sloughing or seepage observed during drilling.
2. Upon completion of drilling test hole open to 13.7 m, dry.
3. Test hole backfilled with auger cuttings and bentonite chips.

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

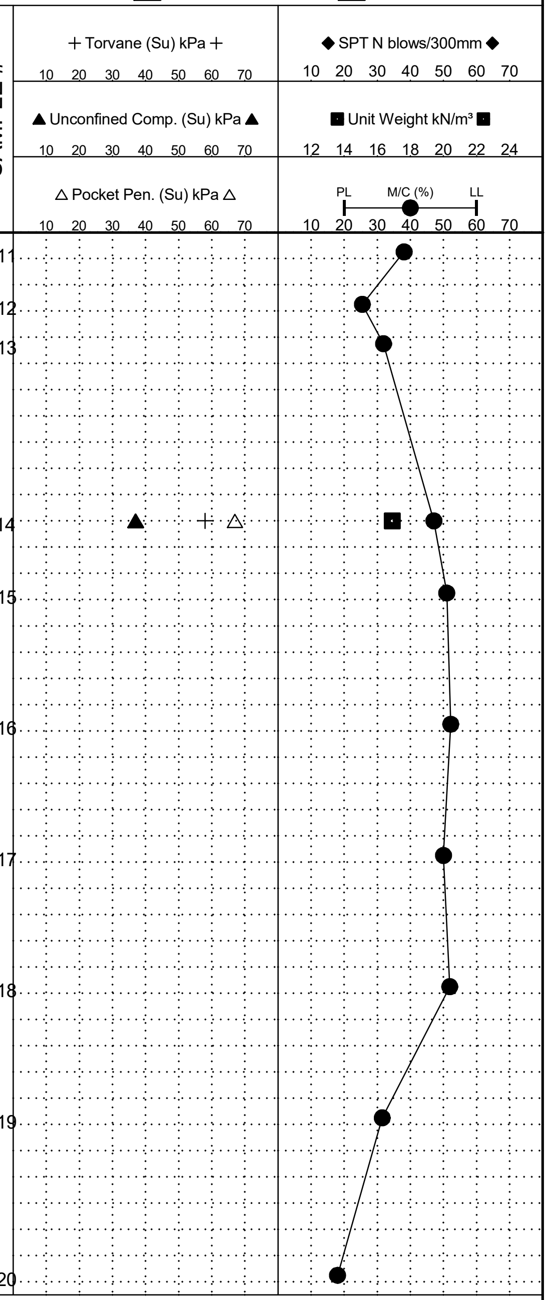
LOGGED BY: CR	COMPLETION DEPTH: 13.72 m
REVIEWED BY: GR	COMPLETION DATE: 26/7/19
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-155**
LOCATION: UTM 14U: 5526691 m N, 627785 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS Augers	ELEVATION (m): 233.632

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
233.632	0	CONCRETE (130 mm thick) - sidewalk	GRAB	G311
		CLAY - silty, trace organics - black, moist, stiff, high plasticity	GRAB	G312
		SILT - light brown, moist, loose	GRAB	G313
		CLAY (Glaciolacustrine) - silty - mottled brown and grey - moist, stiff, high plasticity - trace silt inclusions	SHELBY TUBE	T314
			GRAB	G315
		- grey below 5.5 m	GRAB	G316
			GRAB	G317
			GRAB	G318
		- trace till inclusions, trace gravel below 10.4	GRAB	G319
		SILT (TILL) - trace to some clay, trace sand, trace gravel, grey, wet, loose	GRAB	G320



END OF TEST HOLE AT 12.3 m IN SILT(TILL)
NOTES:
1. No sloughing or seepage observed during drilling.
2. 25 mm PVC Standpipe piezometer w/ Cassagrande tip installed 12.3 m b/l grade.
Top of pipe (T.O.P) 0.075 m below grade.
Water levels:
Sept 23, 2019: 7.27 m below T.O.P. - Ground water elevation - 226.29 m
Nov 13, 2019: 5.10 m below T.O.P. - Ground water elevation - 228.46 m
May 25, 2020: 6.59 m below T.O.P. - Ground water elevation - 226.97 m

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

LOGGED BY: CR	COMPLETION DEPTH: 12.34 m
REVIEWED BY: GR	COMPLETION DATE: 30/7/19
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

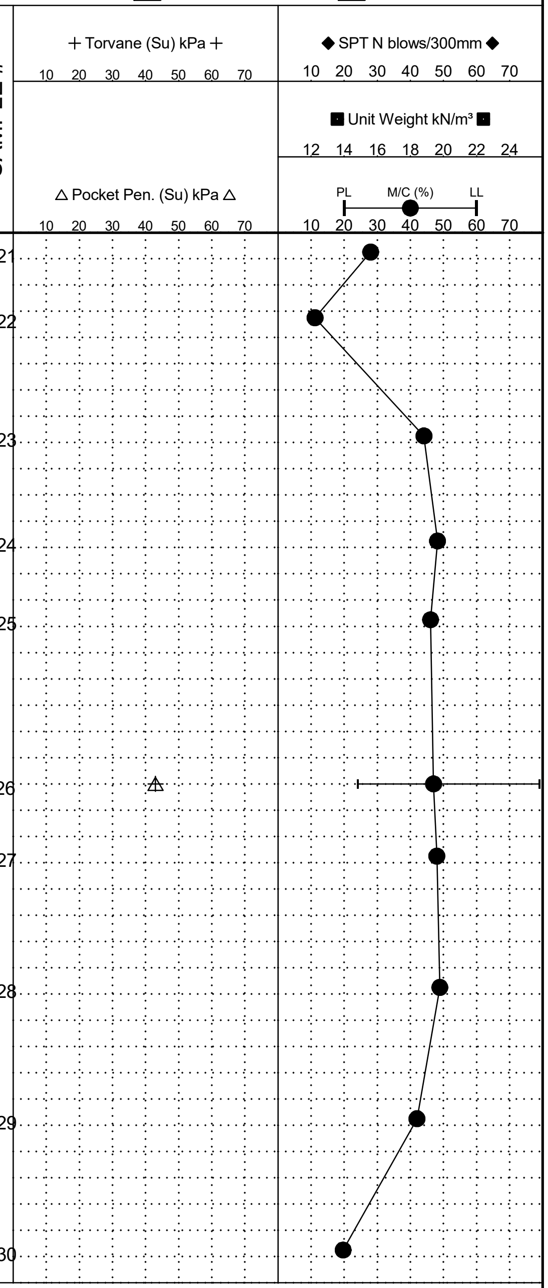
PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-156**
LOCATION: UTM 14U: 5526736 m N, 627787 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS Augers	ELEVATION (m): 233.698

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
233.7	0	CONCRETE (100 mm thick) - sidewalk		
		CLAY (FILL) - trace sand, trace gravel, black, moist, stiff	GRAB	G321
		SILT - light brown, dry to moist, loose	GRAB	G322
		CLAY (Glaciolacustrine) - silty - mottled brown and grey - moist, stiff, high plasticity - trace silt inclusions	GRAB	G323
			GRAB	G324
			GRAB	G325
	5	- grey below 5 m		
	6	- firm below 6 m		
		T326: PL 24, LL 79, Liquidity Index 0.4 92.1% clay, 7.8% silt, 0.1% sand	SHELBY TUBE	T326
			GRAB	G327
			GRAB	G328
			GRAB	G329
	11.5	Below 11.5 m: - trace till inclusions, trace sand, trace gravel	GRAB	G330

Elevation scale: 233, 232, 231, 230, 229, 228, 227, 226, 225, 224, 223, 222. Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12.



END OF TEST HOLE AT 12.2 m IN CLAY

NOTES:

1. No sloughing or seepage observed during drilling.
2. Test hole backfilled with auger cuttings and bentonite chips. Sidewalk patched with concrete.

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

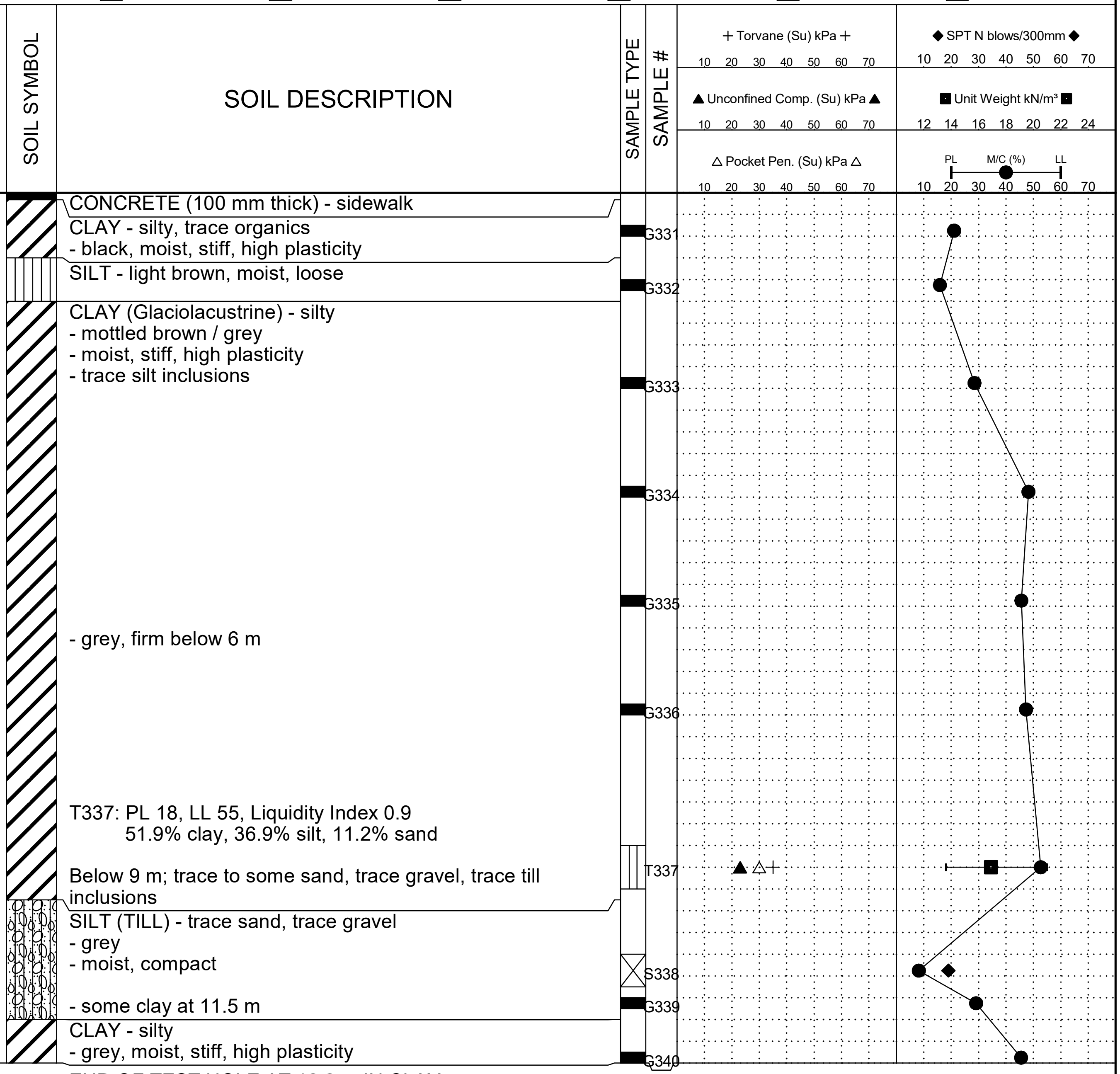
LOGGED BY: CR	COMPLETION DEPTH: 12.19 m
REVIEWED BY: GR	COMPLETION DATE: 30/7/19
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-157**
LOCATION: UTM 14U: 5526797 m N, 627789 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS Augers	ELEVATION (m): 233.786

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
		CONCRETE (100 mm thick) - sidewalk		
233	1	CLAY - silty, trace organics - black, moist, stiff, high plasticity	GRAB	G331
		SILT - light brown, moist, loose	GRAB	G332
232	2	CLAY (Glaciolacustrine) - silty - mottled brown / grey - moist, stiff, high plasticity - trace silt inclusions		
231	3		GRAB	G333
230	4		GRAB	G334
229	5			
228	6	- grey, firm below 6 m	GRAB	G335
227	7		GRAB	G336
226	8			
225	9	T337: PL 18, LL 55, Liquidity Index 0.9 51.9% clay, 36.9% silt, 11.2% sand		
224	10	Below 9 m; trace to some sand, trace gravel, trace till inclusions	SHELBY TUBE	T337
		SILT (TILL) - trace sand, trace gravel - grey - moist, compact		
223	11		SPLIT SPOON	S338
		- some clay at 11.5 m	GRAB	G339
222	12	CLAY - silty - grey, moist, stiff, high plasticity	GRAB	G340



END OF TEST HOLE AT 12.2 m IN CLAY

NOTES:

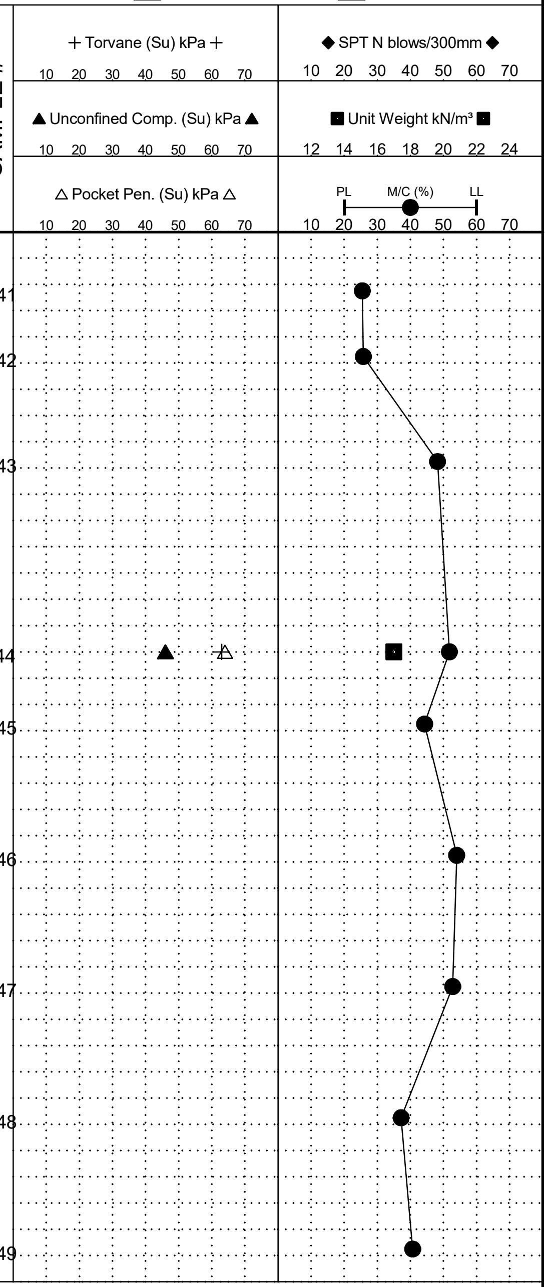
1. No sloughing observed during drilling.
2. Slight seepage observed at 10.7 m from silt till layer.
3. Upon completion of drilling, test hole open to 11.3 m b/l grade, dry.
4. Test hole backfilled with auger cuttings and bentonite chips. Sidewalk patched with concrete.

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-158**
LOCATION: UTM 14U: 5526828 m N, 627790 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS Augers	ELEVATION (m): 233.734

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
		CONCRETE (125 mm thick) - sidewalk		
		CLAY (FILL) - silty, trace organics, trace sand, black, moist		
233		CLAY (Glaciolacustrine) - silty	GRAB	G341
	1	- black with trace organics to 1.5 m		
		- mottled brown and grey below 1.5 m	GRAB	G342
232		- moist, stiff, high plasticity		
	2	- trace silt inclusions		
231			GRAB	G343
	3			
230				
	4			
229			SHELBY TUBE	T344
	5			
228			GRAB	G345
	6	- grey below 6 m		
227				
	7		GRAB	G346
226				
	8			
225			GRAB	G347
	9			
224				
	10	- trace till inclusions, trace sand, trace gravel below 10 m	GRAB	G348
223				
	11			
222			GRAB	G349
	12			



END OF TEST HOLE AT 12.2 m IN CLAY

NOTES:

1. No seepage observed during drilling. Test hole squeezed in at 10 m.
2. Upon completion of drilling, test hole open to 10 m b/l grade, dry.
3. Test hole backfilled with auger cuttings and bentonite chips. Sidewalk patched with concrete.

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

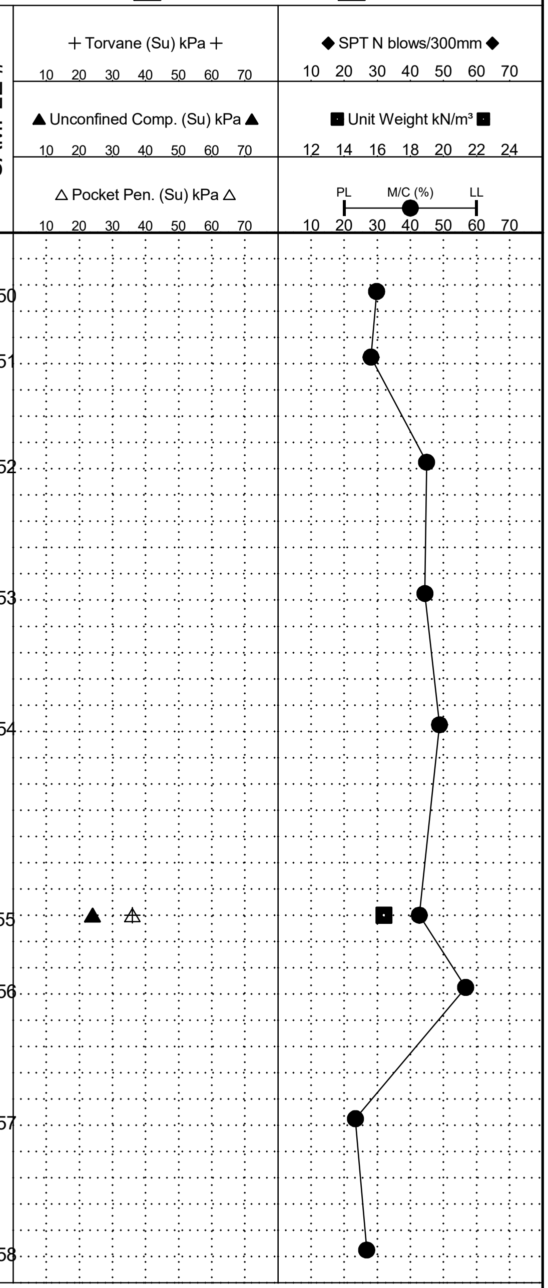
LOGGED BY: CR	COMPLETION DEPTH: 12.19 m
REVIEWED BY: GR	COMPLETION DATE: 31/7/19
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-159**
LOCATION: UTM 14U: 5526888 m N, 627792 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS Augers	ELEVATION (m): 233.818

SAMPLE TYPE	GRAB	SHELBY TUBE	SPLIT SPOON	BULK	NO RECOVERY	CORE
BACKFILL TYPE	BENTONITE	GRAVEL	SLOUGH	GROUT	CUTTINGS	SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
	0	CONCRETE (125 mm thick) - sidewalk		
		CLAY (Glaciolacustrine) - silty - black with trace organics to 1.5 m - mottled brown and grey below 1.5 m - moist, stiff, high plasticity - trace silt inclusions	GRAB	G350
			GRAB	G351
			GRAB	G352
			GRAB	G353
			GRAB	G354
		Below 7.5 m: trace sand, trace gravel, grey, firm	SHELBY TUBE	T355
			GRAB	G356
		Below 10 m: some till inclusions	GRAB	G357
			GRAB	G358

Elevation scale (m): 233, 232, 231, 230, 229, 228, 227, 226, 225, 224, 223, 222
Depth scale (m): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12



END OF TEST HOLE AT 12.2 m IN CLAY

NOTES:
1. Sloughing and seepage observed from till inclusions below 11 m.
2. Upon completion of drilling, test hole open to 8.8 m, water level 5.5 m b/l grade.
3. Test hole backfilled with auger cuttings and bentonite chips.
   Sidewalk patched with concrete.

BH GEOTECH PLOTS-AUGUST 2013 143691.7_RUTLAND TRUNK_GINT.GPJ DATA TEMPLATE - AUGUST 2, 2013.GDT 9/8/20

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

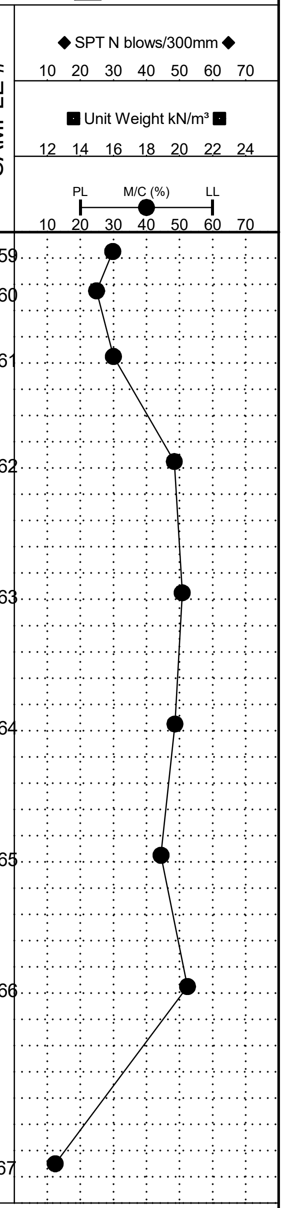
LOGGED BY: CR	COMPLETION DEPTH: 12.19 m
REVIEWED BY: GR	COMPLETION DATE: 31/7/19
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-160**
LOCATION: UTM 14U: 5526926 m N, 627793 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS Augers	ELEVATION (m): 233.925

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
		CONCRETE (125 mm thick) - sidewalk	GRAB	G359
		CLAY (FILL) - silty, trace organics, trace gravel, black, moist, stiff	GRAB	G360
233	1	SILT - light brown, moist, loose		
232	2	CLAY (Glaciolacustrine) - silty - mottled brown and grey - moist, stiff, high plasticity - trace silt inclusions	GRAB	G361
231	3		GRAB	G362
230	4		GRAB	G363
229	5			
228	6		GRAB	G364
227	7		GRAB	G365
226	8			
225	9		GRAB	G366
224	10			
223	11	SILT (TILL) - trace to some clay, trace sand, trace gravel - grey, loose, moist - attempted SPT after refusal, no penetration, sampler bouncing	SHELBY TUBE	T367



END OF TEST HOLE AT 11.3 m IN SILT(TILL) (AUGER REFUSAL)

NOTES:

1. Sloughing and seepage observed from Till b/l 10.7 m.
2. Upon completion of drilling, test hole open to 11 m b/l grade and water level 5.8 m b/l grade.
3. Test hole backfilled with auger cuttings and bentonite chips. Sidewalk patched with concrete.

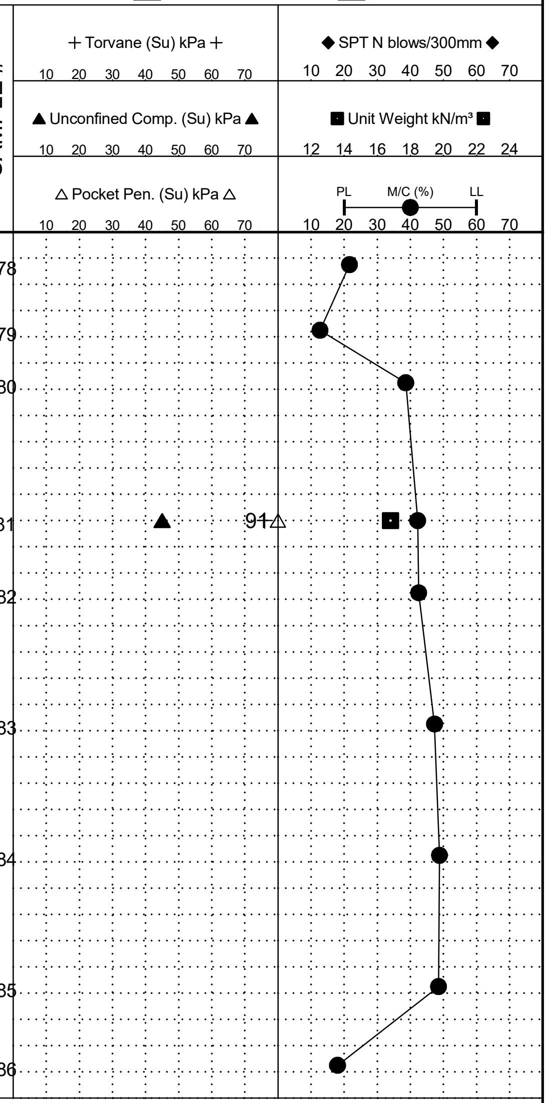
DYREGROV ROBINSON INC. Consulting Geotechnical Engineers	LOGGED BY: CR	COMPLETION DEPTH: 11.28 m
	REVIEWED BY: GR	COMPLETION DATE: 31/7/19
	PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-161**
LOCATION: UTM 14U: 5527027 m N, 627798 E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS Augers	ELEVATION (m): 234.201

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
234	0	CONCRETE (125 mm thick) - sidewalk		
		SAND and GRAVEL (FILL, 100 mm thick) - brown, moist	GRAB	G378
		CLAY - silty, trace organics, black, moist, stiff, high plasticity		
233	1	SILT - light brown, loose, moist	GRAB	G379
		CLAY (Glaciolacustrine) - silty - mottled brown and grey - moist, stiff, high plasticity - trace silt inclusions	GRAB	G380
231	3		SHELBY TUBE	T381
230	4		GRAB	G382
228	6	- grey, wet, firm below 6 m	GRAB	G383
227	7		GRAB	G384
225	9		GRAB	G385
		SILT AND CLAY (TILL) - trace sand, trace gravel - grey, loose, wet G386: 50.9% silt, 44.7% clay, 4.1% sand	GRAB	G386



END OF TEST HOLE AT 10.1 m IN SILT(TILL) (AUGER REFUSAL)

NOTES:

1. SPT attempted after refusal, no penetration sampler bouncing
2. No sloughing observed during drilling.
3. Some seepage observed from silt till layer below 9.5 m.
4. Upon completion of drilling, test hole open to 10.1 m, water level 6 m b/l grade. After auger refusal, air was blowing out of the test hole.
5. Test hole backfilled with auger cuttings and bentonite chips. Sidewalk patched with concrete.

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

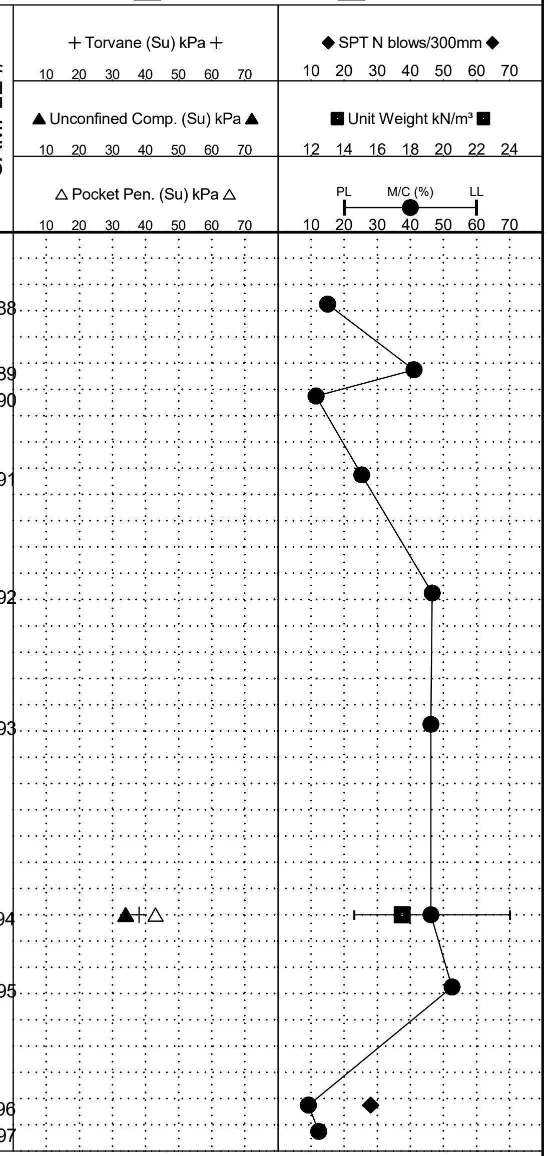
LOGGED BY: CR	COMPLETION DEPTH: 10.06 m
REVIEWED BY: GR	COMPLETION DATE: 1/8/19
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-162**
LOCATION: UTM 14U: 5527094 m N, 627801 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS Augers	ELEVATION (m): 234.342

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE #
234		CONCRETE (100 mm thick) - sidewalk	
		CLAY - silty, trace organics - black, dry, stiff	
233	1	SILT- light brown, dry, loose - moist below 1 m	G388
		CLAY - silty, mottled brown and grey, moist, stiff	G389
232	2	SILT - light brown, moist, loose	G390
231	3	CLAY (Glaciolacustrine) - silty - mottled brown and grey - moist, stiff, high plasticity - trace silt inclusions	G391
230	4		G392
229	5	- grey below 5 m	G393
228	6		
227	7	- firm below 7 m	
226	8	T394: PL 23, LL 70, Liquidity Index 0.5 89.8% clay, 9.5% silt, 0.6% sand	T394
225	9		G395
224	10	SILT (TILL) - trace to some clay, trace sand, trace gravel - grey, moist, compact to dense - SPT attempted after refusal, no penetration sampler bouncing	S396 G397



END OF TEST HOLE AT 10.7 m IN SILT(TILL) (AUGER REFUSAL)

NOTES:
1. No sloughing or seepage observed.
2. Upon completion of drilling, test hole open to 10.7 m & dry. After auger refusal, air was blowing out of the test hole.
3. Test hole backfilled with auger cuttings and bentonite chips. Sidewalk patched with concrete.

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

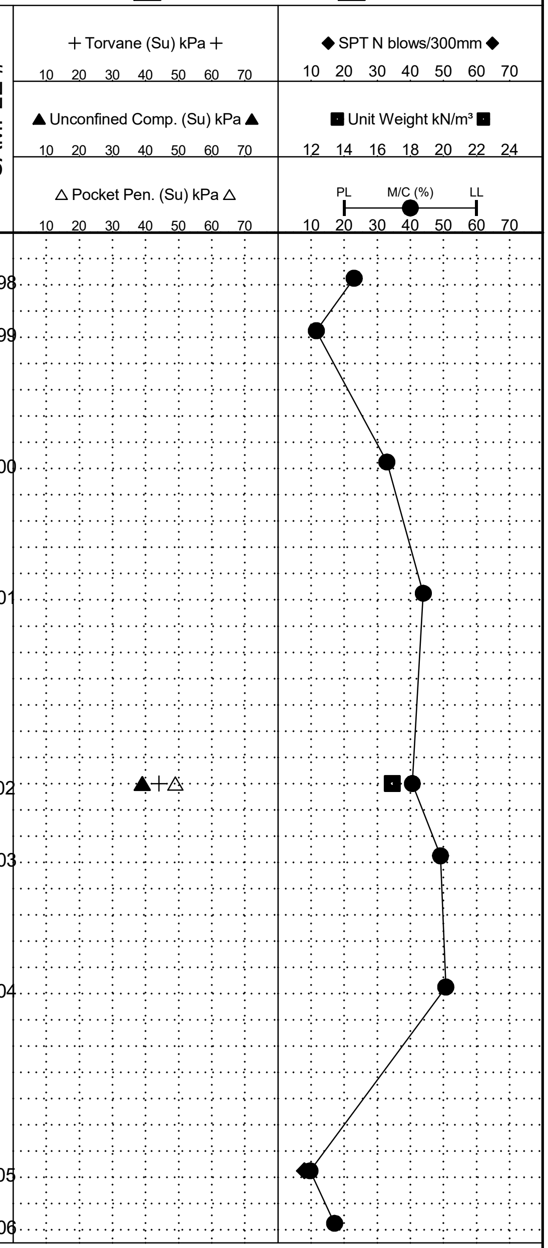
LOGGED BY: CR	COMPLETION DEPTH: 10.67 m
REVIEWED BY: GR	COMPLETION DATE: 1/8/19
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

BH GEOTECH PLOTS-AUGUST 2013 143691.7_RUTLAND TRUNK_GINT.GPJ DATA TEMPLATE - AUGUST 2, 2013.GDT 9/8/20

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-163**
LOCATION: UTM 14U: 5527147 m N, 627802 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS Augers	ELEVATION (m): 234.617

SAMPLE TYPE	GRAB	SHELBY TUBE	SPLIT SPOON	BULK	NO RECOVERY	CORE
BACKFILL TYPE	BENTONITE	GRAVEL	SLOUGH	GROUT	CUTTINGS	SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
		CONCRETE (125 mm thick) - sidewalk		
234		CLAY - silty, trace organics - black, moist, stiff, high plasticity	GRAB	G398
	1	SILT - light brown, loose, moist	GRAB	G399
233		CLAY (Glaciolacustrine) - silty - mottled brown and grey - moist, stiff, high plasticity - trace silt inclusions		
232	2		GRAB	G400
231	3			
230	4		GRAB	G401
229	5	- grey, wet, firm below 5 m		
228	6		SHELBY TUBE	T402
227	7		GRAB	G403
226	8			
225	9		GRAB	G404
224	10	SILT (TILL) -trace to some clay, trace sand, trace gravel - grey, loose, moist - SPT attempted after refusal, no penetration sampler bouncing	SPLIT SPOON	S405
223	11		GRAB	G406



END OF TEST HOLE AT 11.7 m IN SILT(TILL)(AUGER REFUSAL)
Notes:
1. No sloughing or seepage observed.
2. Upon completion of drilling, test hole open to 11.7 m & dry.
2. Test hole backfilled with auger cuttings and bentonite chips.
Sidewalk patched with concrete.

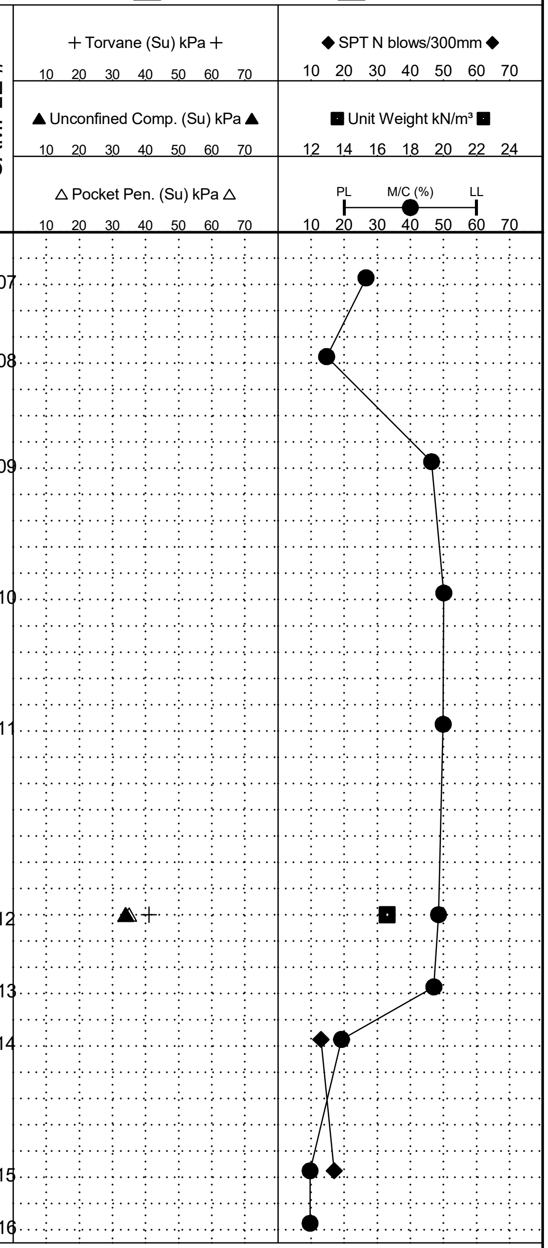
DYREGROV ROBINSON INC. Consulting Geotechnical Engineers	LOGGED BY: CR	COMPLETION DEPTH: 11.73 m
	REVIEWED BY: GR	COMPLETION DATE: 1/8/19
	PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-164**
LOCATION: UTM 14U: 5527192 m N, 627804 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS Augers	ELEVATION (m): 234.641

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
234.6–234.5	0–0.125	CONCRETE (125 mm thick) - sidewalk		
		CLAY - silty, trace organics - black - moist, stiff, high plasticity	GRAB	G407
		SILT - light brown, moist, loose	GRAB	G408
		CLAY (Glaciolacustrine) - silty - mottled brown and grey - moist, stiff, high plasticity - trace silt inclusions	GRAB	G409
			GRAB	G410
			GRAB	G411
		- below 6 m; grey, wet, firm		
		- trace gravel below 8 m	SHELBY TUBE	T412
			GRAB	G413
		SILT (TILL) - trace to some clay, trace sand, trace gravel - grey - moist, loose to compact	SPLIT SPOON	S414
		- compact below 11 m - SPT attempted after refusal, no penetration sampler bouncing	SPLIT SPOON	S415
			GRAB	G416



END OF TEST HOLE AT 11.7 m IN SILT(TILL) (AUGER REFUSAL)

Notes:

1. No sloughing observed during drilling.
2. Some seepage from silt till layer.
3. Upon completion of drilling, test hole open to 11.7 m, water level 6.8 m b/l grade.
4. Test hole backfilled with auger cuttings and bentonite chips.
   Sidewalk patched with concrete.

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

LOGGED BY: CR	COMPLETION DEPTH: 11.73 m
REVIEWED BY: GR	COMPLETION DATE: 2/8/19
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

BH GEOTECH PLOTS-AUGUST 2013 143691.7_RUTLAND TRUNK_GINT.GPJ DATA TEMPLATE - AUGUST 2, 2013.GDT 9/8/20

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-165**
LOCATION: UTM 14U: 5527232 m N, 627806 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS Augers	ELEVATION (m): 234.671

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

Columns: ELEVATION (m) | DEPTH (m) | SOIL SYMBOL | SOIL DESCRIPTION | SAMPLE TYPE | SAMPLE # | + Torvane (Su) kPa + / ▲ Unconfined Comp. (Su) kPa ▲ / △ Pocket Pen. (Su) kPa △ (10 20 30 40 50 60 70) | ◆ SPT N blows/300mm ◆ (10 20 30 40 50 60 70) / ■ Unit Weight kN/m³ ■ (12 14 16 18 20 22 24) / PL M/C (%) LL (10 20 30 40 50 60 70)

SOIL DESCRIPTION

CONCRETE (125 mm thick) - sidewalk

SAND and GRAVEL (FILL, 100 mm thick) - brown, moist

CLAY - silty, trace organics
- black, moist, stiff, high plasticity

SILT - light brown, moist, loose

CLAY (Glaciolacustrine) - silty
- mottled brown and grey
- moist, stiff, high plasticity
- trace silt inclusions

- below 6 m; trace gravel, grey, moist to wet

- trace till inclusions, trace sand, trace gravel below 8.5 m

SILT (TILL) - trace to some clay, trace sand, trace gravel
- grey
- moist, loose to compact with depth

S425) SPT stopped due to sampler bouncing after
15 blows & 150 mm penetration

Samples: G417, G418, G419, G420, T421, G422, G423, S424, S425

Elevation scale: 234, 233, 232, 231, 230, 229, 228, 227, 226, 225, 224, 223

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12

END OF TEST HOLE AT 12.3 m IN SILT(TILL) (AUGER REFUSAL)

Notes:
1. No sloughing or seepage observed during drilling.
2. Upon completion of drilling, test hole open to 11 m b/l grade and water level 9 m b/l grade.
3. Test hole backfilled with auger cuttings and bentonite chips.
Sidewalk patched with concrete.

BH GEOTECH PLOTS-AUGUST 2013 143691.7_RUTLAND TRUNK_GINT.GPJ DATA TEMPLATE - AUGUST 2, 2013.GDT 9/8/20

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

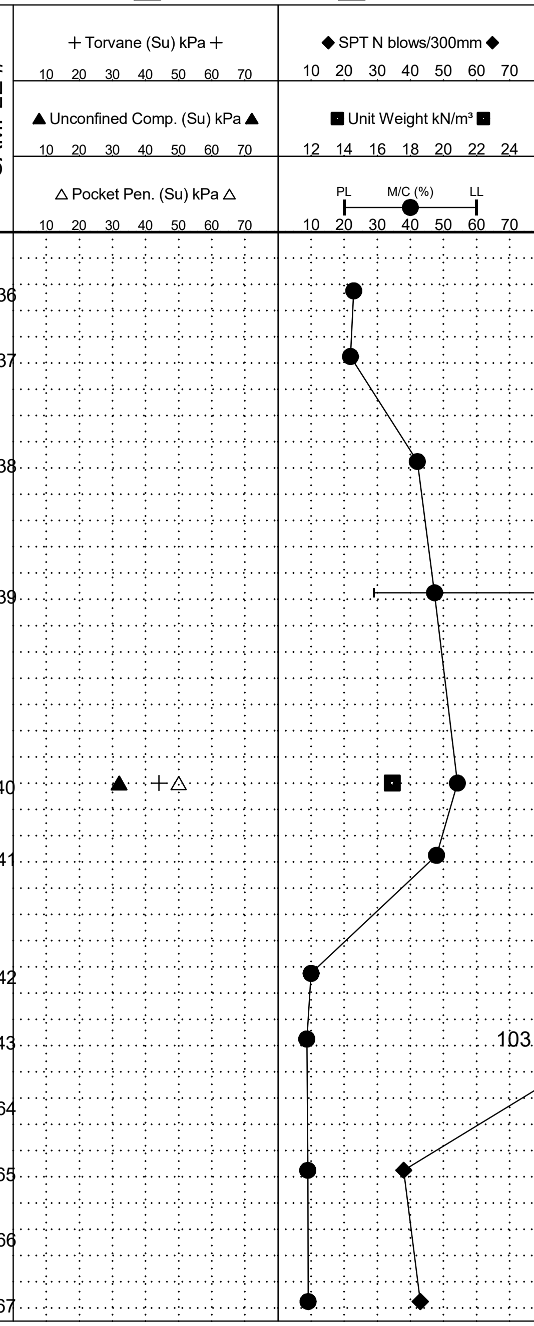
LOGGED BY: CR	COMPLETION DEPTH: 12.34 m
REVIEWED BY: GR	COMPLETION DATE: 2/8/19
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer		CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-166**
LOCATION: UTM 14U: 5527341 m N, 627811 m E			PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER MP8 Drill w/125 mm SS Augers & HQ coring		ELEVATION (m): 234.943

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
234.943	0	TOPSOIL (100 mm thick) - black, dry		
		CLAY - silty, trace organics - black, dry to moist, stiff, high plasticity	GRAB	G436
		SILT - grey, moist, loose	GRAB	G437
		CLAY (Glaciolacustrine) - silty - mottled brown and grey - moist, stiff, high plasticity - trace silt inclusions	GRAB	G438
			GRAB	G439
		G439: PL 29, LL 78, Liquidity Index 0.4 90.9% clay, 8.8% silt, 0.3% sand		
		- below 5.5 m; grey, wet, firm	SHELBY TUBE	T440
			GRAB	G441
		SILT (TILL) - trace to some clay, traces of sand, gravel & cobbles - grey, moist, dense	GRAB	G442
		S443: SPT performed after auger refusal 49.1% silt, 45.5% clay, 5% sand	SPLIT SPOON	S443
			CORE	C564
			SPLIT SPOON	S565
			CORE	C566
			SPLIT SPOON	S567



END OF TEST HOLE AT 12.6 m IN SILT (TILL)

Notes:
1. No sloughing or seepage observed during drilling with augers.
2. Upon completion of drilling with augers, test hole open to 9.6 m b/l grade, dry.
3. Auger refusal occured at 9 m b/l grade, switched to HQ coring with casing advancer.
4. Test hole backfilled with auger cuttings and bentonite chips.

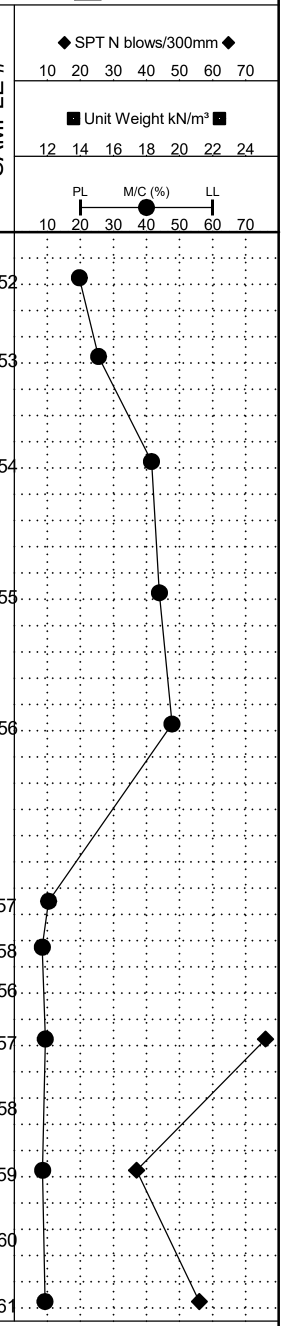
DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

LOGGED BY: CR	COMPLETION DEPTH: 12.65 m
REVIEWED BY: GR	COMPLETION DATE: 2/8/19
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-167**
LOCATION: UTM 14U: 5527394 m N, 627814 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER MP8 Drill w/125 mm SS Augers & HQ coring	ELEVATION (m): 234.591

SAMPLE TYPE	GRAB	SHELBY TUBE	SPLIT SPOON	BULK	NO RECOVERY	CORE
BACKFILL TYPE	BENTONITE	GRAVEL	SLOUGH	GROUT	CUTTINGS	SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
234.591	0	TOPSOIL (50 mm thick) - black, dry		
		CLAY (Glaciolacustrine) - silty - mottled brown and grey - moist, stiff, high plasticity - trace silt inclusions	GRAB	G452
			GRAB	G453
			GRAB	G454
			GRAB	G455
		- grey below 5.5 m	GRAB	G456
		Below 7 m: trace sand, trace gravel, trace till inclusions		
		SILT (TILL) - trace to some clay, trace sand, trace gravel - grey, moist, loose	SHELBY TUBE	T457
		S458) SPT stopped, sampler bouncing after 81 blows & 180 mm penetration	SPLIT SPOON	S458
		- dense to very dense below 8.2 m	CORE	C556
			SPLIT SPOON	S557
			CORE	C558
			SPLIT SPOON	S559
			CORE	C560
			SPLIT SPOON	S561



END OF TEST HOLE AT 12.6 m IN SILT (TILL)

Notes:

1. No sloughing or seepage observed during drilling with augers.
2. Upon completion of drilling with augers, test hole open to 8.5 m b/l grade, dry.
3. Auger refusal occured at 8.5 m b/l grade, switched to HQ coring with casing advancer.
4. Test hole backfilled with auger cuttings and bentonite chips.

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

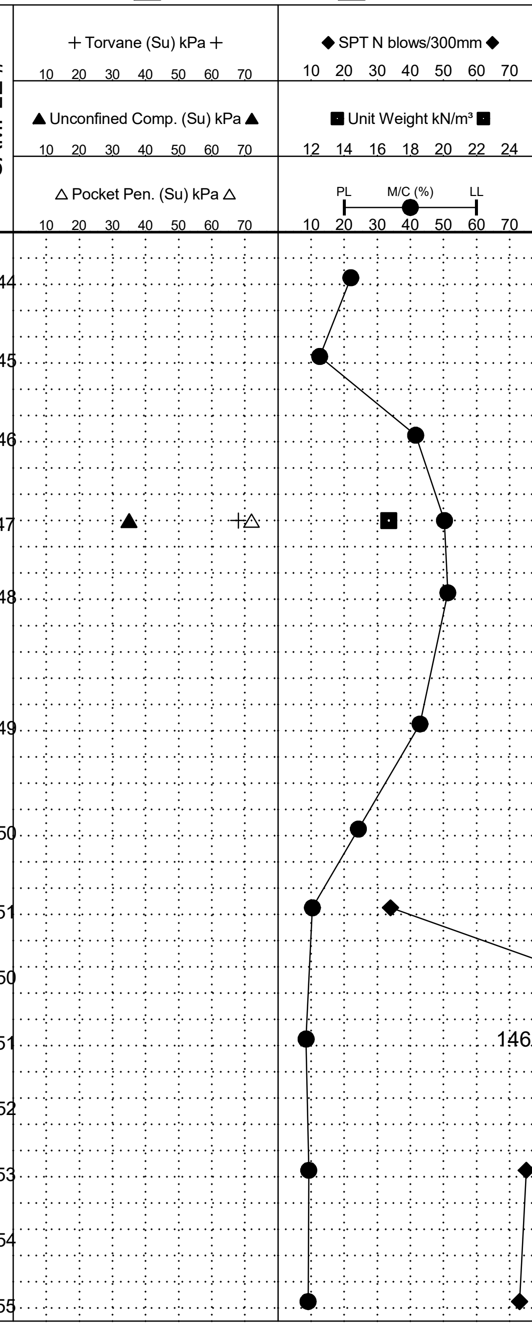
LOGGED BY: CR	COMPLETION DEPTH: 12.65 m
REVIEWED BY: GR	COMPLETION DATE: 14/8/19
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-168**
LOCATION: UTM 14U: 5527447 m N, 627814 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER MP8 Drill w/125 mm SS Augers & HQ coring	ELEVATION (m): 234.971

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE #
	0	TOPSOIL (150 mm thick) - black, dry	
		CLAY - silty, trace organics - black, dry, stiff, high plasticity	G444
234	1	SILT - light brown, dry, loose	G445
233	2	CLAY (Glaciolacustrine) - silty - mottled brown and grey - moist, stiff, high plasticity - trace silt inclusions	G446
232	3		T447
231	4		G448
230	5		
229	6	- grey below 6 m	G449
228	7	Below 7 m: trace sand, trace gravel, trace till inclusions	G450
227	8	SILT (TILL) - trace to some clay, some sand and gravel, trace cobbles - brown - moist, compact to dense	S451, C550
226	9	- dense to very dense below 9 m	S551
225	10		C552
224	11		S553
223	12		C554, S555



END OF TEST HOLE AT 12.6 m IN SILT(TILL)

Notes:

1. No sloughing. Slight seepage observed at 8 m.
2. Auger refusal occured at 8 m b/l grade, switched to HQ coring with casing advancer.
3. After drilling to auger refusal, test hole open to 8 m, water level 7.9 m b/l grade.
4. Test hole backfilled with auger cuttings and bentonite chips.

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

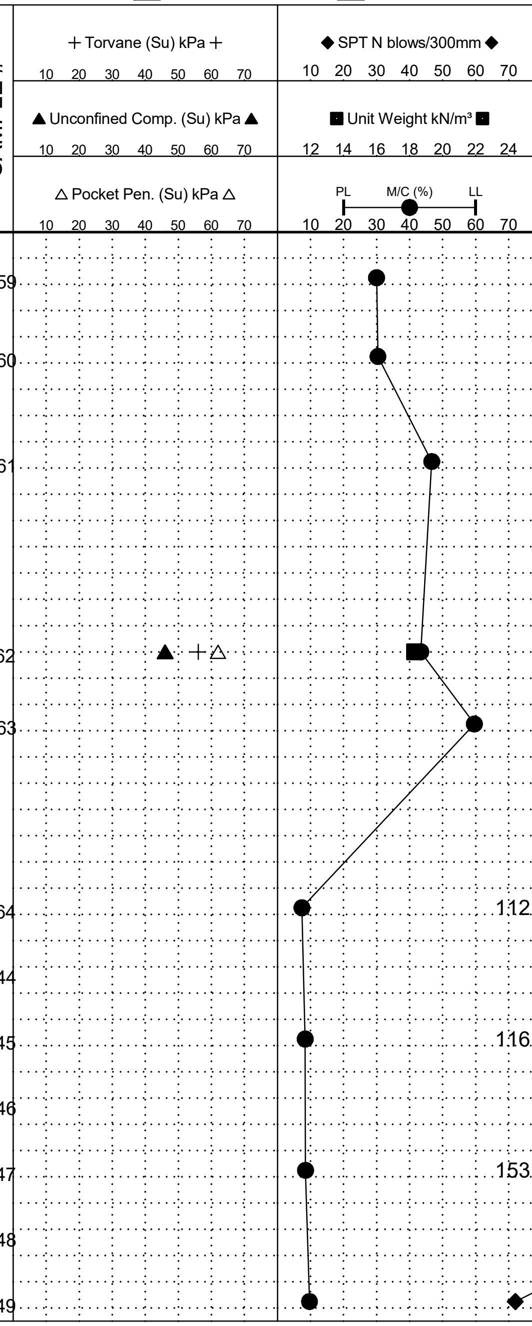
LOGGED BY: CR	COMPLETION DEPTH: 12.65 m
REVIEWED BY: GR	COMPLETION DATE: 14/8/19
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-169**
LOCATION: UTM 14U: 5527517 m N, 627817 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER MP8 Drill w/125 mm SS Augers & HQ coring	ELEVATION (m): 234.916

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
		TOPSOIL (300 mm thick) - black, moist		
234	1	CLAY (Glaciolacustrine) - silty - black with trace organics to 1.8 m - mottled brown / grey below 1.8 m - moist, stiff, high plasticity - trace silt inclusions	GRAB	G459
233	2		GRAB	G460
232	3		GRAB	G461
231	4			
230	5	- below 5 m; trace sand, trace gravel	SHELBY TUBE	T462
229	6	- grey below 5.5 m	GRAB	G463
228	7	SILT (TILL) - trace to some clay, trace sand, trace gravel, trace cobbles - grey - moist - loose to compact becoming very dense below 7.5 m		
227	8		SPLIT SPOON	S464
226	9		CORE	C544
			SPLIT SPOON	S545
225	10		CORE	C546
224	11		SPLIT SPOON	S547
223	12		CORE	C548
			SPLIT SPOON	S549



END OF TEST HOLE AT 12.6 m IN SILT (TILL)
Notes:
1. No sloughing or seepage observed during drilling with augers.
2. High SPT-N at 8 m, switched to HQ coring with casing advancer.
3. Test hole backfilled with auger cuttings and bentonite chips.

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

LOGGED BY: CR	COMPLETION DEPTH: 12.65 m
REVIEWED BY: GR	COMPLETION DATE: 14/8/19
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

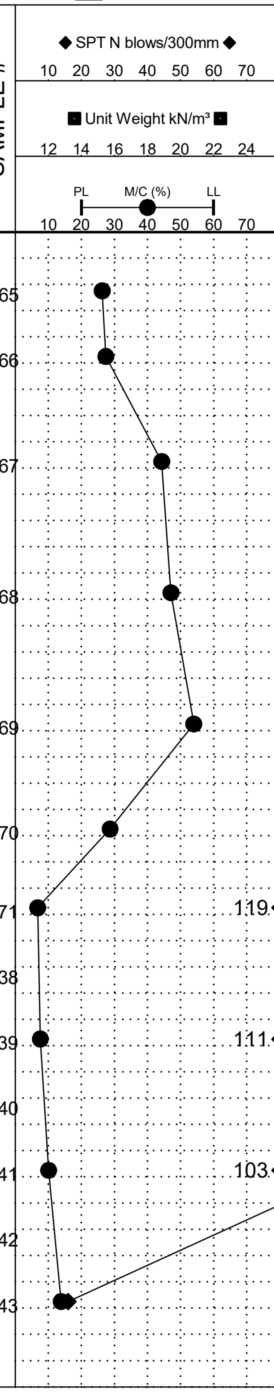
PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-170**
LOCATION: UTM 14U: 5527560 m N, 627819 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER MP8 Drill w/125 mm SS Augers & HQ coring	ELEVATION (m): 235.008

SAMPLE TYPE	GRAB	SHELBY TUBE	SPLIT SPOON	BULK	NO RECOVERY	CORE
BACKFILL TYPE	BENTONITE	GRAVEL	SLOUGH	GROUT	CUTTINGS	SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION
	0	TOPSOIL (50mm thick) - black, moist
		CLAY (Glaciolacustrine) - silty - black with trace organics to 1.5 m - mottled brown / grey below 1.5 m - moist, stiff, high plasticity - trace silt inclusions
230	5	- grey below 5 m
228	7	SILT (TILL) - trace to some clay, traces of sand, gravel, cobbles & boulders - grey - moist, loose - dry to moist, very dense below 7.5 m
224	11	Below 11 m: - casing advancing relatively easy below 11 m - wet, loose to compact After SPT (S543), split barrel sampler driven to 13.4 m with no refusal Below 12.2 m: wet, loose

Elevation scale (m): 234, 233, 232, 231, 230, 229, 228, 227, 226, 225, 224, 223, 222
Depth scale (m): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13

SAMPLE TYPE	SAMPLE #
Grab	G465
Grab	G466
Grab	G467
Grab	G468
Grab	G469
Grab	G470
Split spoon	S471
Core	C538
Split spoon	S539
Core	C540
Split spoon	S541
Core	C542
Split spoon	S543



END OF TEST HOLE AT 13.4 m IN SILT (TILL)
Notes:
1. No sloughing or seepage observed during drilling with augers.
2. Upon completion of drilling with augers, test hole open to 7.4 m b/l grade, dry.
3. Auger refusal occured at 8 m b/l grade, switched to HQ coring with casing advancer.
4. Test hole backfilled with auger cuttings and bentonite chips.

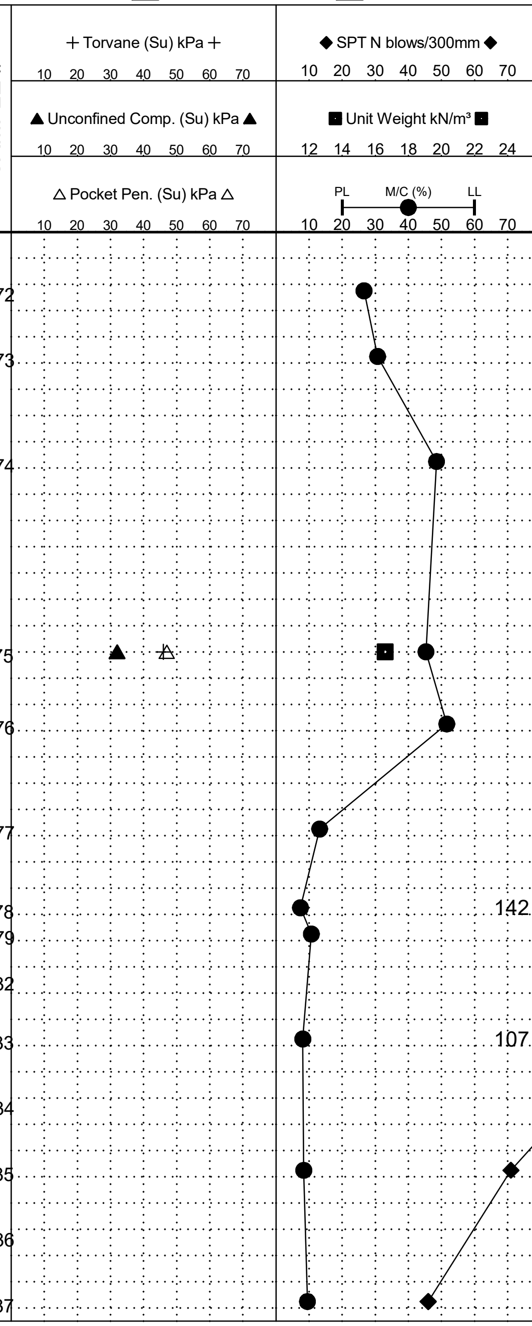
DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

LOGGED BY: CR	COMPLETION DEPTH: 13.41 m
REVIEWED BY: GR	COMPLETION DATE: 15/8/19
PROJECT ENGINEER: Gil Robinson	

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-171**
LOCATION: UTM 14U: 5527597 m N, 627820 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER MP8 Drill w/125 mm SS Augers & HQ coring	ELEVATION (m): 234.987

SAMPLE TYPE	GRAB	SHELBY TUBE	SPLIT SPOON	BULK	NO RECOVERY	CORE
BACKFILL TYPE	BENTONITE	GRAVEL	SLOUGH	GROUT	CUTTINGS	SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
	0	TOPSOIL (75 mm thick) - black, moist		
		CLAY (Glaciolacustrine) - silty - black with trace organics to 1.5 m - mottled brown/grey below 1.5 m - moist, stiff, high plasticity - trace silt inclusions	GRAB	G472
234	1		GRAB	G473
233	2			
232	3		GRAB	G474
231	4			
230	5	Below 5 m: grey, firm, trace sand, trace gravel	SHELBY TUBE	T475
229	6		GRAB	G476
228	7	SILT (TILL) - trace to some clay, trace sand, trace gravel, trace cobbles - grey - moist to wet, loose - dry to moist, very dense below 7.6 m	GRAB	G477
227	8		SPLIT SPOON	S478
			GRAB	G479
226	9		CORE	C532
			SPLIT SPOON	S533
225	10		CORE	C534
224	11		SPLIT SPOON	S535
223	12		CORE	C536
		- moist, dense below 12 m	SPLIT SPOON	S537



END OF TEST HOLE AT 12.6 m IN SILT(TILL)

Notes:

1. No sloughing or seepage observed during drilling with augers.
2. Upon completion of drilling with augers, test hole open to 8.2 m b/l grade, dry.
3. Auger refusal occured at 8.2 m b/l grade, switched to HQ coring with casing advancer.
4. Test hole backfilled with auger cuttings and bentonite chips.

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

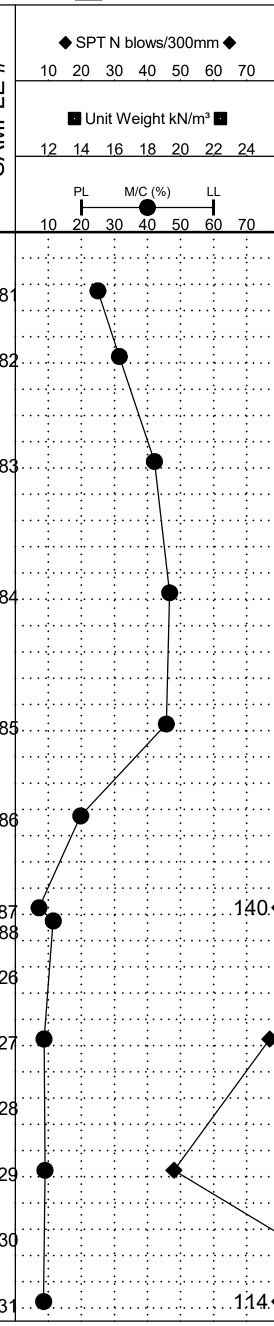
LOGGED BY: CR	COMPLETION DEPTH: 12.65 m
REVIEWED BY: GR	COMPLETION DATE: 19/8/19
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-172**
LOCATION: UTM 14U: 5527626 m N, 627821 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER MP8 Drill w/125 mm SS Augers & HQ coring	ELEVATION (m): 235.066

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE #
		TOPSOIL (75 mm thick) - black, moist	
		CLAY (Glaciolacustrine) - silty - black with trace organics to 1.8 m - mottled brown/grey below 1.8 m - moist, stiff, high plasticity - trace silt inclusions	G481
234	1		G482
233	2		
232	3		G483
231	4		G484
230	5		
229	6	- grey below 5.5 m	G485
		SILT (TILL) - trace to some clay, traces of sand, gravel, cobbles & boulders - grey - moist, loose - dry to moist, dense to very dense below 7.5 m	G486
228	7		
227	8		S487, G488, C526
226	9		S527
225	10		C528
224	11		S529
223	12		C530, S531



END OF TEST HOLE AT 12.6 m IN SILT(TILL)

Notes:
1. No sloughing or seepage observed during drilling with augers.
2. High SPT-N at 7.5 m, switched to HQ coring with casing advancer.
3. Test hole backfilled with auger cuttings and bentonite chips.

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

LOGGED BY: CR	COMPLETION DEPTH: 12.65 m
REVIEWED BY: GR	COMPLETION DATE: 15/8/19
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-173**
LOCATION: UTM 14U: 5527675 m N, 627823 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER MP8 Drill w/125 mm SS Augers & HQ coring	ELEVATION (m): 235.162

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SLOTTED PIEZOMETER	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #

TOPSOIL (75 mm thick) - black, moist

CLAY (Glaciolacustrine) - silty
- black with trace organics to 1.8 m
- mottled brown / grey below 1.8 m
- moist, stiff, high plasticity
- trace silt inclusions

G492: PL 26, LL 78, Liquidity Index 0.3
93.8% clay, 5.8% silt, 0.4% sand

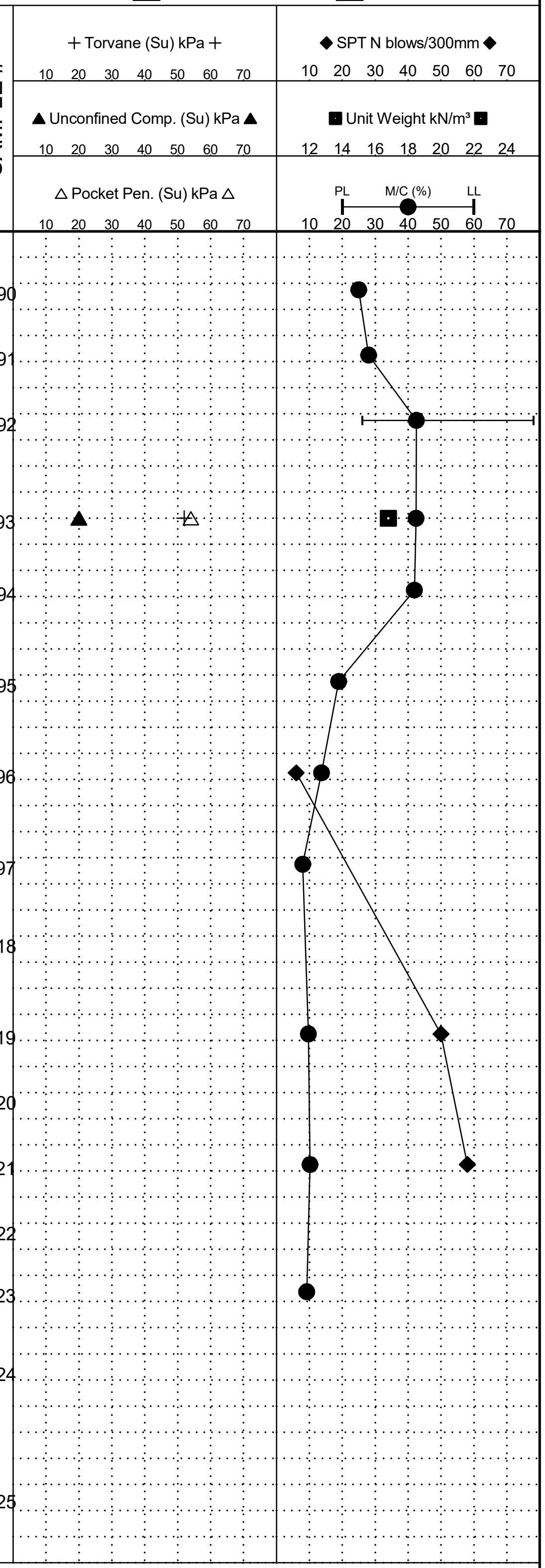
SILT (TILL) - trace to some clay, traces of sand, gravel, cobbles & boulders
- grey
- moist to wet, loose
- moist, dense to very dense below 7 m

S496: 55.3% silt, 39.5% clay, 4.7% sand
S497) SPT stopped, sampler bouncing after 50 blows & 150 mm penetration

S523) SPT stopped, sampler bouncing after 39 blows for 380 mm penetration

BEDROCK
- Red River Formation, Upper Fort Garry Member (dolomite)
- poor to good quality, good below 14 m
- whitish grey color, strong to very strong
- horizontal fractures
- close to moderately close discontinuity spacing
- gapped joint apeture, evidence of water flow (Class 3)
- 3 mm thick clay filling at 13.7 m and 13.9 m
- trace small vugs (< 0.5mm)

Samples: G490, G491, G492, T493, G494, G495, S496, S497, C518, S519, C520, S521, C522, S523, C524, C525



DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

LOGGED BY: CR	COMPLETION DEPTH: 15.54 m
REVIEWED BY: GR	COMPLETION DATE: 15/8/19
PROJECT ENGINEER: Gil Robinson	Page 1 of 2

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-173**
LOCATION: UTM 14U: 5527675 m N, 627823 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER MP8 Drill w/125 mm SS Augers & HQ coring	ELEVATION (m): 235.162

SAMPLE TYPE	GRAB	SHELBY TUBE	SPLIT SPOON	BULK	NO RECOVERY	CORE
BACKFILL TYPE	BENTONITE	GRAVEL	SLOUGH	GROUT	CUTTINGS	SAND

ELEVATION (m)	DEPTH (m)	SLOTTED PIEZOMETER	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	+ Torvane (Su) kPa + 10 20 30 40 50 60 70 / ▲ Unconfined Comp. (Su) kPa ▲ 10 20 30 40 50 60 70 / △ Pocket Pen. (Su) kPa △ 10 20 30 40 50 60 70	◆ SPT N blows/300mm ◆ 10 20 30 40 50 60 70 / ■ Unit Weight kN/m³ ■ 12 14 16 18 20 22 24 / PL M/C (%) LL 10 20 30 40 50 60 70

END OF TEST HOLE AT 15.5 m IN BEDROCK
Notes:
1. No sloughing or seepage observed during driling with augers.
2. Upon completion of drilling with augers, test hole open to 7.5 m b/l grade, dry.
3. Auger refusal occured at 7.5 m, switched to HQ coring with casing advancer.
4. 25 mm PVC Standpipe piezometer w/ Cassagrande tip installed 15.5 m b/l grade.
Top of pipe (T.O.P) 0.05 m below grade.
Water levels:
Sept 23, 2019: 8.43 m below T.O.P. - Ground water elevation - 226.68 m
Nov 13, 2019: 6.44 m below T.O.P. - Ground water elevation - 228.67 m
May 25, 2020: 7.65 m below T.O.P. - Ground water elevation - 227.46 m

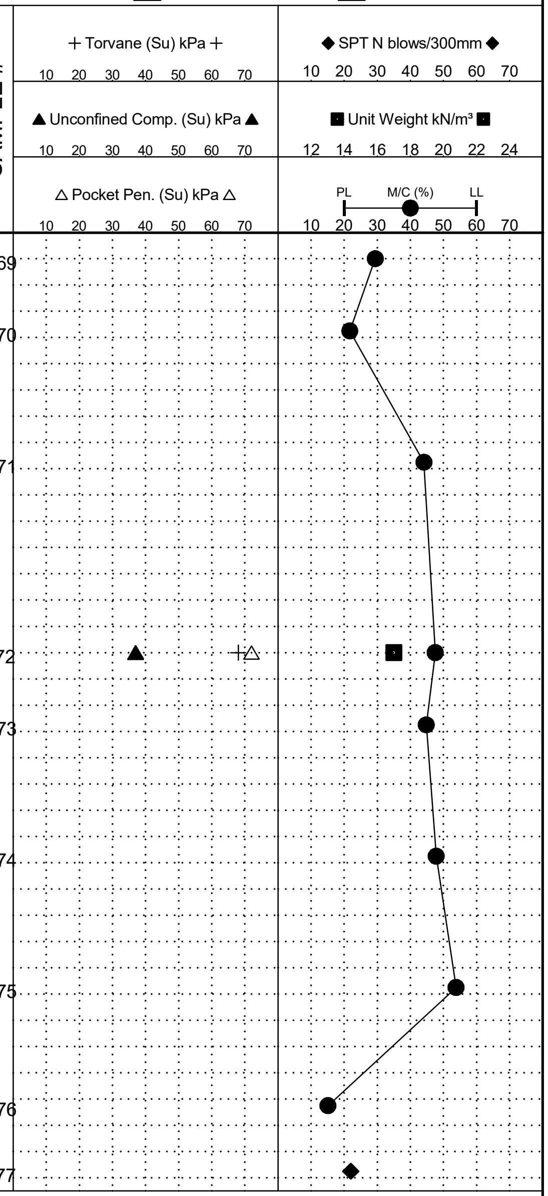
DYREGROV ROBINSON INC. Consulting Geotechnical Engineers	LOGGED BY: CR	COMPLETION DEPTH: 15.54 m
	REVIEWED BY: GR	COMPLETION DATE: 15/8/19
	PROJECT ENGINEER: Gil Robinson	Page 2 of 2

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-239**
LOCATION: UTM 14U: 5526983 m N, 627796 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS Augers	ELEVATION (m): 234.085

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
		CONCRETE (125 mm thick)		
		SAND and GRAVEL (FILL, 100 mm thick) - brown	GRAB	G369
233	1	CLAY - silty, trace organics - black, moist, stiff, high plasticity	GRAB	G370
		SILT - light brown, moist to wet, loose		
232	2	CLAY (Glaciolacustrine) - silty - mottled brown and grey - moist, stiff, high plasticity - trace silt inclusions	GRAB	G371
229	5		SHELBY TUBE	T372
228	6		GRAB	G373
228	6	- grey below 6 m		
227	7		GRAB	G374
225	9		GRAB	G375
224	10	SILT (TILL) - trace to some clay, trace sand, trace gravel - grey, wet, loose becoming compact with depth	GRAB	G376
223	11		SPLIT SPOON	S377



END OF TEST HOLE AT 11.1 m IN SILT(TILL) (AUGER REFUSAL)

NOTES:

1. Some sloughing and seepage observed silt layer 0.6 m.
2. Upon completion of drilling, test hole open to 11 m b/l grade, water level 7.9 m b/l grade.
4. 25 mm PVC Standpipe piezometer w/ Cassagrande tip installed 11.0 m b/l grade. Top of pipe (T.O.P) 0.05 m below grade.

Water levels:
Sept 23, 2019: 7.66 m below T.O.P. - Ground water elevation - 226.37 m
Nov 13, 2019: 5.50 m below T.O.P. - Ground water elevation - 228.53 m
May 25, 2020: 6.94 m below T.O.P. - Ground water elevation - 227.09 m

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

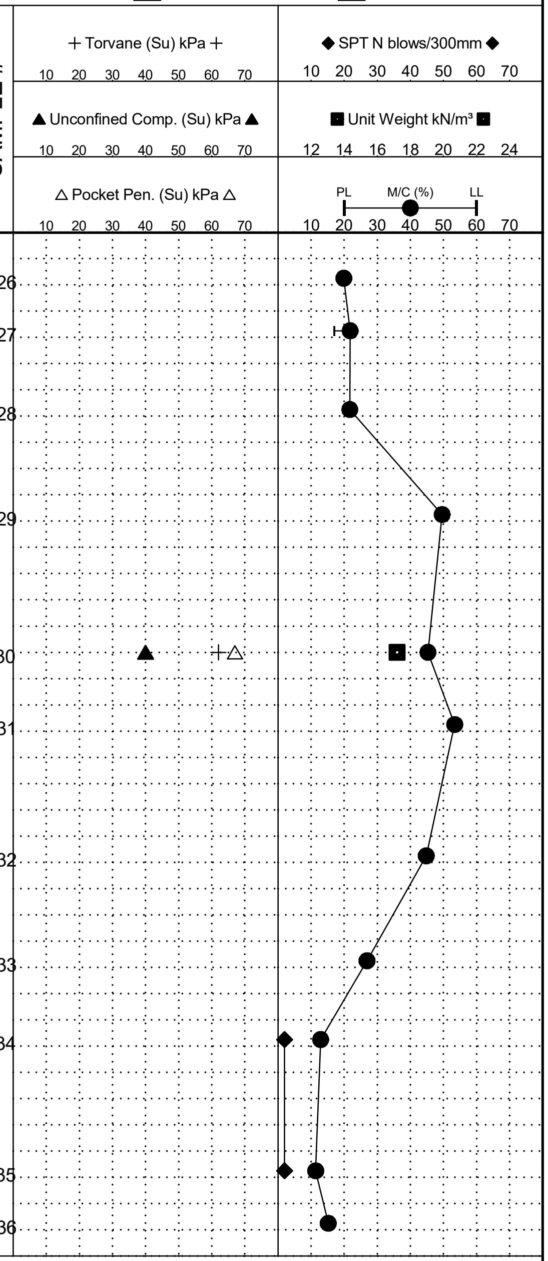
LOGGED BY: CR	COMPLETION DEPTH: 11.13 m
REVIEWED BY: GR	COMPLETION DATE: 1/8/19
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-240**
LOCATION: UTM 14U: 5527296 m N, 627809 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS Augers	ELEVATION (m): 235.113

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE / SAMPLE #
235	0	CLAY - silty, trace organics - black, moist, stiff	
		SILT - light brown, moist, loose, low plasticity G427: PL 17, LL 22, Liquidity Index 1.0	G426, G427, G428
		CLAY (Glaciolacustrine) - silty - mottled brown and grey - moist, stiff, high plasticity - trace silt inclusions	G429
230	5	- trace sand, trace gravel below 5 m	T430
		- grey, wet below 5.5 m	G431, G432
227	8	- trace to some till inclusions below 8 m	G433
226	9	SILT (TILL) - trace to some clay, trace sand, trace gravel - grey - wet, very loose to loose	S434, S435
		- SPT attempted after refusal, no penetration sampler bouncing	G436



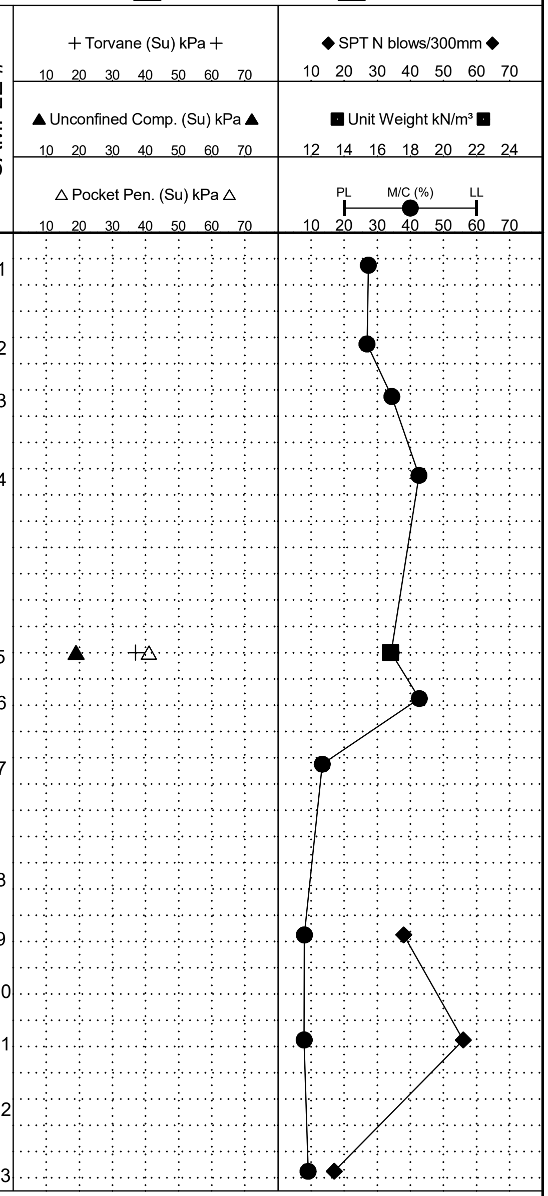
END OF TEST HOLE AT 11.9 m IN SILT(TILL) (AUGER REFUSAL)
NOTES:
1. Sloughing observed from silt till layer below 9.4 m.
2. No seepage observed during drilling.
3. Upon completion of drilling test hole open to 9.4 m, dry.
4. 25 mm PVC Standpipe piezometer w/ Cassagrande tip installed 9.4 m b/l grade.
Top of pipe (T.O.P) 0.05 m below grade.
Water levels:
Sept 23, 2019: 8.45 m below T.O.P. - Ground water elevation - 226.61 m
Nov 13, 2019: 7.80 m below T.O.P. - Ground water elevation - 227.26 m
May 25, 2020: 6.45 m below T.O.P. - Ground water elevation - 228.61 m

DYREGROV ROBINSON INC. Consulting Geotechnical Engineers	LOGGED BY: CR	COMPLETION DEPTH: 11.89 m
	REVIEWED BY: GR	COMPLETION DATE: 2/8/19
	PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **20-244**
LOCATION: UTM 14: 5527747 m N, 627803 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER MP8 Drill w/125 mm SS Augers & HQ coring	ELEVATION (m): 235.222

SAMPLE TYPE	GRAB	SHELBY TUBE	SPLIT SPOON	BULK	NO RECOVERY	CORE
BACKFILL TYPE	BENTONITE	GRAVEL	SLOUGH	GROUT	CUTTINGS	SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
235	0	TOPSOIL (100mm thick) - black, moist		
		CLAY (Glaciolacustrine) - silty, trace sand, trace gravel - black with trace organics to 0.6 m - mottled brown and grey below 0.6 m - moist, stiff, high plasticity - trace silt inclusions	GRAB	G1
234	1		GRAB	G2
233	2		GRAB	G3
232	3		GRAB	G4
231	4	Below 4 m: trace till inclusions, intermediate to high plasticity		
230	5		SHELBY TUBE	T5
		SILT (Till) - trace clay to clayey, trace sand, trace gravel, trace cobbles, trace boulders - brown - moist, dense G7: Silt 53.5%, Clay 43.1%, Sand 3.2%	GRAB	G6
229	6		GRAB	G7
228	7		CORE	C8
227	8		SPLIT SPOON	S9
226	9		CORE	C10
			SPLIT SPOON	S11
225	10	- compact below 10 m	CORE	C12
	11		SPLIT SPOON	S13



END OF TEST HOLE AT 11.1 m IN SILT (TILL)

Notes:

1. No sloughing or seepage observed during drilling with augers.
2. Auger refusal at 7 m b/l grade, switched to HQ coring with casing advancer.
3. Test hole backfilled with auger cuttings and bentonite chips.

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

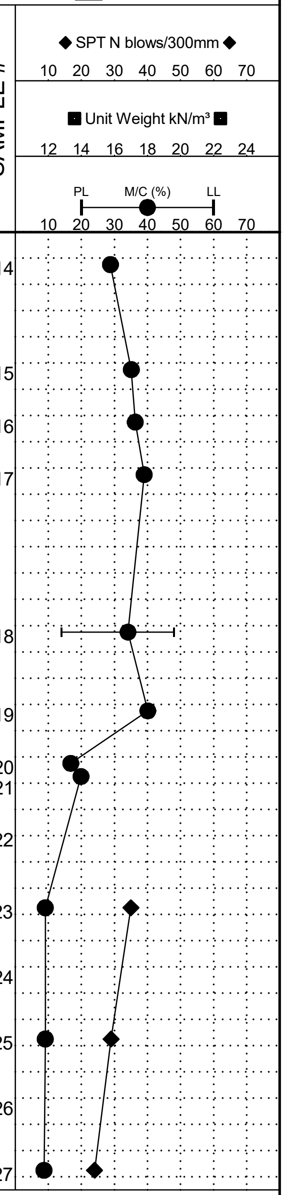
LOGGED BY: CR	COMPLETION DEPTH: 11.13 m
REVIEWED BY: GR	COMPLETION DATE: 11/12/20
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **20-245**
LOCATION: UTM 14U: 5527833 m N, 627830 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER MP8 Drill w/125 mm SS Augers & HQ coring	ELEVATION (m): 235.305

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
235	0	TOPSOIL (150mm thick) - black, moist		
		CLAY (Glaciolacustrine) - silty, trace sand, trace gravel - black with trace organics to 0.6 m - mottled brown and grey below 0.6 m - moist, stiff - high plasticity - trace silt inclusions	GRAB	G14
234	1		GRAB	G15
233	2		GRAB	G16
232	3		GRAB	G17
231	4	- intermediate to high plasticity below 4 m G18: PL 14, LL 48, Liquidity Index 0.6	GRAB	G18
230	5		GRAB	G19
229	6	SILT (Till) - trace clay to clayey, trace sand, trace gravel, trace cobbles - brown - loose, wet G20: Clay 49.6%, Silt 46.9%, Sand 3.3%	GRAB	G20, G21
228	7		CORE	C22
227	8	- compact, moist below 7.5 m	SPLIT SPOON	S23
226	9		CORE	C24
			SPLIT SPOON	S25
225	10		CORE	C26
	11		SPLIT SPOON	S27



END OF TEST HOLE AT 11.1 m IN SILT (TILL)

Notes:

1. Frozen to 0.2 m.
2. No sloughing or seepage observed during drilling with augers.
3. Auger refusal at 6.4 m b/l grade, switched to HQ coring with casing advancer.
4. Test hole backfilled with auger cuttings and bentonite chips.

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

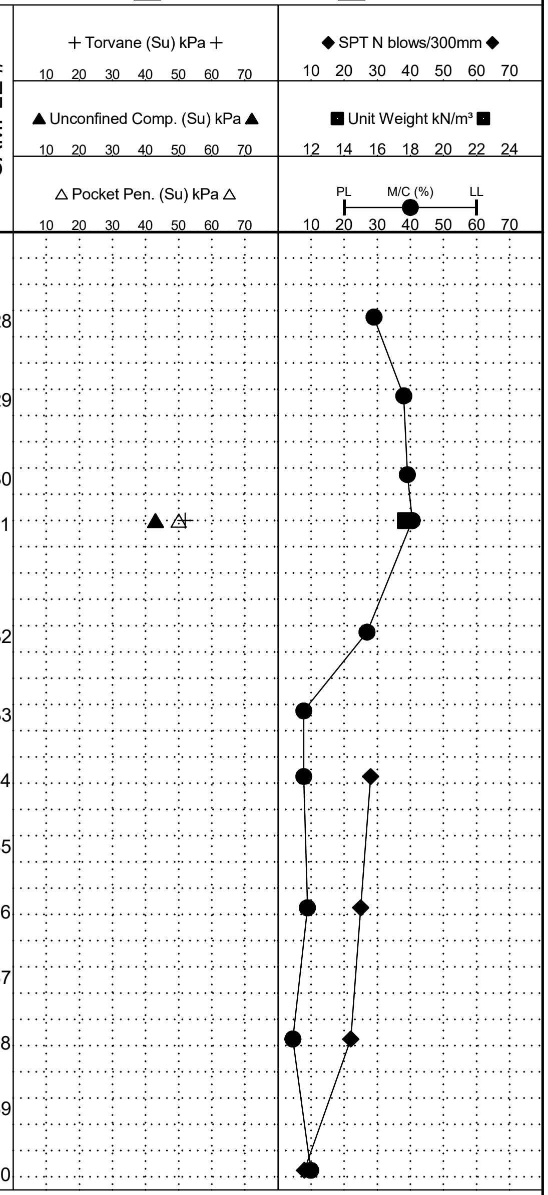
LOGGED BY: CR	COMPLETION DEPTH: 11.13 m
REVIEWED BY: GR	COMPLETION DATE: 11/12/20
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **20-246**
LOCATION: UTM 14U: 5527903 m N, 627832 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER MP8 Drill w/125 mm SS Augers & HQ coring	ELEVATION (m): 235.43

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE / SAMPLE #
235.43 – 235.33	0 – 0.1	TOPSOIL (100mm thick) - black, moist	
235.33 – 229.93	0.1 – 5.5	CLAY (Glaciolacustrine) - silty, trace sand, trace gravel - black with trace organics to 0.6 m - mottled brown and grey below 0.6 m - moist, stiff, high plasticity - trace silt inclusions - intermediate to high plasticity below 4 m	G28, G29, G30 (grab); T31 (Shelby tube); G32 (grab)
229.93 – 224.3	5.5 – 11.1	SILT (Till) - trace clay to clayey, trace sand, trace gravel, trace cobbles - brown - moist, compact S36: Silt 59%, Clay 32.8%, Sand 7.6% - loose, moist to wet below 10 m	G33 (grab); S34 (split spoon); C35 (core); S36 (split spoon); C37 (core); S38 (split spoon); C39 (core); S40 (split spoon)



END OF TEST HOLE AT 11.1 m IN SILT (TILL)

Notes:

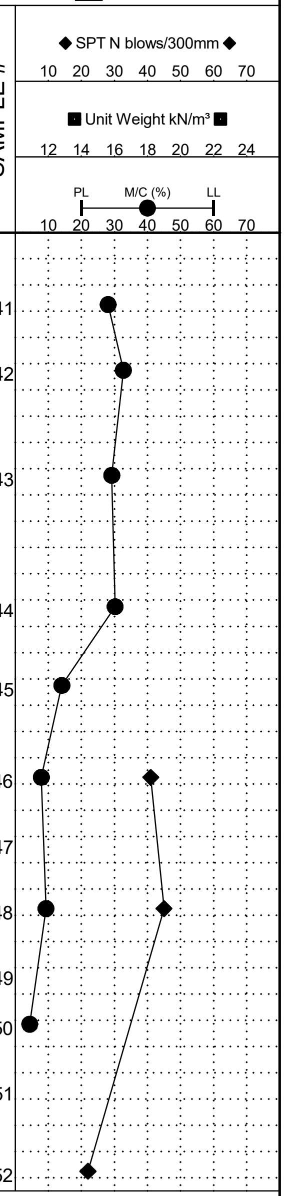
1. Frozen to 0.3 m.
2. No sloughing or seepage observed during drilling with augers.
3. Auger refusal at 6.7 m b/l grade, switched to HQ coring with casing advancer.
4. Test hole backfilled with auger cuttings and bentonite chips.

DYREGROV ROBINSON INC. Consulting Geotechnical Engineers	LOGGED BY: CR	COMPLETION DEPTH: 11.13 m
	REVIEWED BY: GR	COMPLETION DATE: 14/12/20
	PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **20-247**
LOCATION: UTM 14 U: 5527984 m N, 627840 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER MP8 Drill w/125 mm SS Augers & HQ coring	ELEVATION (m): 235.641

SAMPLE TYPE	GRAB	SHELBY TUBE	SPLIT SPOON	BULK	NO RECOVERY	CORE
BACKFILL TYPE	BENTONITE	GRAVEL	SLOUGH	GROUT	CUTTINGS	SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
	0	TOPSOIL (150mm thick) - black, moist		
235		CLAY (Glaciolacustrine) - silty, trace sand, trace gravel - black with trace organics to 0.6 m - mottled brown and grey below 0.6 m - moist, stiff, high plasticity - trace silt inclusions	GRAB	G41
234	2		GRAB	G42
233	3		GRAB	G43
231	4		GRAB	G44
230	5	SILT (Till) - trace clay to clayey, trace sand, trace gravel, trace cobbles, trace boulders - brown - moist, dense S46: Silt 49.6%, Clay 44%, Sand 6%	GRAB	G45
229	6		SPLIT SPOON	S46
228	7		CORE	C47
228	8		SPLIT SPOON	S48
227	9		CORE	C49
226	9	S50) SPT Stopped, sampler bouncing after 32 blows for 75 mm penetration	SPLIT SPOON	S50
225	10	- compact below 10 m	CORE	C51
225	11	S52) No recovery, sampler blocked by stone	SPLIT SPOON	S52



END OF TEST HOLE AT 11.1 m IN SILT (TILL)

Notes:

1. Frozen to 0.3 m.
2. No sloughing or seepage observed during drilling with augers.
3. Auger refusal at 6 m b/l grade, switched to HQ coring with casing advancer.
4. Test hole backfilled with auger cuttings and bentonite chips.

BH GEOTECH PLOTS-AUGUST 2013 143691.7_RUTLAND TRUNK_GINT.GPJ DATA TEMPLATE - AUGUST 2, 2013.GDT 26/4/21

DYREGROV ROBINSON INC. Consulting Geotechnical Engineers	LOGGED BY: CR	COMPLETION DEPTH: 11.13 m
	REVIEWED BY: GR	COMPLETION DATE: 14/12/20
	PROJECT ENGINEER: Gil Robinson	Page 1 of 1

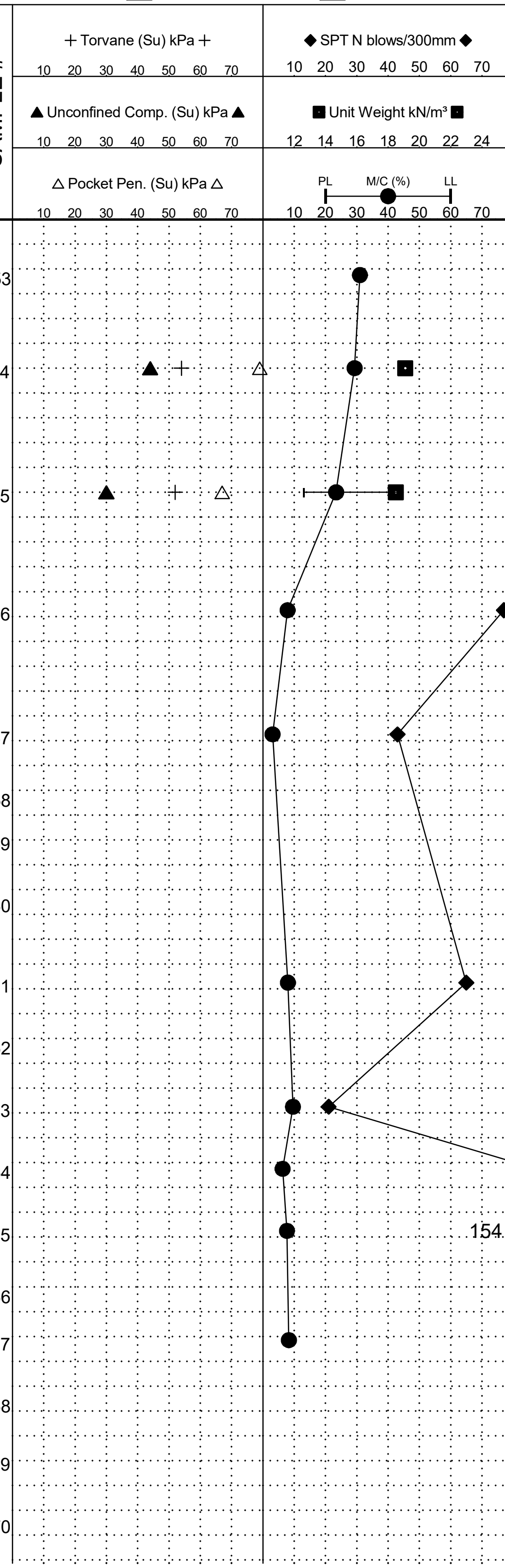
PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **20-248**
LOCATION: UTM 14: 5528050 m N, 627842 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER MP8 Drill w/125 mm SS Augers & HQ coring	ELEVATION (m): 236.028

SAMPLE TYPE	GRAB	SHELBY TUBE	SPLIT SPOON	BULK	NO RECOVERY	CORE
BACKFILL TYPE	BENTONITE	GRAVEL	SLOUGH	GROUT	CUTTINGS	SAND

ELEVATION (m) | DEPTH (m) | SLOTTED PIEZOMETER | SOIL SYMBOL | SOIL DESCRIPTION | SAMPLE TYPE | SAMPLE #

Depth (m)	Soil Description
0.0	TOPSOIL (150mm thick) - black, moist
0.15	CLAY (Glaciolacustrine) - silty, trace sand, trace gravel - black with trace organics to 0.9 m - mottled brown and grey below 0.9 m - moist, stiff, high plasticity - trace silt inclusions Below 3m: - trace till inclusions, intermediate to high plasticity T55: PL 13, LL 43, Liquidity Index 0.3
4.0	SILT (Till) - trace clay to clayey, trace sand, trace gravel, trace cobbles - brown - moist, dense S56: Silt 59.5%, Clay 31.8%, Sand 7.8% S59) SPT stopped, sampler bouncing, no penetration. S67) SPT Stopped, sampler bouncing after 50 blows for 75 mm penetration

Samples: G53, T54, T55, S56, S57, C58, S59, C60, S61, C62, S63, C64, S65, C66, S67, C68, S69, C70



DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

LOGGED BY: CR	COMPLETION DEPTH: 16.76 m
REVIEWED BY: GR	COMPLETION DATE: 18/12/20
PROJECT ENGINEER: Gil Robinson	Page 1 of 2

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **20-248**
LOCATION: UTM 14: 5528050 m N, 627842 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER MP8 Drill w/125 mm SS Augers & HQ coring	ELEVATION (m): 236.028

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SLOTTED PIEZOMETER	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	+ Torvane (Su) kPa + / ▲ Unconfined Comp. (Su) kPa ▲ / △ Pocket Pen. (Su) kPa △ (10 20 30 40 50 60 70)	◆ SPT N blows/300mm ◆ (10 20 30 40 50 60 70) / ■ Unit Weight kN/m³ ■ (12 14 16 18 20 22 24) / PL M/C (%) LL (10 20 30 40 50 60 70)
				BEDROCK - Red River Formation, Upper Fort Garry Member (dolomite) - fair quality, whitish grey color, strong to very strong - horizontal fractures, very close to moderately close discontinuity spacing - gapped joint apeture, evidence of water flow (Class 3) *continued from previous page*				

END OF TEST HOLE AT 16.8 m IN BEDROCK
Notes:
1. Frozen to 0.6 m.
2. No sloughing or seepage observed during driling with augers.
3. Upon completion of drilling to auger refusal, test hole open to 6.5 m b/l grade, dry.
4. Auger refusal occured at 6.5 m, switched to HQ coring with casing advancer.
5. 25 mm PVC Standpipe piezometer w/ Cassagrande tip installed 10.7 m b/l grade.
Top of pipe (T.O.P) 0.05 m below grade.
Water levels:
Jan 7, 2021: 7.37 m b/l T.O.P. - Ground water elevation - 228.61 m

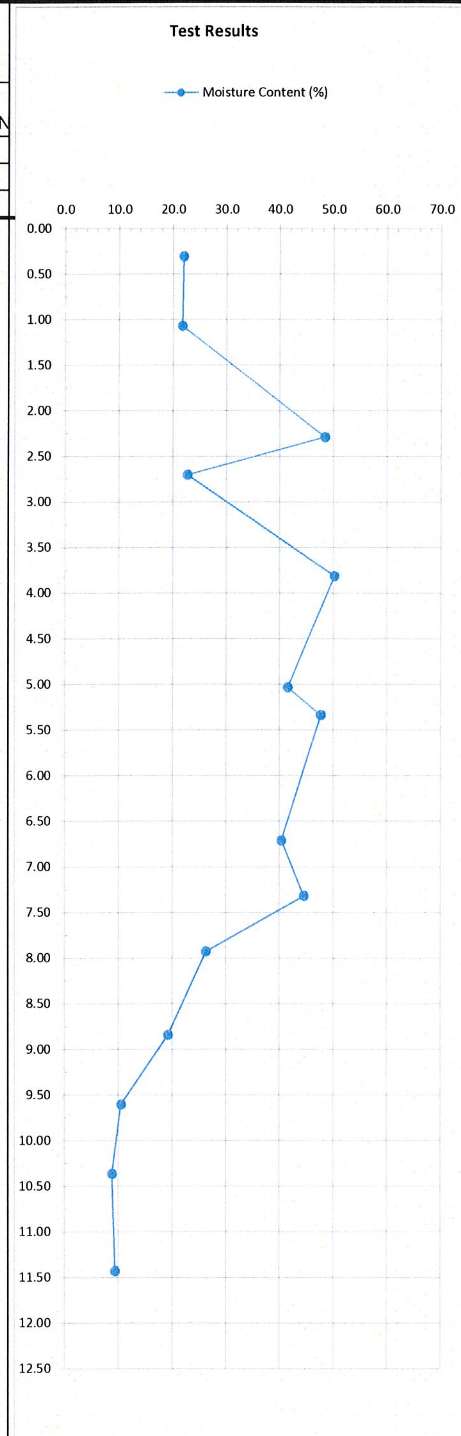
DYREGROV ROBINSON INC. CONSULTING GEOTECHNICAL ENGINEERS	PROJECT # 113324	TEST HOLE NO. 12-11

PROJECT:	Ferry Road LDS	**LOGGED BY:**	RB
LOCATION:	Rutland St. at Ness Ave.	**REVIEWED BY:**	AOD
CONTRACTOR:	Paddock Drilling Ltd.	**DRILL DATE:**	April 20, 2012
METHOD:	Acker Soil Sentry - 125 mm SSA	**DRILL DEPTH (m):**	12.2

UNDRAINED SHEAR STRENGTH Su: QU UNCONFINED COMPRESSION; TV TORVANE; PP POCKET PEN.; γ UNIT WEIGHT

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION		UNDRAINED SHEAR STRENGTH Su
0.00	234.77	0 - 0.17 m	CONCRETE	
		0.17 - 0.46 m	CLAY (Fill) - silty, trace sand, trace gravel	
0.50	234.27		- dark brown, stiff, moist, high plasticity	
		0.46 - 1.7 m	SILT	
1.00	233.77		- tan	
			- loose, wet	
1.50	233.27			
		1.7 - 2.7 m	CLAY - silty	
2.00	232.77		- brown	
			- firm to stiff, moist	
2.50	232.27		- high plasticity	
		2.7 - 3.0 m	SILT - tan, loose, wet	
3.00	231.77	3.0 - 8.5 m	CLAY - silty	
			- brown	
3.50	231.27		- stiff, moist, high plasticity	
4.00	230.77			
4.50	230.27			
			- trace sand, trace gravel, grey below 4.6 m	
5.00	229.77			TV = 103 kPa
				PP = 78 kPa
5.50	229.27			
6.00	228.77			
6.50	228.27			
			- some till inclusions, wet, firm below 6.7 m	TV = 33 kPa
7.00	227.77			
7.50	227.27			
8.00	226.77			
8.50	226.27	8.5 - 12.2 m	SILT (Till) - some sand	
			- trace gravel, trace cobbles	
9.00	225.77		- light grey	
			- loose, wet	
9.50	225.27			
10.00	224.77		- dense, dry below 10.0 m	
10.50	224.27			
11.00	223.77			
11.50	223.27			
12.00	222.77			
		12.2 m	END OF TEST HOLE AT 12.2 m IN SILT TILL	
12.50	222.27		Notes:	

1. Squeezing below 7.0 m in clay layer.
2. Seepage below 8.5 m in silt till layer.
3. Standpipe piezometer with Casagrande tip installed to 9.4 m.
4. Water level measured at 6.44 m below ground surface on May 10, 2012 and 8.46 m on June 12, 2012.
5. Test hole backfilled with sand to 7.0 m, bentonite chips to 5.8 m and auger cuttings to ground surface. Piezometer protected with a flushmount cover.

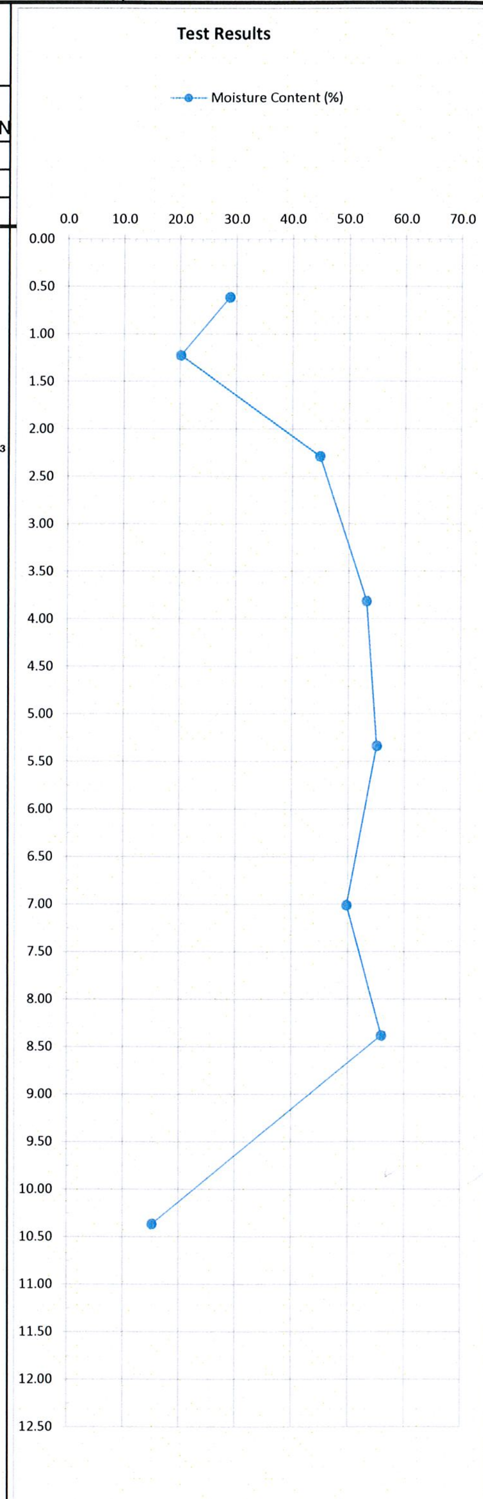


DYREGROV ROBINSON INC. CONSULTING GEOTECHNICAL ENGINEERS	PROJECT # 113324	TEST HOLE NO. 12-12

PROJECT:	Ferry Road LDS	**LOGGED BY:**	RB
LOCATION:	Rutland St. at Bruce Ave.	**REVIEWED BY:**	AOD
CONTRACTOR:	Paddock Drilling Ltd.	**DRILL DATE:**	April 20, 2012
METHOD:	Acker Soil Sentry - 125 mm SSA	**DRILL DEPTH (m):**	12.2

UNDRAINED SHEAR STRENGTH Su: QU = UNCONFINED COMPRESSION; TV = TORVANE; PP = POCKET PEN.; ɣ = UNIT WEIGHT

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION		UNDRAINED SHEAR STRENGTH Su
0.00	233.79	0 - 0.051 m	ASPHALT	
		0.051 - 0.14 m	CONCRETE	
0.50	233.29	0.14 - 0.76 m	CLAY (Fill) - silty, trace sand, trace gravel - dark brown to black, stiff, moist, high plasticity	
1.00	232.79	0.76 - 1.5 m	SILT - tan, loose, moist to wet	
1.50	232.29	1.5 - 9.8 m	CLAY - silty - brown, mottled brown and grey below 2.4 m - very stiff, stiff below 2.1 m - moist, high plasticity	Qu = 83 kPa TV = 106 kPa PP = 191 kPa ɣ = 20.8 kN/m³
2.00	231.79			
2.50	231.29			
3.00	230.79			
3.50	230.29			
4.00	229.79			TV = 54 kPa PP = 37 kPa
4.50	229.29			
5.00	228.79		- firm, trace sand, trace gravel below 5.2 m	TV = 29 kPa PP = 25 kPa
5.50	228.29			
6.00	227.79			
6.50	227.29			
7.00	226.79			TV = 35 kPa PP = 20 kPa
7.50	226.29		- soft below 7.6 m	
8.00	225.79			TV = 20 kPa
8.50	225.29			
9.00	224.79			
9.50	224.29			
10.00	223.79	9.8 - 12.2 m	SILT (Till) - some sand, trace gravel - light grey - loose, wet	
10.50	223.29			No soil recovery below 10.7 m
11.00	222.79		- some cobbles below 11.3 m	
11.50	222.29			
12.00	221.79			
12.50	221.29	12.2 m	END OF TEST HOLE AT 12.2 m IN SILT TILL Notes: 1. Squeezing below 5.2 m in clay layer. 2. Seepage below 7.6 m from clay layer. Water level at 4.9 m 5 minutes after drilling. 3. No soil recovery below 10.7 m. 4. Test hole backfilled with auger cuttings, capped with concrete core and cold patch.	



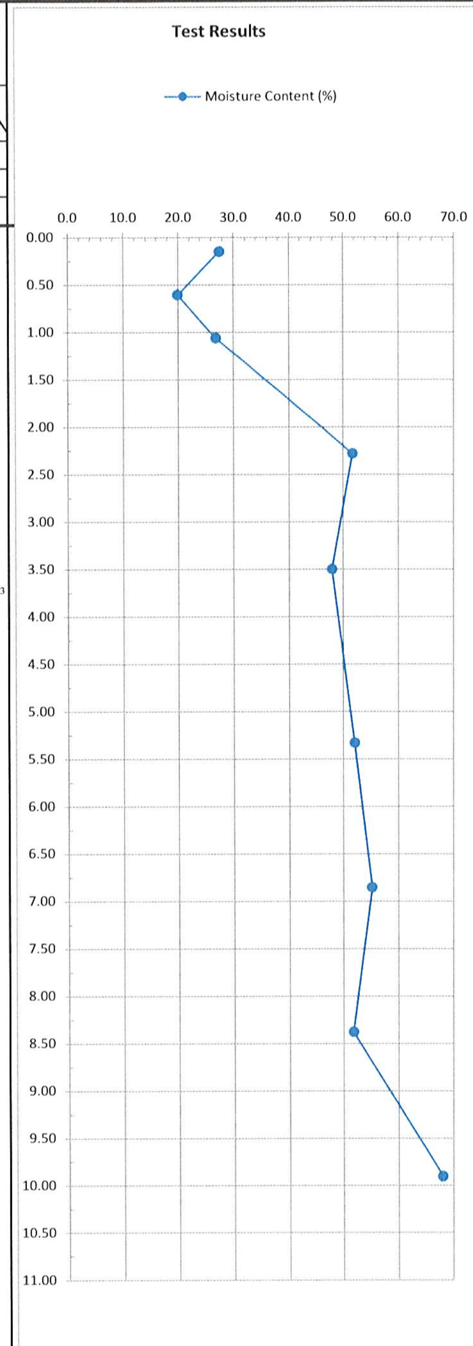
DYREGROV ROBINSON INC. CONSULTING GEOTECHNICAL ENGINEERS	PROJECT # 113324	TEST HOLE NO. 12-13

PROJECT:	Ferry Road LDS	LOGGED BY:	RB
LOCATION:	St. James Collegiate	REVIEWED BY:	AOD
CONTRACTOR:	Paddock Drilling Ltd.	DRILL DATE:	April 30, 2012
METHOD:	Acker MP8 - 125 mm SSA	DRILL DEPTH (m):	10.7

UNDRAINED SHEAR STRENGTH Su

QU	UNCONFINED COMPRESSION
TV	TORVANE
PP	POCKET PEN.
ɣ	UNIT WEIGHT

DEPTH (m)	ELEVATION (m)	SOIL SYMBOL	SOIL DESCRIPTION		UNDRAINED SHEAR STRENGTH Su
0.00	232.81		0 - 0.3 m	CLAY (Topsoil) - silty, trace sand - black, stiff, moist, high plasticity	
0.50	232.31		0.3 - 1.2 m	SILT - some sand - brown, loose, moist	
1.00	231.81			- clayey below 0.6 m	
			1.2 - 10.7 m	CLAY - silty	
1.50	231.31			- mottled brown and grey - firm, moist, high plasticity	
2.00	230.81			- trace silt inclusions - trace gypsum inclusions	PP = 37 kPa
2.50	230.31				
3.00	229.81			- grey below 3.0 m	Qu = 28 kPa TV = 56 kPa
3.50	229.31				PP = 89 kPa ɣ = 16.9 kN/m³
4.00	228.81				
4.50	228.31				
5.00	227.81				TV = 37 kPa
5.50	227.31				PP = 25 kPa
6.00	226.81				
6.50	226.31				TV = 26 kPa
7.00	225.81				
7.50	225.31			- trace till inclusions, trace sand, trace gravel below 7.6 m	
8.00	224.81				TV = 25 kPa
8.50	224.31				
9.00	223.81			- wet below 9.0 m	
9.50	223.31				
10.00	222.81				
10.50	222.31				
			10.7 m	END OF TEST HOLE AT 10.7 m IN CLAY Notes: 1. Squeezing below 6.7 m in clay layer. 2. Test hole backfilled with auger cuttings.	
11.00	221.81				



GEOTECHNICAL
ENGINEERS

APPENDIX C

Glacial Till and Bedrock Core Sample Photographs
(Figures C1 to C13)
&
Bedrock Core Sample Summary (Table C1)

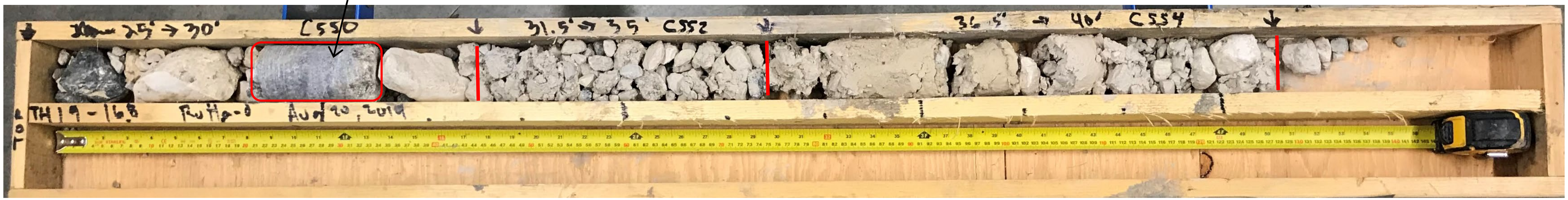
C562) Core Depth: 25 – 30 ft (7.6 – 9.1 m) – 8% recovery
C564) Core Depth: 30.8 – 35 ft (9.3 – 10.7 m) – 45% recovery
C566) Core Depth: 36.5 – 40 ft (11.1 – 12.2 m) – 33% recovery

DYREGROV ROBINSON INC. CONSULTING GEOTECHNICAL ENGINEERS			**Ferry Road & Riverbend CSR – Rutland Trunk Sewer** **Glacial Till Core Photograph – Test Hole 19-166**		
SCALE: NTS	MADE BY: AA	CHKD BY: GR	PROJECT NO. 143691.7	DATE: November 2019	**FIGURE C1**

C556) Core Depth: 25 – 30 ft (7.6 – 9.1 m) – 18% recovery
C558) Core Depth: 31.5 – 35 ft (9.5 – 10.7 m) – 33% recovery
C560) Core Depth: 36.5 – 40 ft (11.1 – 12.2 m) – 57% recovery

DYREGROV ROBINSON INC. CONSULTING GEOTECHNICAL ENGINEERS			**Ferry Road & Riverbend CSR – Rutland Trunk Sewer** **Glacial Till Core Photograph – Test Hole 19-167**		
SCALE: NTS	MADE BY: AA	CHKD BY: GR	PROJECT NO. 143691.7	DATE: November 2019	**FIGURE C2**

Sample submitted for CAI and petrographic analysis



C550) Core Depth: 25 – 30 ft (7.6 – 9.1 m) - 30% recovery including granite cobble
C552) Core Depth: 31.5 – 35 ft (9.5 – 10.7 m) – 28% recovery
C554) Core Depth: 36.5 – 40 ft (11.1 – 12.2 m) – 48% recovery

DYREGROV ROBINSON INC. CONSULTING GEOTECHNICAL ENGINEERS			**Ferry Road & Riverbend CSR – Rutland Trunk Sewer** **Glacial Till Core Photograph – Test Hole 19-168**		
SCALE: NTS	MADE BY: AA	CHKD BY: GR	PROJECT NO. 143691.7	DATE: November 2019	**FIGURE C3**

C544) Core Depth: 26 – 30 ft (7.9 – 9.1 m) – 20% recovery
C546) Core Depth: 31.5 – 35 ft (9.5 – 10.7 m) – 12% recovery
C548) Core Depth: 36.5 – 40 ft (11.1 – 12.2 m) – 43% recovery

DYREGROV ROBINSON INC. CONSULTING GEOTECHNICAL ENGINEERS			**Ferry Road & Riverbend CSR – Rutland Trunk Sewer** **Glacial Till Core Photograph – Test Hole 19-169**		
SCALE: NTS	MADE BY: AA	CHKD BY: GR	PROJECT NO. 143691.7	DATE: November 2019	**FIGURE C4**

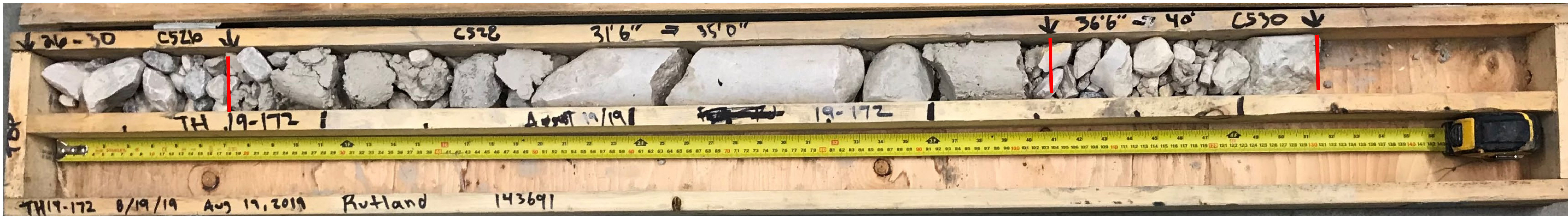
C538) Core Depth: 23 – 30 ft (7.0 – 9.1 m) - 20% recovery including limestone cobble / boulder
C540) Core Depth: 31.5 – 35 ft (9.5 – 10.7 m) - No sample recovery
C542) Core Depth: 36.5 – 40 ft (11.1 – 12.2 m) - No sample recovery

DYREGROV ROBINSON INC. CONSULTING GEOTECHNICAL ENGINEERS			**Ferry Road & Riverbend CSR – Rutland Trunk Sewer** **Glacial Till Core Photograph – Test Hole 19-170**		
SCALE: NTS	MADE BY: AA	CHKD BY: GR	PROJECT NO. 143691.7	DATE: November 2019	**FIGURE C5**

C532) Core Depth: 26 – 30 ft (7.9 – 9.1 m) - 25% recovery
C534) Core Depth: 31.5 – 35 ft (9.5 – 10.7 m) - 24% recovery
C536) Core Depth: 36.5 – 40 ft (11.1 – 12.2 m) - 40% recovery

DYREGROV ROBINSON INC. CONSULTING GEOTECHNICAL ENGINEERS			**Ferry Road & Riverbend CSR – Rutland Trunk Sewer** **Glacial Till Core Photograph – Test Hole 19-171**	
SCALE: NTS	MADE BY: AA	CHKD BY: GR	PROJECT NO. 143691.7	DATE: November 2019

FIGURE C6

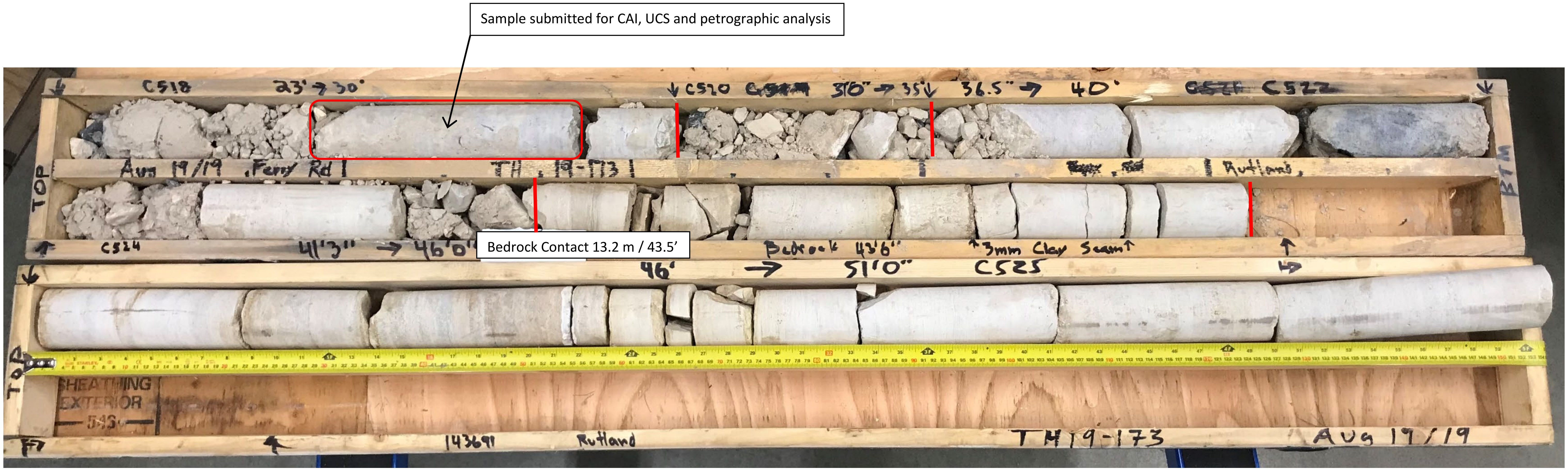


C526) Core Depth: 26 – 30 ft (7.9 – 9.1 m) - 16% recovery
C528) Core Depth: 31.5 – 35 ft (9.5 – 10.7 m) - 76% recovery including limestone cobble / boulder
C530) Core Depth: 36.5 – 40 ft (11.1 – 12.2 m) - 23% recovery

DYREGROV ROBINSON INC.
CONSULTING GEOTECHNICAL ENGINEERS

Ferry Road & Riverbend CSR – Rutland Trunk Sewer
Glacial Till Core Photograph – Test Hole 19-172

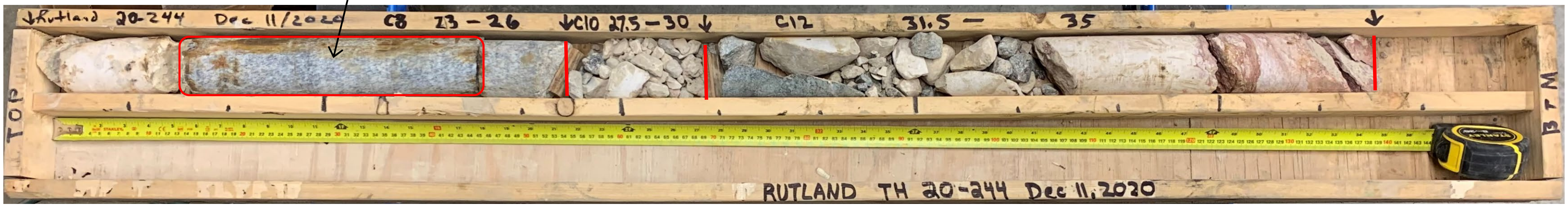
SCALE:	MADE BY:	CHKD BY:	PROJECT NO.	DATE:	
NTS	AA	GR	143691.7	November 2019	**FIGURE C7**



C518) Core Depth: 23 – 30 ft (7.0 – 9.1 m) - 31% recovery including limestone boulder
C520) Core Depth: 31.5 – 35 ft (9.5 – 10.7 m) - 24% recovery
C522) Core Depth: 36.5 – 40 ft (11.1 – 12.2 m) - 57% recovery including limestone & granite cobbles
C524) Core Depth: 41.3 – 43.5 ft (12.6 – 13.2 m) - 76% recovery including limestone cobble
C524) Core Depth: 43.5 – 46 ft (13.2 – 14.0m) - bedrock % Recovered = 100, RQD = 87%
C525) Core Depth: 46 – 51 ft (14.0 – 15.5 m) - bedrock % Recovered = 100, RQD = 87%

DYREGROV ROBINSON INC. CONSULTING GEOTECHNICAL ENGINEERS			**Ferry Road & Riverbend CSR – Rutland Trunk Sewer Bedrock Core Photograph – Test Hole 19-173**		
SCALE: NTS	MADE BY: AA	CHKD BY: GR	PROJECT NO. 143691.7	DATE: December 2020	**FIGURE C8**

Sample submitted for CAI, UCS and petrographic analysis



C8) Core Depth: 23 – 26 ft (7.0 – 7.9 m) - 60% recovery including granite cobble
C10) Core Depth: 27.5 – 30 ft (8.4 – 9.1 m) - 20% recovery
C12) Core Depth: 31.5 – 35 ft (9.5 – 10.7 m) - 62% recovery including limestone cobble

DYREGROV ROBINSON INC. CONSULTING GEOTECHNICAL ENGINEERS			**Ferry Road & Riverbend CSR – Rutland Trunk Sewer** **Glacial Till Core Photograph – Test Hole 20-244**		
SCALE: NTS	MADE BY: AA	CHKD BY: GR	PROJECT NO. 143691.7	DATE: December 2020	**FIGURE C9**

C22) Core Depth: 21 – 25 ft (6.4 – 7.6 m) - 52% recovery including limestone & granite cobbles
C24) Core Depth: 26.5 – 30 ft (8.1 – 9.1 m) - 38% recovery
C26) Core Depth: 31.5 – 35 ft (9.6 – 10.7 m) - 31% recovery

DYREGROV ROBINSON INC. CONSULTING GEOTECHNICAL ENGINEERS			**Ferry Road & Riverbend CSR – Rutland Trunk Sewer** **Glacial Till Core Photograph – Test Hole 20-245**		
SCALE: NTS	MADE BY: AA	CHKD BY: GR	PROJECT NO. 143691.7	DATE: December 2020	**FIGURE C10**

C35) Core Depth: 21.5 – 25 ft (6.5 – 7.6 m) - 43% recovery
C37) Core Depth: 26.5 – 30 ft (8.1 – 9.1 m) - 12% recovery
C39) Core Depth: 31.5 – 35 ft (9.6 – 10.7 m) - 24% recovery

DYREGROV ROBINSON INC.
CONSULTING GEOTECHNICAL ENGINEERS

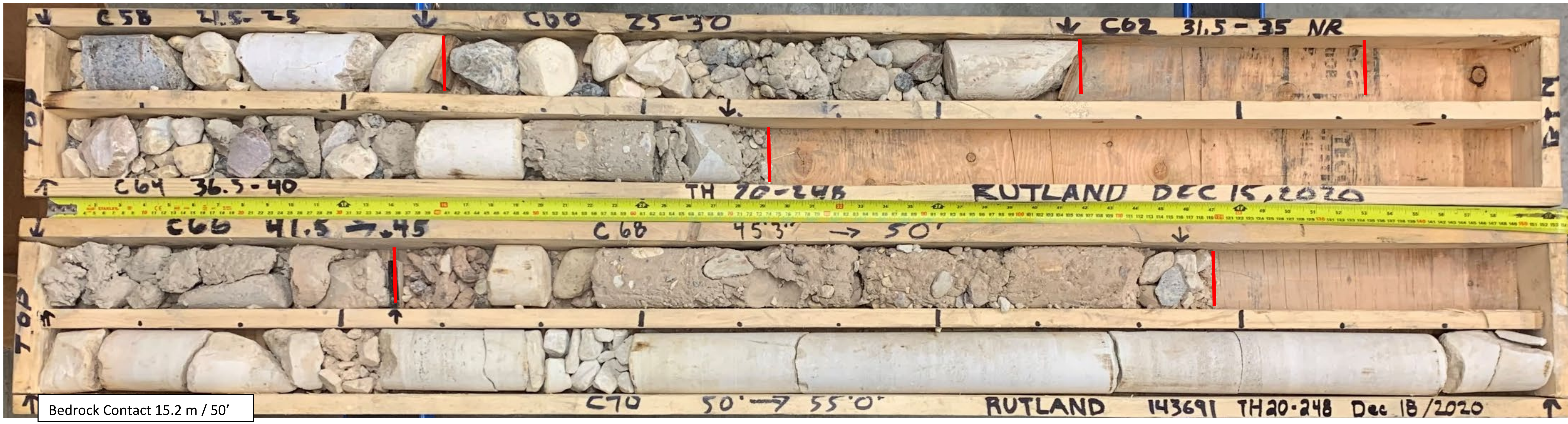
Ferry Road & Riverbend CSR – Rutland Trunk Sewer
Glacial Till Core Photograph – Test Hole 20-246

SCALE:	MADE BY:	CHKD BY:	PROJECT NO.	DATE:	
NTS	AA	GR	143691.7	December 2020	**FIGURE C11**

C47) Core Depth: 21.5 – 25 ft (6.5 – 7.6 m) - 15% recovery
C49) Core Depth: 26.5 – 30 ft (8.1 – 9.1 m) - 33% recovery
C51) Core Depth: 30.3 – 35 ft (9.1 – 10.7 m) - 49% recovery including limestone

DYREGROV ROBINSON INC. CONSULTING GEOTECHNICAL ENGINEERS	**Ferry Road & Riverbend CSR – Rutland Trunk Sewer** **Glacial Till Core Photograph – Test Hole 20-247**

SCALE:	MADE BY:	CHKD BY:	PROJECT NO.	DATE:	
NTS	AA	GR	143691.7	December 2020	**FIGURE C12**



C58) Core Depth: 21.5 – 25 ft (6.6 – 7.6 m) - 38% recovery
C60) Core Depth: 25 – 30 ft (7.6 – 9.1 m) - 42% recovery
C62) Core Depth: 31.5 – 35 ft (9.6 – 10.7 m) - 0% recovery
C64) Core Depth: 36.5 – 40 ft (11.2 – 12.2 m) - 69% recovery
C66) Core Depth: 41.5 – 45 ft (12.7 – 13.7 m) - 33% recovery
C68) Core Depth: 45.3 – 50 ft (13.8 – 15.2 m) - 58% recovery
C70) Core Depth: 50 – 55 ft (15.2 – 16.8 m) – bedrock, 100 % recovery, RQD = 68%

DYREGROV ROBINSON INC.
CONSULTING GEOTECHNICAL ENGINEERS

Ferry Road & Riverbend CSR – Rutland Trunk Sewer
Glacial Till & Bedrock Core Photograph – Test Hole 20-248

SCALE:	MADE BY:	CHKD BY:	PROJECT NO.	DATE:	
NTS	AA	GR	143691.7	December 2020	**FIGURE C13**

Ferry Road & Riverbend CSR - Rutland Trunk Sewer

Table C1) Bedrock Core Sample Summary

Test Hole	Sample #	Coring Details					Core Sample		%Recovery	RQD
		Depth (m)		Depth (ft)		Length	Lrecovered	L > 4"		
		from	to	from	to	(inches)	(inches)	(inches)		
19-173	C524	13.26	14.02	43.50	46.00	30	28	9	93%	30%
	C525	14.02	15.54	46.00	51.00	60	60	52	100%	87%
20-248	C70	15.24	16.76	50.00	55.00	60	60	41	100%	68%

GEOTECHNICAL
ENGINEERS

APPENDIX D

Laboratory Testing Results

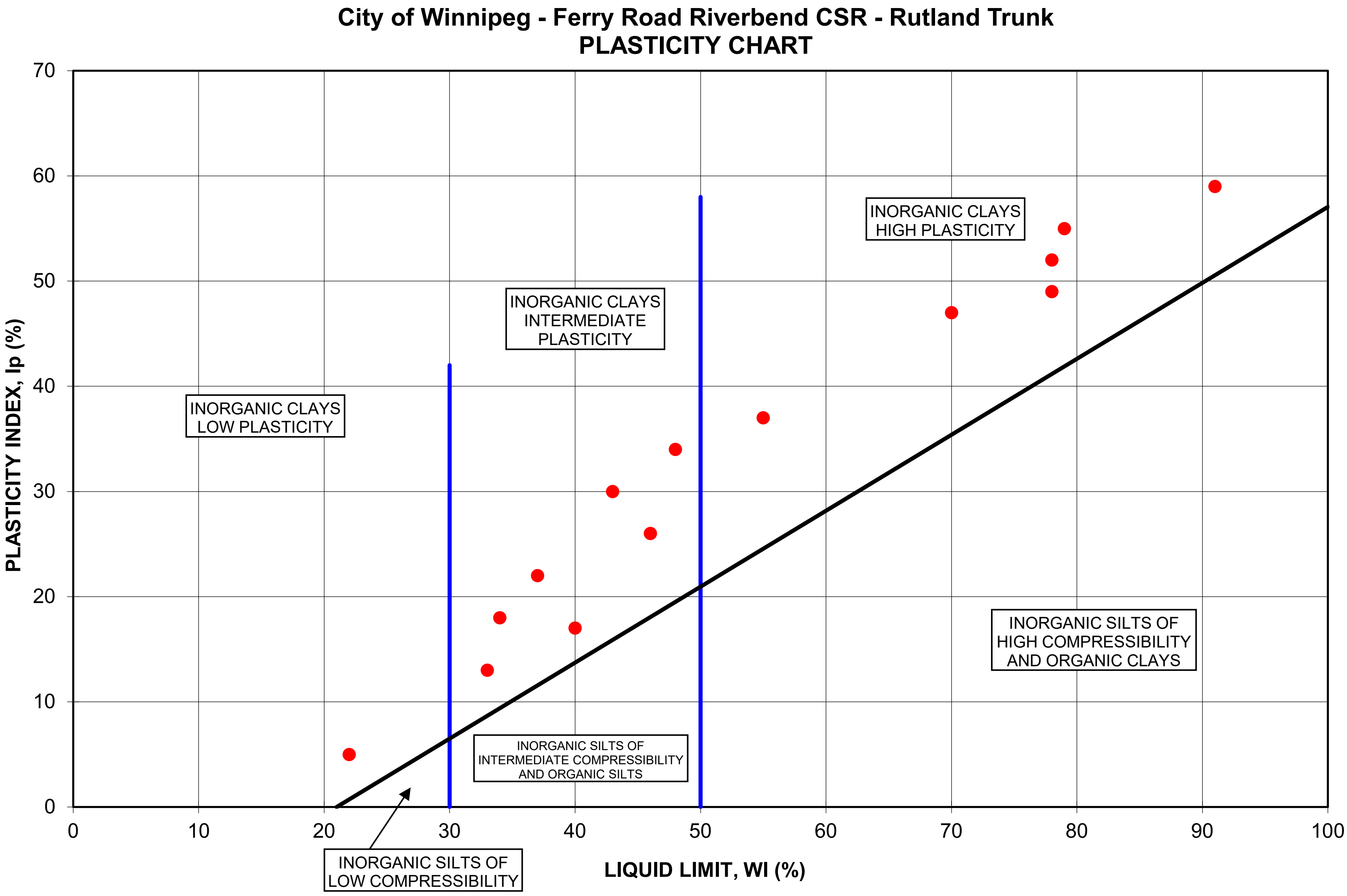
Tables D1 to D4
Moisture Contents
Strength and Unit Weight Testing (Shelby Tube Samples)
Atterberg Limits
Particle Size Distribution
Soil Chemistry (Bureau Veritas Laboratories)
Swell Testing (Wood PLC)

City of Winnipeg - Ferry Road Riverbend CSR - Rutland Trunk

Table D1) Summary of Plastic Limits, Liquid Limits, Plasticity Indices and Liquidity Indices (ASTM D4318)

Test Hole	Sample		Soil Type	In-Situ Moisture	Plastic Limit	Liquid Limit	Plasticity Index	Liquidity Index	Classification (see plasticity chart)
	No.	Depth (m)		(%)	(%)	(%)			
19-148	T296	3.4	Clay (Alluvium)	33	23	40	17	**0.6**	CI
19-149	G289	7.3	Clay (Alluvium)	33	16	34	18	**0.9**	CI
19-150	G277	4.6	Clay (Alluvium)	22	15	37	22	**0.3**	CI
19-151	T269	5.0	Clay (Alluvium)	33	20	46	26	**0.5**	CI
19-151	G272	8.8	Clay (Alluvium)	34	20	33	13	**1.1**	CI
19-152	G240	4.3	Clay (Glaciolacustrine)	53	32	91	59	**0.4**	CH
19-156	T326	6.5	Clay (Glaciolacustrine)	47	24	79	55	**0.4**	CH
19-157	T337	9.5	Clay (Glaciolacustrine)	53	18	55	37	**0.9**	CH
19-162	T394	7.9	Clay (Glaciolacustrine)	46	23	70	47	**0.5**	CH
19-166	G439	4.3	Clay (Glaciolacustrine)	47	29	78	49	**0.4**	CH
19-173	G492	2.3	Clay (Glaciolacustrine)	43	26	78	52	**0.3**	CH
19-240	G427	1.2	Silt	22	17	22	5	**1.0**	ML
20-245	G18	4.6	Silty Clay (Glaciolacustrine)	34	14	48	34	**0.6**	CI
20-248	T55	3.4	Silty Clay (Glaciolacustrine)	23	13	43	30	**0.3**	CI

Refer to Lab Testing Reports in Appendix D


City of Winnipeg - Ferry Road Riverbend CSR - Rutland Trunk
PLASTICITY CHART
PLASTICITY INDEX, Ip (%)
LIQUID LIMIT, Wl (%)
0
10
20
30
40
50
60
70
80
90
100
INORGANIC CLAYS LOW PLASTICITY
INORGANIC CLAYS INTERMEDIATE PLASTICITY
INORGANIC CLAYS HIGH PLASTICITY
INORGANIC SILTS OF HIGH COMPRESSIBILITY AND ORGANIC CLAYS
INORGANIC SILTS OF INTERMEDIATE COMPRESSIBILITY AND ORGANIC SILTS
INORGANIC SILTS OF LOW COMPRESSIBILITY

City of Winnipeg - Ferry Road Riverbend CSR - Rutland Trunk

Table D2) Summary of Particle Size Distribution Tests (ASTM D422)

Test Hole	Sample No.	Sample Depth (m)	Soil Type	Clay (%)	Silt (%)	Sand (%)	Classification (see plasticity chart)
19-148	T296	3.4	Clay (Alluvium)	46.1	52.7	1.2	CI
19-148	G302	8.5	Glacial Till	33.7	60.2	5.8	n/a
19-149	G289	7.3	Clay (Alluvium)	44.2	50.1	5.6	CI
19-150	G277	4.6	Clay (Alluvium)	53.3	40.3	6.4	CI
19-151	T269	5.0	Clay (Alluvium)	50.0	49.3	0.7	CI
19-151	G272	8.8	Clay (Alluvium)	47.7	50.0	2.3	CI
19-152	G240	4.3	Clay (Glaciolacustrine)	99.9	0.0	0.1	CH
19-156	T326	6.5	Clay (Glaciolacustrine)	92.1	7.8	0.1	CH
19-157	T337	9.5	Clay (Glaciolacustrine)	51.9	36.9	11.2	CH
19-161	G386	9.8	Glacial Till	44.7	50.9	4.1	n/a
19-162	T394	7.9	Clay (Glaciolacustrine)	89.8	9.5	0.6	CH
19-166	G439	4.3	Clay (Glaciolacustrine)	90.9	8.8	0.3	CH
19-166	S443	9.3	Glacial Till	45.5	49.1	5.0	n/a
19-173	G492	2.3	Clay (Glaciolacustrine)	93.8	5.8	0.4	CH
19-173	S496	6.3	Glacial Till	39.5	55.3	4.7	n/a
20-244	G7	6.2	Glacial Till	43.1	53.5	3.2	n/a
20-245	G20	6.2	Glacial Till	49.6	46.9	3.3	n/a
20-246	S36	7.8	Glacial Till	32.8	59.0	7.6	n/a
20-247	S46	6.3	Glacial Till	44.0	49.6	6.0	n/a
20-248	S56	4.8	Glacial Till	31.8	59.5	7.8	n/a

Refer to Lab Testing Report in Appendix D

City of Winnipeg - Ferry Road Riverbend CSR - Rutland Trunk

Table D3) Summary of Soil Chemistry Test Results

Test Hole	Soil Sample		Soil Type	Calculated Sulphate (SO4)	Soluble Sulphate (SO4)	Soluble Chloride (CL)	Soluble Conductivity	Resistivity (calculated)	pH
	No.	Depth (m)		%	mg/L	mg/L	dS/m	ohm-m	
19-149	G286	2.7	Clay (Alluvium)	0.017	300	30	1.2	8.7	7.55
19-151	G267	2.2	Silt (Alluvium)	0.0010	21	18	0.29	35	7.81
19-153	G248	4.1	Clay (Glaciolacustrine)	0.34	3200	490	6.1	1.6	7.59
19-161	G383	5.7	Clay (Glaciolacustrine)	0.20	2100	220	3.9	2.6	7.68
19-167	G456	5.7	Clay (Glaciolacustrine)	0.13	1500	17	2.6	3.8	7.81
19-172	G486	6.6	Glacial Till	0.064	1500	850	5.3	1.9	7.83
20-244	T5	4.9	Clay (Glaciolacustrine)	0.11	1500	470	3.7	2.7	7.89
20-248	S57	6.4	Glacial Till	0.006	280	150	1.2	8.5	8.29

Refer to Lab Testing Reports in Appendix D

City of Winnipeg - Ferry Road Riverbend CSR - Rutland Trunk

Table D4) Summary of Swell Testing (ASTM D4546-14 Method A)

Test Hole	Sample		Soil Type	Swell	Est. Swell Pressure
	No.	Depth (m)		%	kPa
19-156	T326	6.4	Clay (Glaciolacustrine)	2.2	68
19-162	T394	7.9	Clay (Glaciolacustrine)	1.6	40
19-173	T493	3.4	Clay (Glaciolacustrine)	1.3	41

Refer to Lab Testing Report in Appendix D

Ferry Road & Riverbend CSR - Rutland Trunk Sewer

SOIL SAMPLE MOISTURE CONTENTS

Test Hole No.	Sample No.	Depth (m)	Elev. (m)	Moisture Content (%)
19-147	G304	0.7	227.93	25.7
19-147	G305	1.4	227.17	19.0
19-147	G306	2.7	225.95	26.4
19-147	G307	4.2	224.43	26.4
19-147	G308	5.7	222.91	19.7
19-147	S309	6.3	222.30	12.5
19-148	G293	0.7	229.88	25.3
19-148	G294	1.4	229.12	19.8
19-148	G295	2.2	228.36	24.6
19-148	T296	3.4	227.22	33.3
19-148	G297	4.2	226.38	31.7
19-148	G298	5.7	224.86	27.0
19-148	G299	6.6	223.94	12.1
19-148	G300	7.2	223.33	51.4
19-148	G301	7.8	222.72	11.4
19-148	G302	8.5	222.11	9.6
19-148	S303	9.4	221.20	15.8
19-149	G284	0.7	230.32	23.0
19-149	G285	1.4	229.56	26.3
19-149	G286	2.7	228.34	20.7
19-149	T287A	4.7	226.32	33.0
19-149	T287B	4.9	226.10	40.2
19-149	G288	5.7	225.30	38.6
19-149	G289	7.2	223.77	32.9
19-149	G290	8.8	222.25	40.6
19-149	G291	9.4	221.64	11.4
19-150	G274	0.7	231.21	25.3
19-150	G275	1.1	230.76	12.3
19-150	G276	2.7	229.23	28.2
19-150	G277	4.5	227.40	22.2
19-150	G278	6.0	225.88	31.5
19-150	G279	7.2	224.66	28.2
19-150	G280	8.2	223.75	37.6
19-150	G281	8.5	223.44	14.6
19-150	G282	10.0	221.92	32.8
19-150	G283	10.3	221.61	16.3
19-151	G265	0.7	230.35	17.5
19-151	G266	1.4	229.59	25.1
19-151	G267	2.2	228.83	25.5
19-151	G268	3.0	228.07	26.1
19-151	T269A	4.7	226.35	34.3
19-151	T269B	4.9	226.13	32.9
19-151	G270	5.7	225.33	31.6
19-151	G271	7.2	223.80	39.4
19-151	G272	8.8	222.28	33.8
19-151	G273	10.3	220.75	15.6
19-152	G237	0.7	232.00	22.6
19-152	G238	1.4	231.24	34.6
19-152	G239	2.7	230.02	45.6
19-152	G240	4.2	228.50	53.3
19-152	T241	6.4	226.29	48.8
19-152	G242	7.2	225.45	58.9
19-152	G243	8.8	223.93	58.7
19-152	G244	10.3	222.40	51.9
19-153	G245	0.7	231.86	24.5
19-153	G246	1.4	231.10	33.5
19-153	G247	2.7	229.88	45.1
19-153	G248	4.2	228.36	49.5
19-153	G249	5.7	226.84	47.8
19-153	G250	7.2	225.31	51.8
19-153	T251	9.4	223.10	60.4
19-153	G252	10.3	222.26	51.7
19-153	G253	11.8	220.74	15.6
19-154	G254	0.1	232.56	26.7
19-154	G255	0.8	231.80	22.6
19-154	G256	1.4	231.19	26.7
19-154	G257	2.7	229.97	49.7
19-154	G258	4.2	228.45	49.0
19-154	G259	5.7	226.93	48.4
19-154	G260	7.2	225.40	51.4
19-154	G261	8.8	223.88	50.6
19-154	G262	10.3	222.35	55.0
19-154	G263	11.8	220.83	39.2
19-154	G264	12.7	219.91	21.6

Test Hole No.	Sample No.	Depth (m)	Elev. (m)	Moisture Content (%)
19-155	G311	0.2	233.40	38.1
19-155	G312	0.8	232.79	25.5
19-155	G313	1.3	232.33	31.9
19-155	T314	3.4	230.28	47.1
19-155	G315	4.2	229.44	51.0
19-155	G316	5.7	227.92	52.2
19-155	G317	7.2	226.39	50.0
19-155	G318	8.8	224.87	51.9
19-155	G319	10.3	223.34	31.5
19-155	G320	12.1	221.51	18.0
19-156	G321	0.2	233.47	28.0
19-156	G322	1.0	232.71	11.2
19-156	G323	2.4	231.34	44.1
19-156	G324	3.6	230.12	48.2
19-156	G325	4.5	229.20	46.1
19-156	T326	6.4	227.30	47.0
19-156	G327	7.2	226.46	48.0
19-156	G328	8.8	224.94	48.9
19-156	G329	10.3	223.41	42.0
19-156	G330	11.8	221.89	19.7
19-157	G331	0.5	233.26	21.1
19-157	G332	1.3	232.49	15.9
19-157	G333	2.7	231.12	28.5
19-157	G334	4.2	229.60	48.2
19-157	G335	5.7	228.08	45.6
19-157	G336	7.2	226.55	47.3
19-157	T337	9.4	224.34	52.7
19-157	S338	10.9	222.89	8.2
19-157	G339	11.4	222.44	29.1
19-157	G340	12.1	221.67	45.5
19-158	G341	0.7	233.04	25.5
19-158	G342	1.4	232.28	25.8
19-158	G343	2.7	231.06	48.2
19-158	T344	4.9	228.85	51.8
19-158	G345	5.7	228.02	44.3
19-158	G346	7.2	226.49	54.0
19-158	G347	8.8	224.97	52.8
19-158	G348	10.3	223.44	37.2
19-158	G349	11.8	221.92	40.7
19-159	G350	0.7	233.13	29.8
19-159	G351	1.4	232.37	28.1
19-159	G352	2.7	231.15	44.9
19-159	G353	4.2	229.63	44.4
19-159	G354	5.7	228.11	48.8
19-159	T355	7.9	225.90	42.7
19-159	G356	8.8	225.06	56.7
19-159	G357	10.3	223.53	23.4
19-159	G358	11.8	222.01	26.8
19-160	G359	0.2	233.70	29.8
19-160	G360	0.5	233.40	24.9
19-160	G361	1.4	232.48	30.0
19-160	G362	2.7	231.26	48.4
19-160	G363	4.2	229.74	50.8
19-160	G364	5.7	228.22	48.6
19-160	G365	7.2	226.69	44.4
19-160	G366	8.8	225.17	52.4
19-160	T367	11.0	222.96	12.4
19-161	G378	0.2	233.97	21.6
19-161	G379	1.1	233.06	12.7
19-161	G380	1.8	232.45	38.6
19-161	T381	3.4	230.85	42.2
19-161	G382	4.2	230.01	42.5
19-161	G383	5.7	228.49	47.3
19-161	G384	7.2	226.96	48.8
19-161	G385	8.8	225.44	48.5
19-161	G386	9.7	224.52	18.0
19-162	G388	0.8	233.50	15.0
19-162	G389	1.4	232.89	41.1
19-162	G390	1.8	232.59	11.5
19-162	G391	2.7	231.67	25.3
19-162	G392	4.2	230.15	46.6
19-162	G393	5.7	228.63	46.2
19-162	T394	7.9	226.42	46.2
19-162	G395	8.8	225.58	52.6
19-162	S396	10.1	224.21	9.2
19-162	G397	10.3	224.05	12.3

Ferry Road & Riverbend CSR - Rutland Trunk Sewer

SOIL SAMPLE MOISTURE CONTENTS

Test Hole No.	Sample No.	Depth (m)	Elev. (m)	Moisture Content (%)
19-163	G398	0.5	234.09	23.0
19-163	G399	1.1	233.48	11.6
19-163	G400	2.7	231.95	32.9
19-163	G401	4.2	230.43	43.9
19-163	T402	6.4	228.22	40.6
19-163	G403	7.2	227.38	49.1
19-163	G404	8.8	225.86	50.7
19-163	S405	10.9	223.72	9.7
19-163	G406	11.5	223.11	17.1
19-164	G407	0.5	234.11	26.6
19-164	G408	1.4	233.19	14.7
19-164	G409	2.7	231.97	46.4
19-164	G410	4.2	230.45	50.1
19-164	G411	5.7	228.93	49.9
19-164	T412	7.9	226.72	48.5
19-164	G413	8.8	225.88	47.1
19-164	G414	9.4	225.27	19.2
19-164	S415	10.9	223.74	9.7
19-164	G416	11.5	223.13	9.7
19-165	G417	0.5	234.14	21.7
19-165	G418	1.3	233.37	13.7
19-165	G419	2.7	232.00	46.3
19-165	G420	4.2	230.48	47.0
19-165	T421	6.4	228.27	49.4
19-165	G422	7.2	227.43	42.4
19-165	G423	8.8	225.91	44.5
19-165	S424	10.6	224.08	9.0
19-165	S425	12.3	222.40	12.2
19-166	G436	0.7	234.25	22.9
19-166	G437	1.4	233.49	21.9
19-166	G438	2.7	232.27	42.1
19-166	G439	4.2	230.75	47.3
19-166	T440	6.4	228.54	54.2
19-166	G441	7.2	227.70	47.9
19-166	G442	8.5	226.48	10.0
19-166	S443	9.4	225.57	8.7
19-166	S563	9.3	225.66	5.1
19-166	S565	10.9	224.04	9.0
19-166	S567	11.7	223.28	9.1
19-167	G452	0.5	234.06	19.7
19-167	G453	1.4	233.14	25.5
19-167	G454	2.7	231.92	41.5
19-167	G455	4.2	230.40	43.9
19-167	G456	5.7	228.88	47.7
19-167	T457	7.9	226.67	10.4
19-167	S458	8.3	226.28	8.5
19-167	S557	9.4	225.22	9.4
19-167	S559	10.9	223.69	8.6
19-167	S561	12.4	222.17	9.3
19-168	G444	0.5	234.44	22.0
19-168	G445	1.4	233.52	12.6
19-168	G446	2.4	232.61	41.6
19-168	T447	3.4	231.62	50.3
19-168	G448	4.2	230.78	51.3
19-168	G449	5.7	229.26	42.9
19-168	G450	6.9	228.04	24.3
19-168	S451	7.8	227.12	10.4
19-168	S551	9.4	225.60	8.5
19-168	S553	10.9	224.07	9.3
19-168	S555	12.4	222.55	9.1

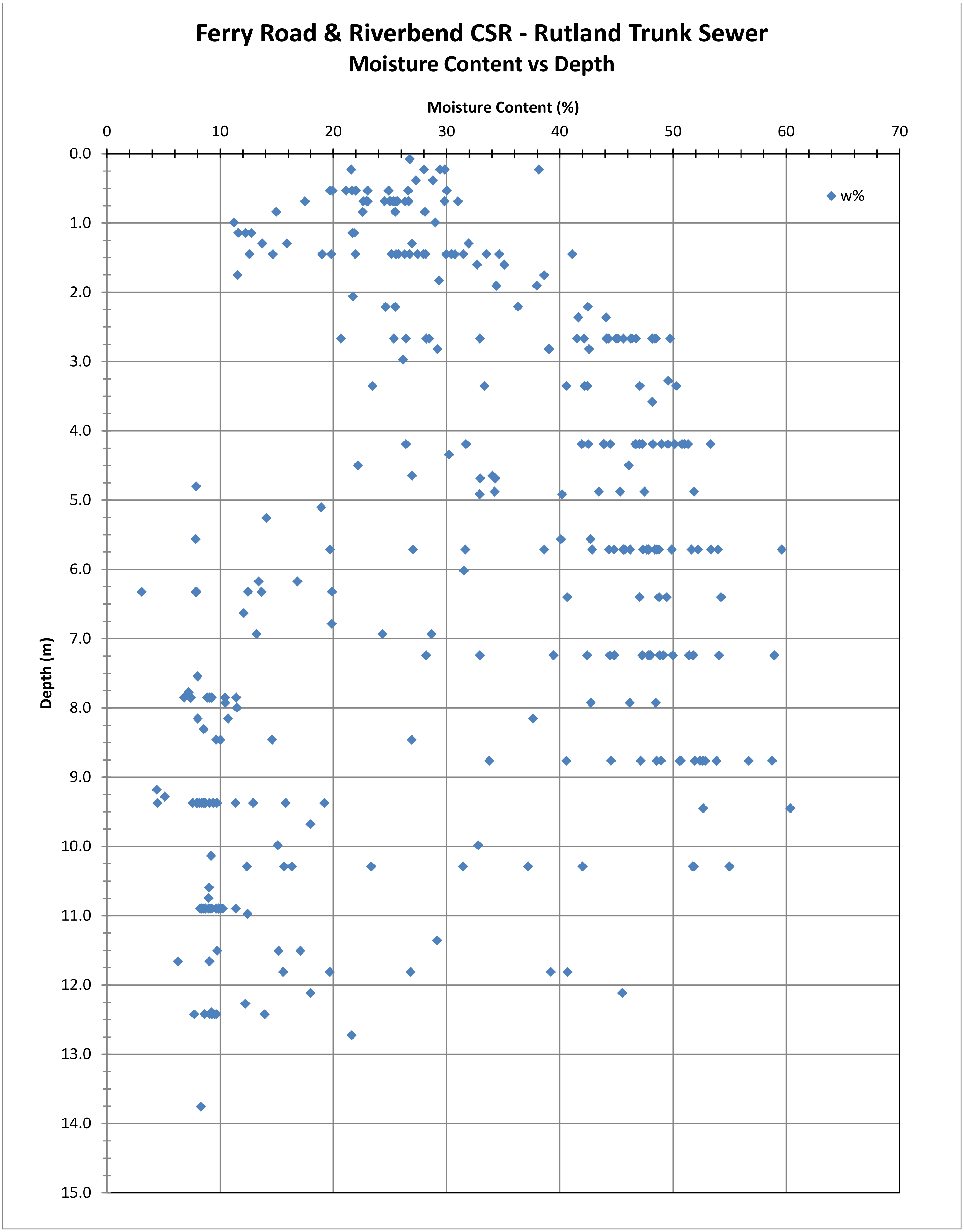
Test Hole No.	Sample No.	Depth (m)	Elev. (m)	Moisture Content (%)
19-169	G459	0.5	234.39	30.0
19-169	G460	1.4	233.47	30.4
19-169	G461	2.7	232.25	46.7
19-169	T462	4.9	230.04	43.4
19-169	G463	5.7	229.21	59.6
19-169	S464	7.8	227.07	7.4
19-169	S545	9.4	225.55	8.4
19-169	S547	10.9	224.02	8.5
19-169	S549	12.4	222.50	9.7
19-170	G465	0.7	234.31	26.3
19-170	G466	1.4	233.55	27.4
19-170	G467	2.7	232.33	44.3
19-170	G468	4.2	230.81	47.1
19-170	G469	5.7	229.29	54.0
19-170	G470	6.9	228.07	28.7
19-170	S471	7.8	227.15	6.8
19-170	S539	9.4	225.63	7.6
19-170	S541	10.9	224.10	10.1
19-170	S543	12.4	222.58	13.9
19-171	G472	0.7	234.30	26.6
19-171	G473	1.4	233.54	30.7
19-171	G474	2.7	232.32	48.5
19-171	T475	4.9	230.11	45.3
19-171	G476	5.7	229.28	51.6
19-171	G477	6.9	228.06	13.2
19-171	S478	7.8	227.14	7.4
19-171	G479	8.2	226.84	10.7
19-171	S533	9.4	225.62	8.1
19-171	S535	10.9	224.09	8.4
19-171	S537	12.4	222.57	9.5
19-172	G481	0.7	234.37	25.0
19-172	G482	1.4	233.61	31.5
19-172	G483	2.7	232.39	42.1
19-172	G484	4.2	230.87	46.7
19-172	G485	5.7	229.35	45.7
19-172	G486	6.8	228.28	19.8
19-172	S487	7.8	227.29	7.2
19-172	G488	8.0	227.06	11.5
19-172	S527	9.4	225.69	8.7
19-172	S529	10.7	224.32	9.0
19-172	S531	12.4	222.64	8.6
19-173	G490	0.7	234.47	25.0
19-173	G491	1.4	233.71	28.0
19-173	G492	2.2	232.95	42.5
19-173	T493	3.4	231.81	42.4
19-173	G494	4.2	230.97	41.9
19-173	G495	5.1	230.05	18.9
19-173	S496	6.3	228.84	13.7
19-173	S497	7.5	227.62	8.0
19-173	S519	9.4	225.79	9.7
19-173	S521	10.9	224.26	10.2
19-173	S523	12.4	222.77	9.2
19-239	G369	0.2	233.85	29.4
19-239	G370	1.1	232.94	21.7
19-239	G371	2.7	231.41	44.1
19-239	T372	4.9	229.20	47.5
19-239	G373	5.7	228.37	44.8
19-239	G374	7.2	226.84	47.8
19-239	G375	8.8	225.32	53.8
19-239	G376	10.0	224.10	15.1

Ferry Road & Riverbend CSR - Rutland Trunk Sewer

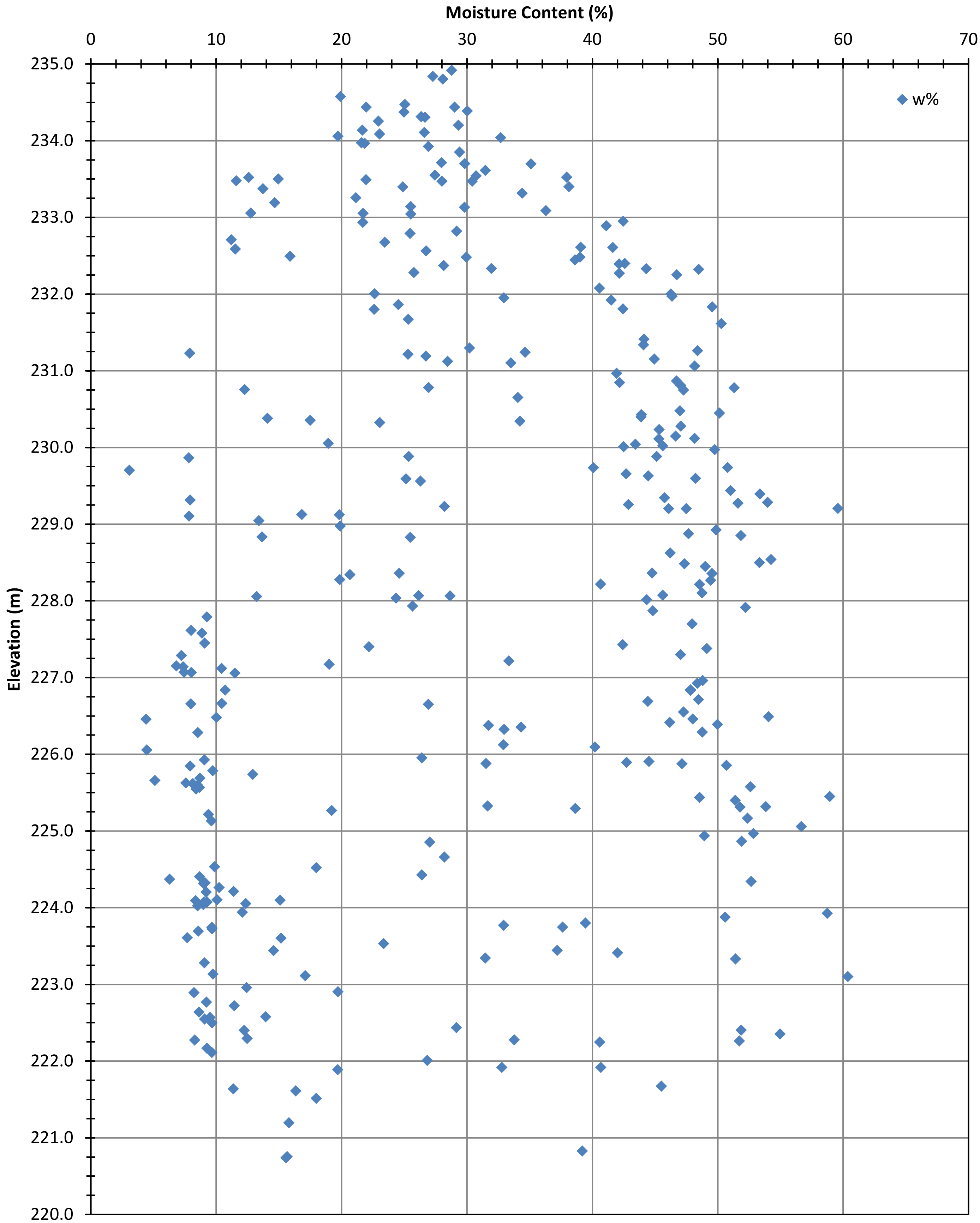
SOIL SAMPLE MOISTURE CONTENTS

Test Hole No.	Sample No.	Depth (m)	Elev. (m)	Moisture Content (%)
19-240	G426	0.5	234.58	19.9
19-240	G427	1.1	233.97	21.8
19-240	G428	2.1	233.05	21.7
19-240	G429	3.3	231.83	49.6
19-240	T430	4.9	230.23	45.3
19-240	G431	5.7	229.40	53.4
19-240	G432	7.2	227.87	44.8
19-240	G433	8.5	226.65	26.9
19-240	S434	9.4	225.74	12.9
19-240	S435	10.9	224.21	11.4
19-240	G436	11.5	223.60	15.2
20-244	G1	0.4	234.84	27.3
20-244	G2	1.3	233.92	26.9
20-244	G3	1.9	233.32	34.4
20-244	G4	2.8	232.40	42.6
20-244	T5	4.9	230.34	34.2
20-244	G6	5.6	229.66	42.7
20-244	G7	6.2	229.05	13.4
20-244	C8	7.5	227.75	n/a
20-244	S9	8.2	227.07	8.0
20-244	C10	8.8	226.46	n/a
20-244	S11	9.4	225.85	7.9
20-244	C12	10.1	225.09	n/a
20-244	S13	10.9	224.32	9.1
20-245	G14	0.4	234.92	28.8
20-245	G15	1.6	233.70	35.1
20-245	G16	2.2	233.09	36.3
20-245	G17	2.8	232.48	39.0
20-245	G18	4.6	230.65	34.1
20-245	G19	5.6	229.74	40.1
20-245	G20	6.2	229.13	16.8
20-245	G21	6.3	228.98	19.9
20-245	C22	7.0	228.29	n/a
20-245	S23	7.8	227.45	9.1
20-245	C24	8.6	226.69	n/a
20-245	S25	9.4	225.93	9.1
20-245	C26	10.1	225.17	n/a
20-245	S27	10.9	224.40	8.7

Test Hole No.	Sample No.	Depth (m)	Elev. (m)	Moisture Content (%)
20-246	G28	1.0	234.44	29.0
20-246	G29	1.9	233.53	38.0
20-246	G30	2.8	232.61	39.1
20-246	T31	3.4	232.08	40.6
20-246	G32	4.6	230.78	26.9
20-246	G33	5.6	229.87	7.8
20-246	S34	6.3	229.11	7.8
20-246	C35	7.1	228.34	n/a
20-246	S36	7.8	227.58	8.9
20-246	C37	8.6	226.82	n/a
20-246	S38	9.4	226.06	4.5
20-246	C39	10.1	225.30	n/a
20-246	S40	10.9	224.53	9.9
20-247	G41	0.8	234.80	28.1
20-247	G42	1.6	234.04	32.7
20-247	G43	2.8	232.82	29.2
20-247	G44	4.3	231.30	30.2
20-247	G45	5.3	230.38	14.1
20-247	S46	6.3	229.32	7.9
20-247	C47	7.1	228.55	n/a
20-247	S48	7.8	227.79	9.3
20-247	C49	8.6	227.03	n/a
20-247	S50	9.2	226.46	4.4
20-247	C51	9.9	225.70	n/a
20-247	S52	10.9	224.74	n/a
20-248	G53	0.7	235.34	31.0
20-248	T54	1.8	234.20	29.3
20-248	T55	3.4	232.68	23.4
20-248	S56	4.8	231.23	7.9
20-248	S57	6.3	229.71	3.1
20-248	C58	7.1	228.94	n/a
20-248	S59	7.6	228.41	n/a
20-248	C60	8.4	227.65	n/a
20-248	S61	9.4	226.66	8.0
20-248	C62	10.1	225.90	n/a
20-248	S63	10.9	225.13	9.6
20-248	C64	11.7	224.37	6.3
20-248	S65	12.4	223.61	7.7
20-248	C66	13.2	222.85	n/a
20-248	S67	13.8	222.28	8.3


Ferry Road & Riverbend CSR - Rutland Trunk Sewer
Moisture Content vs Depth
Moisture Content (%)
0
10
20
30
40
50
60
70
Depth (m)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
w%

Ferry Road & Riverbend CSR - Rutland Trunk Sewer
Moisture Content vs Elevation



DYREGROV ROBINSON INC.

UNCONFINED COMPRESSION TEST

PROJECT: Contract 6 - Rutland Trunk Sewer
PROJECT No.: 143691.7

DATE: y-Aug 2019 / Dec 2(

Test Hole	**19-148**		**Depth**	**10-12**	**feet**
			Sample No.	**T296**	
Wet + Tare Wt.	290.86	g	Length		mm
Dry + Tare Wt.	225.88	g	Diameter		mm
Tare Wt.	31.00	g	Area		mm²
Wt. Water	64.98	g	Weight		g
Dry Wt.	194.88	g	Strain		%
Moisture Cont.	**33.3**	**%**	Avg. Area		mm²
Wet Density	**#DIV/0!**	lb/ft³	***#DIV/0!***	*kN/m³*	
Pocket Pen: Rdg	1.00	tsf	**Torvane:** Rdg	0.33	tsf
Su	**1.00**	**ksf**	Std vane Su	**0.68**	**ksf**
Su	*47.9*	*kPa*	Su	*32.4*	*kPa*
Qu: Displacement	n/a	mm			
Load Cell		kN			
Su		*kPa*			
Su		**ksf**			

Test Hole	**n/a**		**Depth**		**feet**
			Sample No.		
Wet + Tare Wt.		g	Length		mm
Dry + Tare Wt.		g	Diameter		mm
Tare Wt.		g	Area		mm²
Wt. Water		g	Weight		g
Dry Wt.		g	Strain		%
Moisture Cont.		**%**	Avg. Area		mm²
Wet Density		lb/ft³		*kN/m³*	
Pocket Pen: Rdg		tsf	**Torvane:** Rdg		tsf
Su		**ksf**	Std vane Su		**ksf**
Su		*kPa*	Su		*kPa*
Qu: Displacement		mm			
Load Cell		kN			
Su		*kPa*			
Su		**ksf**			

Test Hole	**19-149**		**Depth**	**15-15.8**	**feet**
			Sample No.	**T287A**	
Wet + Tare Wt.	282.53	g	Length		mm
Dry + Tare Wt.	220.30	g	Diameter		mm
Tare Wt.	31.51	g	Area		mm²
Wt. Water	62.23	g	Weight		g
Dry Wt.	188.79	g	Strain		%
Moisture Cont.	**33.0**	**%**	Avg. Area		mm²
Wet Density	**#DIV/0!**	lb/ft³	***#DIV/0!***	*kN/m³*	
Pocket Pen: Rdg	0.50	tsf	**Torvane:** Rdg	0.22	tsf
Su	**0.50**	**ksf**	Std vane Su	**0.45**	**ksf**
Su	*23.9*	*kPa*	Su	*21.6*	*kPa*
Qu: Displacement	n/a	mm			
Load Cell		kN			
Su		*kPa*			
Su		**ksf**			

Test Hole	**19-149**		**Depth**	**15.8-16.5**	**feet**
			Sample No.	**T287B**	
Wet + Tare Wt.	269.84	g	Length	175	mm
Dry + Tare Wt.	203.29	g	Diameter	72	mm
Tare Wt.	37.75	g	Area	4072	mm²
Wt. Water	66.55	g	Weight	1243.72	g
Dry Wt.	165.54	g	Strain	15.00	%
Moisture Cont.	**40.2**	**%**	Avg. Area	4790	mm²
Wet Density	**108.97**	lb/ft³	***17.12***	*kN/m³*	
Pocket Pen: Rdg	0.70	tsf	**Torvane:** Rdg	0.33	tsf
Su	**0.70**	**ksf**	Std vane Su	**0.68**	**ksf**
Su	*33.5*	*kPa*	Su	*32.4*	*kPa*
Qu: Displacement	26.25	mm			
Load Cell	0.170	kN			
Su	*17.7*	*kPa*			
Su	**0.37**	**ksf**			

Test Hole	**19-151**		**Depth**	**15-15.8**	**feet**
			Sample No.	**T269A**	
Wet + Tare Wt.	229.69	g	Length		mm
Dry + Tare Wt.	178.97	g	Diameter		mm
Tare Wt.	31.13	g	Area		mm²
Wt. Water	50.72	g	Weight		g
Dry Wt.	147.84	g	Strain		%
Moisture Cont.	**34.3**	**%**	Avg. Area		mm²
Wet Density		lb/ft³		*kN/m³*	
Pocket Pen: Rdg	0.40	tsf	**Torvane:** Rdg	0.20	tsf
Su	**0.40**	**ksf**	Std vane Su	**0.41**	**ksf**
Su	*19.2*	*kPa*	Su	*19.6*	*kPa*
Qu: Displacement	n/a	mm			
Load Cell		kN			
Su		*kPa*			
Su		**ksf**			

Test Hole	**19-151**		**Depth**	**15.8-16.5**	**feet**
			Sample No.	**T269B**	
Wet + Tare Wt.	242.55	g	Length	175	mm
Dry + Tare Wt.	190.05	g	Diameter	72	mm
Tare Wt.	30.50	g	Area	4072	mm²
Wt. Water	52.50	g	Weight	1291.13	g
Dry Wt.	159.55	g	Strain	15.00	%
Moisture Cont.	**32.9**	**%**	Avg. Area	4790	mm²
Wet Density	**113.12**	lb/ft³	***17.77***	*kN/m³*	
Pocket Pen: Rdg	1.00	tsf	**Torvane:** Rdg	0.53	tsf
Su	**1.00**	**ksf**	Std vane Su	**1.09**	**ksf**
Su	*47.9*	*kPa*	Su	*52.0*	*kPa*
Qu: Displacement	26.25	mm			
Load Cell	0.349	kN			
Su	*36.4*	*kPa*			
Su	**0.76**	**ksf**			

DYREGROV ROBINSON INC. **UNCONFINED COMPRESSION TEST**

PROJECT: Contract 6 - Rutland Trunk Sewer **DATE:** y-Aug 2019 / Dec 2(
PROJECT No.: 143691.7

Test Hole	**19-152**	**Depth**	**20-22 feet**	**Test Hole**	**19-153**	**Depth**	**30-32 feet**
		Sample No.	**T241**			**Sample No.**	**T251**
Wet + Tare Wt.	188.07 g	Length	mm	Wet + Tare Wt.	320.53 g	Length	175 mm
Dry + Tare Wt.	136.47 g	Diameter	mm	Dry + Tare Wt.	211.48 g	Diameter	72 mm
Tare Wt.	30.65 g	Area	mm²	Tare Wt.	30.84 g	Area	4072 mm²
Wt. Water	51.60 g	Weight	g	Wt. Water	109.05 g	Weight	1152.62 g
Dry Wt.	105.82 g	Strain	%	Dry Wt.	180.64 g	Strain	3.71 %
Moisture Cont.	**48.8 %**	Avg. Area	mm²	**Moisture Cont.**	**60.4 %**	Avg. Area	4229 mm²
Wet Density	lb/ft³		*kN/m³*	**Wet Density**	**100.99** lb/ft³		***15.86*** *kN/m³*
Pocket Pen: Rdg	1.10 tsf	**Torvane:** Rdg	0.54 tsf	**Pocket Pen**: Rdg	0.84 tsf	**Torvane:** Rdg	0.48 tsf
Su	**1.10 ksf**	Std vane Su	**1.11 ksf**	Su	**0.84 ksf**	Std vane Su	**0.98 ksf**
Su	*52.7 kPa*	Su	*53.0 kPa*	Su	*40.2 kPa*	Su	*47.1 kPa*
Qu: Displacement	N/A mm			**Qu:** Displacement	6.50 mm		
Load Cell	kN			Load Cell	0.245 kN		
Su	*kPa*			Su	*29.0 kPa*		
Su	**ksf**			Su	**0.61 ksf**		
Test Hole	**19-155**	**Depth**	**10-12 feet**	**Test Hole**	**19-156**	**Depth**	**20-22 feet**
		Sample No.	**T314**			**Sample No.**	**T326**
Wet + Tare Wt.	255.86 g	Length	178 mm	Wet + Tare Wt.	269.16 g	Length	mm
Dry + Tare Wt.	186.56 g	Diameter	71 mm	Dry + Tare Wt.	195.38 g	Diameter	mm
Tare Wt.	39.28 g	Area	3959 mm²	Tare Wt.	38.54 g	Area	mm²
Wt. Water	69.30 g	Weight	1216.98 g	Wt. Water	73.78 g	Weight	g
Dry Wt.	147.28 g	Strain	5.48 %	Dry Wt.	156.84 g	Strain	%
Moisture Cont.	**47.1 %**	Avg. Area	4189 mm²	**Moisture Cont.**	**47.0 %**	Avg. Area	mm²
Wet Density	**107.80** lb/ft³		***16.93*** *kN/m³*	**Wet Density**	lb/ft³		*kN/m³*
Pocket Pen: Rdg	1.40 tsf	**Torvane:** Rdg	0.59 tsf	**Pocket Pen**: Rdg	0.90 tsf	**Torvane:** Rdg	0.44 tsf
Su	**1.40 ksf**	Std vane Su	**1.21 ksf**	Su	**0.90 ksf**	Std vane Su	**0.90 ksf**
Su	*67.0 kPa*	Su	*57.9 kPa*	Su	*43.1 kPa*	Su	*43.1 kPa*
Qu: Displacement	9.75 mm			**Qu:** Displacement	N/A mm		
Load Cell	0.312 kN			Load Cell	kN		
Su	*37.2 kPa*			Su	*kPa*		
Su	**0.78 ksf**			Su	**ksf**		
Test Hole	**19-157**	**Depth**	**30-32 feet**	**Test Hole**	**19-158**	**Depth**	**15-17 feet**
		Sample No.	**T337**			**Sample No.**	**T344**
Wet + Tare Wt.	251.96 g	Length	175 mm	Wet + Tare Wt.	308.88 g	Length	176 mm
Dry + Tare Wt.	177.64 g	Diameter	71 mm	Dry + Tare Wt.	216.19 g	Diameter	71 mm
Tare Wt.	36.52 g	Area	3959 mm²	Tare Wt.	37.42 g	Area	3959 mm²
Wt. Water	74.32 g	Weight	1195.50 g	Wt. Water	92.69 g	Weight	1209.78 g
Dry Wt.	141.12 g	Strain	5.57 %	Dry Wt.	178.77 g	Strain	5.11 %
Moisture Cont.	**52.7 %**	Avg. Area	4193 mm²	**Moisture Cont.**	**51.8 %**	Avg. Area	4173 mm²
Wet Density	**107.72** lb/ft³		***16.92*** *kN/m³*	**Wet Density**	**108.38** lb/ft³		***17.03*** *kN/m³*
Pocket Pen: Rdg	0.63 tsf	**Torvane:** Rdg	0.36 tsf	**Pocket Pen**: Rdg	1.33 tsf	**Torvane:** Rdg	0.64 tsf
Su	**0.63 ksf**	Std vane Su	**0.74 ksf**	Su	**1.33 ksf**	Std vane Su	**1.31 ksf**
Su	*30.2 kPa*	Su	*35.3 kPa*	Su	*63.7 kPa*	Su	*62.8 kPa*
Qu: Displacement	9.75 mm			**Qu:** Displacement	9.00 mm		
Load Cell	0.195 kN			Load Cell	0.388 kN		
Su	*23.3 kPa*			Su	*46.5 kPa*		
Su	**0.49 ksf**			Su	**0.97 ksf**		

DYREGROV ROBINSON INC. **UNCONFINED COMPRESSION TEST**

PROJECT: Contract 6 - Rutland Trunk Sewer **DATE:** y-Aug 2019 / Dec 2(
PROJECT No.: 143691.7

Test Hole	**19-159**		**Depth**	**25-27**	**feet**
			Sample No.	**T355**	
Wet + Tare Wt.	330.02	g	Length	172	mm
Dry + Tare Wt.	242.48	g	Diameter	71	mm
Tare Wt.	37.60	g	Area	3959	mm²
Wt. Water	87.54	g	Weight	1137.45	g
Dry Wt.	204.88	g	Strain	6.54	%
Moisture Cont.	**42.7**	**%**	Avg. Area	4236	mm²
Wet Density	**104.27**	lb/ft³	***16.38***	*kN/m³*	
Pocket Pen: Rdg	0.75	tsf	**Torvane:** Rdg	0.37	tsf
Su	**0.75**	**ksf**	Std vane Su	**0.76**	**ksf**
Su	*35.9*	*kPa*	Su	*36.3*	*kPa*
Qu: Displacement	11.25	mm			
Load Cell	0.205	kN			
Su	*24.2*	*kPa*			
Su	**0.51**	**ksf**			

Test Hole	**19-160**		**Depth**	**35-36**	**feet**
			Sample No.	**T367**	
Wet + Tare Wt.	302.40	g	Length		mm
Dry + Tare Wt.	273.11	g	Diameter		mm
Tare Wt.	37.32	g	Area		mm²
Wt. Water	29.29	g	Weight		g
Dry Wt.	235.79	g	Strain		%
Moisture Cont.	**12.4**	**%**	Avg. Area		mm²
Wet Density		lb/ft³		*kN/m³*	
Pocket Pen: Rdg		tsf	**Torvane:** Rdg		tsf
Su		**ksf**	Std vane Su		**ksf**
Su		*kPa*	Su		*kPa*
Qu: Displacement		mm			
Load Cell		kN	Silt Till - trace sand, gravel		
Su		*kPa*	grey, moist, loose		
Su		**ksf**			

Test Hole	**19-161**		**Depth**	**10-12**	**feet**
			Sample No.	**T381**	
Wet + Tare Wt.	246.89	g	Length	170	mm
Dry + Tare Wt.	182.84	g	Diameter	71	mm
Tare Wt.	30.96	g	Area	3959	mm²
Wt. Water	64.05	g	Weight	1149.77	g
Dry Wt.	151.88	g	Strain	5.15	%
Moisture Cont.	**42.2**	**%**	Avg. Area	4174	mm²
Wet Density	**106.64**	lb/ft³	***16.75***	*kN/m³*	
Pocket Pen: Rdg	1.90	tsf	**Torvane:** Rdg	0.77	tsf
Su	**1.90**	**ksf**	Std vane Su	**1.58**	**ksf**
Su	*91.0*	*kPa*	Su	*75.5*	*kPa*
Qu: Displacement	8.75	mm			
Load Cell	0.377	kN			
Su	*45.2*	*kPa*			
Su	**0.94**	**ksf**			

Test Hole	**19-162**		**Depth**	**25-27**	**feet**
			Sample No.	**T394**	
Wet + Tare Wt.	344.60	g	Length	176	mm
Dry + Tare Wt.	245.88	g	Diameter	70	mm
Tare Wt.	32.06	g	Area	3848	mm²
Wt. Water	98.72	g	Weight	1210.40	g
Dry Wt.	213.82	g	Strain	5.11	%
Moisture Cont.	**46.2**	**%**	Avg. Area	4056	mm²
Wet Density	**111.56**	lb/ft³	***17.52***	*kN/m³*	
Pocket Pen: Rdg	0.90	tsf	**Torvane:** Rdg	0.39	tsf
Su	**0.90**	**ksf**	Std vane Su	**0.80**	**ksf**
Su	*43.1*	*kPa*	Su	*38.2*	*kPa*
Qu: Displacement	9.00	mm			
Load Cell	0.273	kN			
Su	*33.7*	*kPa*			
Su	**0.70**	**ksf**			

Test Hole	**19-163**		**Depth**	**20-22**	**feet**
			Sample No.	**T402**	
Wet + Tare Wt.	365.65	g	Length	175	mm
Dry + Tare Wt.	268.77	g	Diameter	71	mm
Tare Wt.	30.43	g	Area	3959	mm²
Wt. Water	96.88	g	Weight	1197.26	g
Dry Wt.	238.34	g	Strain	5.71	%
Moisture Cont.	**40.6**	**%**	Avg. Area	4199	mm²
Wet Density	**107.88**	lb/ft³	***16.95***	*kN/m³*	
Pocket Pen: Rdg	1.03	tsf	**Torvane:** Rdg	0.45	tsf
Su	**1.03**	**ksf**	Std vane Su	**0.92**	**ksf**
Su	*49.3*	*kPa*	Su	*44.1*	*kPa*
Qu: Displacement	10.00	mm			
Load Cell	0.324	kN			
Su	*38.6*	*kPa*			
Su	**0.81**	**ksf**			

Test Hole	**19-164**		**Depth**	**25-27**	**feet**
			Sample No.	**T412**	
Wet + Tare Wt.	358.12	g	Length	176	mm
Dry + Tare Wt.	253.72	g	Diameter	71	mm
Tare Wt.	38.28	g	Area	3959	mm²
Wt. Water	104.40	g	Weight	1179.00	g
Dry Wt.	215.44	g	Strain	5.11	%
Moisture Cont.	**48.5**	**%**	Avg. Area	4173	mm²
Wet Density	**105.63**	lb/ft³	***16.59***	*kN/m³*	
Pocket Pen: Rdg	0.73	tsf	**Torvane:** Rdg	0.42	tsf
Su	**0.73**	**ksf**	Std vane Su	**0.86**	**ksf**
Su	*35.0*	*kPa*	Su	*41.2*	*kPa*
Qu: Displacement	9.00	mm			
Load Cell	0.278	kN			
Su	*33.3*	*kPa*			
Su	**0.70**	**ksf**			

DYREGROV ROBINSON INC. — ***UNCONFINED COMPRESSION TEST***

PROJECT: Contract 6 - Rutland Trunk Sewer
PROJECT No.: 143691.7
DATE: y-Aug 2019 / Dec 2(

Test Hole	**19-165**		**Depth**	**20-22**	**feet**
			Sample No.	**T421**	
Wet + Tare Wt.	251.93	g	Length	176	mm
Dry + Tare Wt.	181.16	g	Diameter	71	mm
Tare Wt.	38.01	g	Area	3959	mm²
Wt. Water	70.77	g	Weight	1147.98	g
Dry Wt.	143.15	g	Strain	7.10	%
Moisture Cont.	**49.4**	**%**	Avg. Area	4262	mm²
Wet Density	**102.85**	lb/ft³		***16.16***	*kN/m³*
Pocket Pen: Rdg	1.18	tsf	**Torvane:** Rdg	0.54	tsf
Su	**1.18**	**ksf**	Std vane Su	**1.11**	**ksf**
Su	*56.5*	*kPa*	Su	*53.0*	*kPa*
Qu: Displacemer	12.50	mm			
Load Cell	0.246	kN			
Su	*28.9*	*kPa*			
Su	**0.60**	**ksf**			

Test Hole	**19-166**		**Depth**	**20-22**	**feet**
			Sample No.	**T440**	
Wet + Tare Wt.	283.40	g	Length	176	mm
Dry + Tare Wt.	194.61	g	Diameter	71	mm
Tare Wt.	30.91	g	Area	3959	mm²
Wt. Water	88.79	g	Weight	1199.60	g
Dry Wt.	163.70	g	Strain	4.55	%
Moisture Cont.	**54.2**	**%**	Avg. Area	4148	mm²
Wet Density	**107.47**	lb/ft³		***16.88***	*kN/m³*
Pocket Pen: Rdg	1.05	tsf	**Torvane:** Rdg	0.45	tsf
Su	**1.05**	**ksf**	Std vane Su	**0.92**	**ksf**
Su	*50.3*	*kPa*	Su	*44.1*	*kPa*
Qu: Displacemer	8.00	mm			
Load Cell	0.261	kN			
Su	*31.5*	*kPa*			
Su	**0.66**	**ksf**			

Test Hole	**19-167**		**Depth**	**25-27**	**feet**
			Sample No.	**T457**	
Wet + Tare Wt.	351.05	g	Length		mm
Dry + Tare Wt.	320.72	g	Diameter		mm
Tare Wt.	30.43	g	Area		mm²
Wt. Water	30.33	g	Weight		g
Dry Wt.	290.29	g	Strain		%
Moisture Cont.	**10.4**	**%**	Avg. Area		mm²
Wet Density	**#DIV/0!**	lb/ft³		***#DIV/0!***	*kN/m³*
Pocket Pen: Rdg		tsf	**Torvane:** Rdg		tsf
Su		**ksf**	Std vane Su		**ksf**
Su		*kPa*	Su		*kPa*
Qu: Displacement		mm			
Load Cell		kN	Silt Till - trace sand, gravel		
Su		*kPa*	grey, moist, loose		
Su		**ksf**			

Test Hole	**19-168**		**Depth**	**10-12**	**feet**
			Sample No.	**T447**	
Wet + Tare Wt.	297.14	g	Length	176	mm
Dry + Tare Wt.	208.08	g	Diameter	71	mm
Tare Wt.	30.92	g	Area	3959	mm²
Wt. Water	89.06	g	Weight	1187.81	g
Dry Wt.	177.16	g	Strain	3.55	%
Moisture Cont.	**50.3**	**%**	Avg. Area	4105	mm²
Wet Density	**106.42**	lb/ft³		***16.72***	*kN/m³*
Pocket Pen: Rdg	1.50	tsf	**Torvane:** Rdg	0.69	tsf
Su	**1.50**	**ksf**	Std vane Su	**1.41**	**ksf**
Su	*71.8*	*kPa*	Su	*67.7*	*kPa*
Qu: Displacemer	6.25	mm			
Load Cell	0.287	kN			
Su	*35.0*	*kPa*			
Su	**0.73**	**ksf**			

Test Hole	**19-169**		**Depth**	**15-17**	**feet**
			Sample No.	**T462**	
Wet + Tare Wt.	414.27	g	Length	176	mm
Dry + Tare Wt.	298.04	g	Diameter	71	mm
Tare Wt.	30.41	g	Area	3959	mm²
Wt. Water	116.23	g	Weight	1298.37	g
Dry Wt.	267.63	g	Strain	6.11	%
Moisture Cont.	**43.4**	**%**	Avg. Area	4217	mm²
Wet Density	**116.32**	lb/ft³		***18.27***	*kN/m³*
Pocket Pen: Rdg	1.30	tsf	**Torvane:** Rdg	0.57	tsf
Su	**1.30**	**ksf**	Std vane Su	**1.17**	**ksf**
Su	*62.2*	*kPa*	Su	*55.9*	*kPa*
Qu: Displacemer	10.75	mm			
Load Cell	0.383	kN			
Su	*45.4*	*kPa*			
Su	**0.95**	**ksf**			

Test Hole	**19-171**		**Depth**	**15-17**	**feet**
			Sample No.	**T475**	
Wet + Tare Wt.	312.05	g	Length	176	mm
Dry + Tare Wt.	224.37	g	Diameter	72	mm
Tare Wt.	30.84	g	Area	4072	mm²
Wt. Water	87.68	g	Weight	1213.14	g
Dry Wt.	193.53	g	Strain	4.69	%
Moisture Cont.	**45.3**	**%**	Avg. Area	4272	mm²
Wet Density	**105.69**	lb/ft³		***16.60***	*kN/m³*
Pocket Pen: Rdg	0.98	tsf	**Torvane:** Rdg	0.47	tsf
Su	**0.98**	**ksf**	Std vane Su	**0.96**	**ksf**
Su	*46.9*	*kPa*	Su	*46.1*	*kPa*
Qu: Displacemer	8.25	mm			
Load Cell	0.270	kN			
Su	*31.6*	*kPa*			
Su	**0.66**	**ksf**			

DYREGROV ROBINSON INC.

UNCONFINED COMPRESSION TEST

PROJECT: Contract 6 - Rutland Trunk Sewer

PROJECT No.: 143691.7

DATE: y-Aug 2019 / Dec 2(

Test Hole	**19-173**		**Depth**	**10-12**	**feet**
			Sample No.	**T493**	
Wet + Tare Wt.	216.71	g	Length	169	mm
Dry + Tare Wt.	161.37	g	Diameter	72	mm
Tare Wt.	30.95	g	Area	4072	mm²
Wt. Water	55.34	g	Weight	1180.12	g
Dry Wt.	130.42	g	Strain	2.22	%
Moisture Cont.	**42.4**	**%**	Avg. Area	4164	mm²
Wet Density	**107.07**	lb/ft³		***16.82***	*kN/m³*
Pocket Pen: Rdç	1.13	tsf	**Torvane:** Rdg	0.53	tsf
Sι	**1.13**	**ksf**	Std vane Su	**1.09**	**ksf**
Sι	*54.1*	*kPa*	Su	*52.0*	*kPa*
Qu: Displacemer	3.75	mm			
Load Cell	0.163	kN			
Su	*19.6*	*kPa*			
Su	**0.41**	**ksf**			

Test Hole	**19-239**		**Depth**	**15-17**	**feet**
			Sample No.	**T372**	
Wet + Tare Wt.	257.71	g	Length	175	mm
Dry + Tare Wt.	184.60	g	Diameter	71	mm
Tare Wt.	30.61	g	Area	3959	mm²
Wt. Water	73.11	g	Weight	1197.99	g
Dry Wt.	153.99	g	Strain	4.86	%
Moisture Cont.	**47.5**	**%**	Avg. Area	4161	mm²
Wet Density	**107.94**	lb/ft³		***16.96***	*kN/m³*
Pocket Pen: Rdç	1.50	tsf	**Torvane:** Rdg	0.69	tsf
Sι	**1.50**	**ksf**	Std vane Su	**1.41**	**ksf**
Sι	*71.8*	*kPa*	Su	*67.7*	*kPa*
Qu: Displacemer	8.50	mm			
Load Cell	0.311	kN			
Su	*37.4*	*kPa*			
Su	**0.78**	**ksf**			

Test Hole	**19-240**		**Depth**	**15-17**	**feet**
			Sample No.	**T430**	
Wet + Tare Wt.	270.66	g	Length	178	mm
Dry + Tare Wt.	197.60	g	Diameter	71	mm
Tare Wt.	36.43	g	Area	3959	mm²
Wt. Water	73.06	g	Weight	1235.92	g
Dry Wt.	161.17	g	Strain	3.51	%
Moisture Cont.	**45.3**	**%**	Avg. Area	4103	mm²
Wet Density	**109.48**	lb/ft³		***17.20***	*kN/m³*
Pocket Pen: Rdç	1.40	tsf	**Torvane:** Rdg	0.65	tsf
Sι	**1.40**	**ksf**	Std vane Su	**1.33**	**ksf**
Sι	*67.0*	*kPa*	Su	*63.7*	*kPa*
Qu: Displacemer	6.25	mm			
Load Cell	0.326	kN			
Su	*39.7*	*kPa*			
Su	**0.83**	**ksf**			

Test Hole			**Depth**		**feet**
			Sample No.		
Wet + Tare Wt.		g	Length		mm
Dry + Tare Wt.		g	Diameter		mm
Tare Wt.		g	Area	0	mm²
Wt. Water		g	Weight		g
Dry Wt.		g	Strain		%
Moisture Cont.		**%**	Avg. Area		mm²
Wet Density		lb/ft³			*kN/m³*
Pocket Pen: Rdg		tsf	**Torvane:** Rdg		tsf
Su		**ksf**	Std vane Su		**ksf**
Su		*kPa*	Su		*kPa*
Qu: Displacement		mm			
Load Cell		kN			
Su		*kPa*			
Su		**ksf**			

Test Hole			**Depth**		**feet**
			Sample No.		
Wet + Tare Wt.		g	Length		mm
Dry + Tare Wt.		g	Diameter		mm
Tare Wt.		g	Area		mm²
Wt. Water		g	Weight		g
Dry Wt.		g	Strain		%
Moisture Cont.		**%**	Avg. Area		mm²
Wet Density		lb/ft³			*kN/m³*
Pocket Pen: Rdg		tsf	**Torvane:** Rdg		tsf
Su		**ksf**	Std vane Su		**ksf**
Su		*kPa*	Su		*kPa*
Qu: Displacement		mm			
Load Cell		kN			
Su		*kPa*			
Su		**ksf**			

Test Hole			**Depth**		**feet**
			Sample No.		
Wet + Tare Wt.		g	Length		mm
Dry + Tare Wt.		g	Diameter		mm
Tare Wt.		g	Area	0	mm²
Wt. Water		g	Weight		g
Dry Wt.		g	Strain		%
Moisture Cont.		**%**	Avg. Area		mm²
Wet Density		lb/ft³			*kN/m³*
Pocket Pen: Rdg		tsf	**Torvane:** Rdg		tsf
Su		**ksf**	Std vane Su		**ksf**
Su		*kPa*	Su		*kPa*
Qu: Displacement		mm			
Load Cell		kN			
Su		*kPa*			
Su		**ksf**			

DYREGROV ROBINSON INC.

UNCONFINED COMPRESSION TEST

PROJECT: Contract 6 - Rutland Trunk Sewer

PROJECT No.: 143691.7

DATE: December 2020

Test Hole	**20-244**		**Depth**	**15-17**	**feet**
			Sample No.	**T5**	
Wet + Tare Wt.	425.37	g	Length	176	mm
Dry + Tare Wt.	324.95	g	Diameter	72	mm
Tare Wt.	31.56	g	Area	4072	mm²
Wt. Water	100.42	g	Weight	1225.05	g
Dry Wt.	293.39	g	Strain	8.52	%
Moisture Cont.	**34.2**	**%**	Avg. Area	4451	mm²
Wet Density	**106.72**	lb/ft³		***16.77***	*kN/m³*
Pocket Pen: Rdg	0.85	tsf	**Torvane:** Rdg	0.38	tsf
Su	**0.85**	**ksf**	Std vane Su	**0.77**	**ksf**
Su	*40.7*	*kPa*	Su	*36.8*	*kPa*
Qu: Displacemer	15.00	mm			
Load Cell	0.165	kN			
Su	*18.5*	*kPa*			
Su	**0.39**	**ksf**			

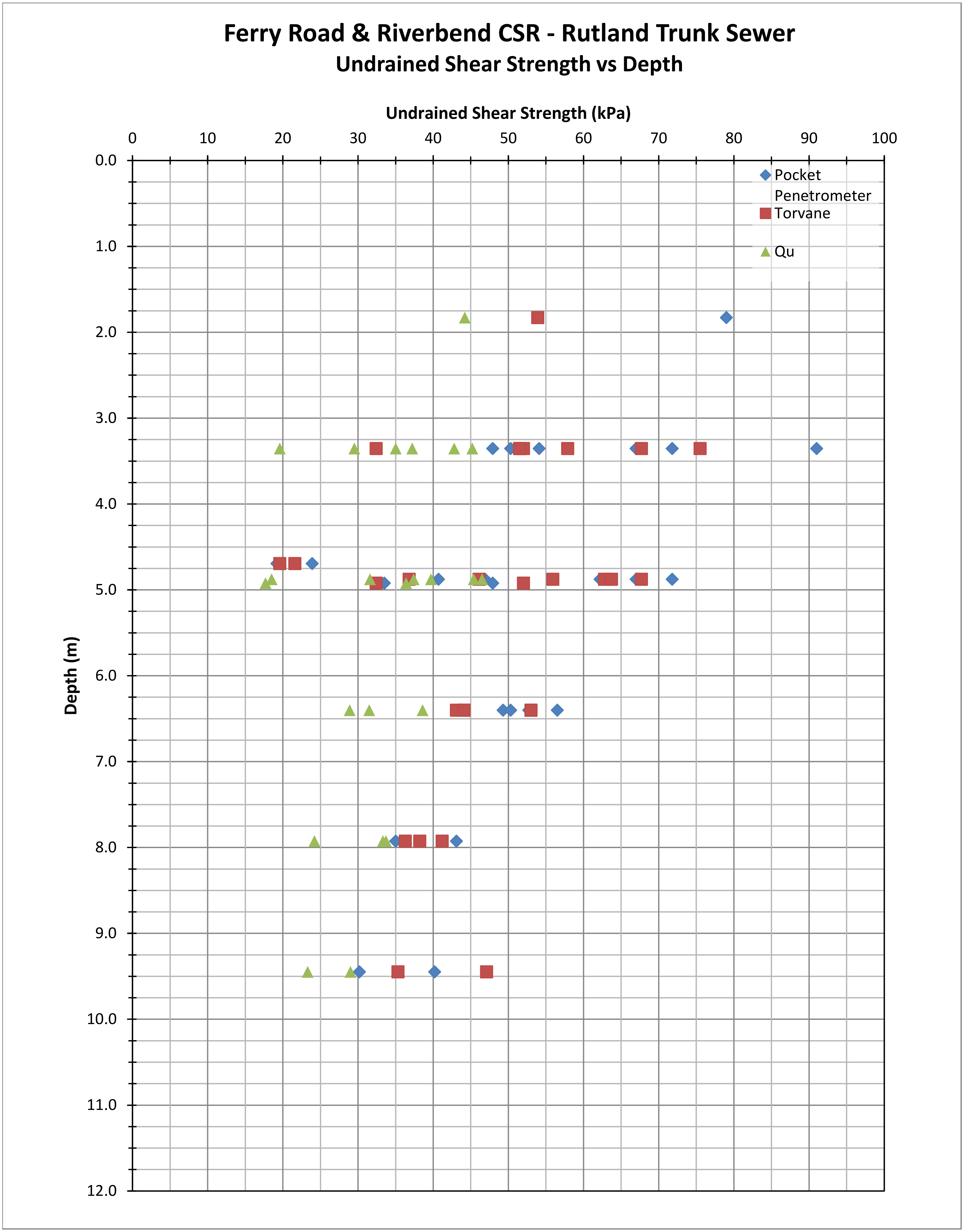
Test Hole	**20-246**		**Depth**	**10-12**	**feet**
			Sample No.	**T31**	
Wet + Tare Wt.	355.35	g	Length	177	mm
Dry + Tare Wt.	261.63	g	Diameter	72	mm
Tare Wt.	30.60	g	Area	4072	mm²
Wt. Water	93.72	g	Weight	1298.38	g
Dry Wt.	231.03	g	Strain	5.65	%
Moisture Cont.	**40.6**	**%**	Avg. Area	4315	mm²
Wet Density	**112.47**	lb/ft³		***17.67***	*kN/m³*
Pocket Pen: Rdg	1.05	tsf	**Torvane:** Rdg	0.53	tsf
Su	**1.05**	**ksf**	Std vane Su	**1.08**	**ksf**
Su	*50.3*	*kPa*	Su	*51.5*	*kPa*
Qu: Displacemer	10.00	mm			
Load Cell	0.369	kN			
Su	*42.8*	*kPa*			
Su	**0.89**	**ksf**			

Test Hole	**20-248**		**Depth**	**5-7**	**feet**
			Sample No.	**T54**	
Wet + Tare Wt.	364.95	g	Length	176	mm
Dry + Tare Wt.	289.25	g	Diameter	72	mm
Tare Wt.	31.08	g	Area	4072	mm²
Wt. Water	75.70	g	Weight	1394.98	g
Dry Wt.	258.17	g	Strain	5.68	%
Moisture Cont.	**29.3**	**%**	Avg. Area	4317	mm²
Wet Density	**121.53**	lb/ft³		***19.09***	*kN/m³*
Pocket Pen: Rdg	1.65	tsf	**Torvane:** Rdg	0.55	tsf
Su	**1.65**	**ksf**	Std vane Su	**1.13**	**ksf**
Su	*79.0*	*kPa*	Su	*53.9*	*kPa*
Qu: Displacemer	10.00	mm			
Load Cell	0.382	kN			
Su	*44.2*	*kPa*			
Su	**0.92**	**ksf**			

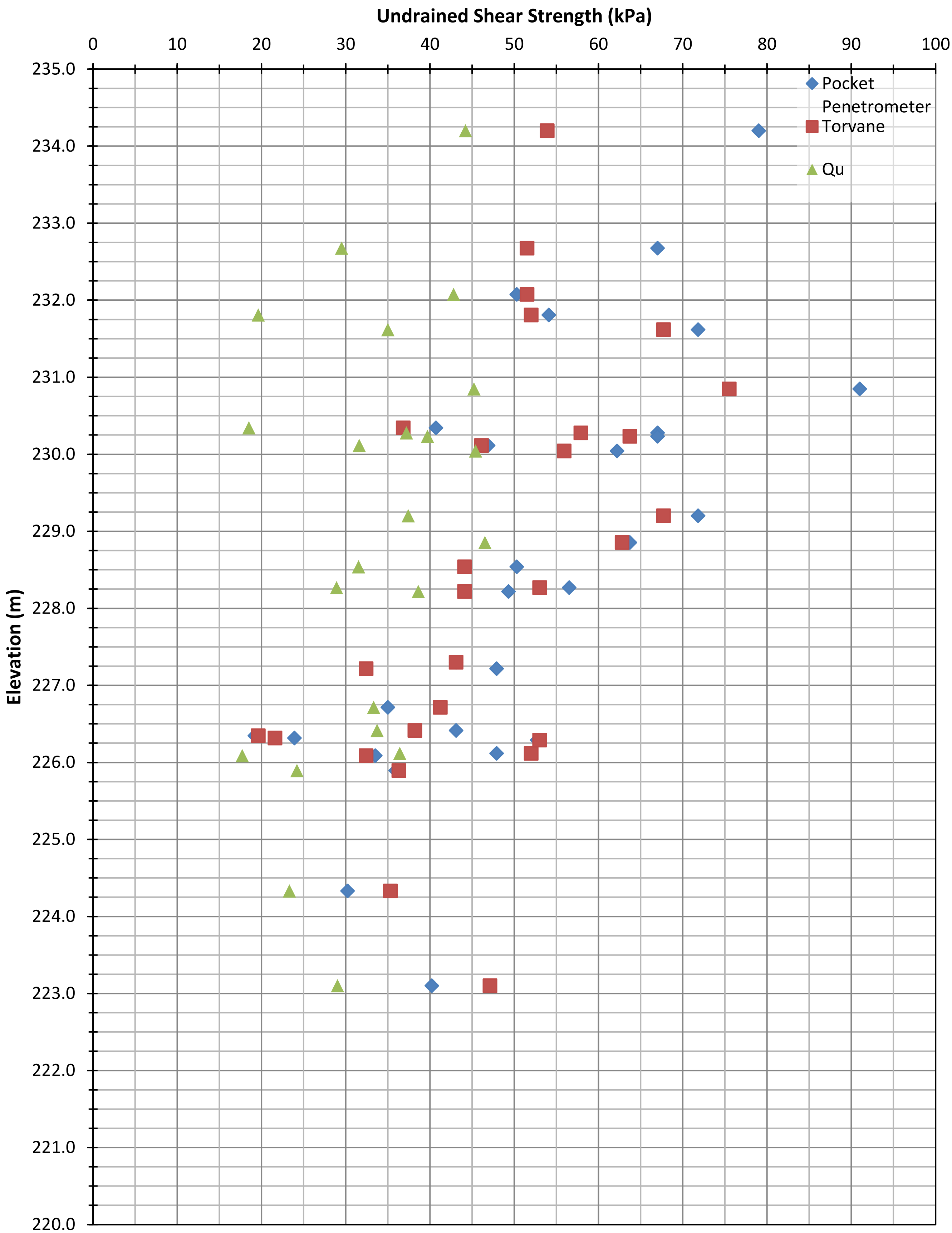
Test Hole	**20-248**		**Depth**	**10-12**	**feet**
			Sample No.	**T55**	
Wet + Tare Wt.	466.23	g	Length	175	mm
Dry + Tare Wt.	383.72	g	Diameter	72	mm
Tare Wt.	31.80	g	Area	4072	mm²
Wt. Water	82.51	g	Weight	1341.50	g
Dry Wt.	351.92	g	Strain	6.57	%
Moisture Cont.	**23.4**	**%**	Avg. Area	4358	mm²
Wet Density	**117.54**	lb/ft³		***18.46***	*kN/m³*
Pocket Pen: Rdg	1.40	tsf	**Torvane:** Rdg	0.53	tsf
Su	**1.40**	**ksf**	Std vane Su	**1.08**	**ksf**
Su	*67.0*	*kPa*	Su	*51.5*	*kPa*
Qu: Displacement	11.50	mm			
Load Cell	0.257	kN			
Su	*29.5*	*kPa*			
Su	**0.62**	**ksf**			

Test Hole			**Depth**		**feet**
			Sample No.		
Wet + Tare Wt.		g	Length		mm
Dry + Tare Wt.		g	Diameter		mm
Tare Wt.		g	Area		mm²
Wt. Water		g	Weight		g
Dry Wt.		g	Strain		%
Moisture Cont.		**%**	Avg. Area		mm²
Wet Density		lb/ft³			*kN/m³*
Pocket Pen: Rdg		tsf	**Torvane:** Rdg		tsf
Su		**ksf**	Std vane Su		**ksf**
Su		*kPa*	Su		*kPa*
Qu: Displacement		mm			
Load Cell		kN			
Su		*kPa*			
Su		**ksf**			

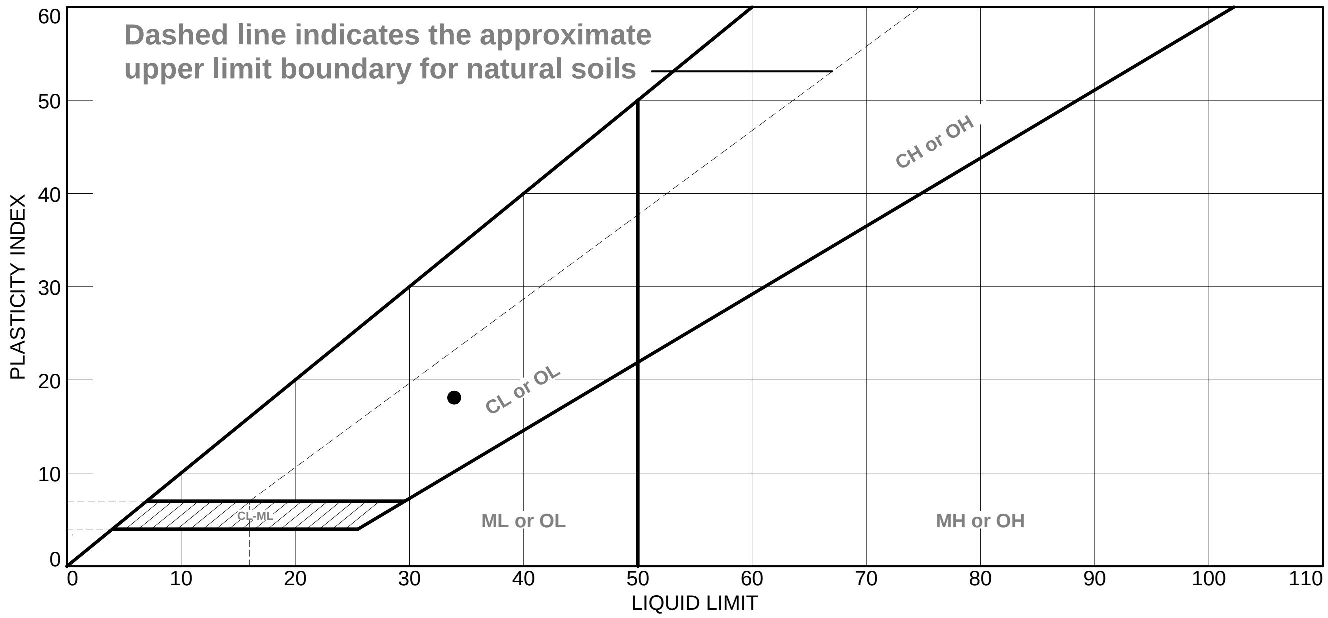
Test Hole			**Depth**		**feet**
			Sample No.		
Wet + Tare Wt.		g	Length		mm
Dry + Tare Wt.		g	Diameter		mm
Tare Wt.		g	Area	0	mm²
Wt. Water		g	Weight		g
Dry Wt.		g	Strain		%
Moisture Cont.		**%**	Avg. Area		mm²
Wet Density		lb/ft³			*kN/m³*
Pocket Pen: Rdg		tsf	**Torvane:** Rdg		tsf
Su		**ksf**	Std vane Su		**ksf**
Su		*kPa*	Su		*kPa*
Qu: Displacement		mm			
Load Cell		kN			
Su		*kPa*			
Su		**ksf**			

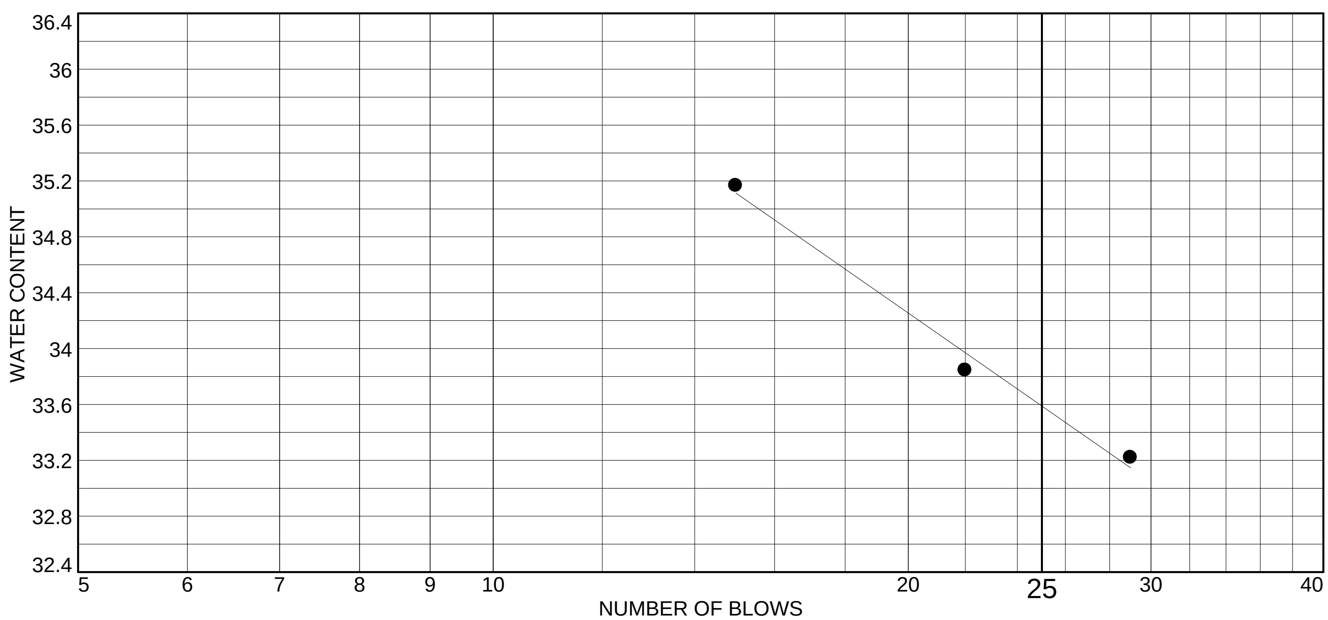

Ferry Road & Riverbend CSR - Rutland Trunk Sewer
Undrained Shear Strength vs Depth
Undrained Shear Strength (kPa)
0
10
20
30
40
50
60
70
80
90
100
Depth (m)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
Pocket Penetrometer
Torvane
Qu

Ferry Road & Riverbend CSR - Rutland Trunk Sewer
Undrained Shear Strength vs Elevation



LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	SILT and CLAY - trace sand - intermediate plasticity	34	16	18	99.7	94.3	CI

Project No. 143691.7 **Client:** TETRA TECH

Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)

Location: 19-149
Sample Number: G289 **Depth:** 7.3 m

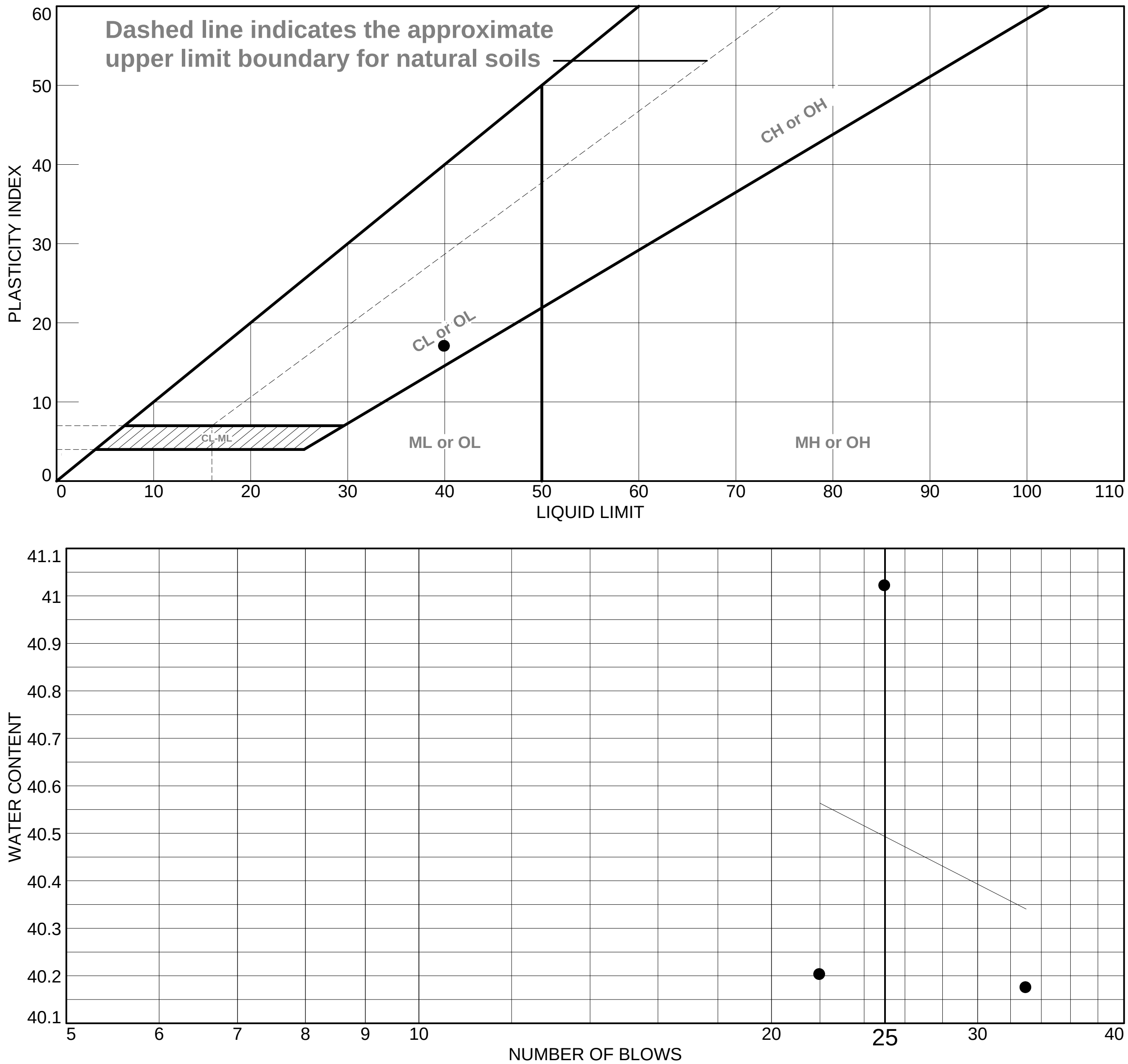
Dyregrov Robinson Inc.

Winnipeg, Manitoba

Remarks:

Figure 2 of 2

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	SILT and CLAY - trace sand - intermediate plasticity	40	23	17	100.0	98.8	CI

Project No. 143691.7 **Client:** TETRA TECH

Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)

Location: 19-148
Sample Number: T296 **Depth:** 3-3.7 m

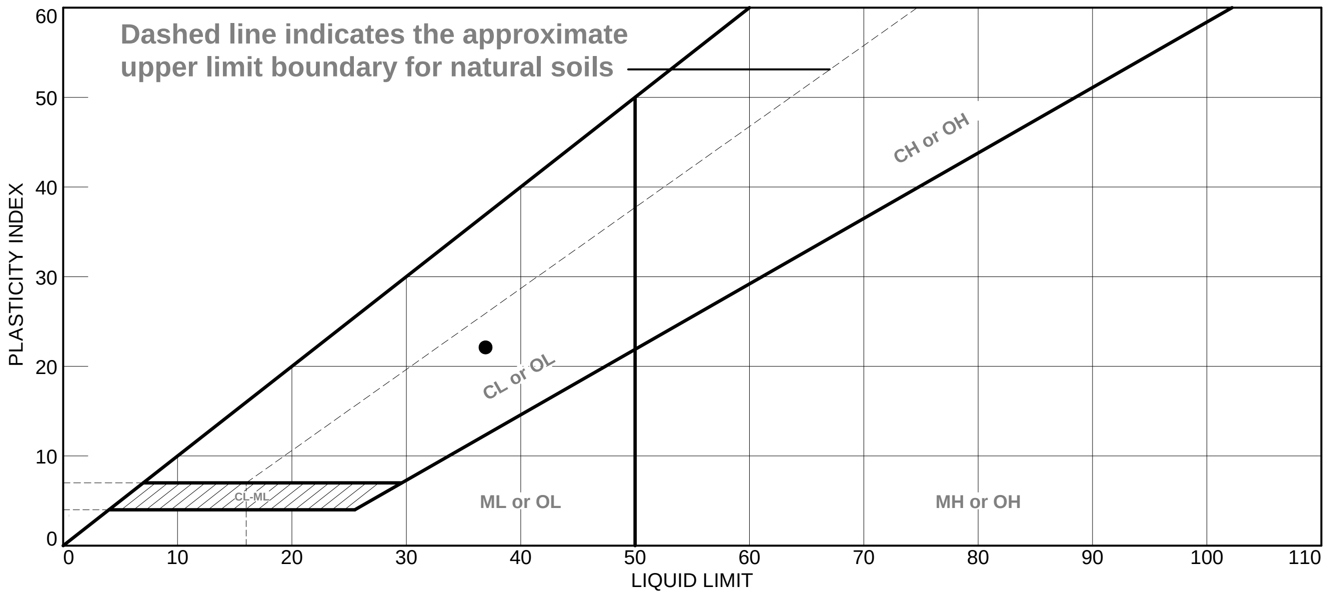
Remarks:

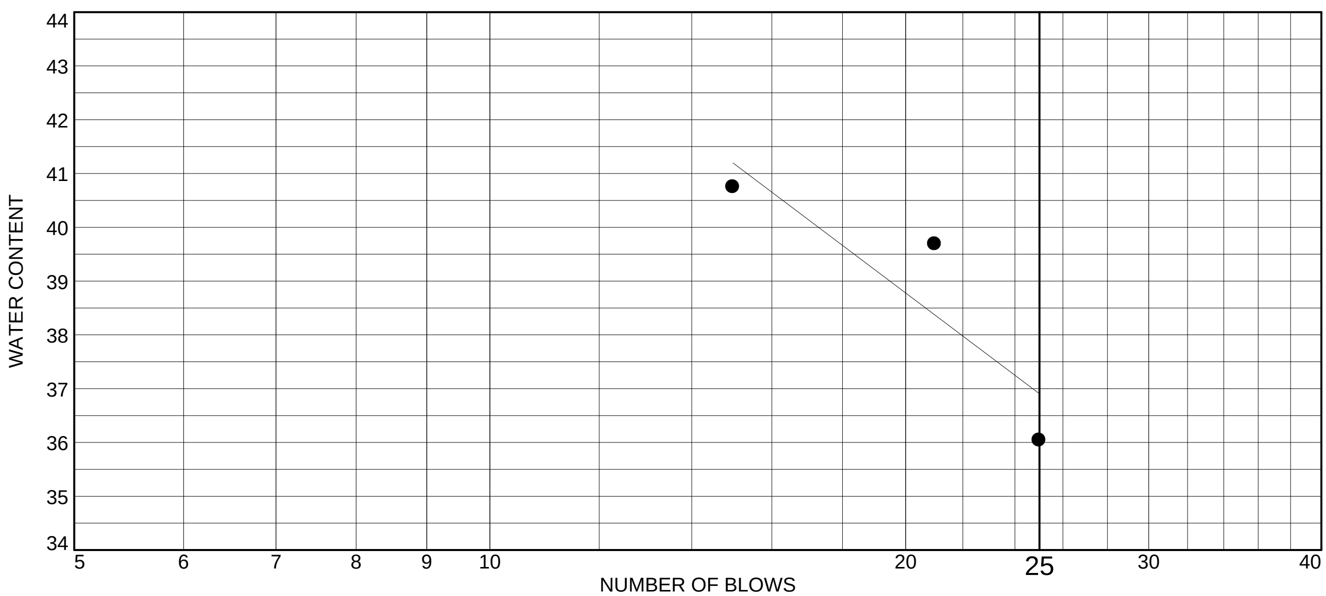
Dyregrov Robinson Inc.

Winnipeg, Manitoba

Figure 2 of 2

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	CLAY and SILT - trace sand - intermediate plasticity	37	15	22	99.5	93.6	CI

Project No. 143691.7 **Client:** TETRA TECH

Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)

Location: 19-150

Sample Number: G277 **Depth:** 4.6 m

Remarks:

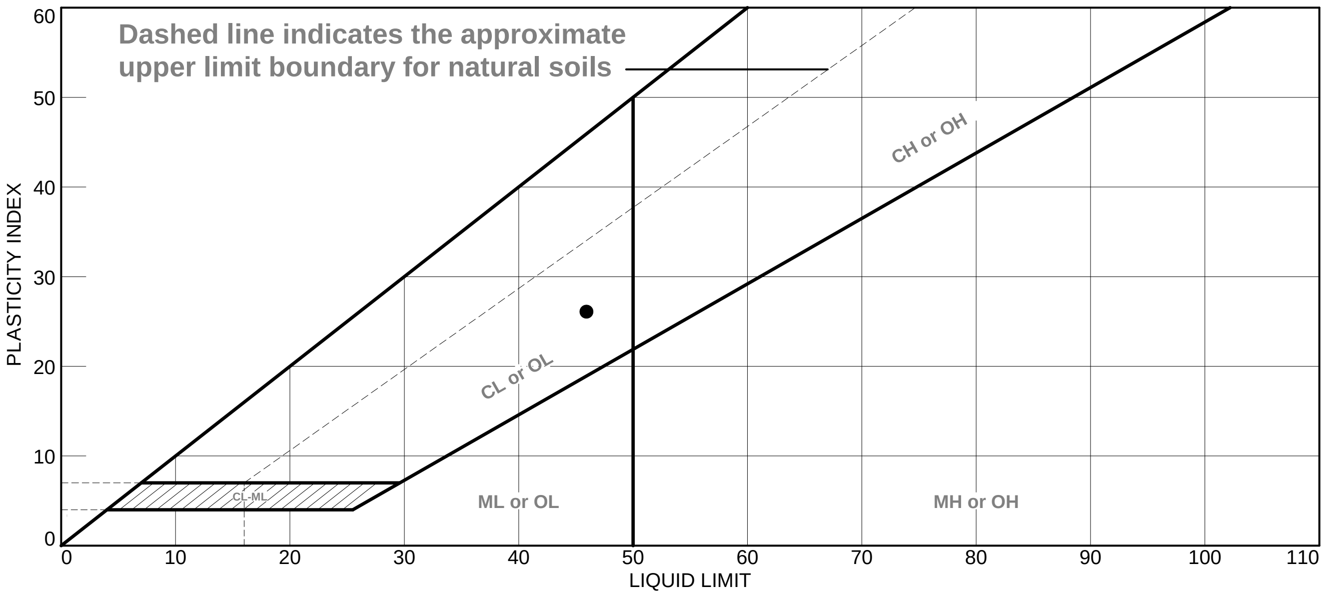
Dyregrov Robinson Inc.

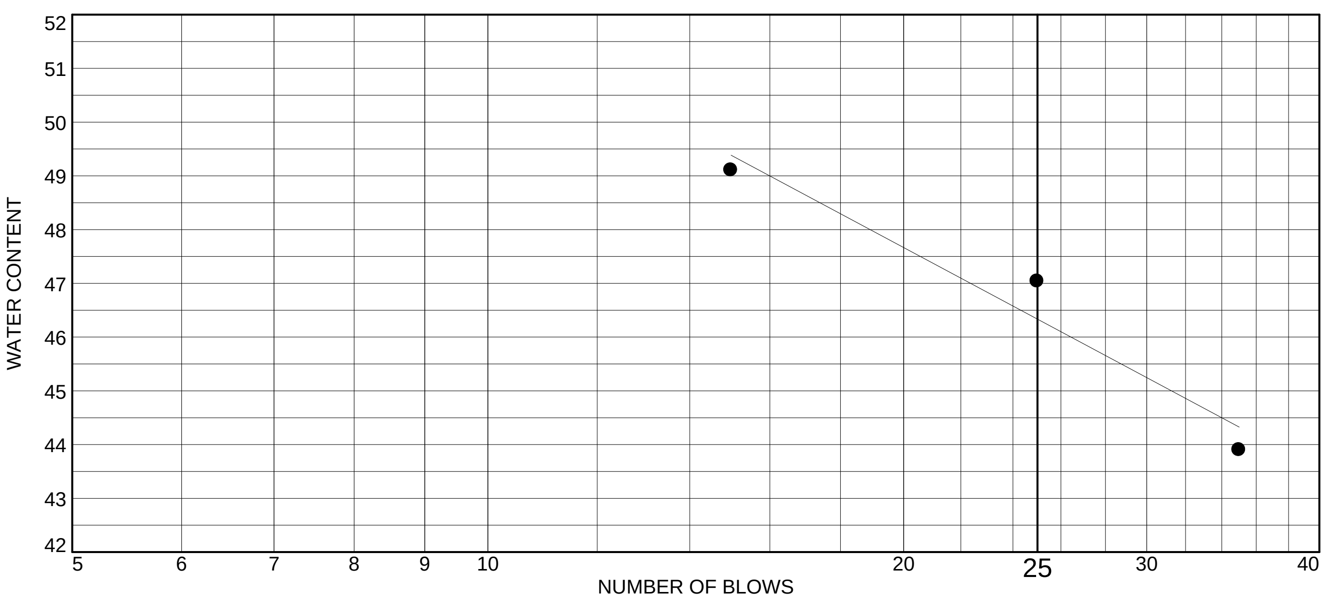
Winnipeg, Manitoba

Figure 2 of 2

Tested By: Chris Ribachuk

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	CLAY and SILT - trace sand - intermediate plasticity	46	20	26	99.9	99.3	CI

Project No. 143691.7 **Client:** TETRA TECH

Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)

Location: 19-151
Sample Number: T269B **Depth:** 4.6-5.2 m

Remarks:

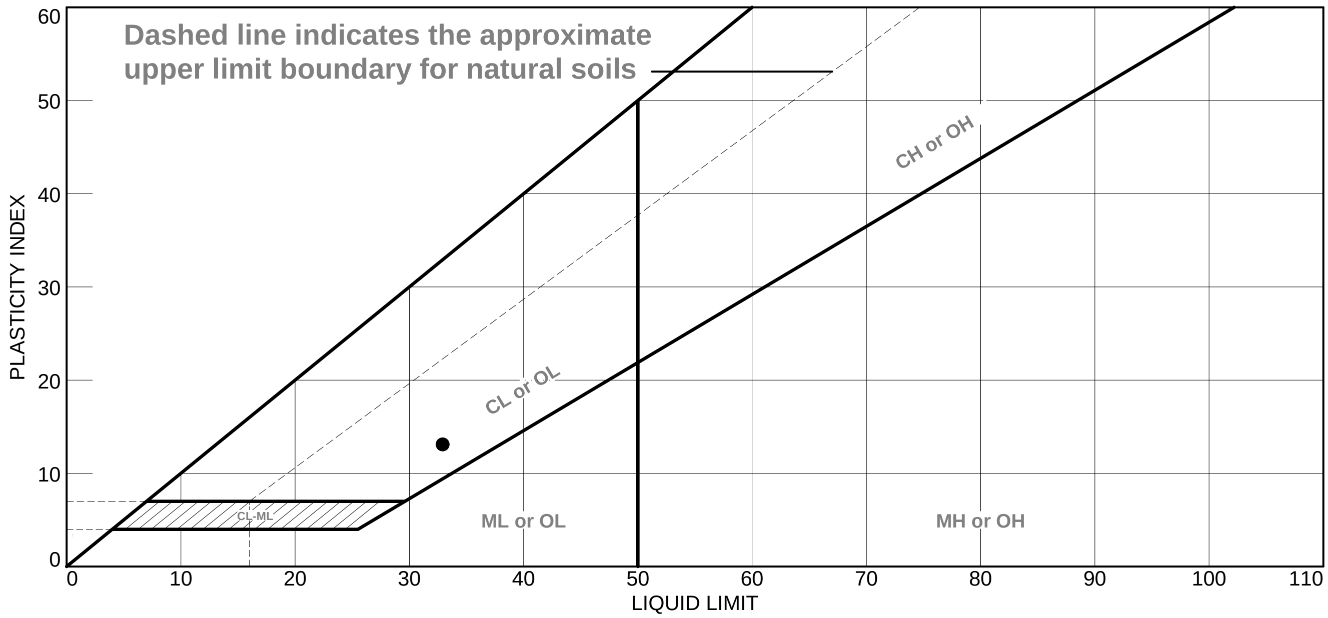
Dyregrov Robinson Inc.

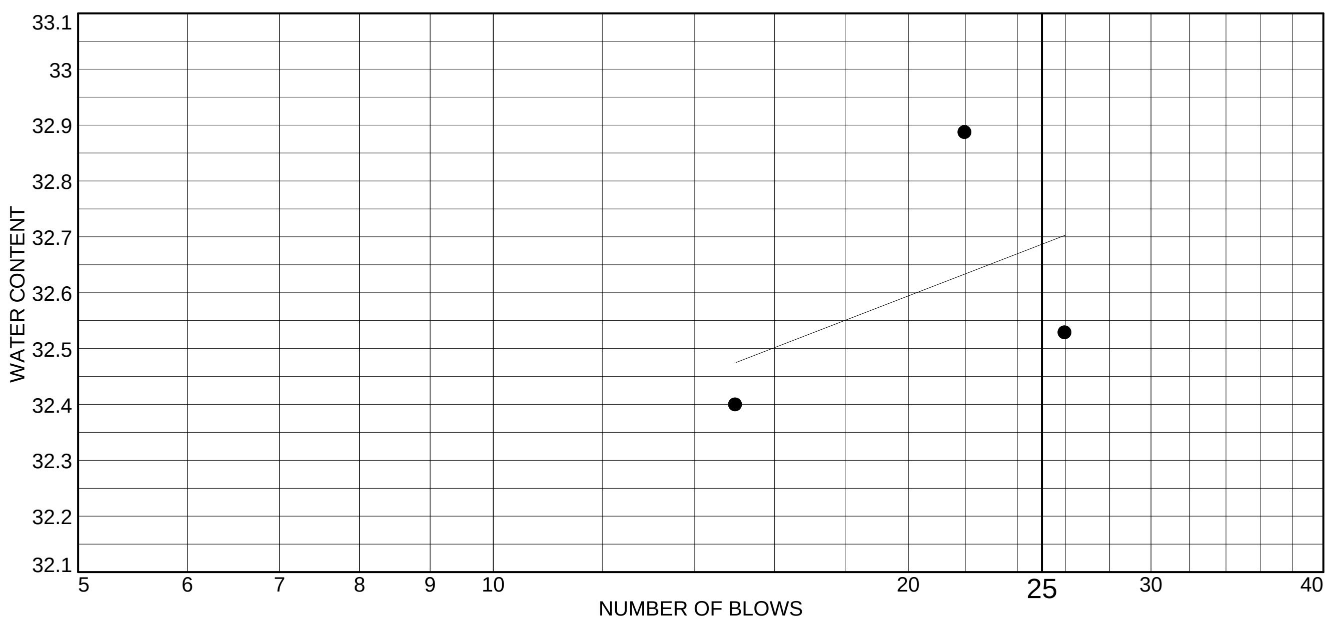
Winnipeg, Manitoba

Figure 2 of 2

Tested By: Chris Ribachuk

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	SILT and CLAY - trace sand - intermediate plasticity	33	20	13	99.9	97.7	CI

Project No. 143691.7 **Client:** TETRA TECH

Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)

Location: 19-151
Sample Number: G272 **Depth:** 8.8 m

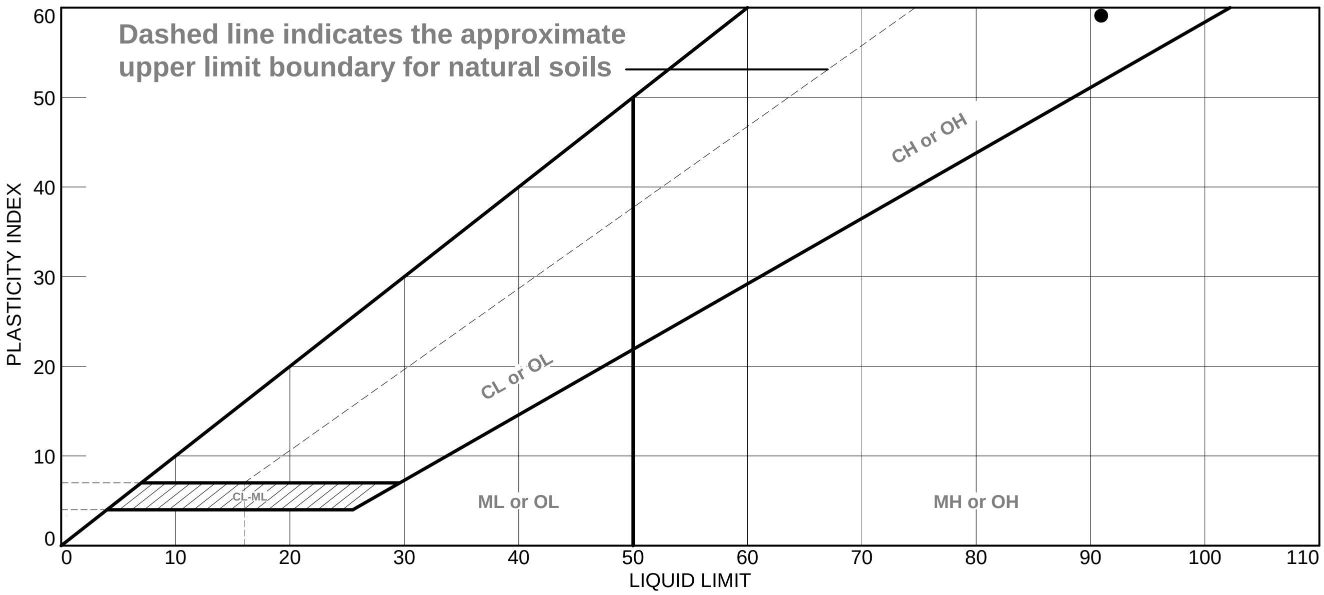
Remarks:

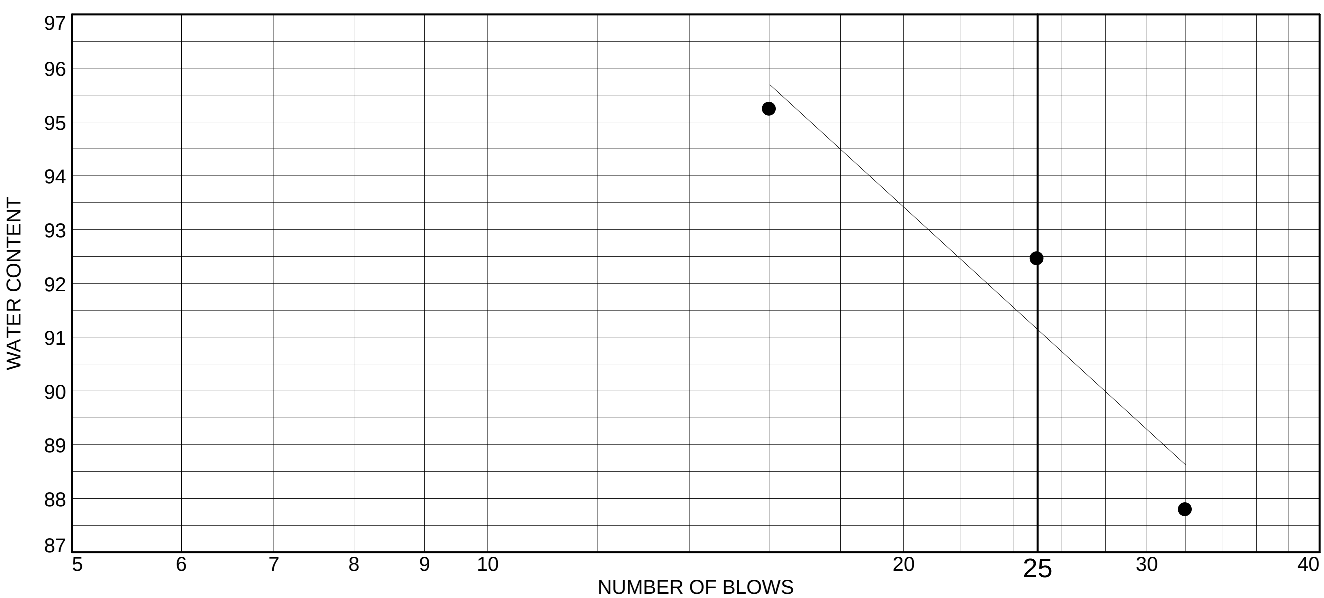
Dyregrov Robinson Inc.

Winnipeg, Manitoba

Figure 2 of 2

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	CLAY - high plasticity	91	32	59	100.0	99.9	CH

Project No. 143691.7 **Client:** TETRA TECH

Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)

Location: 19-152
Sample Number: G240 **Depth:** 4.3 m

Dyregrov Robinson Inc.

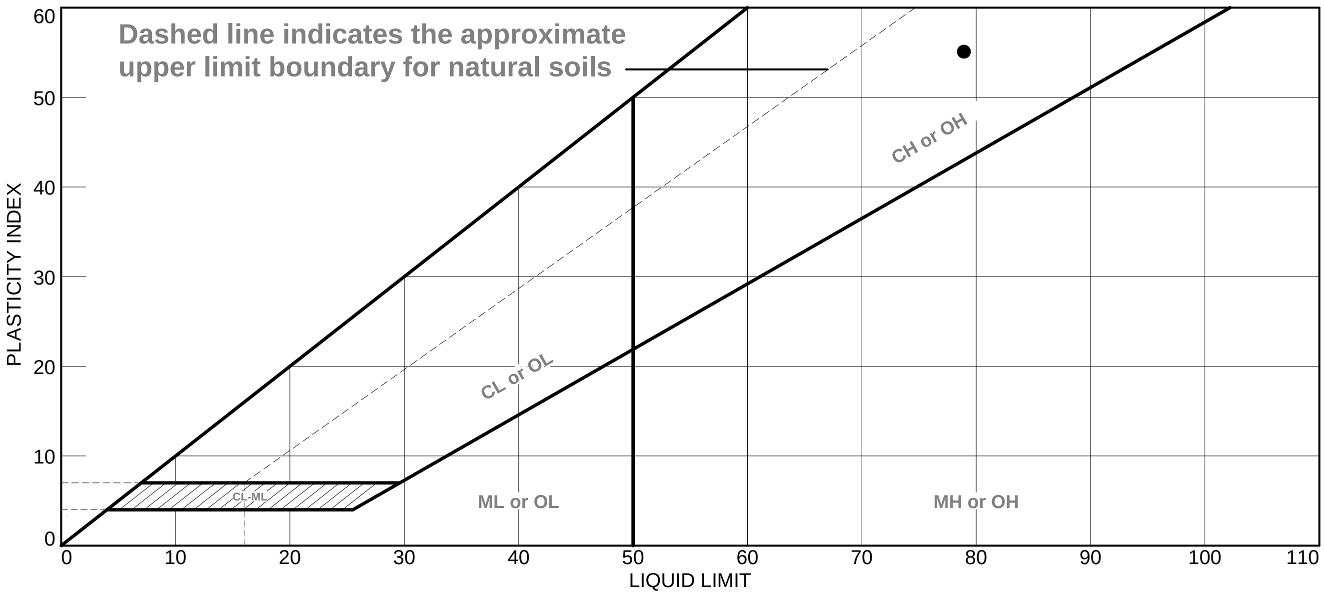
Winnipeg, Manitoba

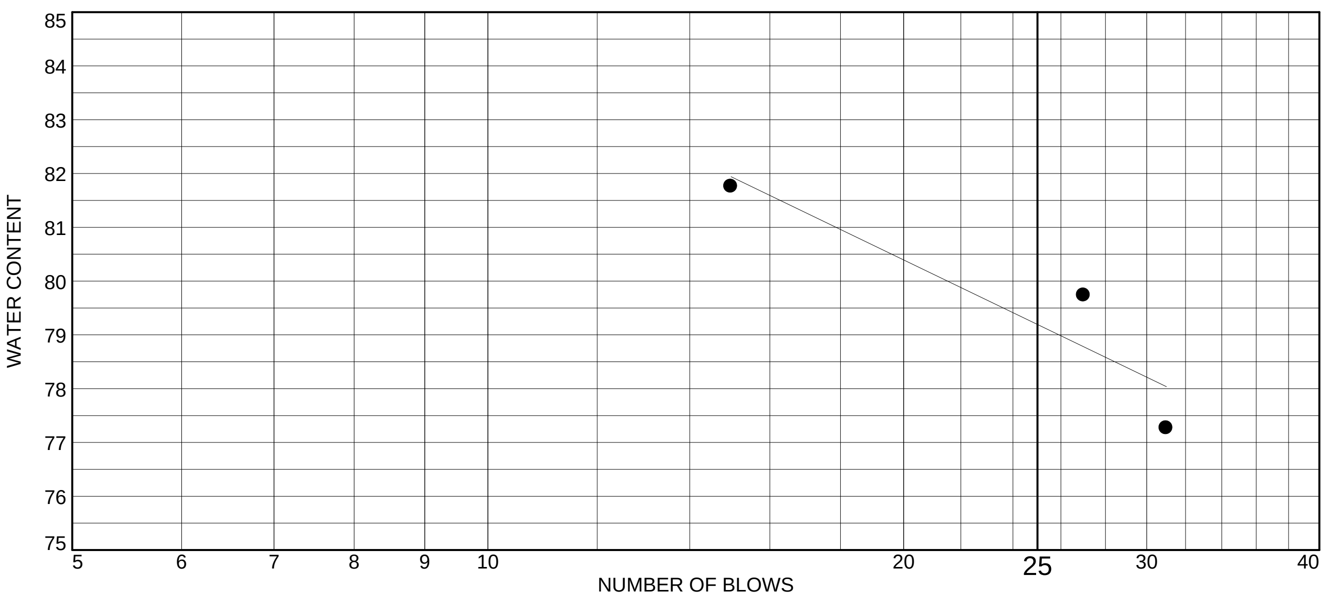
Remarks:

Figure 2 of 2

Tested By: Chris Ribachuk

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	CLAY - trace silt - high plasticity	79	24	55	100.0	99.9	CH

Project No. 143691.7 **Client:** TETRA TECH

Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)

Location: 19-156
Sample Number: T326 **Depth:** 6.1-6.7 m

Dyregrov Robinson Inc.

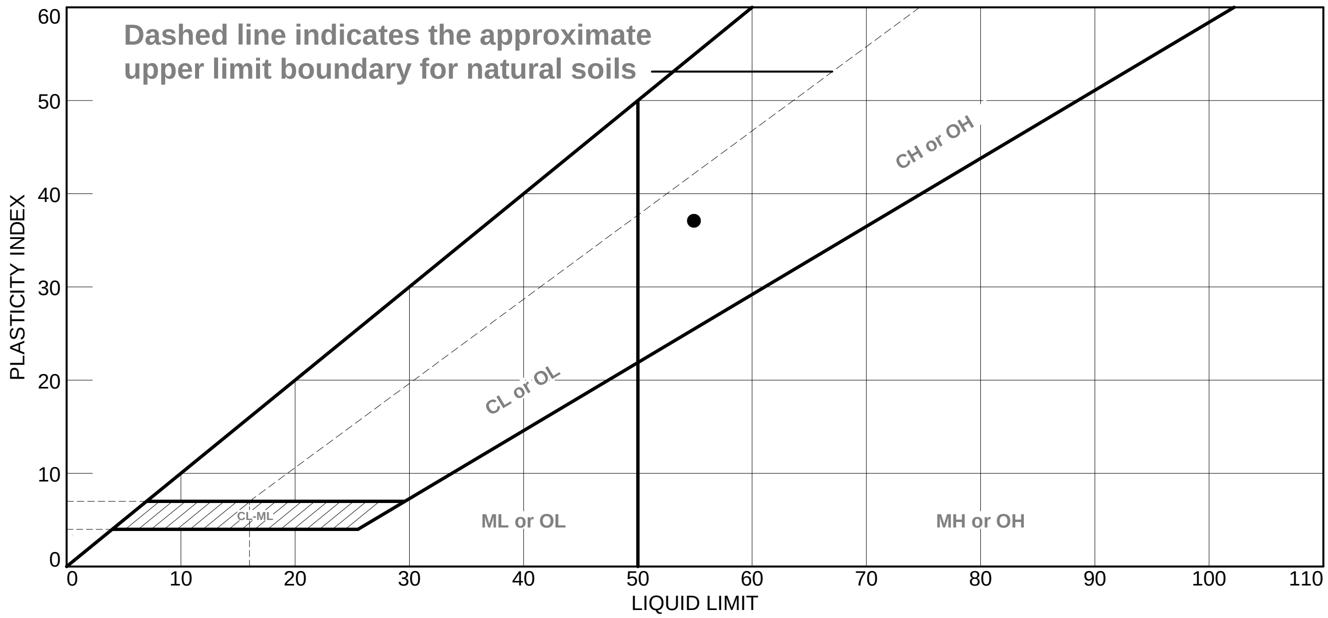
Winnipeg, Manitoba

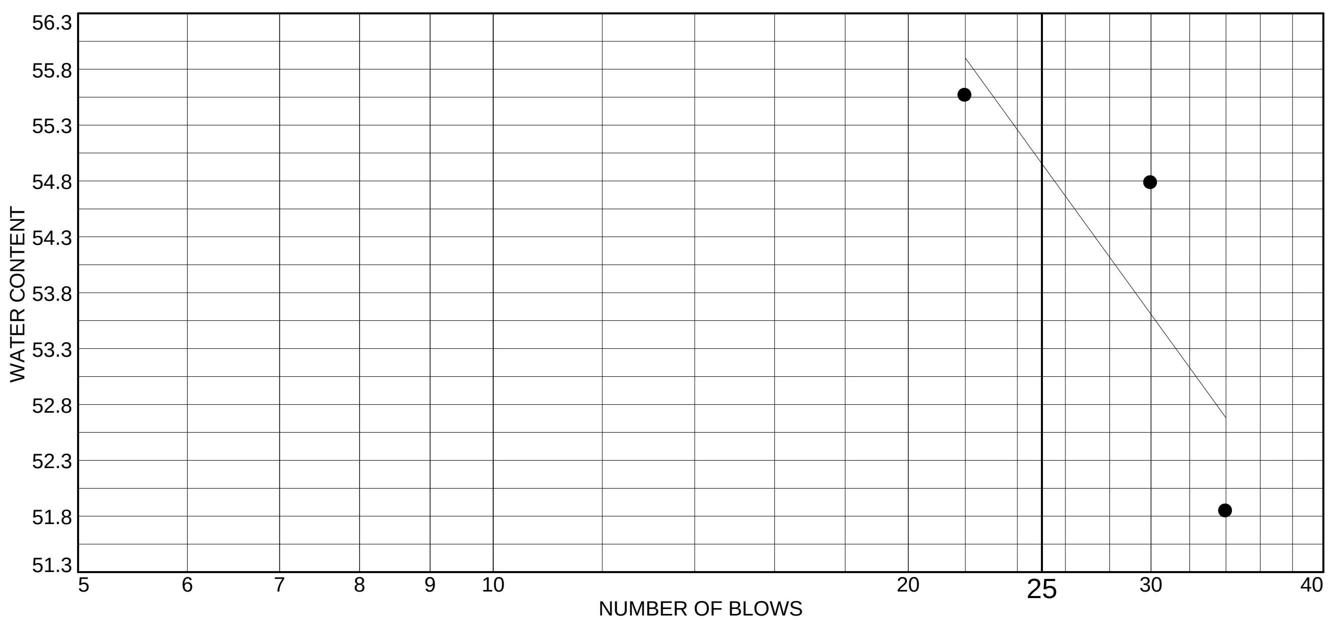
Remarks:

Figure 2 of 2

Tested By: Chris Ribachuk

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	CLAY and SILT, trace sand	55	18	37	95.6	88.8	CH

Project No. 143691.7 **Client:** TETRA TECH

Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)

Location: 19-157
Sample Number: T337 **Depth:** 9.1 - 9.8 m

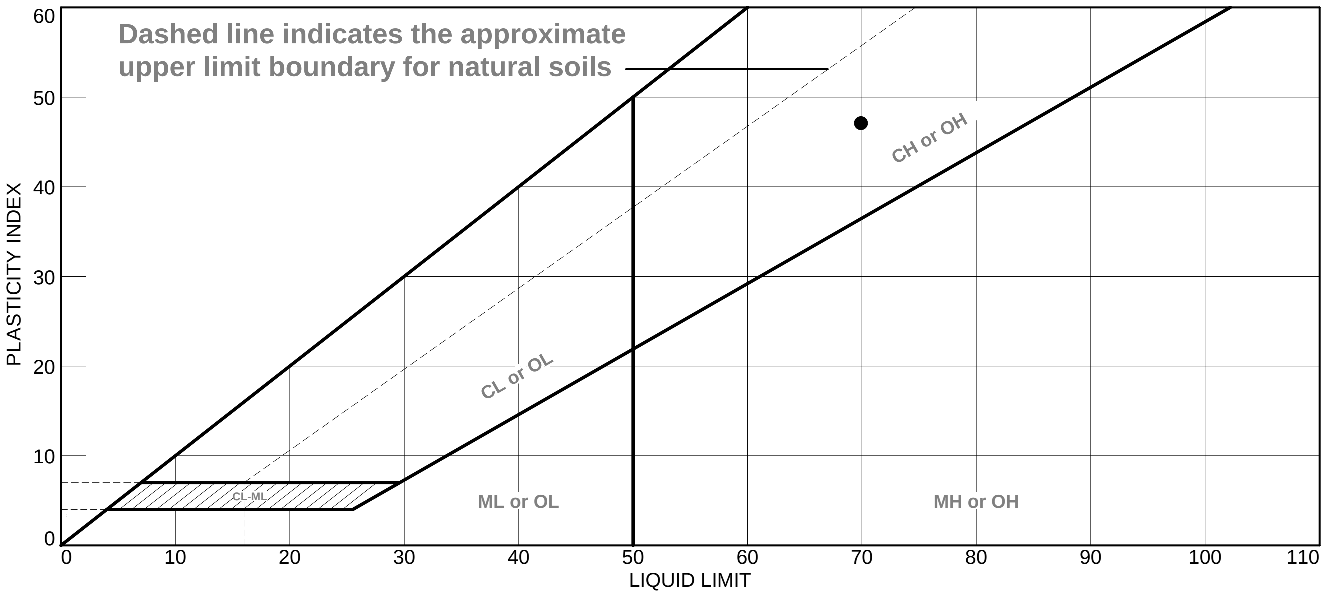
Remarks:

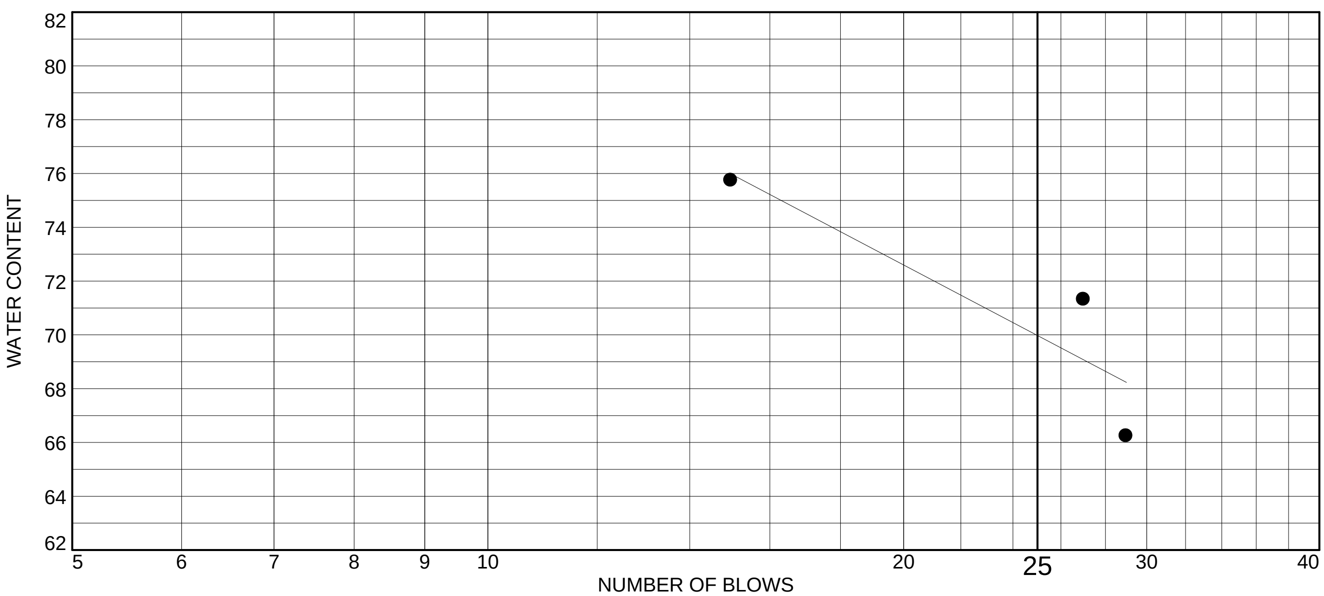
Dyregrov Robinson Inc.

Winnipeg, Manitoba

Figure 2 of 2

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	CLAY - trace silt. trace sand - high plasticity	70	23	47	99.7	99.3	CH

Project No. 143691.7 **Client:** TETRA TECH

Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)

Location: 19-162

Sample Number: T394 **Depth:** 7.6-8.2 m

Remarks:

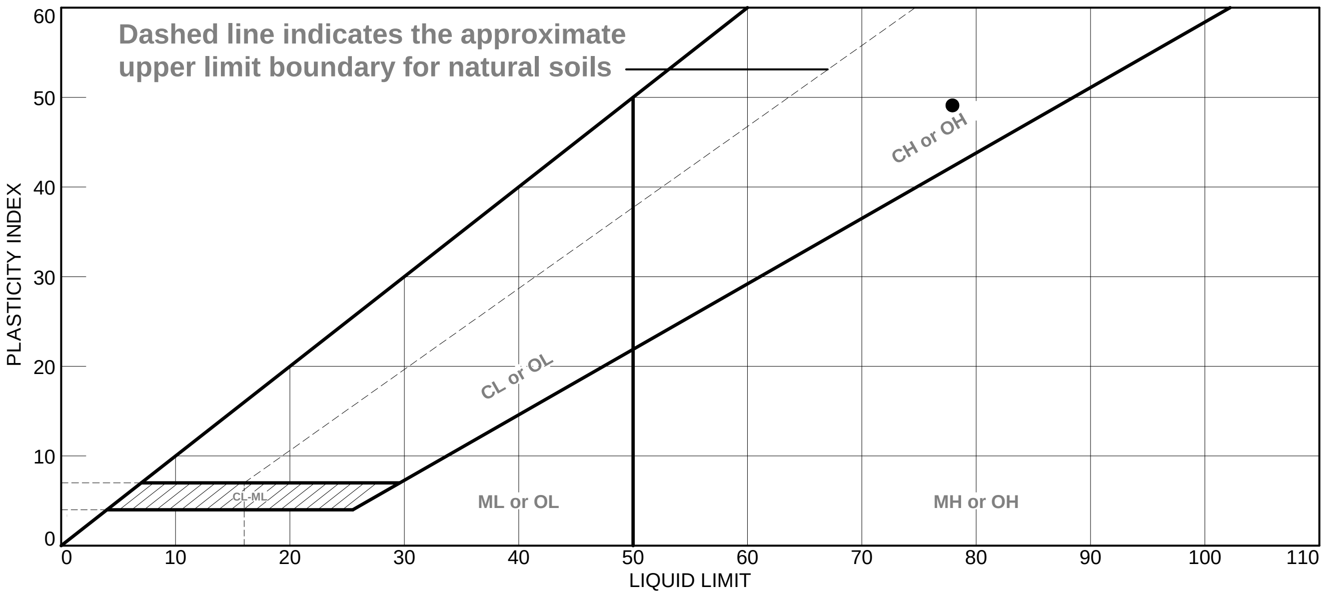
Dyregrov Robinson Inc.

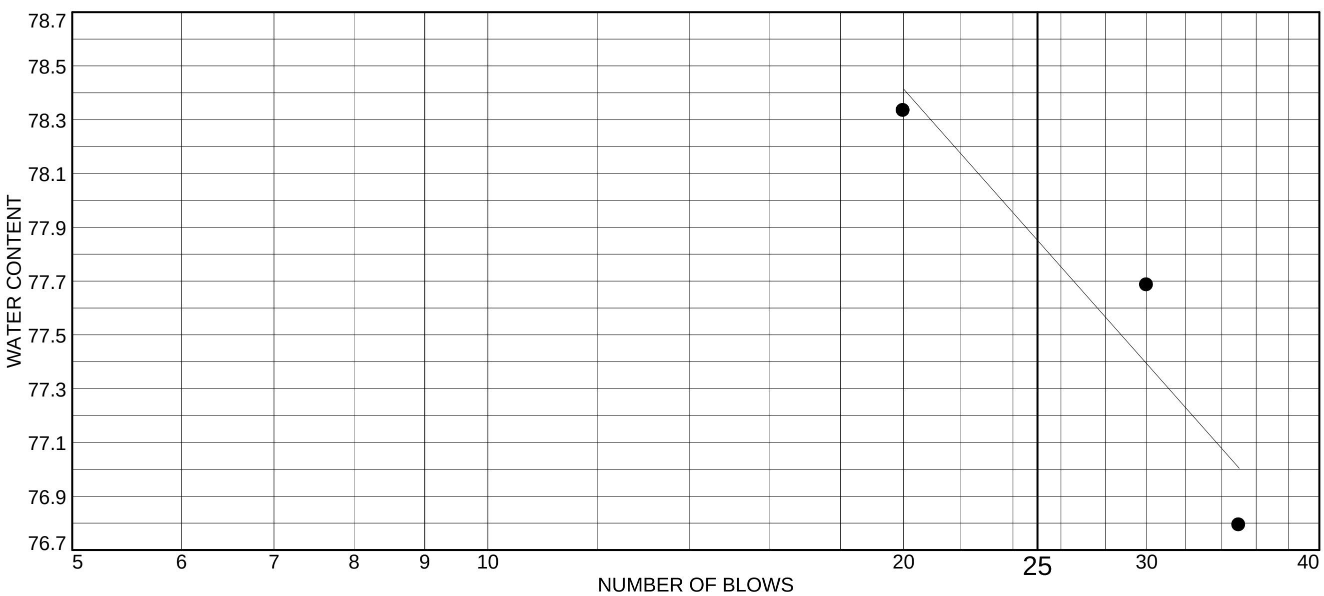
Winnipeg, Manitoba

Figure 2 of 2

Tested By: Chris Ribachuk

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	CLAY - trace silt, trace sand - high plasticity	78	29	49	99.9	99.7	CH

Project No. 143691.7 **Client:** TETRA TECH

Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)

Location: 19-166
Sample Number: G439 **Depth:** 4.3 m

Dyregrov Robinson Inc.

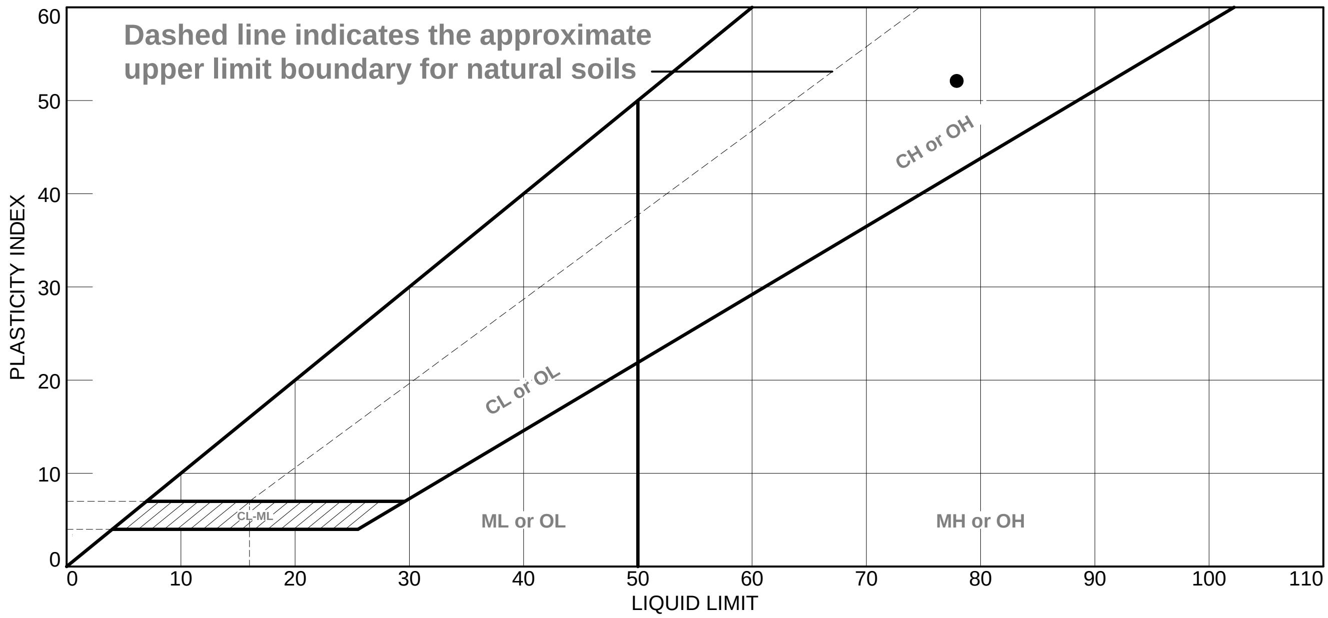
Winnipeg, Manitoba

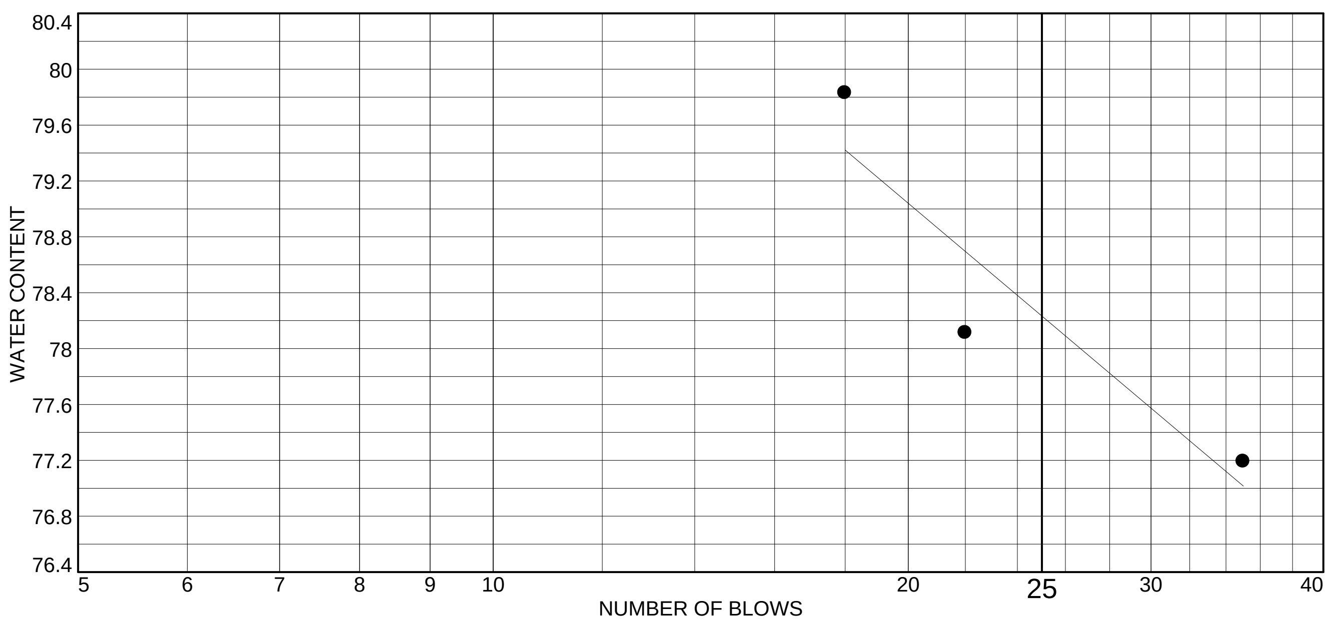
Remarks:

Figure 2 of 2

Tested By: Chris Ribachuk

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	CLAY - trace silt, trace sand - high plasticity	78	26	52	99.9	99.6	CH

Project No. 143691.7 **Client:** TETRA TECH

Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)

Location: 19-173
Sample Number: G492 **Depth:** 2.3 m

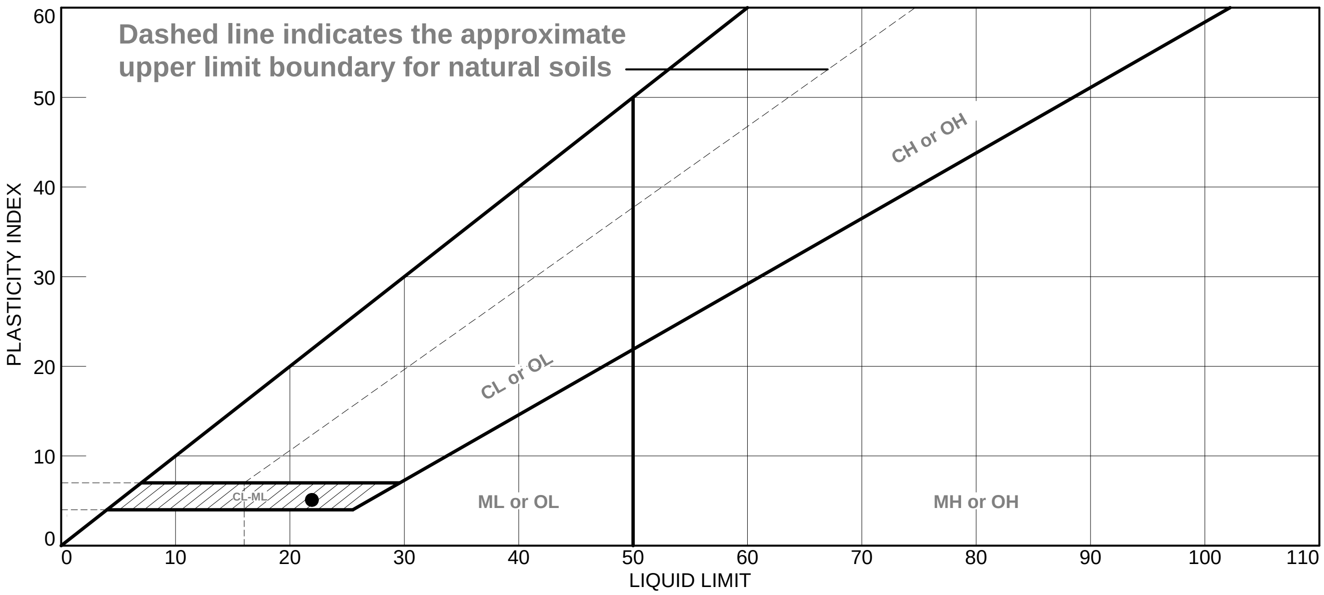
Dyregrov Robinson Inc.

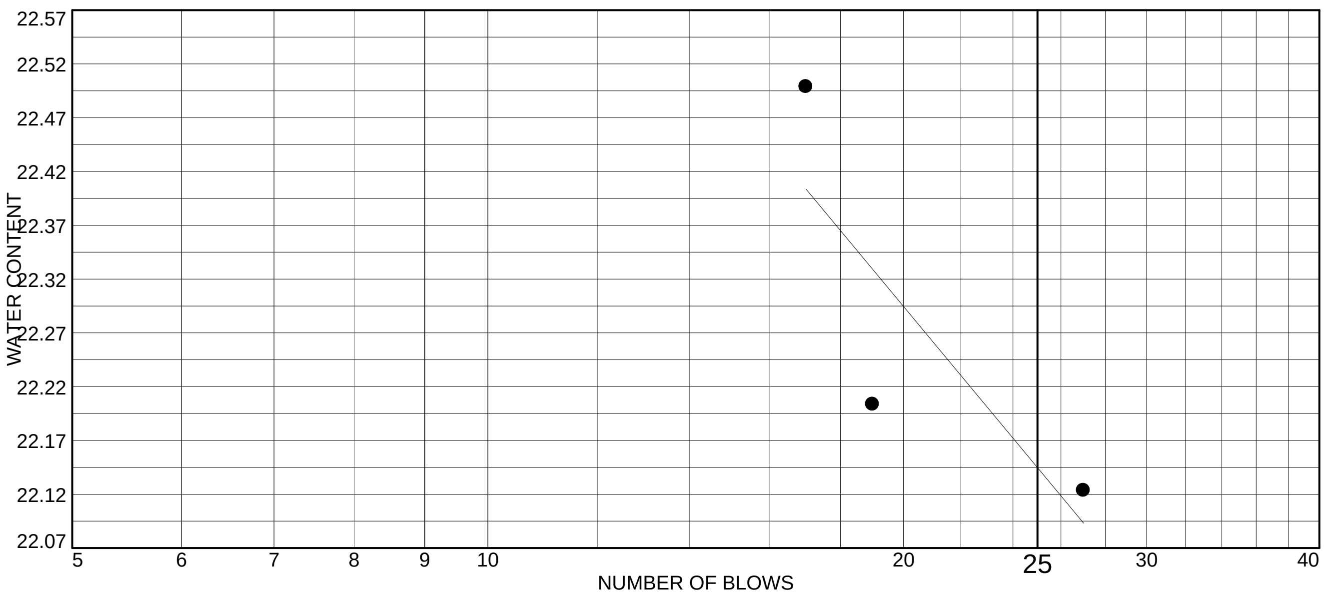
Winnipeg, Manitoba

Remarks:

Figure 2 of 2

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	SILT - low plasticity	22	17	5			ML

Project No. 143691.7 **Client:** TETRA TECH

Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)

Location: 19-240

Sample Number: G427 **Depth:** 1.2 m

Dyregrov Robinson Inc.

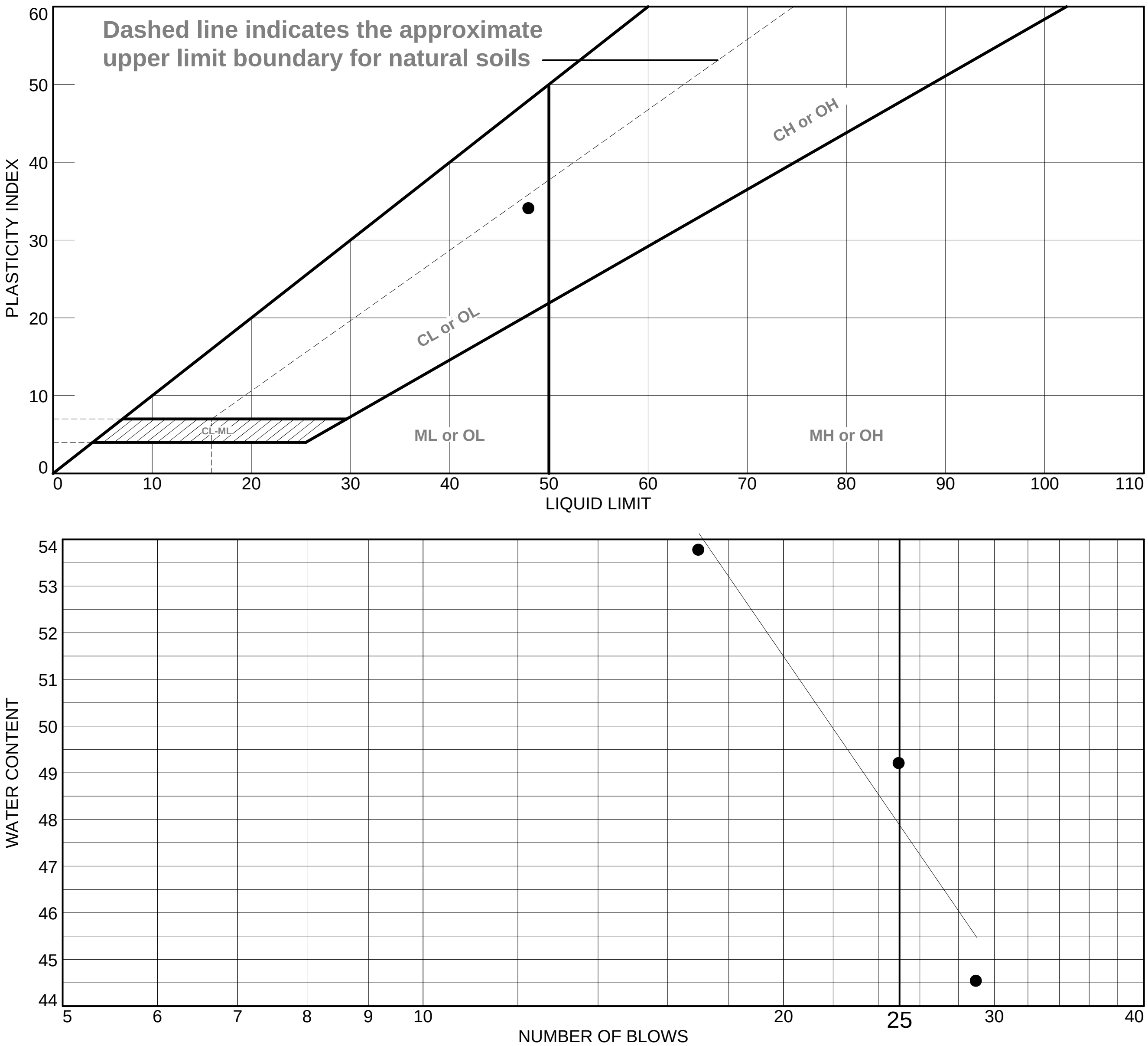
Winnipeg, Manitoba

Remarks:

Figure 1 of 1

Tested By: Chris Ribachuk

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	CLAY - intermediate plasticity	48	14	34			

Project No. 143691 **Client:** Tetra Tech Canada Inc.

Project: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer

Location: TH20-245

Sample Number: G18 **Depth:** 4.6 m

Dyregrov Robinson Inc.

Winnipeg, Manitoba

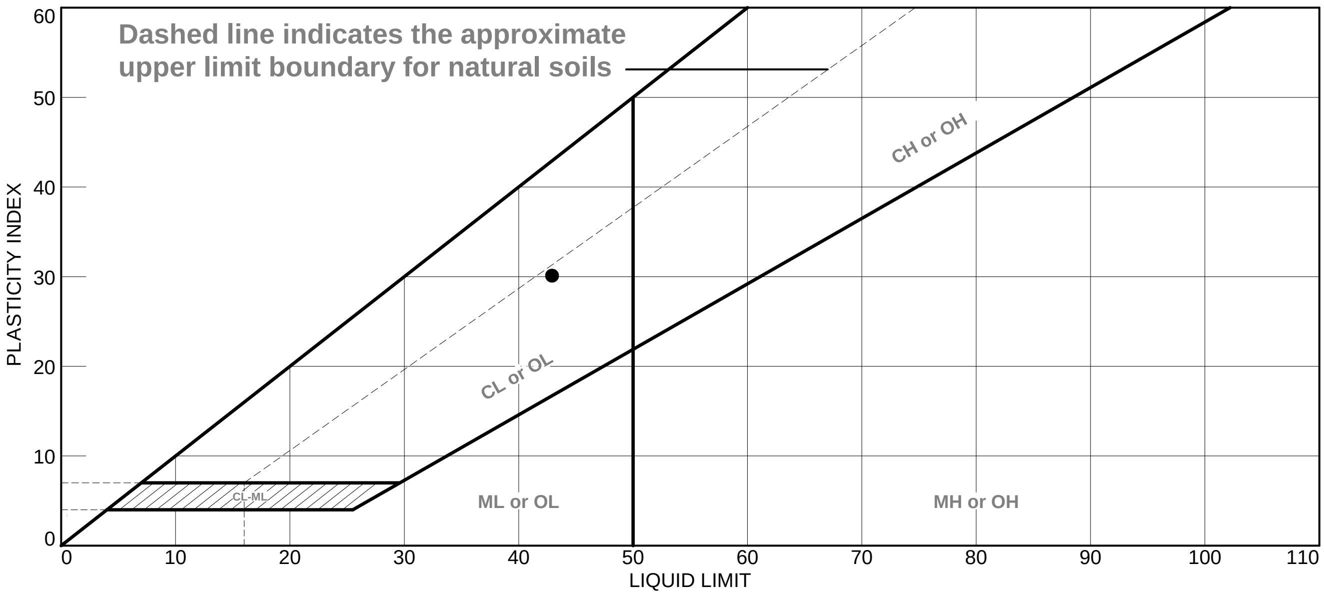
Remarks:

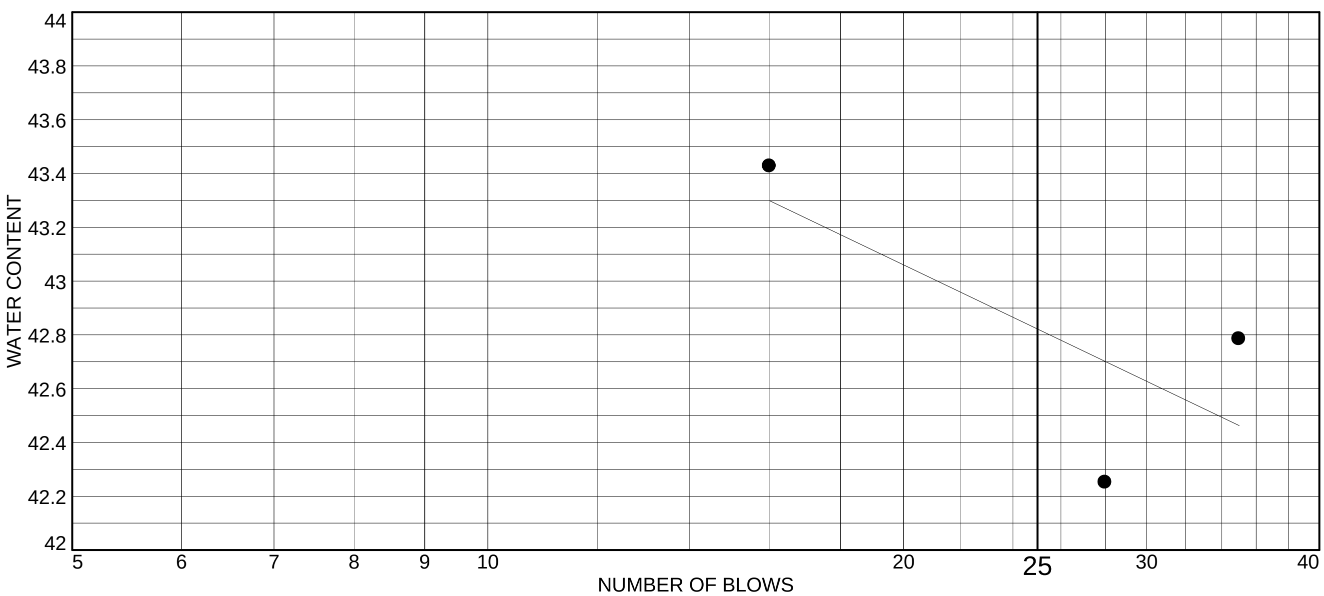
●CI

Figure 1

Tested By: Chris Ribachuk

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	CLAY - intermediate plasticity	43	13	30			

Project No. 143691 **Client:** Tetra Tech Canada Inc.

Project: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer

Location: TH20-248

Sample Number: T55 **Depth:** 3-3.7 m

Remarks:
●CI

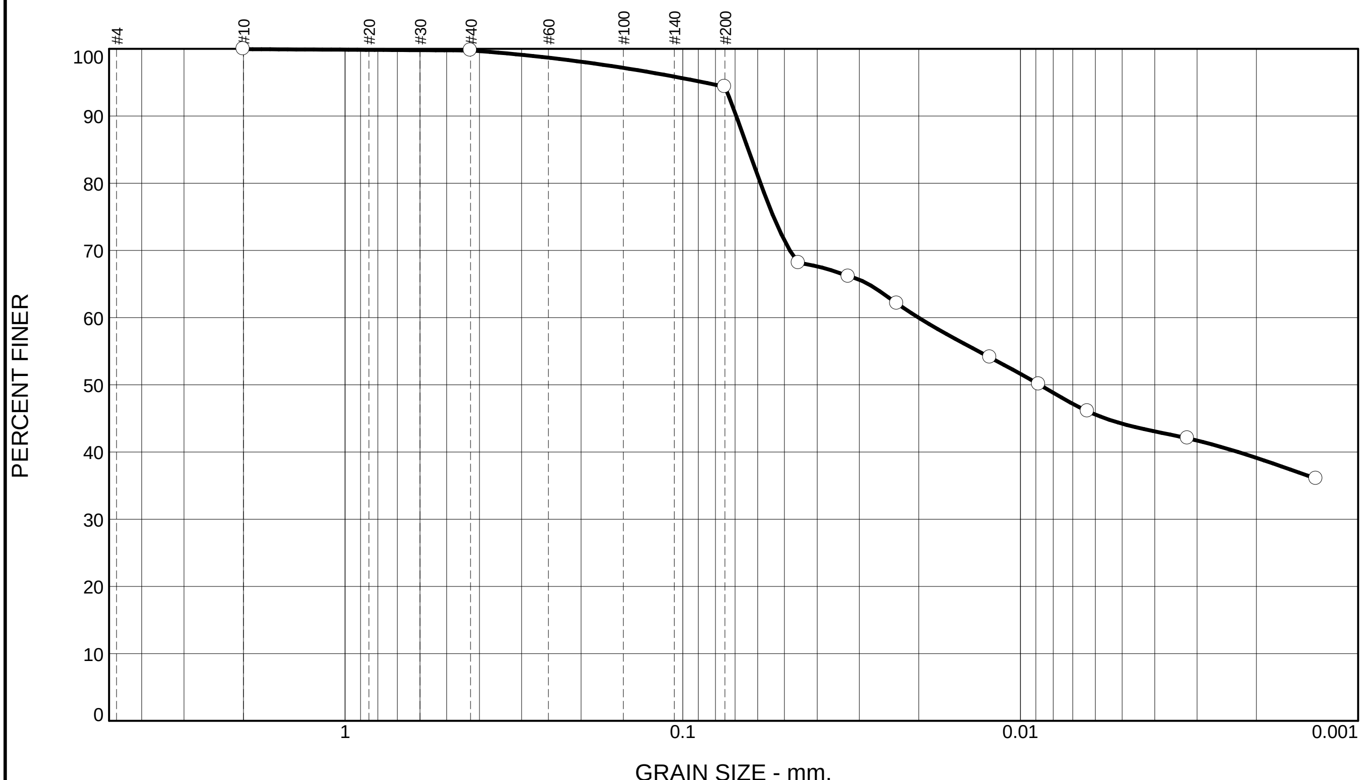
Dyregrov Robinson Inc.

Winnipeg, Manitoba

Figure 1

Tested By: Chris Ribachuk

Particle Size Distribution Report



% Gravel	% Sand			% Fines	
Fine	Coarse	Medium	Fine	Silt	Clay
		0.2	5.4	50.1	44.2

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	99.9		
#40	99.7		
#200	94.3		
0.0454 mm.	68.1		
0.0323 mm.	66.1		
0.0232 mm.	62.1		
0.0123 mm.	54.1		
0.0088 mm.	50.1		
0.0063 mm.	46.1		
0.0032 mm.	42.0		
0.0013 mm.	36.0		

* (no specification provided)

Soil Description

SILT and CLAY - trace sand
- intermediate plasticity

Atterberg Limits

PL= 16 LL= 34 PI= 18

Coefficients

D_{90}= 0.0695 D_{85}= 0.0639 D_{60}= 0.0200
D_{50}= 0.0088 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CI AASHTO= A-6(16)

Remarks

Location: 19-149
Sample Number: G289 **Depth:** 7.3 m **Date:** 2019-7-29

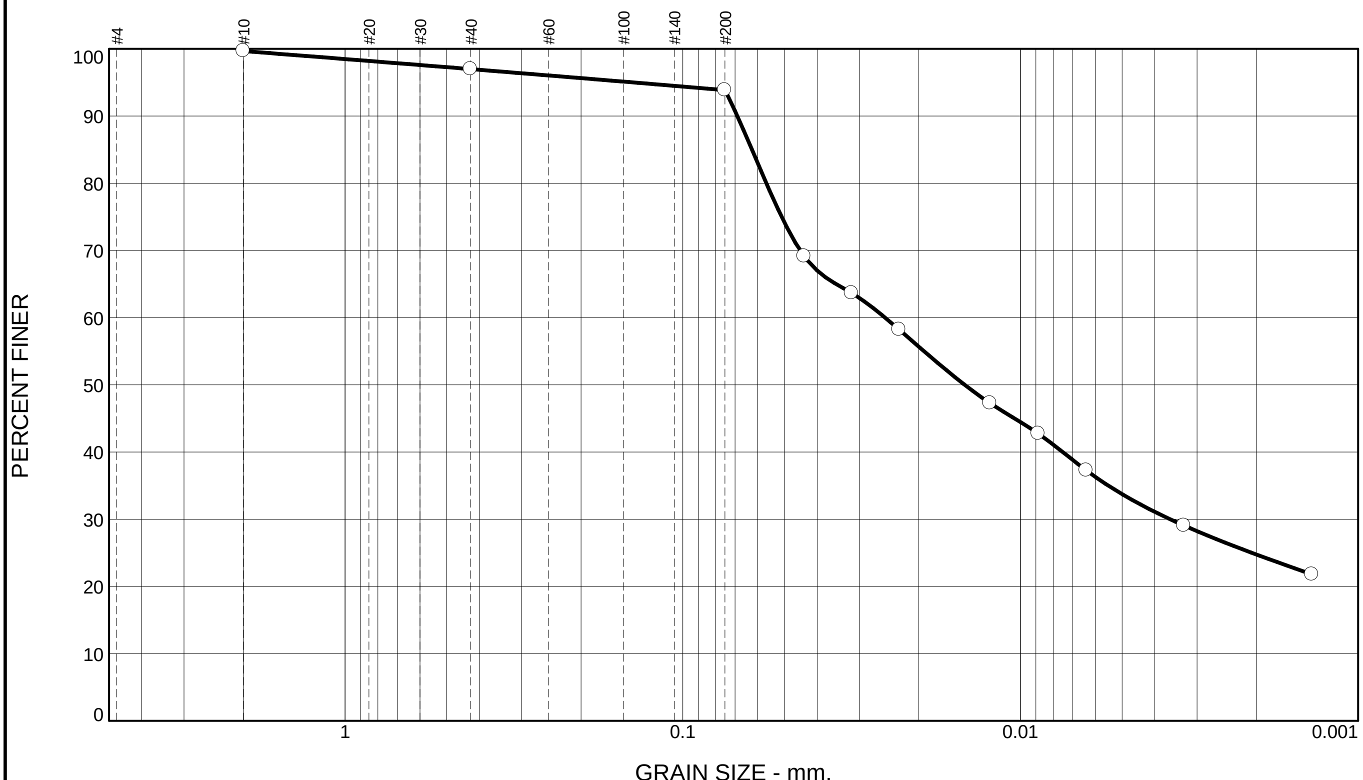
Dyregrov Robinson Inc.

Winnipeg, Manitoba

Client: TETRA TECH
Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)
Project No: 143691.7 **Figure** 1 of 2

Tested By: Chris Ribachuk

Particle Size Distribution Report



% Gravel	% Sand			% Fines	
Fine	Coarse	Medium	Fine	Silt	Clay
		2.7	3.1	60.2	33.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	99.7		
#40	97.0		
#200	93.9		
0.0436 mm.	69.1		
0.0316 mm.	63.7		
0.0228 mm.	58.2		
0.0123 mm.	47.3		
0.0088 mm.	42.7		
0.0064 mm.	37.3		
0.0033 mm.	29.1		
0.0014 mm.	21.8		

* (no specification provided)

Soil Description

SILT(Till) - clayey, trace sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.0689 D_{85}= 0.0624 D_{60}= 0.0252
D_{50}= 0.0146 D_{30}= 0.0036 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= ML AASHTO=

Remarks

Location: 19-148
Sample Number: G302 **Depth:** 8.5 m **Date:** 2019-7-29

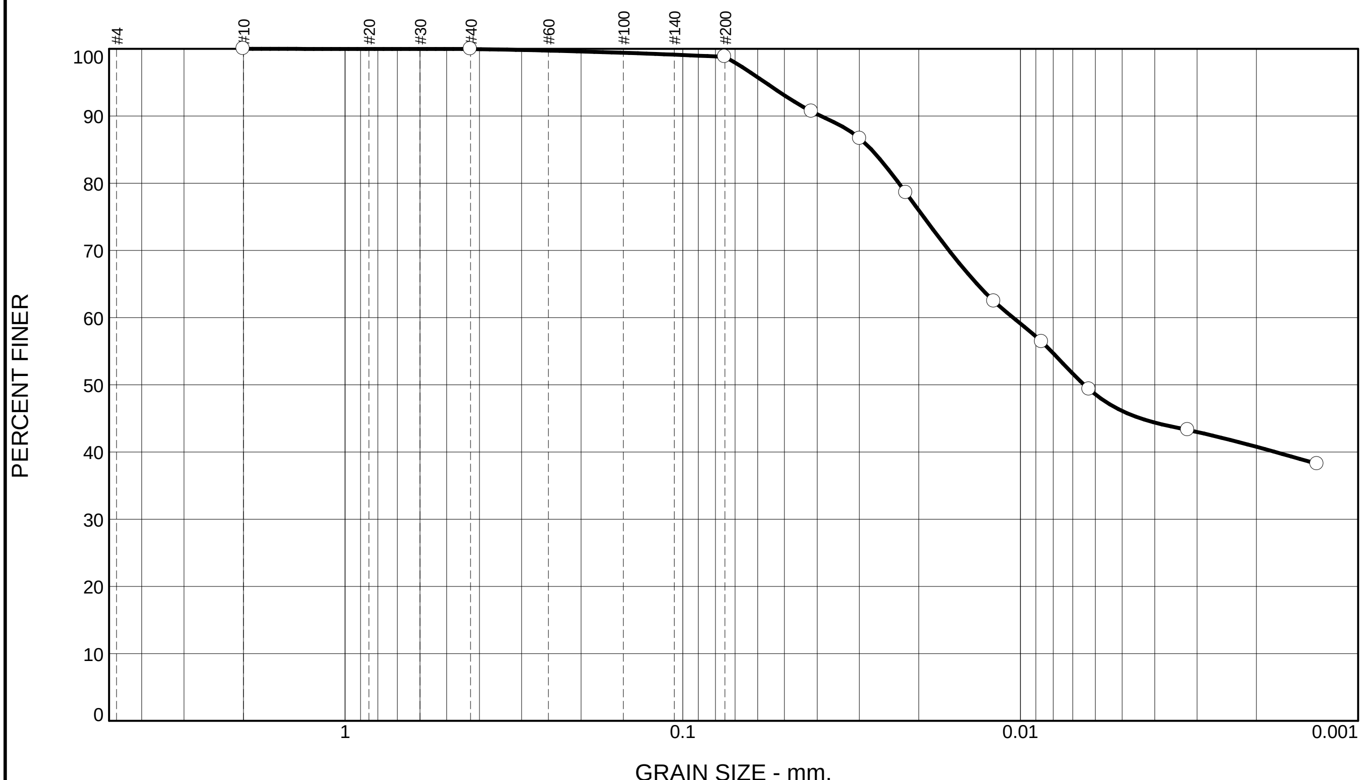
Dyregrov Robinson Inc.

Winnipeg, Manitoba

Client: TETRA TECH
Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)
Project No: 143691.7 **Figure** 1 of 1

Tested By: Chris Ribachuk

Particle Size Distribution Report



% Gravel	% Sand			% Fines	
Fine	Coarse	Medium	Fine	Silt	Clay
		0.0	1.2	52.7	46.1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#40	100.0		
#200	98.8		
0.0415 mm.	90.7		
0.0299 mm.	86.6		
0.0218 mm.	78.6		
0.0120 mm.	62.4		
0.0086 mm.	56.4		
0.0063 mm.	49.3		
0.0032 mm.	43.3		
0.0013 mm.	38.2		

* (no specification provided)

Soil Description

SILT and CLAY - trace sand
- intermediate plasticity

Atterberg Limits

PL= 23 LL= 40 PI= 17

Coefficients

D_{90}= 0.0390 D_{85}= 0.0276 D_{60}= 0.0105
D_{50}= 0.0065 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CI AASHTO= A-6(19)

Remarks

Location: 19-148
Sample Number: T296 **Depth:** 3-3.7 m **Date:** 2019-7-19

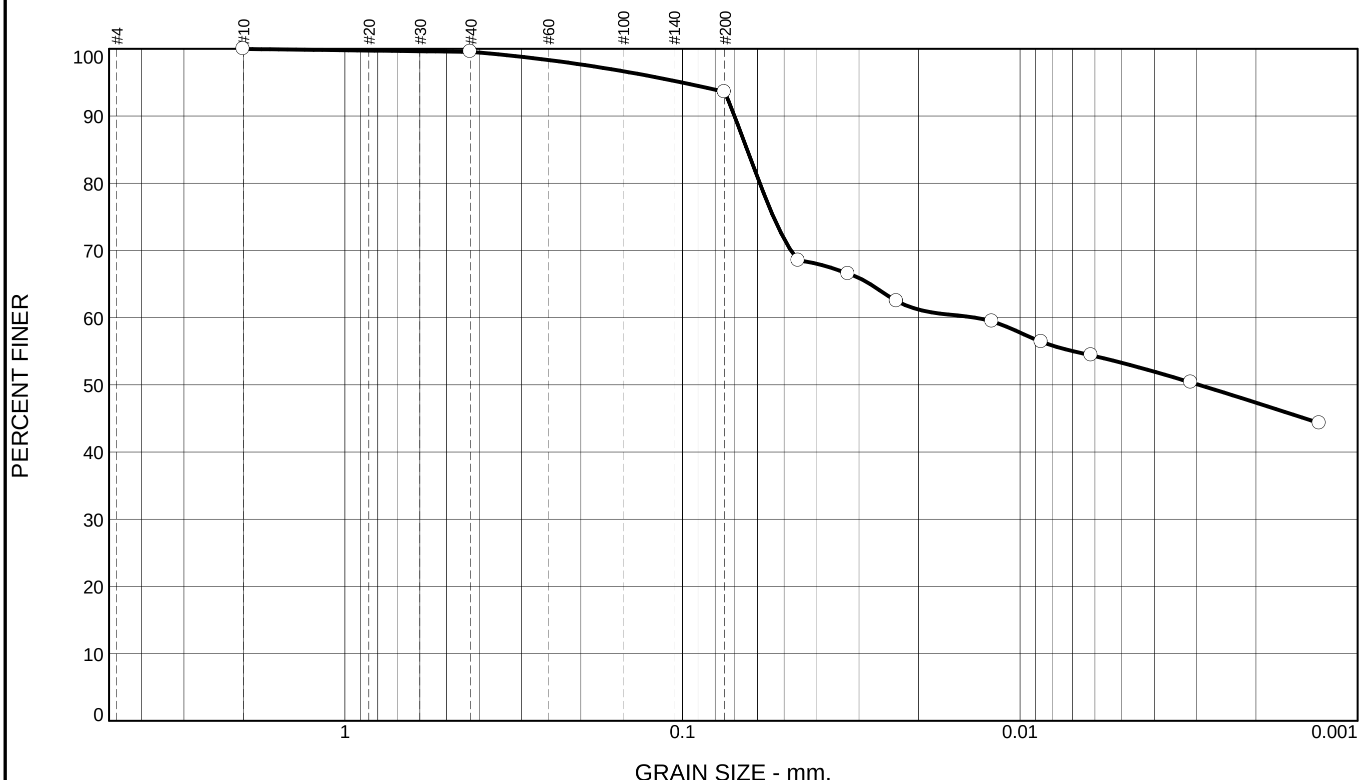
Dyregrov Robinson Inc.

Winnipeg, Manitoba

Client: TETRA TECH
Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)
Project No: 143691.7 **Figure** 1 of 2

Tested By: Chris Ribachuk

Particle Size Distribution Report



% Gravel	% Sand			% Fines	
Fine	Coarse	Medium	Fine	Silt	Clay
		0.5	5.9	40.3	53.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#40	99.5		
#200	93.6		
0.0454 mm.	68.5		
0.0323 mm.	66.5		
0.0232 mm.	62.5		
0.0121 mm.	59.4		
0.0086 mm.	56.4		
0.0062 mm.	54.4		
0.0031 mm.	50.3		
0.0013 mm.	44.3		

* (no specification provided)

Soil Description

CLAY and SILT - trace sand
- intermediate plasticity

Atterberg Limits

PL= 15 LL= 37 PI= 22

Coefficients

D_{90}= 0.0702 D_{85}= 0.0643 D_{60}= 0.0136
D_{50}= 0.0030 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CI AASHTO= A-6(20)

Remarks

Location: 19-150
Sample Number: G277 **Depth:** 4.6 m **Date:** 2019-7-29

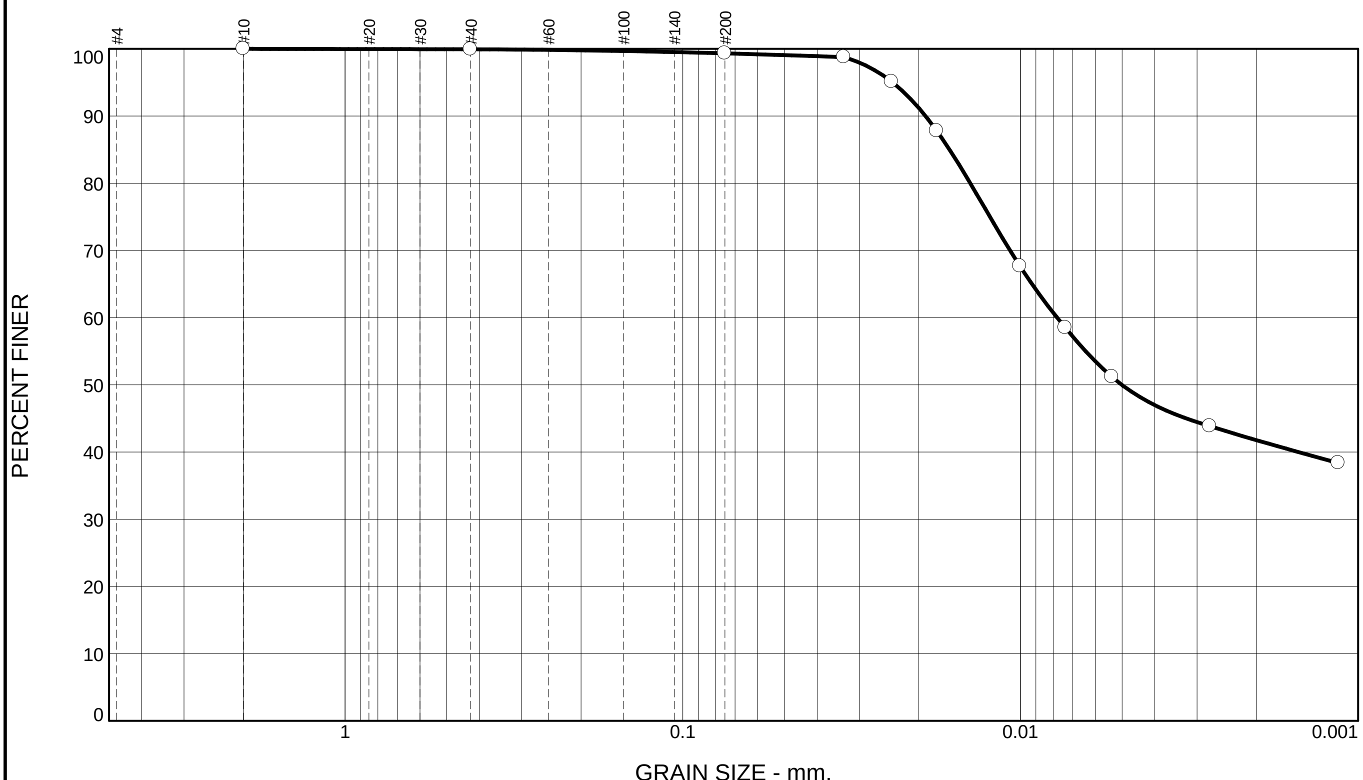
Dyregrov Robinson Inc.

Winnipeg, Manitoba

Client: TETRA TECH
Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)
Project No: 143691.7 **Figure** 1 of 2

Tested By: Chris Ribachuk

Particle Size Distribution Report



% Gravel	% Sand			% Fines	
Fine	Coarse	Medium	Fine	Silt	Clay
		0.1	0.6	49.3	50.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#40	99.9		
#200	99.3		
0.0333 mm.	98.8		
0.0241 mm.	95.1		
0.0177 mm.	87.8		
0.0100 mm.	67.6		
0.0074 mm.	58.5		
0.0054 mm.	51.2		
0.0027 mm.	43.8		
0.0011 mm.	38.4		

* (no specification provided)

Soil Description

CLAY and SILT - trace sand
- intermediate plasticity

Atterberg Limits

PL= 20 LL= 46 PI= 26

Coefficients

D_{90}= 0.0191 D_{85}= 0.0162 D_{60}= 0.0078
D_{50}= 0.0050 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CI AASHTO= A-7-6(28)

Remarks

Location: 19-151
Sample Number: T269B **Depth:** 4.6-5.2 m **Date:** 2019-7-26

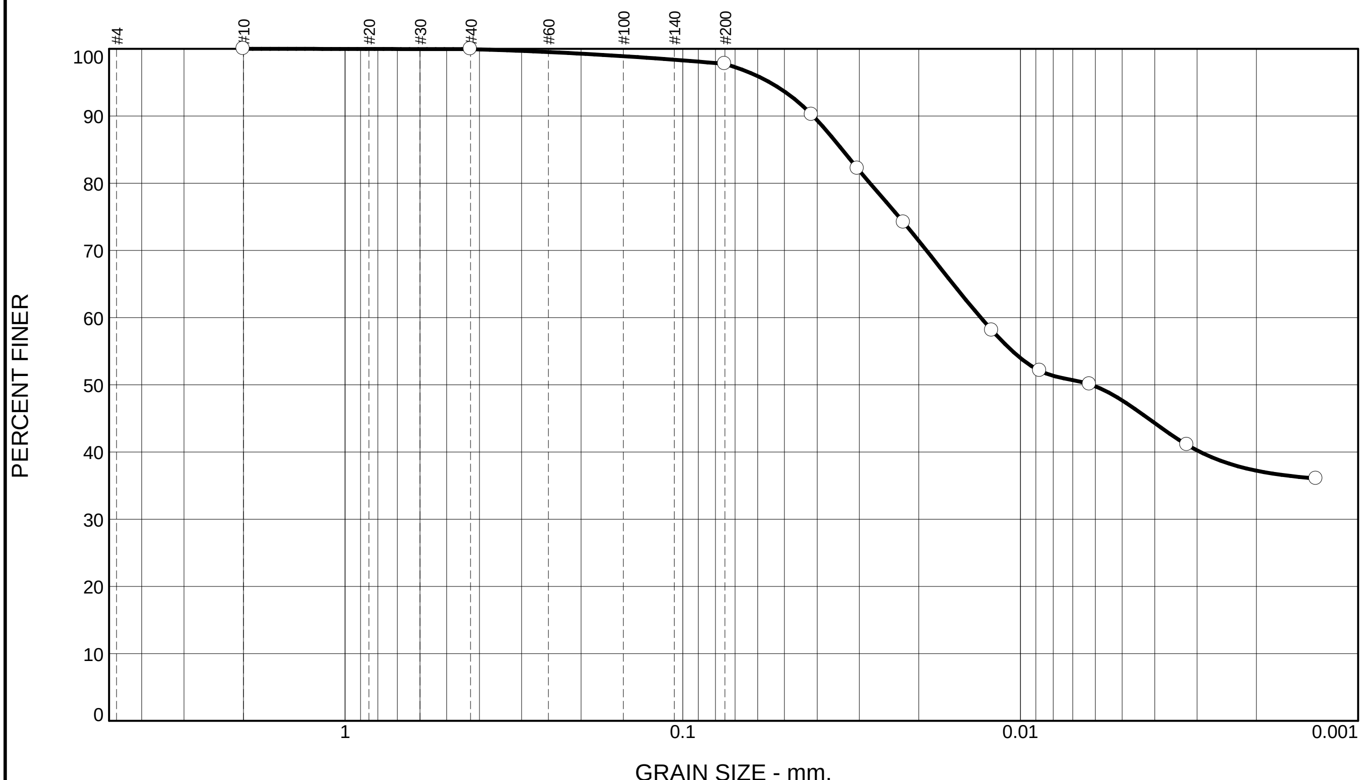
Dyregrov Robinson Inc.

Winnipeg, Manitoba

Client: TETRA TECH
Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)
Project No: 143691.7 **Figure** 1 of 2

Tested By: Chris Ribachuk

Particle Size Distribution Report



% Gravel	% Sand			% Fines	
Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.1	2.2	50.0	47.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#40	99.9		
#200	97.7		
0.0415 mm.	90.2		
0.0304 mm.	82.2		
0.0222 mm.	74.2		
0.0121 mm.	58.1		
0.0088 mm.	52.1		
0.0062 mm.	50.1		
0.0032 mm.	41.0		
0.0013 mm.	36.0		

* (no specification provided)

Soil Description

SILT and CLAY - trace sand
- intermediate plasticity

Atterberg Limits

PL= 20 LL= 33 PI= 13

Coefficients

D_{90}= 0.0411 D_{85}= 0.0337 D_{60}= 0.0131
D_{50}= 0.0062 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(13)

Remarks

Location: 19-151
Sample Number: G272 **Depth:** 8.8 m **Date:** 2019-7-26

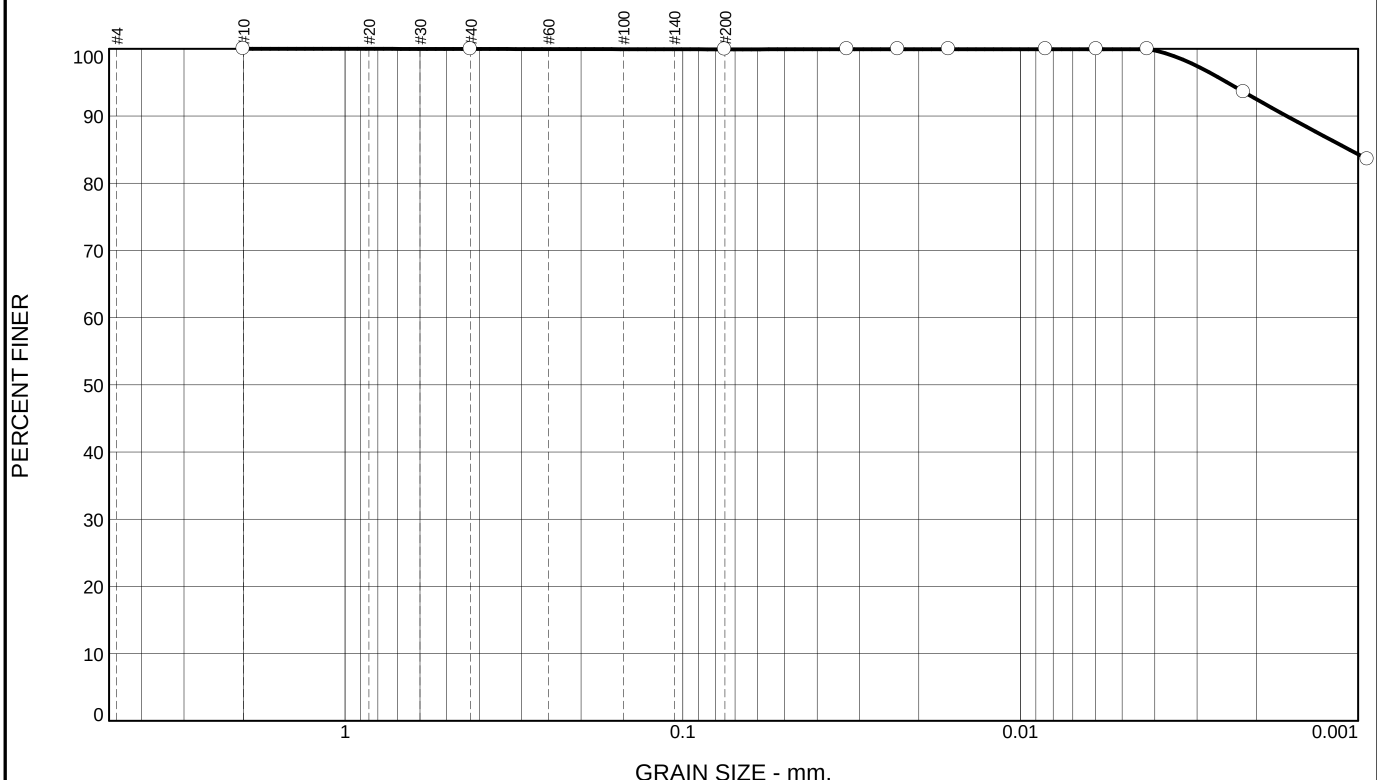
Dyregrov Robinson Inc.

Winnipeg, Manitoba

Client: TETRA TECH
Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)
Project No: 143691.7 **Figure** 1 of 2

Tested By: Chris Ribachuk

Particle Size Distribution Report



% Gravel	% Sand			% Fines	
Fine	Coarse	Medium	Fine	Silt	Clay
		0.0	0.1	0.0	99.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#40	100.0		
#200	99.9		
0.0326 mm.	99.9		
0.0230 mm.	99.9		
0.0163 mm.	99.9		
0.0084 mm.	99.9		
0.0059 mm.	99.9		
0.0042 mm.	99.9		
0.0022 mm.	93.6		
0.0009 mm.	83.6		

* (no specification provided)

Soil Description

CLAY
- high plasticity

Atterberg Limits

PL= 32 LL= 91 PI= 59

Coefficients

D_{90}= 0.0016 D_{85}= 0.0011 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CH AASHTO= A-7-5(71)

Remarks

Location: 19-152
Sample Number: G240 **Depth:** 4.3 m **Date:** 2019-7-26

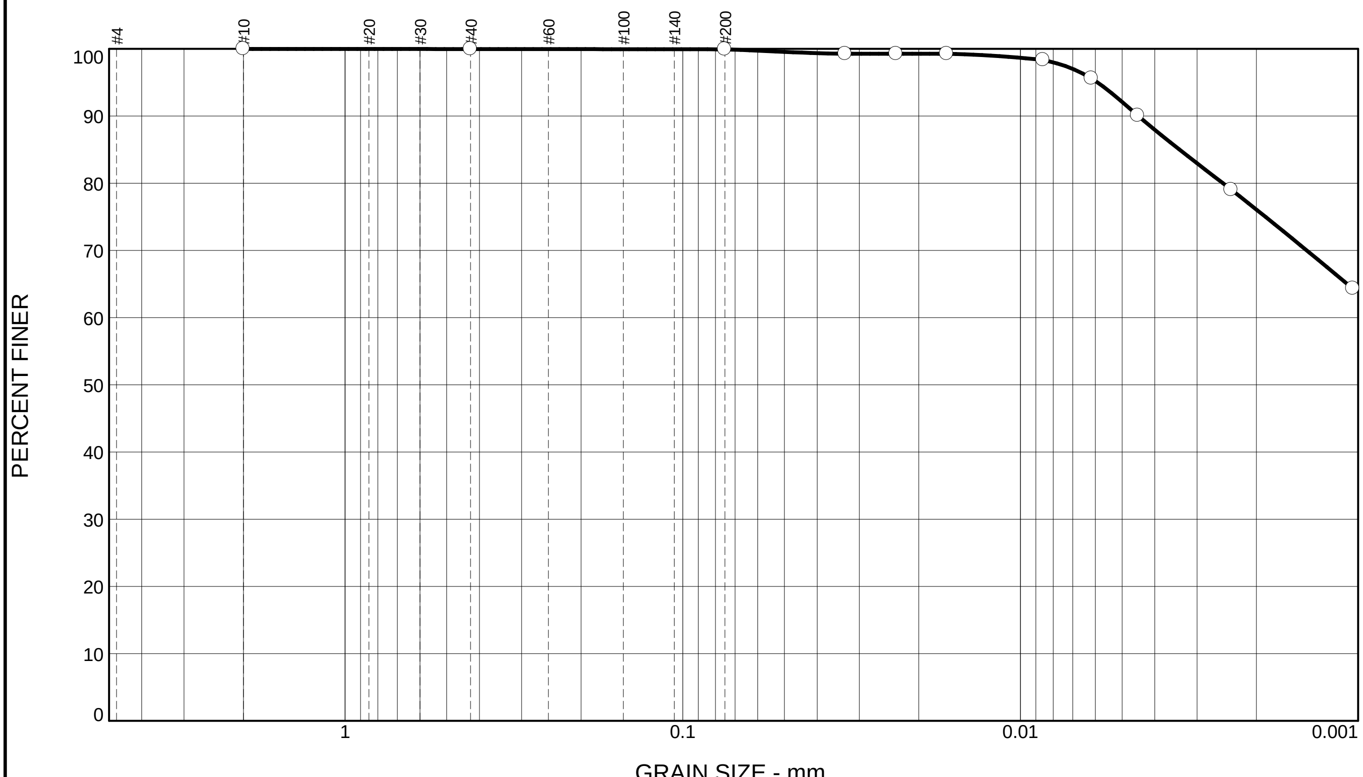
Dyregrov Robinson Inc.

Winnipeg, Manitoba

Client: TETRA TECH
Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)
Project No: 143691.7 **Figure** 1 of 2

Tested By: Chris Ribachuk

Particle Size Distribution Report



% Gravel	% Sand			% Fines	
Fine	Coarse	Medium	Fine	Silt	Clay
		0.0	0.1	7.8	92.1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#40	100.0		
#200	99.9		
0.0330 mm.	99.3		
0.0233 mm.	99.3		
0.0165 mm.	99.3		
0.0086 mm.	98.3		
0.0062 mm.	95.6		
0.0045 mm.	90.1		
0.0024 mm.	79.0		
0.0010 mm.	64.3		

* (no specification provided)

Soil Description

CLAY - trace silt
- high plasticity

Atterberg Limits

PL= 24 LL= 79 PI= 55

Coefficients

D_{90}= 0.0045 D_{85}= 0.0034 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CH AASHTO= A-7-6(64)

Remarks

Location: 19-156
Sample Number: T326 **Depth:** 6.1-6.7 m **Date:**

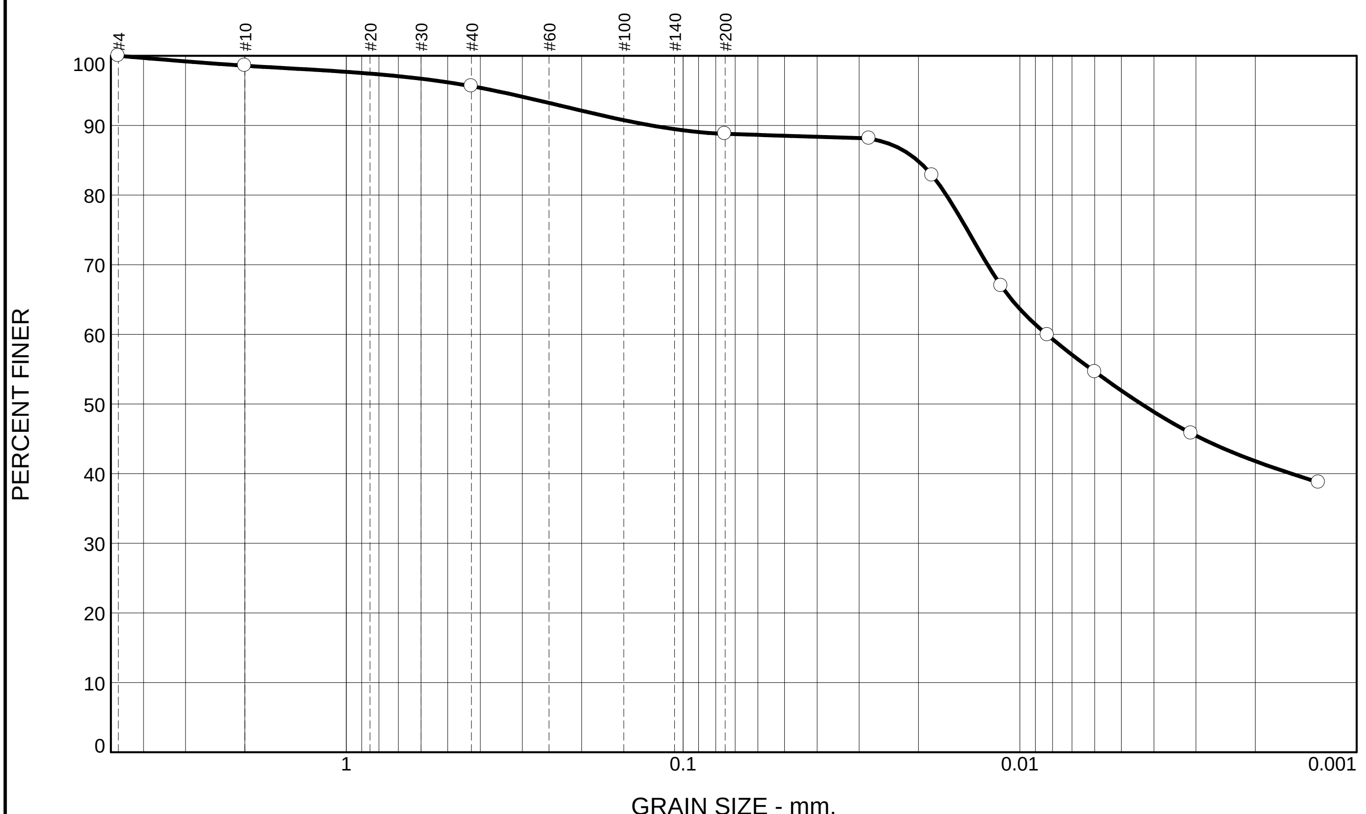
Dyregrov Robinson Inc.

Winnipeg, Manitoba

Client: TETRA TECH
Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)
Project No: 143691.7 **Figure** 1 of 2

Tested By: Chris Ribachuk

Particle Size Distribution Report



% Gravel	% Sand			% Fines	
Fine	Coarse	Medium	Fine	Silt	Clay
0.0	1.4	3.0	6.8	36.9	51.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	98.6		
#40	95.6		
#200	88.8		
0.0280 mm.	88.1		
0.0182 mm.	82.8		
0.0114 mm.	67.0		
0.0083 mm.	59.9		
0.0060 mm.	54.6		
0.0031 mm.	45.8		
0.0013 mm.	38.7		

* (no specification provided)

Soil Description

CLAY and SILT, trace sand

Atterberg Limits

PL= 18 LL= 55 PI= 37

Coefficients

D_{90}= 0.1243 D_{85}= 0.0201 D_{60}= 0.0083
D_{50}= 0.0044 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CH AASHTO= A-7-6(35)

Remarks

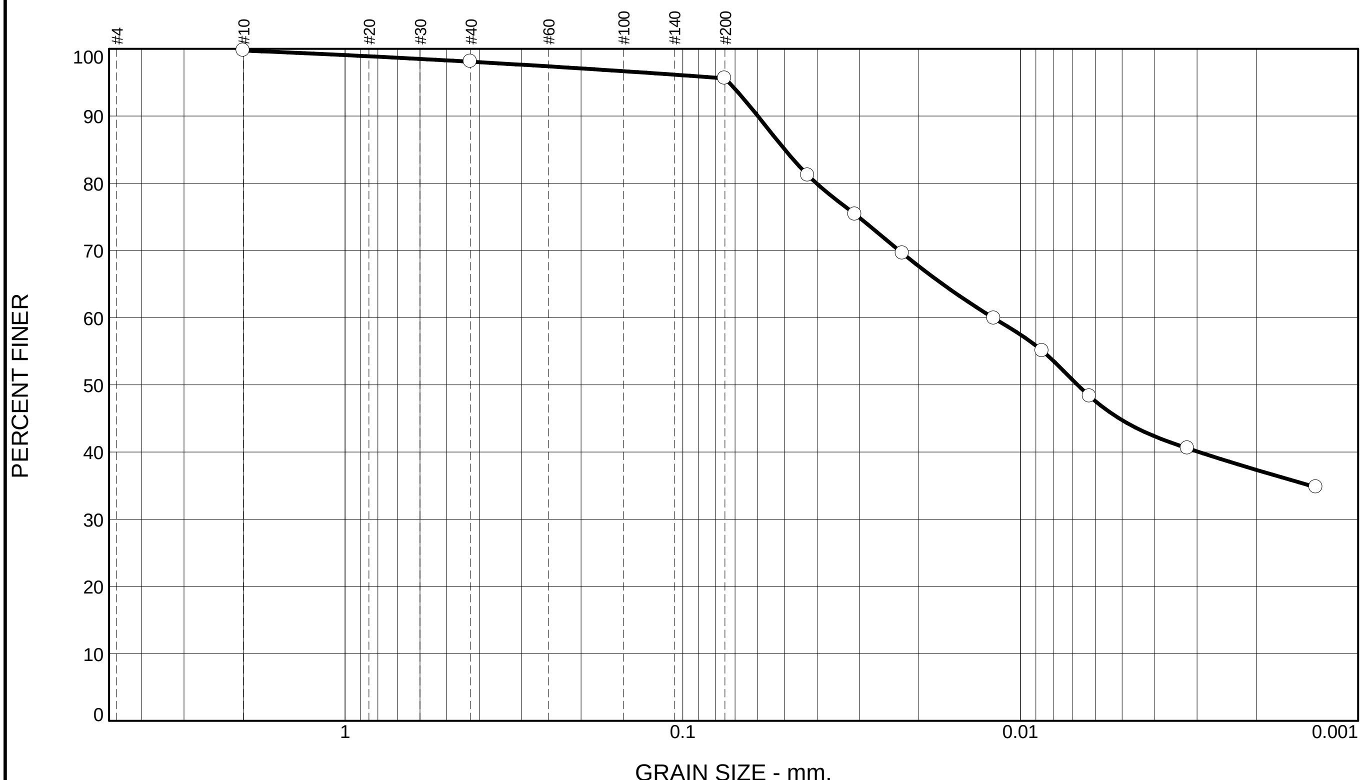
Location: 19-157
Sample Number: T337 **Depth:** 9.1 - 9.8 m **Date:** July 2019

Dyregrov Robinson Inc.

Winnipeg, Manitoba

Client: TETRA TECH
Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)
Project No: 143691.7 **Figure** 1 of 2

Particle Size Distribution Report



% Gravel	% Sand			% Fines	
Fine	Coarse	Medium	Fine	Silt	Clay
		1.6	2.5	50.9	44.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	99.7		
#40	98.1		
#200	95.6		
0.0426 mm.	81.2		
0.0309 mm.	75.4		
0.0223 mm.	69.6		
0.0120 mm.	59.9		
0.0086 mm.	55.1		
0.0062 mm.	48.3		
0.0032 mm.	40.5		
0.0013 mm.	34.7		

* (no specification provided)

Soil Description

SILT and CLAY(TILL) - trace sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.0600 D_{85}= 0.0499 D_{60}= 0.0121
D_{50}= 0.0068 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= MH AASHTO=

Remarks

Location: 19-161
Sample Number: G386 **Depth:** 9.8 m **Date:** 2019-8-1

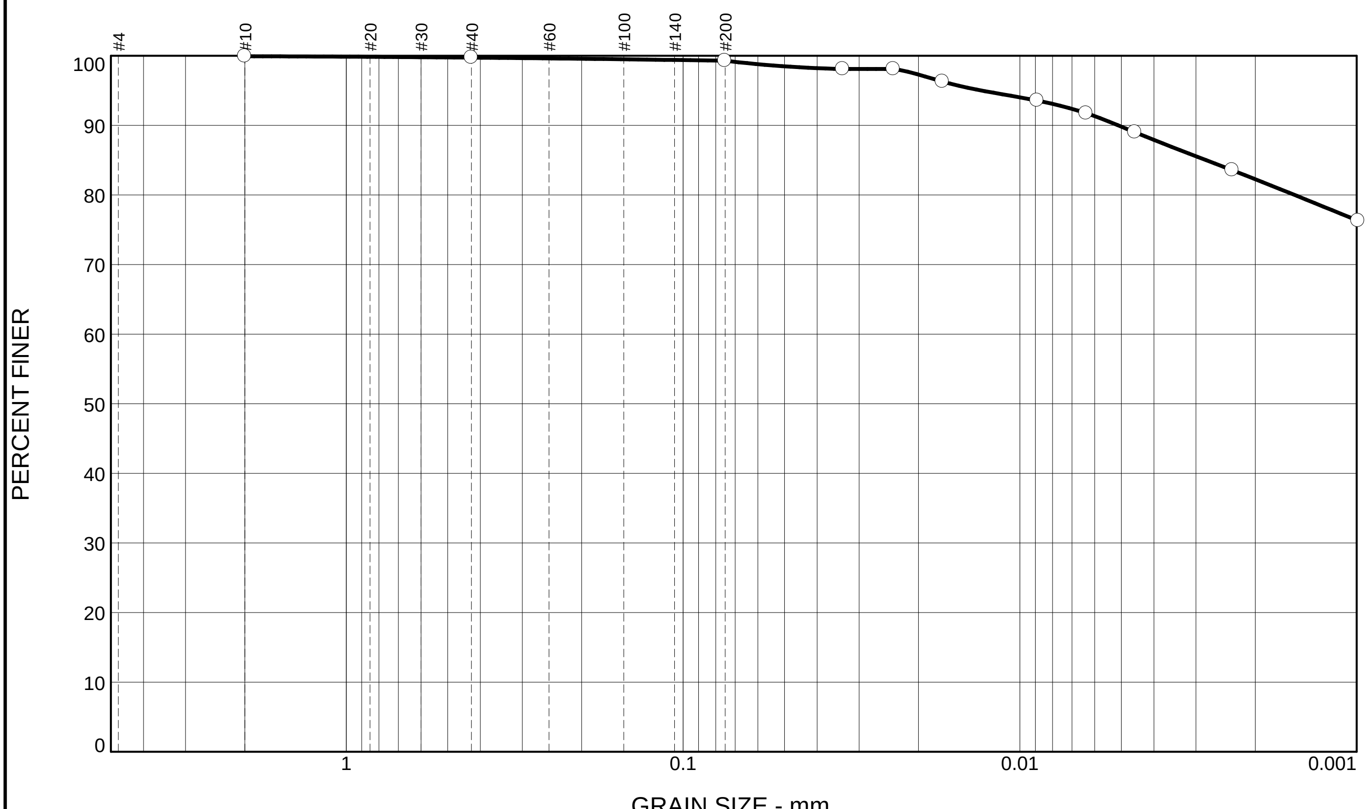
Dyregrov Robinson Inc.

Winnipeg, Manitoba

Client: TETRA TECH
Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)
Project No: 143691.7 **Figure** 1 of 1

Tested By: Chris Ribachuk

Particle Size Distribution Report



% Gravel	% Sand			% Fines	
Fine	Coarse	Medium	Fine	Silt	Clay
		0.2	0.4	9.5	89.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	99.9		
#40	99.7		
#200	99.3		
0.0336 mm.	98.1		
0.0237 mm.	98.1		
0.0170 mm.	96.3		
0.0089 mm.	93.6		
0.0063 mm.	91.7		
0.0046 mm.	89.0		
0.0023 mm.	83.6		
0.0010 mm.	76.3		

* (no specification provided)

Soil Description

CLAY - trace silt. trace sand
- high plasticity

Atterberg Limits

PL= 23 LL= 70 PI= 47

Coefficients

D_{90}= 0.0051 D_{85}= 0.0028 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CH AASHTO= A-7-6(53)

Remarks

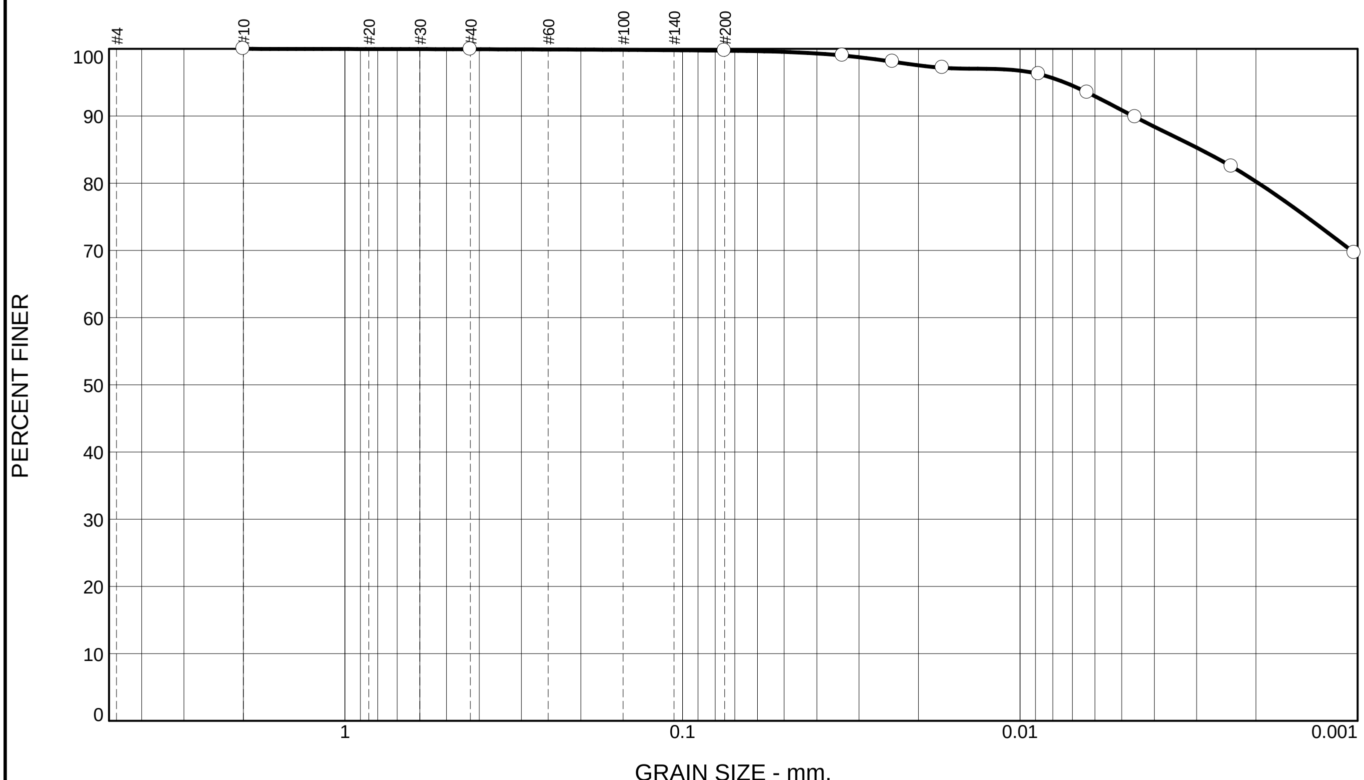
Location: 19-162
Sample Number: T394 **Depth:** 7.6-8.2 m **Date:** 2019-8-1

Dyregrov Robinson Inc.

Winnipeg, Manitoba

Client: TETRA TECH
Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)
Project No: 143691.7 **Figure** 1 of 2

Particle Size Distribution Report



% Gravel	% Sand			% Fines	
Fine	Coarse	Medium	Fine	Silt	Clay
		0.1	0.2	8.8	90.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#40	99.9		
#200	99.7		
0.0336 mm.	99.0		
0.0239 mm.	98.1		
0.0170 mm.	97.2		
0.0088 mm.	96.2		
0.0063 mm.	93.5		
0.0046 mm.	89.8		
0.0024 mm.	82.5		
0.0010 mm.	69.6		

* (no specification provided)

Soil Description

CLAY - trace silt, trace sand
- high plasticity

Atterberg Limits

PL= 29 LL= 78 PI= 49

Coefficients

D_{90}= 0.0046 D_{85}= 0.0029 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CH AASHTO= A-7-6(58)

Remarks

Location: 19-166
Sample Number: G439 **Depth:** 4.3 m **Date:** 2019-8-2

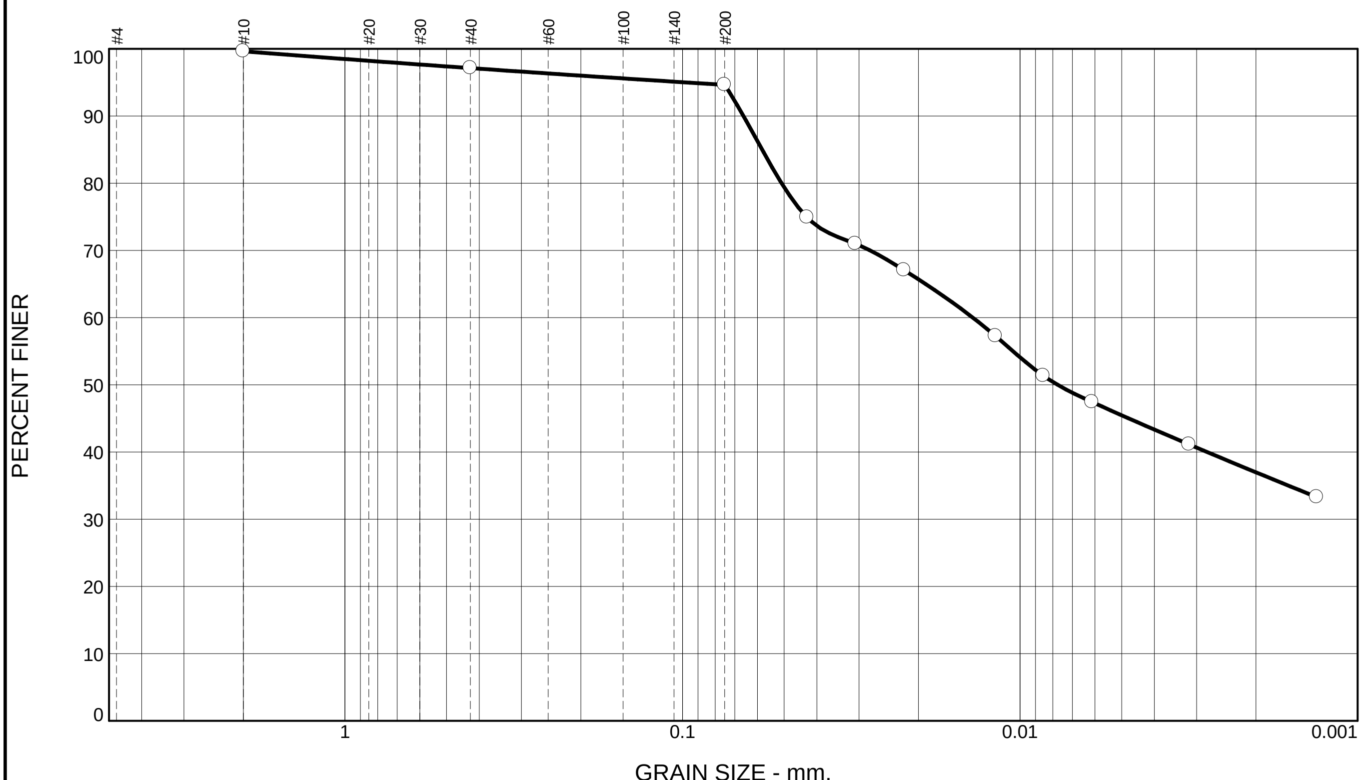
Dyregrov Robinson Inc.

Winnipeg, Manitoba

Client: TETRA TECH
Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)
Project No: 143691.7 **Figure** 1 of 2

Tested By: Chris Ribachuk

Particle Size Distribution Report



% Gravel	% Sand			% Fines	
Fine	Coarse	Medium	Fine	Silt	Clay
		2.5	2.5	49.1	45.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	99.6		
#40	97.1		
#200	94.6		
0.0428 mm.	74.9		
0.0307 mm.	71.0		
0.0221 mm.	67.1		
0.0118 mm.	57.2		
0.0085 mm.	51.4		
0.0061 mm.	47.4		
0.0032 mm.	41.1		
0.0013 mm.	33.3		

* (no specification provided)

Soil Description

SILT and CLAY(TILL) - trace sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.0660 D_{85}= 0.0581 D_{60}= 0.0138
D_{50}= 0.0077 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= ML AASHTO=

Remarks

Location: 19-166
Sample Number: S443 **Depth:** 9.1-9.6 m **Date:** 2019-8-2

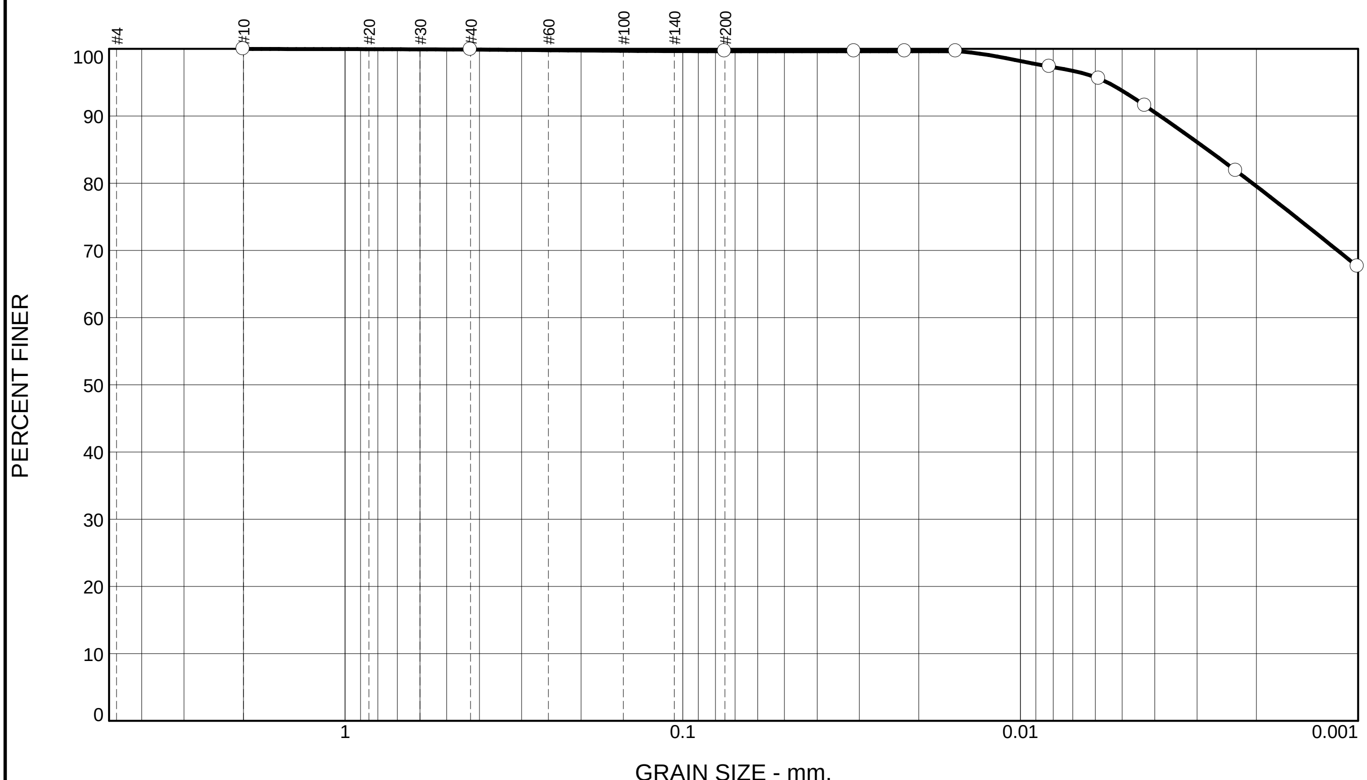
Dyregrov Robinson Inc.

Winnipeg, Manitoba

Client: TETRA TECH
Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)
Project No: 143691.7 **Figure** 1 of 1

Tested By: Chris Ribachuk

Particle Size Distribution Report



% Gravel	% Sand			% Fines	
Fine	Coarse	Medium	Fine	Silt	Clay
		0.1	0.3	5.8	93.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#40	99.9		
#200	99.6		
0.0310 mm.	99.6		
0.0220 mm.	99.6		
0.0155 mm.	99.6		
0.0082 mm.	97.3		
0.0059 mm.	95.6		
0.0043 mm.	91.6		
0.0023 mm.	81.8		
0.0010 mm.	67.6		

* (no specification provided)

Soil Description

CLAY - trace silt, trace sand
- high plasticity

Atterberg Limits

PL= 26 LL= 78 PI= 52

Coefficients

D_{90}= 0.0039 D_{85}= 0.0028 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CH AASHTO= A-7-6(61)

Remarks

Location: 19-173
Sample Number: G492 **Depth:** 2.3 m **Date:** 2019-8-15

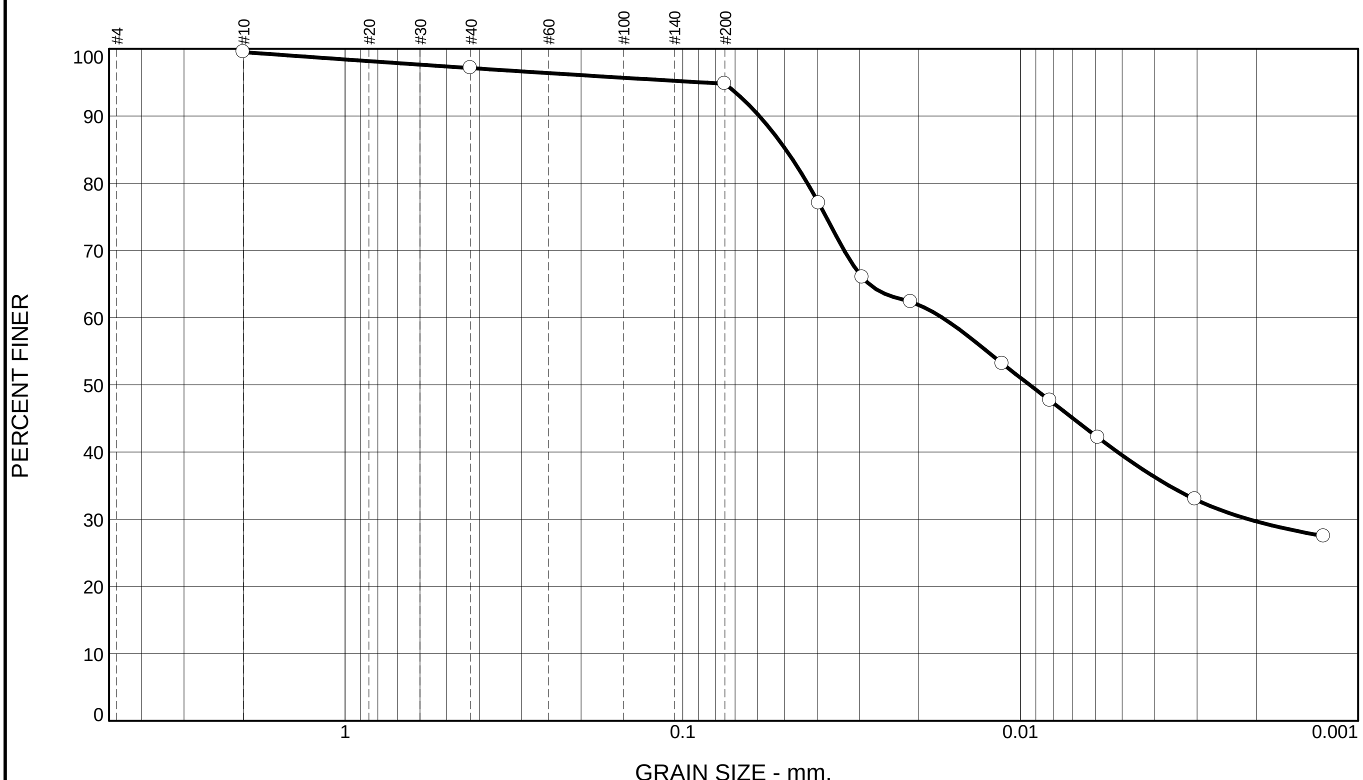
Dyregrov Robinson Inc.

Winnipeg, Manitoba

Client: TETRA TECH
Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)
Project No: 143691.7 **Figure** 1 of 2

Tested By: Chris Ribachuk

Particle Size Distribution Report



% Gravel	% Sand			% Fines	
Fine	Coarse	Medium	Fine	Silt	Clay
		2.4	2.3	55.3	39.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	99.5		
#40	97.1		
#200	94.8		
0.0395 mm.	77.0		
0.0294 mm.	66.0		
0.0211 mm.	62.3		
0.0113 mm.	53.1		
0.0082 mm.	47.6		
0.0059 mm.	42.1		
0.0030 mm.	33.0		
0.0013 mm.	27.5		

* (no specification provided)

Soil Description

SILT and CLAY(TILL) - trace sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.0593 D_{85}= 0.0495 D_{60}= 0.0171
D_{50}= 0.0094 D_{30}= 0.0021 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= MH AASHTO=

Remarks

Location: 19-173
Sample Number: S496 **Depth:** 6.1-6.5 m **Date:** 2019-8-15

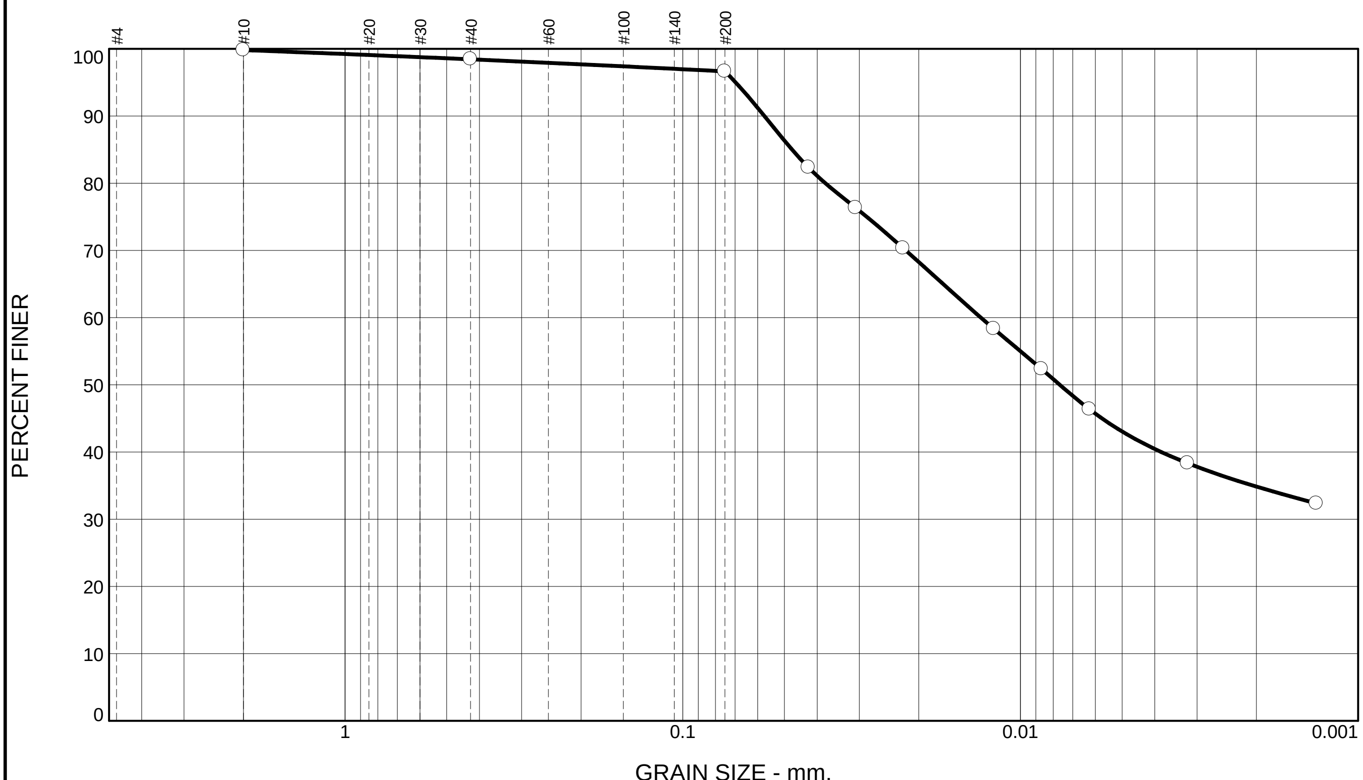
Dyregrov Robinson Inc.

Winnipeg, Manitoba

Client: TETRA TECH
Project: Ferry Road & Riverbend CSR - Rutland Trunk Sewer (Contract 6)
Project No: 143691.7 **Figure** 1 of 1

Tested By: Chris Ribachuk

Particle Size Distribution Report



% Gravel	% Sand			% Fines	
Fine	Coarse	Medium	Fine	Silt	Clay
		1.4	1.8	53.5	43.1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	99.8		
#40	98.4		
#200	96.6		
0.0424 mm.	82.3		
0.0307 mm.	76.3		
0.0222 mm.	70.3		
0.0120 mm.	58.3		
0.0087 mm.	52.3		
0.0062 mm.	46.3		
0.0032 mm.	38.3		
0.0013 mm.	32.3		

* (no specification provided)

Soil Description

SILT and CLAY (Till), trace sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.0573 D_{85}= 0.0475 D_{60}= 0.0131
D_{50}= 0.0076 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Location: TH20-244
Sample Number: G7 **Depth:** 6.1 M **Date:** Jan 11, 2021

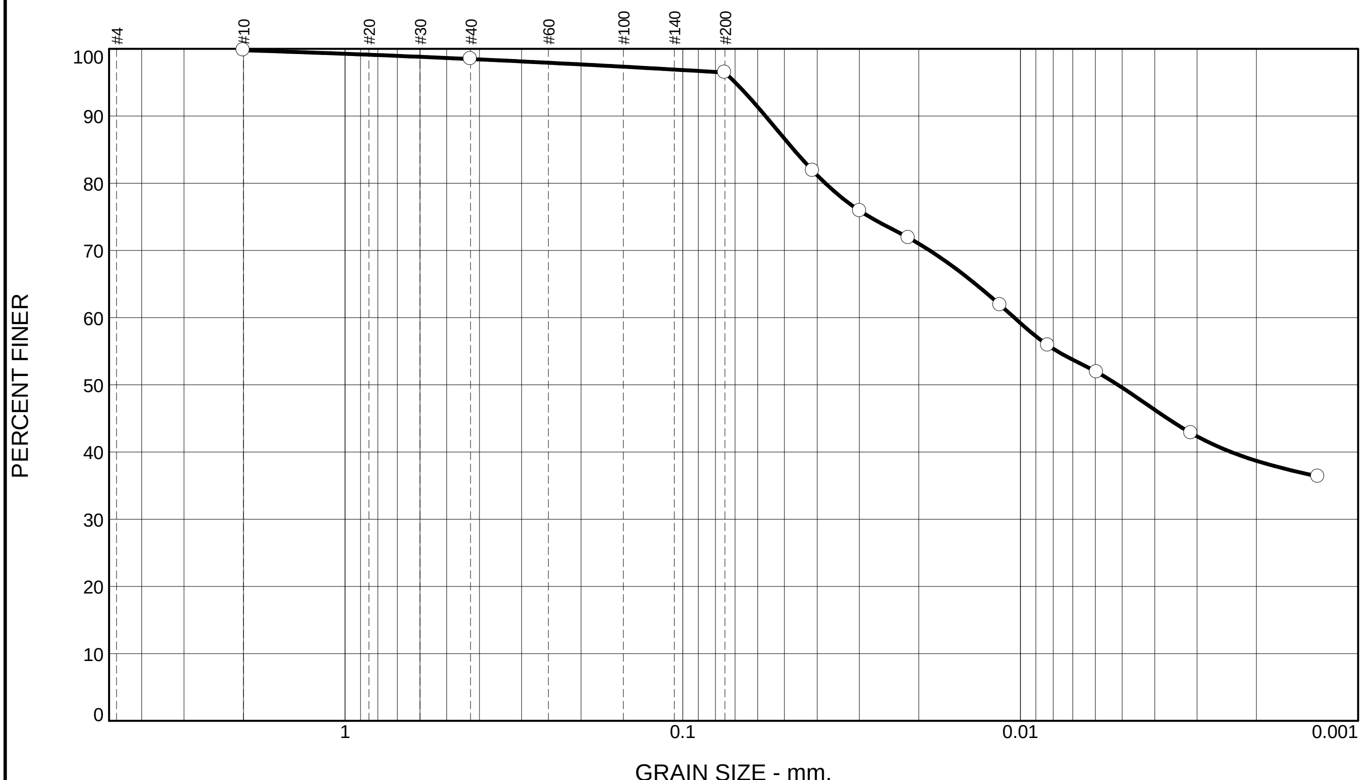
Dyregrov Robinson Inc.

Winnipeg, Manitoba

Client: Tetra Tech Canada Inc.
Project: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer
Project No: 143691 **Figure** 1

Tested By: Chris Ribachuk

Particle Size Distribution Report



% Gravel	% Sand			% Fines	
Fine	Coarse	Medium	Fine	Silt	Clay
		1.3	2.0	46.9	49.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	99.8		
#40	98.5		
#200	96.5		
0.0412 mm.	81.9		
0.0299 mm.	75.9		
0.0214 mm.	71.9		
0.0115 mm.	61.9		
0.0083 mm.	55.9		
0.0059 mm.	51.9		
0.0031 mm.	42.8		
0.0013 mm.	36.3		

* (no specification provided)

Soil Description

CLAY and SILT(Till), trace sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.0569 D_{85}= 0.0469 D_{60}= 0.0104
D_{50}= 0.0051 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Location: TH20-245
Sample Number: G20 **Depth:** 6.1 m **Date:** 1/11/21

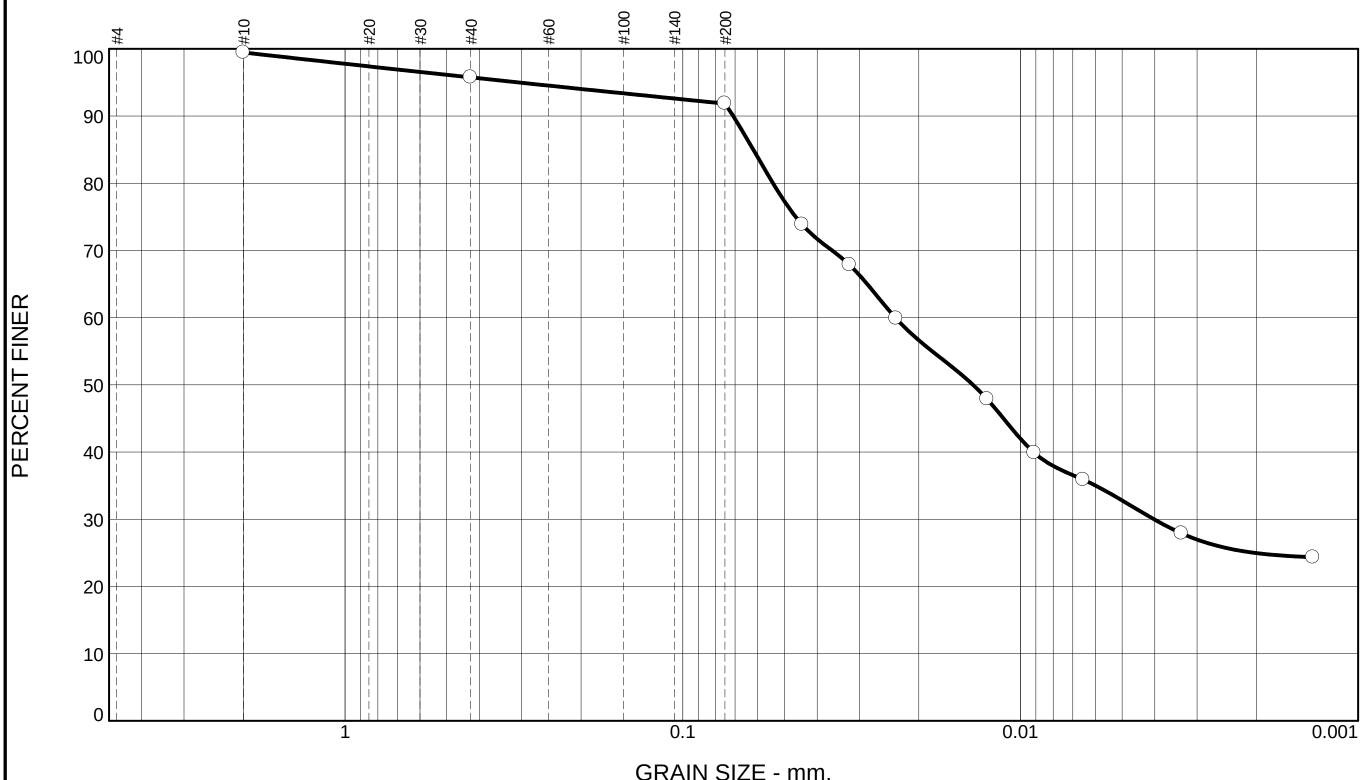
Dyregrov Robinson Inc.

Winnipeg, Manitoba

Client: Tetra Tech Canada Inc.
Project: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer
Project No: 143691 **Figure** 1

Tested By: Chris Ribachuk

Particle Size Distribution Report



% Gravel	% Sand			% Fines	
Fine	Coarse	Medium	Fine	Silt	Clay
		3.7	3.9	59.0	32.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	99.4		
#40	95.7		
#200	91.8		
0.0443 mm.	73.8		
0.0321 mm.	67.9		
0.0233 mm.	59.9		
0.0125 mm.	47.9		
0.0091 mm.	39.9		
0.0065 mm.	35.9		
0.0033 mm.	27.9		
0.0014 mm.	24.3		

* (no specification provided)

Soil Description

SILT (Till) - clayey, trace sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.0709 D_{85}= 0.0618 D_{60}= 0.0235
D_{50}= 0.0138 D_{30}= 0.0040 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Location: TH20-246
Sample Number: S36 **Depth:** 7.8 m **Date:** 1/11/21

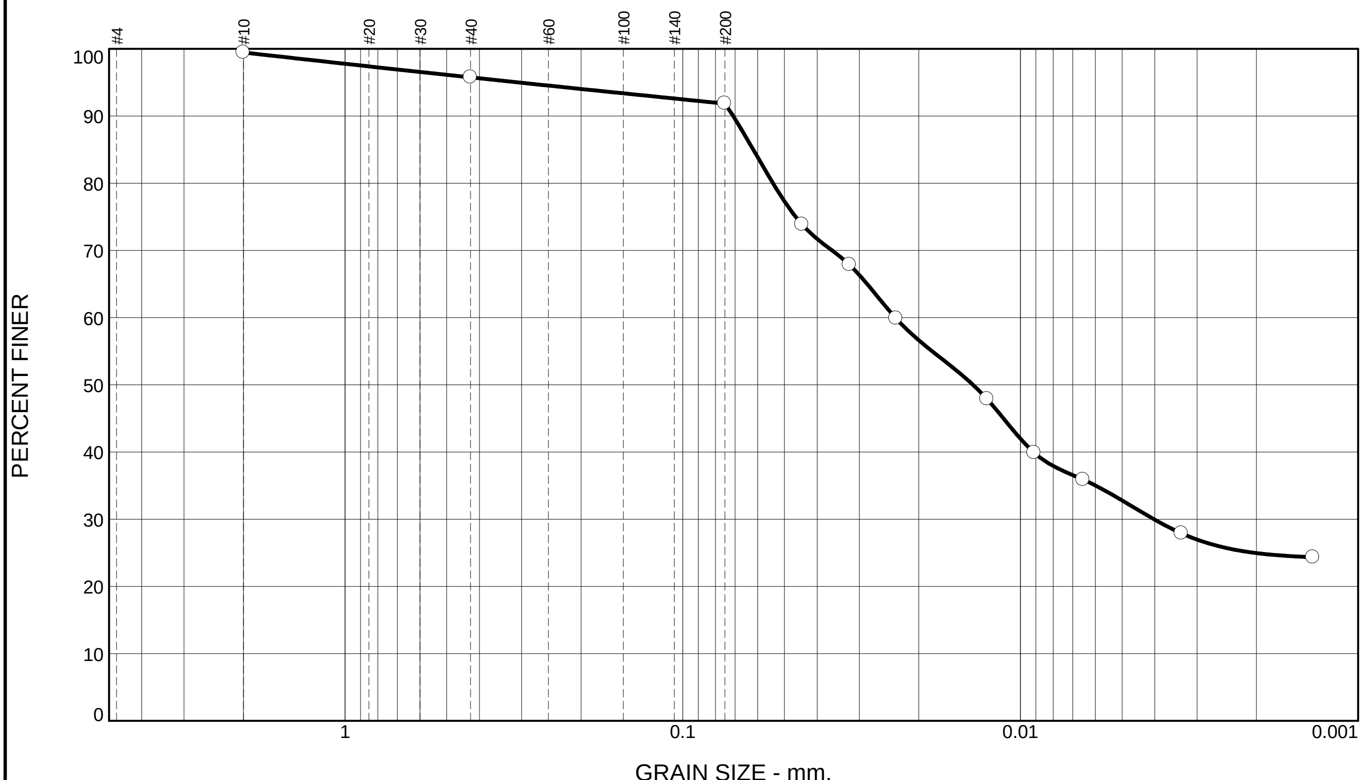
Dyregrov Robinson Inc.

Winnipeg, Manitoba

Client: Tetra Tech Canada Inc.
Project: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer
Project No: 143691 **Figure** 1

Tested By: Chris Ribachuk

Particle Size Distribution Report



% Gravel	% Sand			% Fines	
Fine	Coarse	Medium	Fine	Silt	Clay
		3.7	3.9	59.0	32.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	99.4		
#40	95.7		
#200	91.8		
0.0443 mm.	73.8		
0.0321 mm.	67.9		
0.0233 mm.	59.9		
0.0125 mm.	47.9		
0.0091 mm.	39.9		
0.0065 mm.	35.9		
0.0033 mm.	27.9		
0.0014 mm.	24.3		

* (no specification provided)

Soil Description

SILT - clayey, trace sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.0709 D_{85}= 0.0618 D_{60}= 0.0235
D_{50}= 0.0138 D_{30}= 0.0040 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Location: TH20-246
Sample Number: S36 **Depth:** 6.1-8 m **Date:** 1/11/21

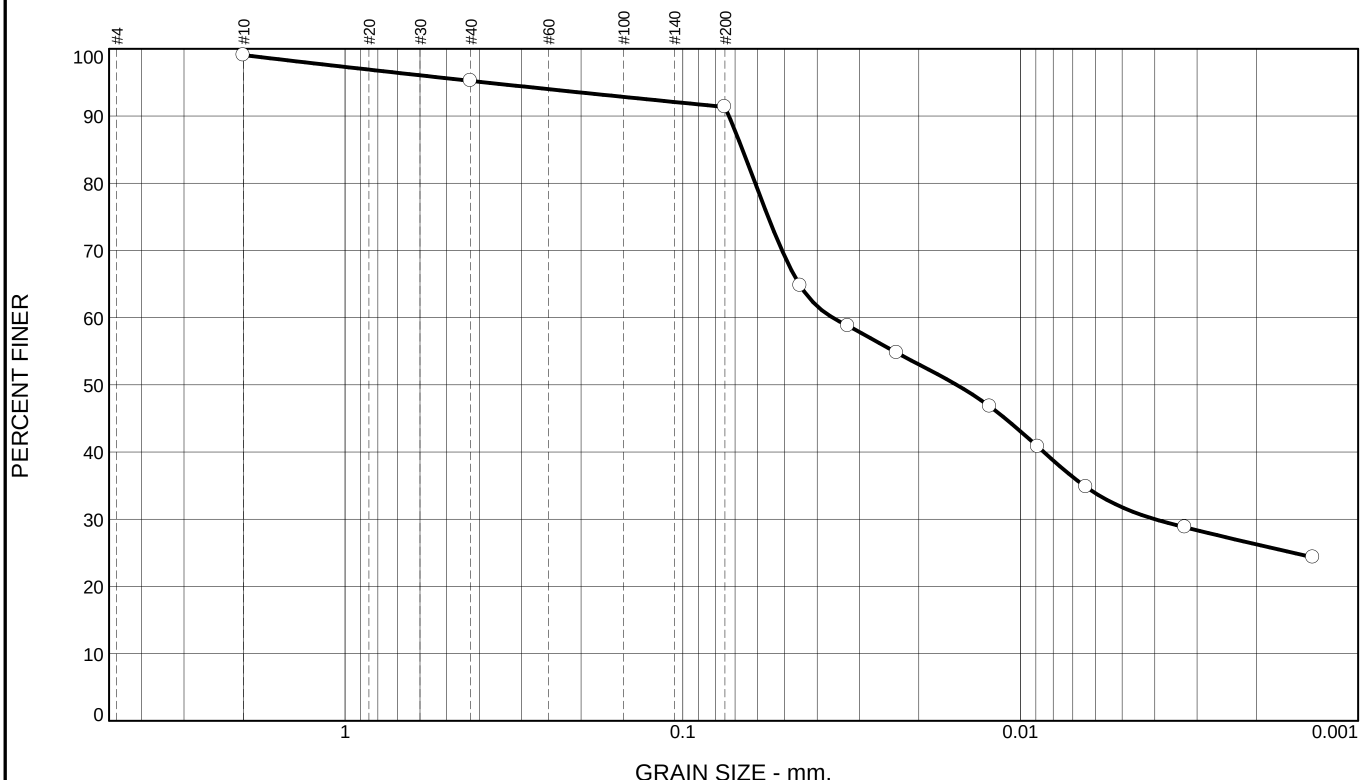
Dyregrov Robinson Inc.

Winnipeg, Manitoba

Client: Tetra Tech Canada Inc.
Project: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer
Project No: 143691 **Figure** 1

Tested By: Chris Ribachuk

Particle Size Distribution Report



% Gravel	% Sand			% Fines	
Fine	Coarse	Medium	Fine	Silt	Clay
		3.9	3.9	59.5	31.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	99.1		
#40	95.2		
#200	91.3		
0.0449 mm.	64.8		
0.0324 mm.	58.8		
0.0232 mm.	54.8		
0.0123 mm.	46.8		
0.0089 mm.	40.8		
0.0064 mm.	34.8		
0.0033 mm.	28.8		
0.0014 mm.	24.3		

* (no specification provided)

Soil Description

SILT(Till) - clayey, trace sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.0730 D_{85}= 0.0666 D_{60}= 0.0360
D_{50}= 0.0155 D_{30}= 0.0040 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Location: TH20-248
Sample Number: S56 **Depth:** 4.6-5 m **Date:** 1/11/21

Dyregrov Robinson Inc.

Winnipeg, Manitoba

Client: Tetra Tech Canada Inc.
Project: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer
Project No: 143691 **Figure** 1

Tested By: Chris Ribachuk

Your Project #: 143691.7
Site Location: RUTLAND TRUNK SEWER
Your C.O.C. #: N017656

Attention: GIL ROBINSON

DYREGROV ROBINSON INC
UNIT 1, 1692 DUBLIN AVENUE
WINNIPEG, MB
CANADA R3H 1A8

Report Date: 2020/03/03
Report #: R2852659
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C013407
Received: 2020/02/25, 09:00

Sample Matrix: Soil
Samples Received: 6

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Chloride (Soluble)	6	2020/03/02	2020/03/02	AB SOP-00033 / AB SOP-00020	SM 23-4500-Cl-E m
Resistivity	6	N/A	2020/03/02		Auto Calc
Conductivity @25C (Soluble)	6	2020/03/02	2020/03/02	AB SOP-00033 / AB SOP-00004	SM 23 2510 B m
pH @25C (Soluble)	6	2020/03/02	2020/03/02	AB SOP-00033 / AB SOP-00006	SM 23 4500 H+B m
Soluble Ions	6	2020/03/02	2020/03/02	AB SOP-00033 / AB SOP-00042	EPA 6010d R5 m
Soluble Ions Calculation	6	2020/02/26	2020/03/02		Auto Calc
Soluble Paste	6	2020/03/02	2020/03/02	AB SOP-00033	Carter 2nd ed 15.2 m

Remarks:

Bureau Veritas Laboratories are accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by BV Labs are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in BV Labs profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and BV Labs 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. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

BV Labs liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. BV Labs 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 BV Labs, unless otherwise agreed in writing. BV Labs is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

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. When sampling is not conducted by BV Labs, results relate to the supplied 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.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Your Project #: 143691.7
Site Location: RUTLAND TRUNK SEWER
Your C.O.C. #: N017656

Attention: GIL ROBINSON

DYREGROV ROBINSON INC
UNIT 1, 1692 DUBLIN AVENUE
WINNIPEG, MB
CANADA R3H 1A8

Report Date: 2020/03/03
Report #: R2852659
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C013407
Received: 2020/02/25, 09:00

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Customer Solutions, Western Canada Customer Experience Team
Email: customersolutionswest@bvlabs.com
Phone# (403) 291-3077
==
This report has been generated and distributed using a secure automated process.
BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

BV Labs Job #: C013407
Report Date: 2020/03/03

DYREGROV ROBINSON INC
Client Project #: 143691.7
Site Location: RUTLAND TRUNK SEWER
Sampler Initials: CR

RESULTS OF CHEMICAL ANALYSES OF SOIL

BV Labs ID		XL2647	XL2648		XL2649		
Sampling Date		2020/02/24	2020/02/24		2020/02/24		
COC Number		N017656	N017656		N017656		
	UNITS	**19-149 (G286-2.7)**	**19-151 (G267-2.2)**	**RDL**	**19-153 (G248-4.1)**	**RDL**	**QC Batch**
Calculated Parameters							
Resistivity @ 25 °C	ohm-m	8.7	35	0.050	1.6	0.050	9777999
Calculated Sulphate (SO4)	%	0.017	0.0010	0.00013	0.34	0.00013	9778002
Soluble Parameters							
Soluble Chloride (Cl)	mg/L	30	18	5.0	490 (1)	10	9783378
Soluble Conductivity	dS/m	1.2	0.29	0.020	6.1	0.020	9782932
Soluble pH	pH	7.55	7.81	N/A	7.59	N/A	9781975
Saturation %	%	56	49	N/A	110	N/A	9781971
Soluble Sulphate (SO4)	mg/L	300	21	5.0	3200	5.0	9783029

RDL = Reportable Detection Limit
N/A = Not Applicable
(1) Detection limits raised due to dilution to bring analyte within the calibrated range.

BV Labs ID		XL2650	XL2651		XL2652		
Sampling Date		2020/02/24	2020/02/24		2020/02/24		
COC Number		N017656	N017656		N017656		
	UNITS	**19-161 (G383-5.7)**	**19-167 (G456-5.7)**	**RDL**	**19- 172 (G486-6.6)**	**RDL**	**QC Batch**
Calculated Parameters							
Resistivity @ 25 °C	ohm-m	2.6	3.8	0.050	1.9	0.050	9777999
Calculated Sulphate (SO4)	%	0.20	0.13	0.00013	0.064	0.00013	9778002
Soluble Parameters							
Soluble Chloride (Cl)	mg/L	220	17	5.0	850 (1)	25	9783378
Soluble Conductivity	dS/m	3.9	2.6	0.020	5.3	0.020	9782932
Soluble pH	pH	7.68	7.81	N/A	7.83	N/A	9781975
Saturation %	%	95	86	N/A	41	N/A	9781971
Soluble Sulphate (SO4)	mg/L	2100	1500	5.0	1500	5.0	9783029

RDL = Reportable Detection Limit
N/A = Not Applicable
(1) Detection limits raised due to dilution to bring analyte within the calibrated range.

Bureau Veritas Laboratories Calgary: 2021 - 41st Avenue N.E. T2E 6P2 Telephone (403) 291-3077 Fax (403) 291-9468

GENERAL COMMENTS

Results relate only to the items tested.

Bureau Veritas Laboratories Calgary: 2021 - 41st Avenue N.E. T2E 6P2 Telephone (403) 291-3077 Fax (403) 291-9468

BV Labs Job #: C013407
Report Date: 2020/03/03

DYREGROV ROBINSON INC
Client Project #: 143691.7
Site Location: RUTLAND TRUNK SEWER
Sampler Initials: CR

QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
9781971	IK0	QC Standard	Saturation %	2020/03/02		101	%	75 - 125
9781971	IK0	RPD	Saturation %	2020/03/02	0.42		%	12
9781971	IK0	RPD [XL2648-01]	Saturation %	2020/03/02	9.8		%	12
9781975	JHC	QC Standard	Soluble pH	2020/03/02		99	%	98 - 102
9781975	JHC	Spiked Blank	Soluble pH	2020/03/02		99	%	97 - 103
9781975	JHC	RPD [XL2648-01]	Soluble pH	2020/03/02	0.26		%	N/A
9782932	LZ0	QC Standard	Soluble Conductivity	2020/03/02		96	%	75 - 125
9782932	LZ0	Spiked Blank	Soluble Conductivity	2020/03/02		99	%	90 - 110
9782932	LZ0	Method Blank	Soluble Conductivity	2020/03/02	ND, RDL=0.020		dS/m	
9782932	LZ0	RPD	Soluble Conductivity	2020/03/02	0.57		%	20
9783029	LQ1	QC Standard	Soluble Sulphate (SO4)	2020/03/02		90	%	75 - 125
9783029	LQ1	Method Blank	Soluble Sulphate (SO4)	2020/03/02	ND, RDL=5.0		mg/L	
9783029	LQ1	RPD	Soluble Sulphate (SO4)	2020/03/02	4.3		%	30
9783378	STI	Matrix Spike	Soluble Chloride (Cl)	2020/03/02		100	%	75 - 125
9783378	STI	QC Standard	Soluble Chloride (Cl)	2020/03/02		90	%	75 - 125
9783378	STI	Spiked Blank	Soluble Chloride (Cl)	2020/03/02		106	%	80 - 120
9783378	STI	Method Blank	Soluble Chloride (Cl)	2020/03/02	ND, RDL=5.0		mg/L	
9783378	STI	RPD	Soluble Chloride (Cl)	2020/03/02	11		%	30

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.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

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.

Bureau Veritas Laboratories Calgary: 2021 - 41st Avenue N.E. T2E 6P2 Telephone (403) 291-3077 Fax (403) 291-9468

VALIDATION SIGNATURE PAGE

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

Ghayasuddin Khan, M.Sc., P.Chem., QP, Scientific Specialist, Inorganics

---

BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Your P.O. #: 143691.7
Your Project #: 143691.7
Site Location: RUTLAND N. OF SILVER
Your C.O.C. #: N017649

Attention: GIL ROBINSON

DYREGROV ROBINSON INC
UNIT 1, 1692 DUBLIN AVENUE
WINNIPEG, MB
CANADA R3H 1A8

Report Date: 2021/02/02
Report #: R2982658
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C106368
Received: 2021/01/29, 13:00

Sample Matrix: Soil
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Chloride (Soluble)	2	2021/02/01	2021/02/01	AB SOP-00033 / AB SOP-00020	SM 23-4500-Cl-E m
Resistivity	2	N/A	2021/02/01		Auto Calc
Conductivity @25C (Soluble)	2	2021/02/01	2021/02/01	AB SOP-00033 / AB SOP-00004	SM 23 2510 B m
pH @25C (Soluble)	2	2021/02/01	2021/02/01	AB SOP-00033 / AB SOP-00006	SM 23 4500 H+B m
Soluble Ions	2	2021/02/01	2021/02/01	AB SOP-00033 / AB SOP-00042	EPA 6010d R5 m
Soluble Ions Calculation	2	2021/01/30	2021/02/01		Auto Calc
Soluble Paste	2	2021/02/01	2021/02/01	AB SOP-00033	Carter 2nd ed 15.2 m

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas 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. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas 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 Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

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. When sampling is not conducted by Bureau Veritas, results relate to the supplied 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.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Bureau Veritas Laboratories Calgary: 2021 - 41st Avenue N.E. T2E 6P2 Telephone (403) 291-3077 Fax (403) 291-9468

Your P.O. #: 143691.7
Your Project #: 143691.7
Site Location: RUTLAND N. OF SILVER
Your C.O.C. #: N017649

Attention: GIL ROBINSON

DYREGROV ROBINSON INC
UNIT 1, 1692 DUBLIN AVENUE
WINNIPEG, MB
CANADA R3H 1A8

Report Date: 2021/02/02
Report #: R2982658
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C106368
Received: 2021/01/29, 13:00

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Customer Solutions, Western Canada Customer Experience Team
Email: customersolutionswest@bureauveritas.com
Phone# (403) 291-3077
==
This report has been generated and distributed using a secure automated process.
BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Bureau Veritas Laboratories Calgary: 2021 - 41st Avenue N.E. T2E 6P2 Telephone (403) 291-3077 Fax (403) 291-9468

BUREAU VERITAS

BV Labs Job #: C106368
Report Date: 2021/02/02

DYREGROV ROBINSON INC
Client Project #: 143691.7
Site Location: RUTLAND N. OF SILVER
Your P.O. #: 143691.7
Sampler Initials: CR

RESULTS OF CHEMICAL ANALYSES OF SOIL

BV Labs ID		ZF9026		ZF9027		
Sampling Date		2020/12/01		2020/12/01		
COC Number		N017649		N017649		
	UNITS	**TH20-244 (T5)**	**RDL**	**TH20-248 (S57)**	**RDL**	**QC Batch**
Calculated Parameters						
Resistivity @ 25 °C	ohm-m	2.7	0.050	8.5	0.050	A145428
Calculated Sulphate (SO4)	%	0.11	0.00013	0.0063	0.00013	A145429
Soluble Parameters						
Soluble Chloride (Cl)	mg/L	470 (1)	20	150	10	A146734
Soluble Conductivity	dS/m	3.7	0.020	1.2	0.020	A146752
Soluble pH	pH	7.89	N/A	8.29	N/A	A146596
Saturation %	%	73	N/A	23	N/A	A146264
Soluble Sulphate (SO4)	mg/L	1500	5.0	280	5.0	A146727

RDL = Reportable Detection Limit
N/A = Not Applicable
(1) Detection limits raised due to dilution to bring analyte within the calibrated range.

Bureau Veritas Laboratories Calgary: 2021 - 41st Avenue N.E. T2E 6P2 Telephone (403) 291-3077 Fax (403) 291-9468

GENERAL COMMENTS

Sample ZF9026 [TH20-244 (T5)] : Sample was analyzed past method specified hold time for pH @25C (Soluble). Sample was analyzed past method specified hold time for Conductivity @25C (Soluble). Sample was analyzed past method specified hold time for Chloride (Soluble).

Sample ZF9027 [TH20-248 (S57)] : Sample was analyzed past method specified hold time for pH @25C (Soluble). Sample was analyzed past method specified hold time for Conductivity @25C (Soluble). Sample was analyzed past method specified hold time for Chloride (Soluble).

Results relate only to the items tested.

Bureau Veritas Laboratories Calgary: 2021 - 41st Avenue N.E. T2E 6P2 Telephone (403) 291-3077 Fax (403) 291-9468

BV Labs Job #: C106368
Report Date: 2021/02/02

DYREGROV ROBINSON INC
Client Project #: 143691.7
Site Location: RUTLAND N. OF SILVER
Your P.O. #: 143691.7
Sampler Initials: CR

QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
A146264	EH2	QC Standard	Saturation %	2021/02/01		99	%	75 - 125
A146264	EH2	RPD	Saturation %	2021/02/01	8.9		%	12
A146264	EH2	RPD [ZF9026-01]	Saturation %	2021/02/01	2.2		%	12
A146596	JHC	QC Standard	Soluble pH	2021/02/01		99	%	98 - 102
A146596	JHC	Spiked Blank	Soluble pH	2021/02/01		100	%	97 - 103
A146596	JHC	RPD [ZF9026-01]	Soluble pH	2021/02/01	0.25		%	N/A
A146727	PL	QC Standard	Soluble Sulphate (SO4)	2021/02/01		104	%	75 - 125
A146727	PL	Method Blank	Soluble Sulphate (SO4)	2021/02/01	ND, RDL=5.0		mg/L	
A146727	PL	RPD	Soluble Sulphate (SO4)	2021/02/01	3.5		%	30
A146734	STI	Matrix Spike	Soluble Chloride (Cl)	2021/02/01		116	%	75 - 125
A146734	STI	QC Standard	Soluble Chloride (Cl)	2021/02/01		98	%	75 - 125
A146734	STI	Spiked Blank	Soluble Chloride (Cl)	2021/02/01		108	%	80 - 120
A146734	STI	Method Blank	Soluble Chloride (Cl)	2021/02/01	ND, RDL=10		mg/L	
A146734	STI	RPD	Soluble Chloride (Cl)	2021/02/01	NC		%	30
A146752	LZ0	QC Standard	Soluble Conductivity	2021/02/01		96	%	75 - 125
A146752	LZ0	Spiked Blank	Soluble Conductivity	2021/02/01		99	%	90 - 110
A146752	LZ0	Method Blank	Soluble Conductivity	2021/02/01	ND, RDL=0.020		dS/m	
A146752	LZ0	RPD	Soluble Conductivity	2021/02/01	11		%	20

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.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

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 <= 2x RDL).

Bureau Veritas Laboratories Calgary: 2021 - 41st Avenue N.E. T2E 6P2 Telephone (403) 291-3077 Fax (403) 291-9468

VALIDATION SIGNATURE PAGE

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

Sandy (Wei) Yuan, M.Sc., QP, Scientific Specialist

BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

SWELL TEST REPORT

ASTM D4546-14 TEST METHOD A

Client	Dyregrov Robinson Inc.	Test Hole	TH156	Test Start:	15-Mar-20
Project	Project #14369	Sample	T326	Tested By:	NM
Project No.	WX11735	Depth	20-22 ft		

Before Test

Consolidation ring no.	#12	
Mass of ring	90.51	g
Inside diameter of the ring	6.337	cm
Height of the specimen, H_o	2.496	cm
Area of the specimen	31.540	cm2
Mass (specimen + ring)	228.73	g
Mass of wet sample	138.2	g
Initial Moisture Content	55.3%	

After Test

Mass(sample$_{wet}$+ring+tare)	301.20	g
Mass of tare	71.55	g
Mass (wet soil + ring)	229.65	g
Mass of wet sample	139.14	g
Mass (dry soil+ring+can)	251.06	g
Mass of dry specimen	89.00	g
Final MC of specimen	56.3%	
Specific gravity of Solids	2.7	
Seating pressure	1	kPa

Soil Properties

Mass of solids	89	g
Mass of water in specimen before test	49.22	g
Mass of water in specimen after test	50.14	g
Height of Solids	1.0451	cm
Height of water before test	1.5606	cm
Height of water after test	1.5897	cm
Change in height of specimen after test	0.0189	cm
Height of specimen after test	2.4771	cm
Void ratio before test	1.388	
Void ratio after test	1.370	
Degree of saturation before test	107.56%	
Degree of saturation after test	111.02%	
Dry Density before test	1.131	g/cm3

Visual Description of Soil

Clay (CH) - silty, trace sand, high plastic, moist,
dark greyish brown

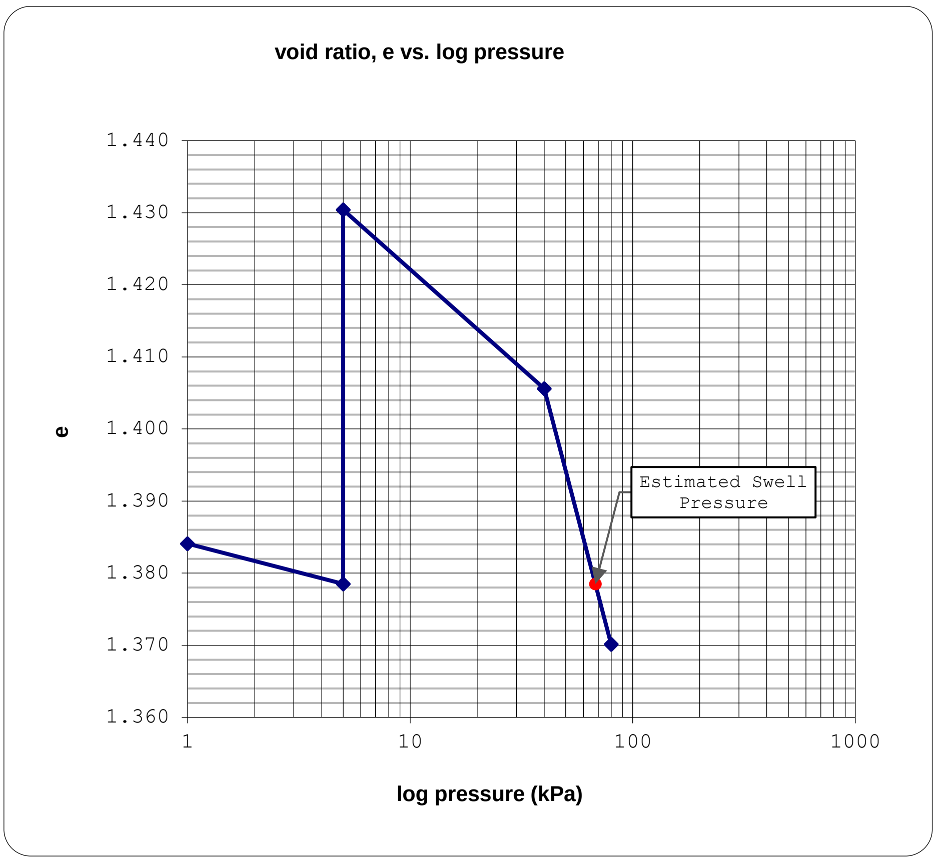


TABLE 1: Test Summary

Load No.	Pressure	Void Ratio
Seating	1	1.384
1	5	1.379
2	5	1.430
3	40	1.406
4	80	1.370

Final Results:

Swell (+) / Collpase (-) Strain	=	2.2%	Swell
Estimated Swell Pressure	=	68	kPa

SWELL TEST REPORT

ASTM D4546-14 TEST METHOD A

Client	Dyregrov Robinson Inc.	Test Hole	TH162	Test Start:	15-Mar-20
Project	Project #14369	Sample	T394	Tested By:	NM
Project No.	WX11735	Depth	25-27 ft		

Before Test

Consolidation ring no.	#4	
Mass of ring	109.99	g
Inside diameter of the ring	6.346	cm
Height of the specimen, H_o	2.455	cm
Area of the specimen	31.629	cm2
Mass (specimen + ring)	244.60	g
Mass of wet sample	134.6	g
Initial Moisture Content	52.1%	

After Test

Mass(samplewet+ring+tare)	357.82	g
Mass of tare	114.30	g
Mass (wet soil + ring)	243.52	g
Mass of wet sample	133.53	g
Mass (dry soil+ring+can)	312.81	g
Mass of dry specimen	88.52	g
Final MC of specimen	50.8%	
Specific gravity of Solids	2.7	
Seating pressure	1	kPa

Soil Properties

Mass of solids	88.52	g
Mass of water in specimen before test	46.09	g
Mass of water in specimen after test	45.01	g
Height of Solids	1.0365	cm
Height of water before test	1.4572	cm
Height of water after test	1.4230	cm
Change in height of specimen after test	0.0737	cm
Height of specimen after test	2.3813	cm
Void ratio before test	1.368	
Void ratio after test	1.297	
Degree of saturation before test	102.73%	
Degree of saturation after test	105.82%	
Dry Density before test	1.140	g/cm3

Visual Description of Soil

Clay (CH) - silty, trace sand, high plastic, moist, dark greyish brown

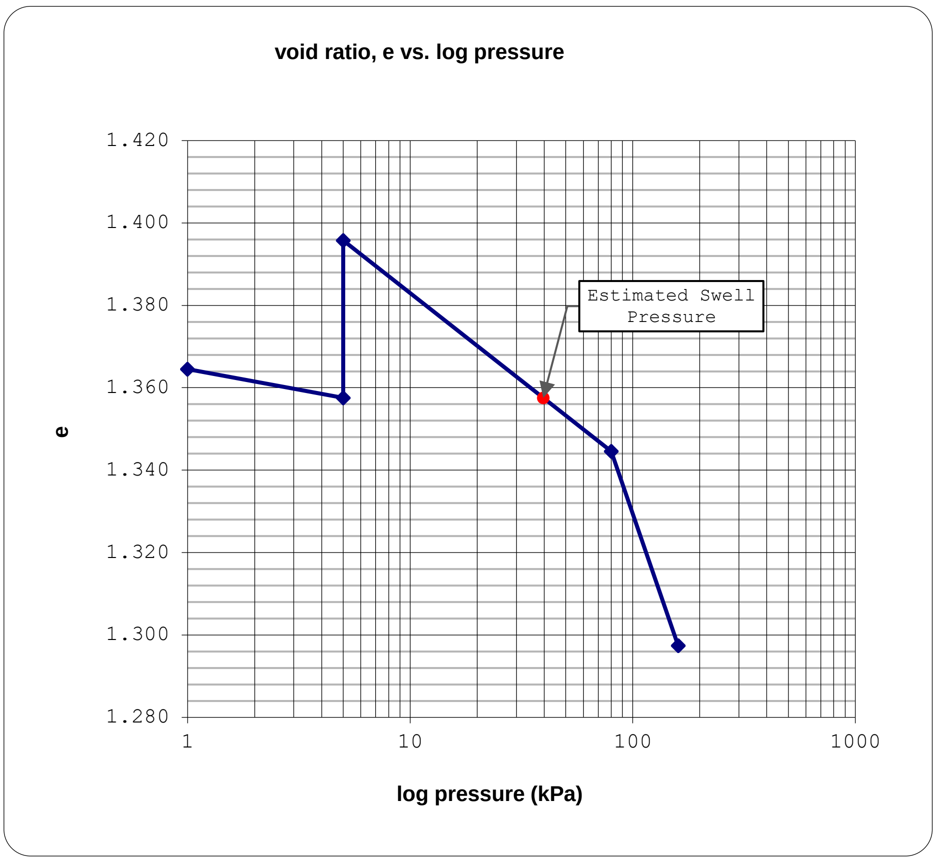


TABLE 1: Test Summary

Load No.	Pressure	Void Ratio
Seating	1	1.365
1	5	1.358
2	5	1.396
3	80	1.345
4	160	1.297

Final Results:

Swell (+) / Collpase (-) Strain	=	1.6%	Swell
Estimated Swell Pressure	=	40	kPa

SWELL TEST REPORT

ASTM D4546-14 TEST METHOD A

Client	Dyregrov Robinson Inc.	Test Hole	TH19-173	Test Start:	19-Mar-20
Project	Project 14369.7	Sample	T493	Tested By:	NM/IT
Project No.	WX11735	Depth	10-12 ft		

Before Test

Consolidation ring no.	#4	
Mass of ring	109.99	g
Inside diameter of the ring	6.346	cm
Height of the specimen, H_o	2.487	cm
Area of the specimen	31.629	cm2
Mass (specimen + ring)	247.33	g
Mass of wet sample	137.3	g
Initial Moisture Content	47.8%	

After Test

Mass(sample$_{wet}$+ring+tare)	384.99	g
Mass of tare	137.38	g
Mass (wet soil + ring)	247.61	g
Mass of wet sample	137.62	g
Mass (dry soil+ring+can)	340.30	g
Mass of dry specimen	92.93	g
Final MC of specimen	48.1%	
Specific gravity of Solids	2.7	
Seating pressure	1	kPa

Soil Properties

Mass of solids	92.93	g
Mass of water in specimen before test	44.41	g
Mass of water in specimen after test	44.69	g
Height of Solids	1.0882	cm
Height of water before test	1.4041	cm
Height of water after test	1.4129	cm
Change in height of specimen after test	0.1537	cm
Height of specimen after test	2.3333	cm
Void ratio before test	1.285	
Void ratio after test	1.144	
Degree of saturation before test	100.38%	
Degree of saturation after test	113.48%	
Dry Density before test	1.181	g/cm3

Visual Description of Soil

Clay (CH) - silty, trace sand, high plastic, moist, dark greyish brown

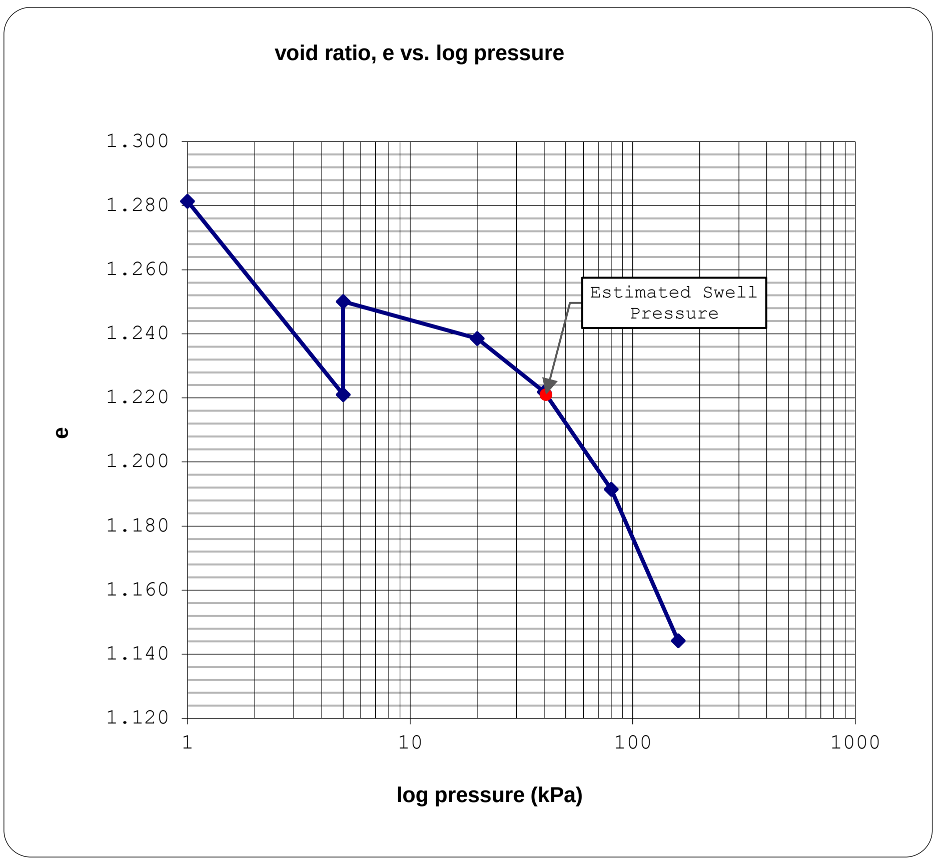


TABLE 1: Test Summary

Load No.	Pressure	Void Ratio
Seating	1	1.281
1	5	1.221
2	5	1.250
3	20	1.239
4	40	1.222
5	80	1.192
6	160	1.144

Final Results:

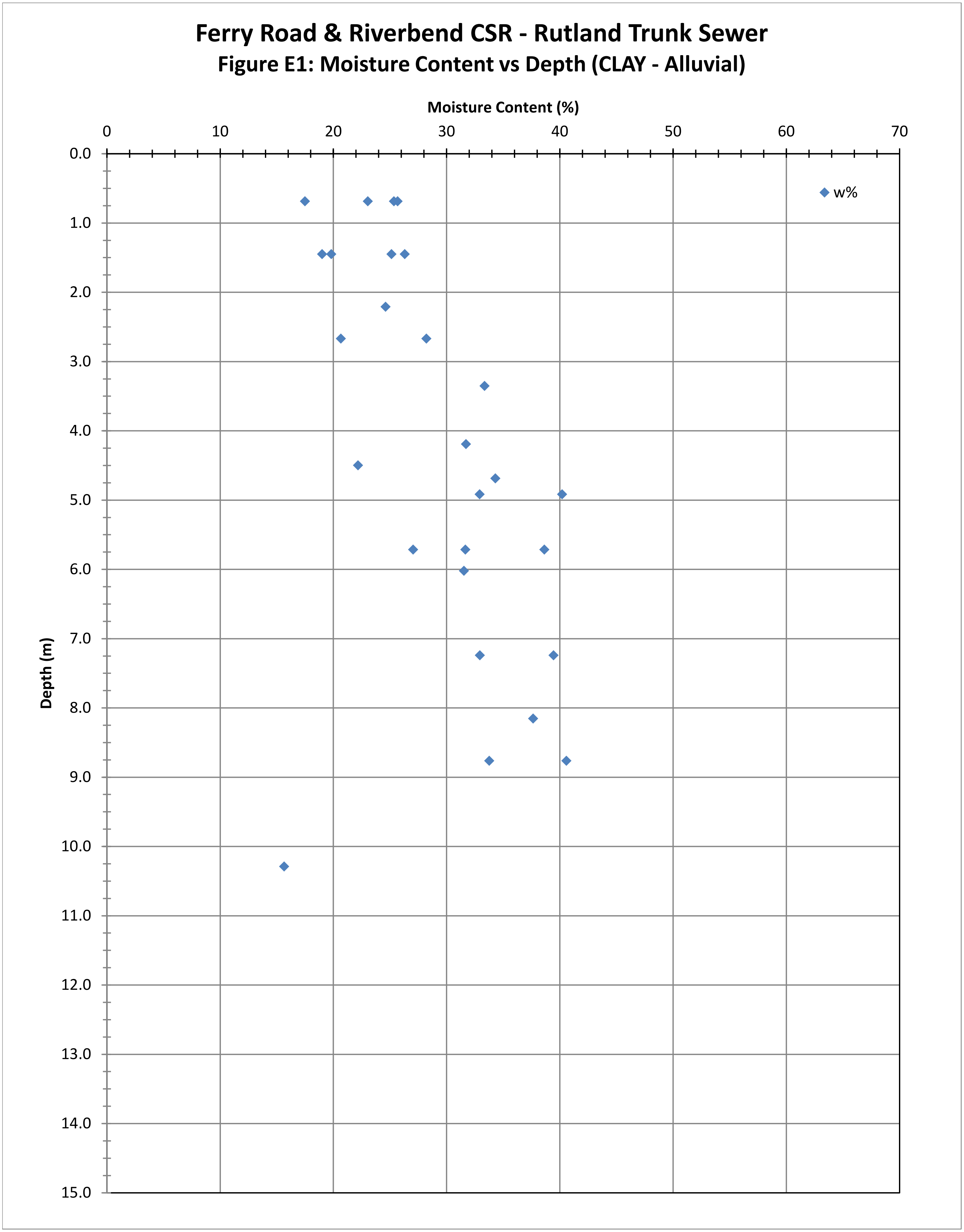
Swell (+) / Collpase (-) Strain = 1.3% Swell

Estimated Swell Pressure = 41 kPa

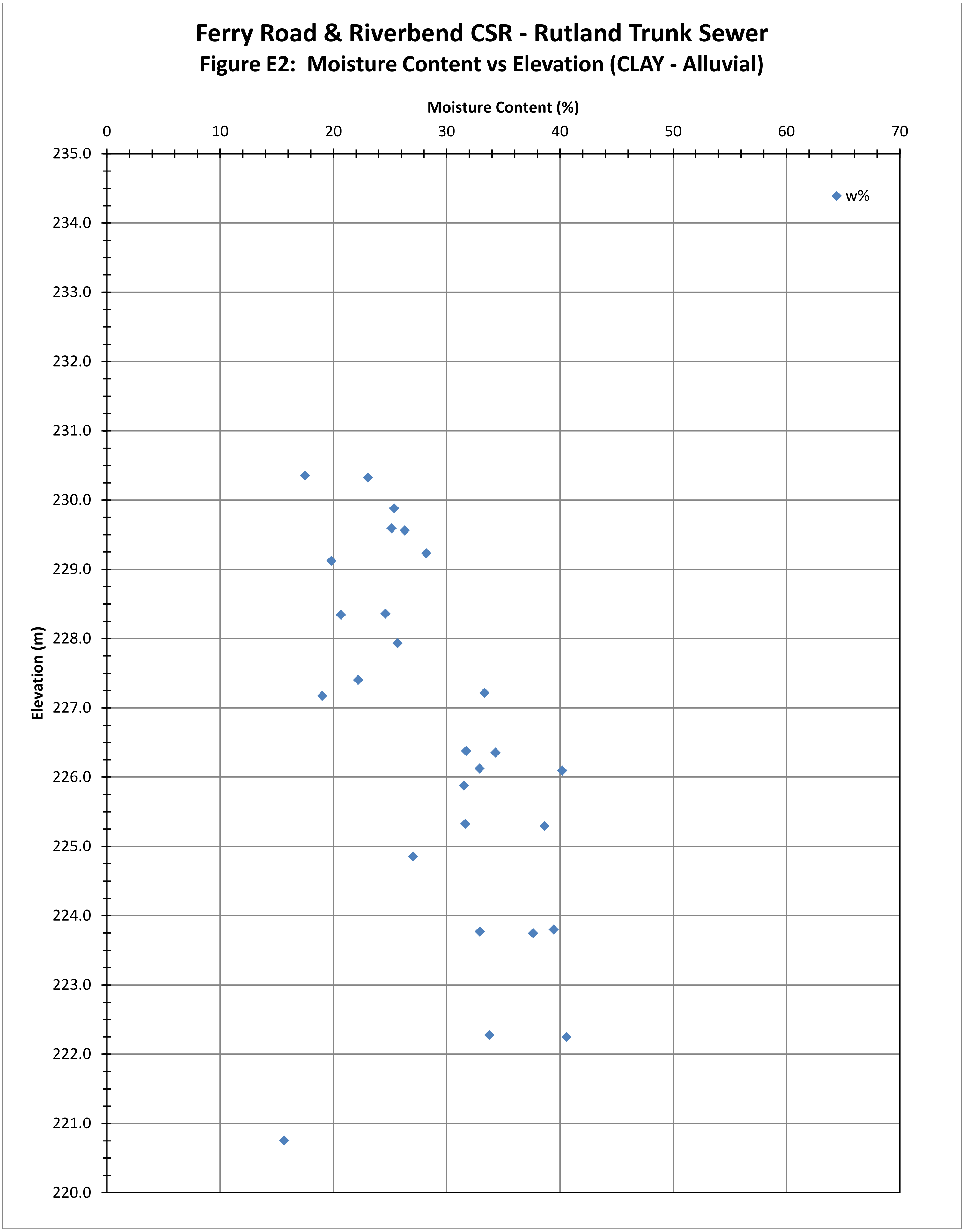
APPENDIX E

Laboratory Testing Plots

Figures E1 to E18



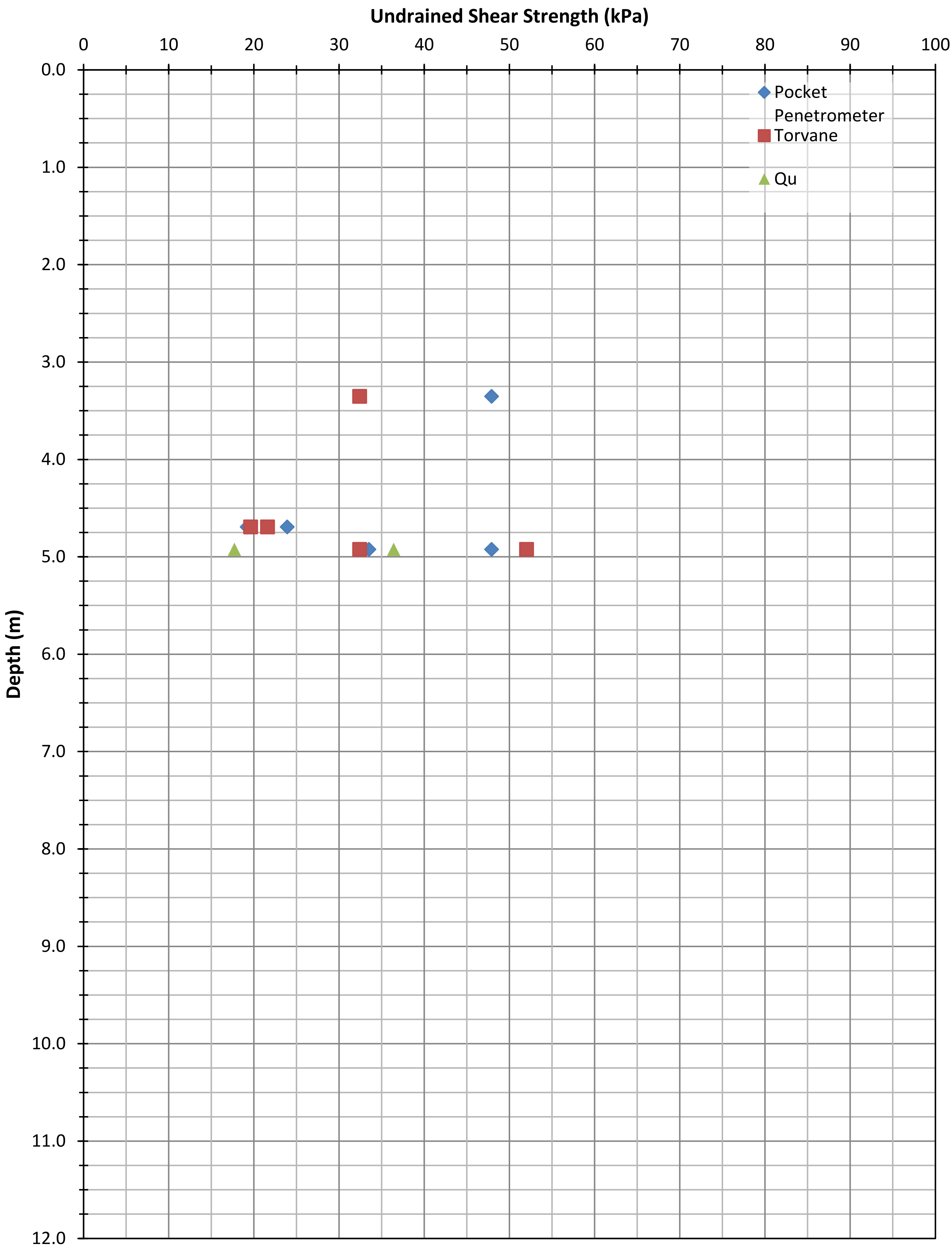
Ferry Road & Riverbend CSR - Rutland Trunk Sewer
Figure E1: Moisture Content vs Depth (CLAY - Alluvial)
Moisture Content (%)
0
10
20
30
40
50
60
70
Depth (m)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
w%



Ferry Road & Riverbend CSR - Rutland Trunk Sewer
Figure E2: Moisture Content vs Elevation (CLAY - Alluvial)
Moisture Content (%)
0
10
20
30
40
50
60
70
Elevation (m)
235.0
234.0
233.0
232.0
231.0
230.0
229.0
228.0
227.0
226.0
225.0
224.0
223.0
222.0
221.0
220.0
w%

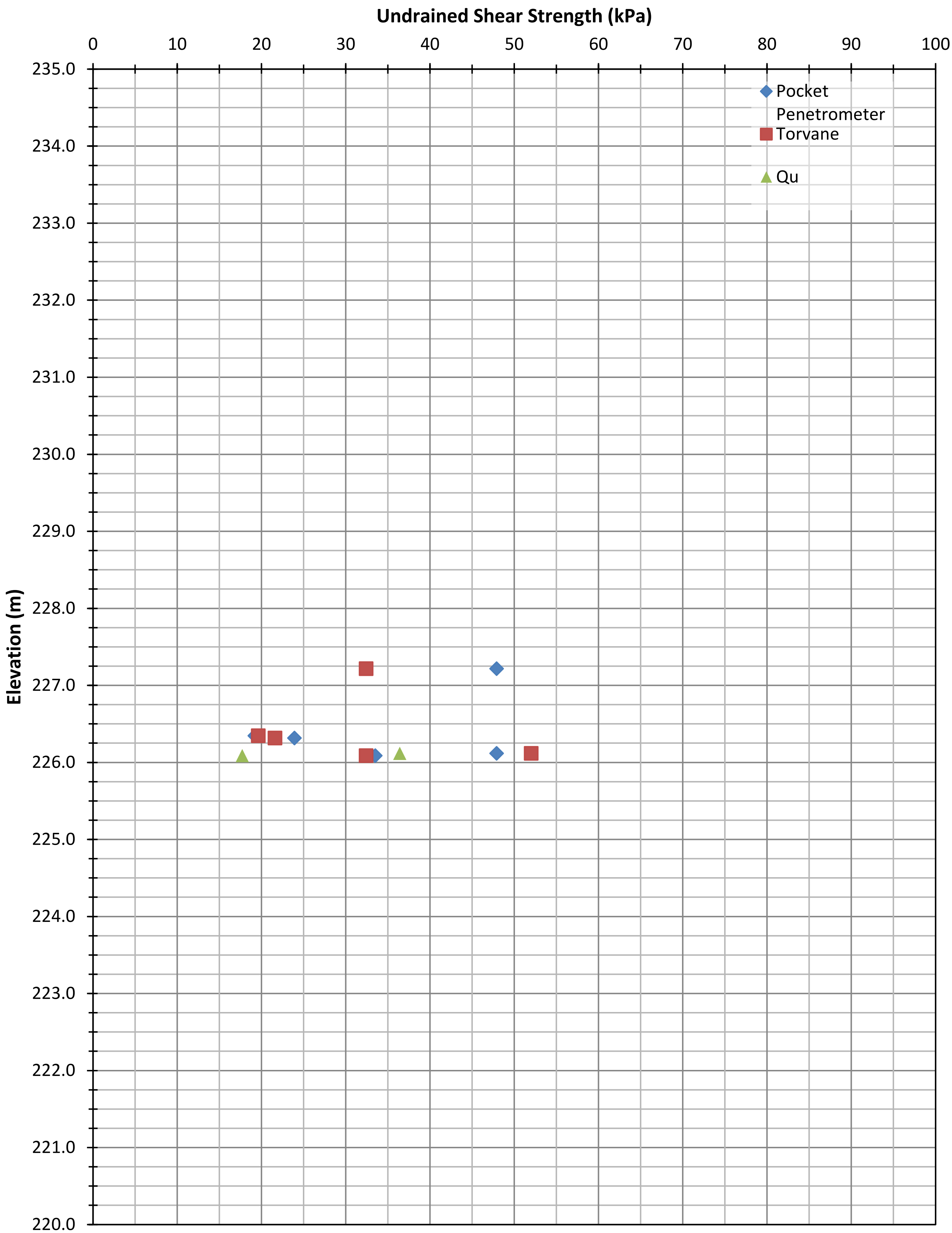
Ferry Road & Riverbend CSR - Rutland Trunk Sewer

Figure E3: Undrained Shear Strength vs Depth (Alluvial Clay)



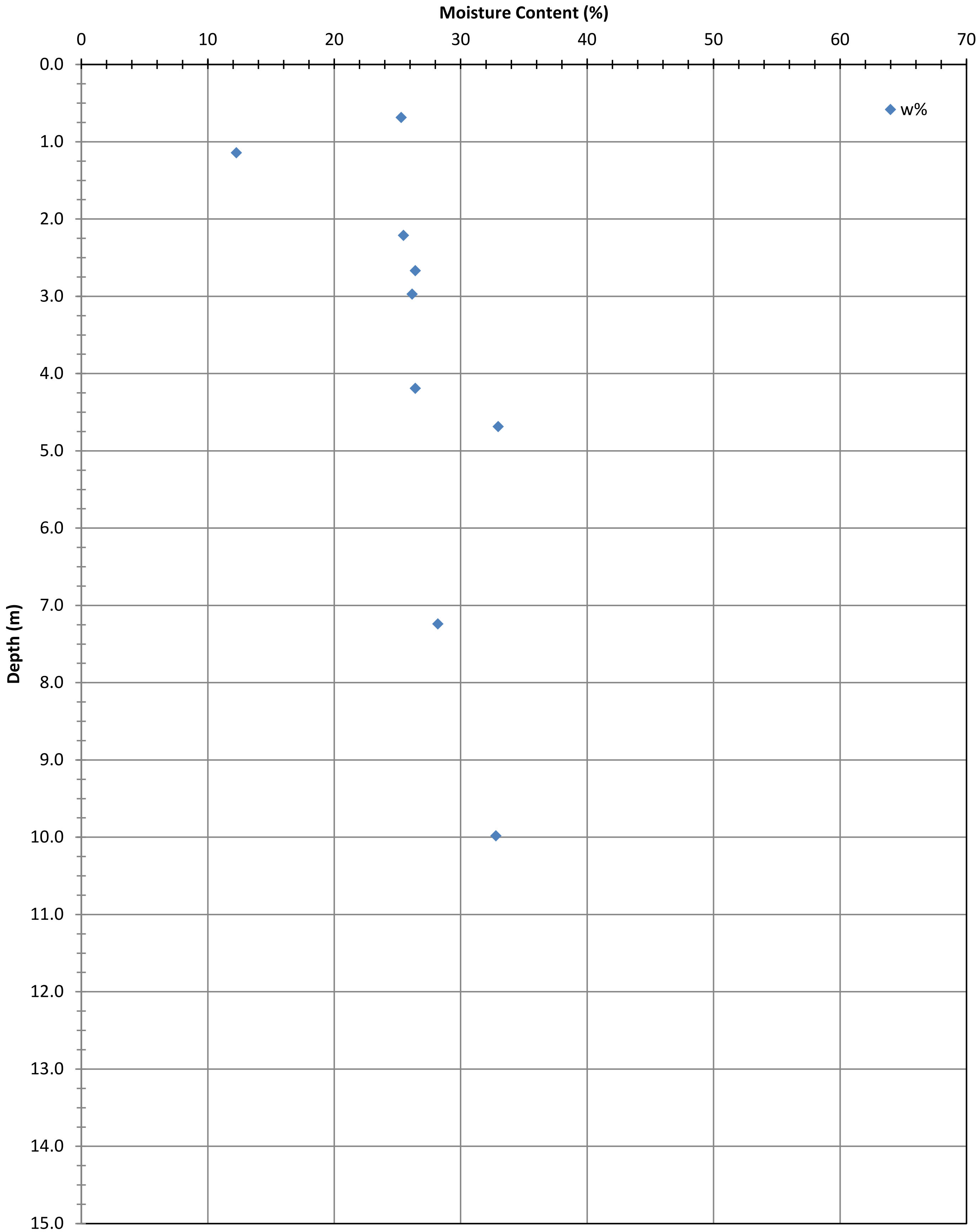
Ferry Road & Riverbend CSR - Rutland Trunk Sewer

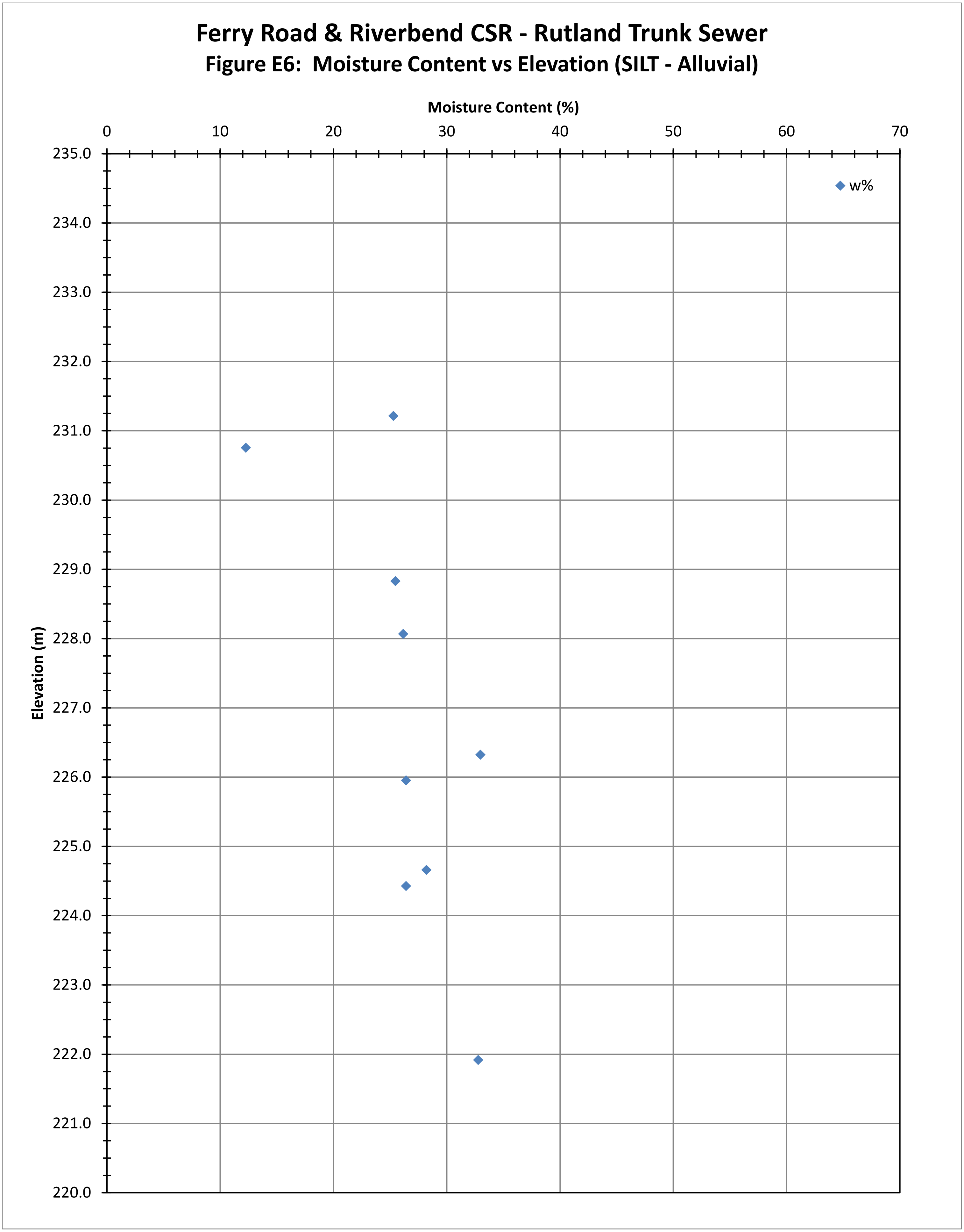
Figure E4: Undrained Shear Strength vs Elevation (Alluvial Clay)



Ferry Road & Riverbend CSR - Rutland Trunk Sewer

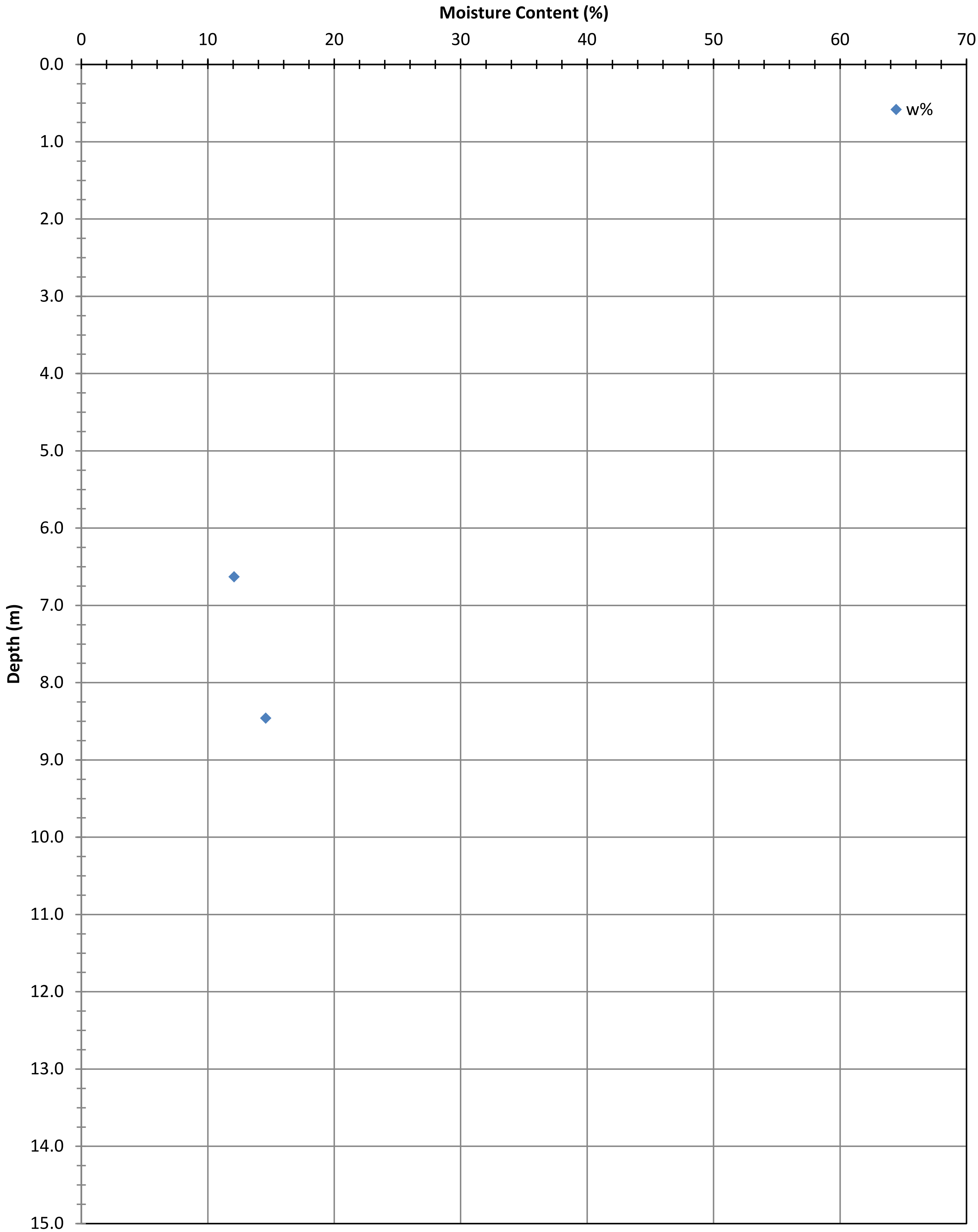
Figure E5: Moisture Content vs Depth (SILT - Alluvial)

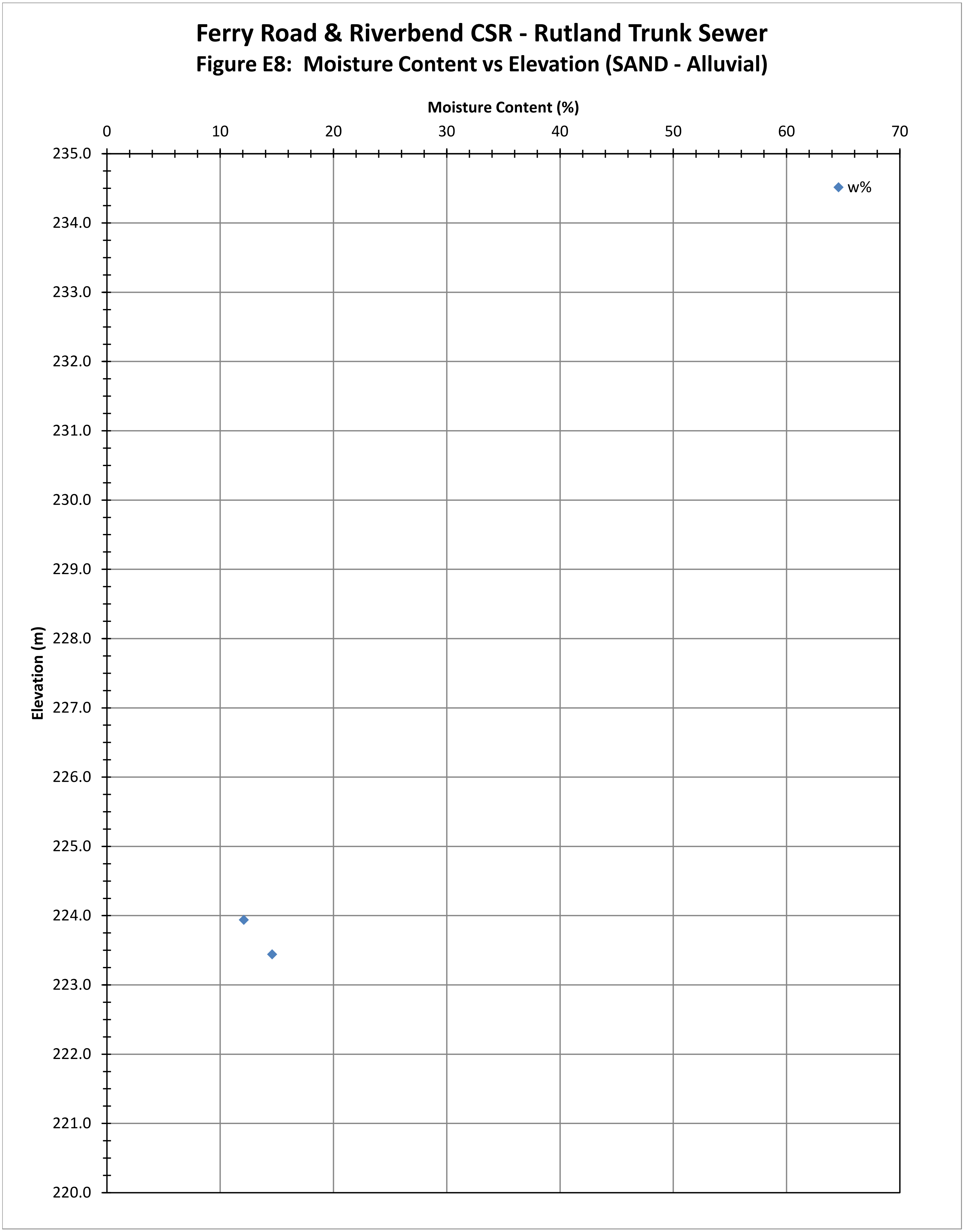




Ferry Road & Riverbend CSR - Rutland Trunk Sewer
Figure E6: Moisture Content vs Elevation (SILT - Alluvial)
Moisture Content (%)
0
10
20
30
40
50
60
70
235.0
234.0
233.0
232.0
231.0
230.0
229.0
228.0
227.0
226.0
225.0
224.0
223.0
222.0
221.0
220.0
Elevation (m)
w%

Ferry Road & Riverbend CSR - Rutland Trunk Sewer
Figure E7: Moisture Content vs Depth (SAND - Alluvial)

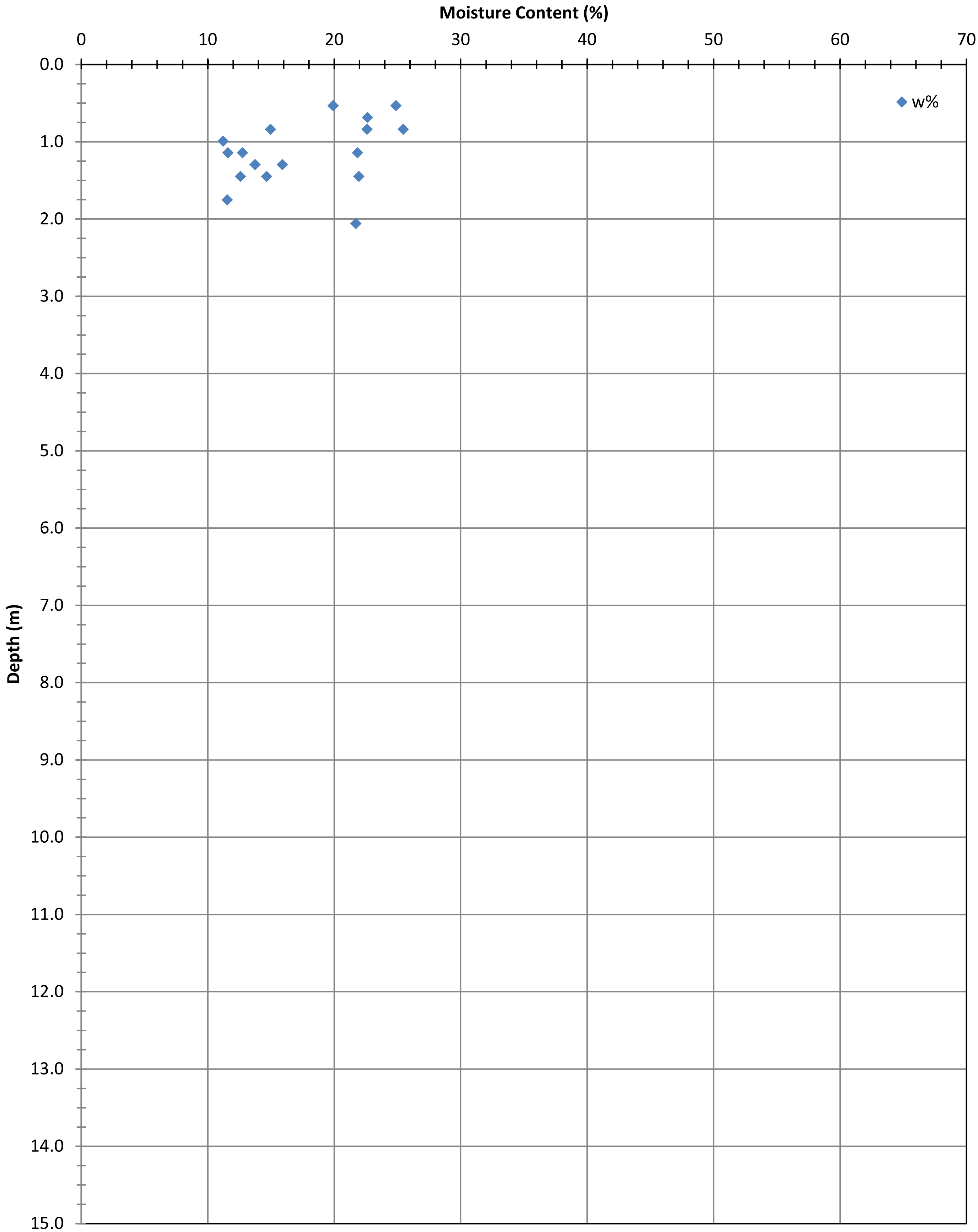




Ferry Road & Riverbend CSR - Rutland Trunk Sewer
Figure E8: Moisture Content vs Elevation (SAND - Alluvial)
Moisture Content (%)
0
10
20
30
40
50
60
70
Elevation (m)
235.0
234.0
233.0
232.0
231.0
230.0
229.0
228.0
227.0
226.0
225.0
224.0
223.0
222.0
221.0
220.0
w%

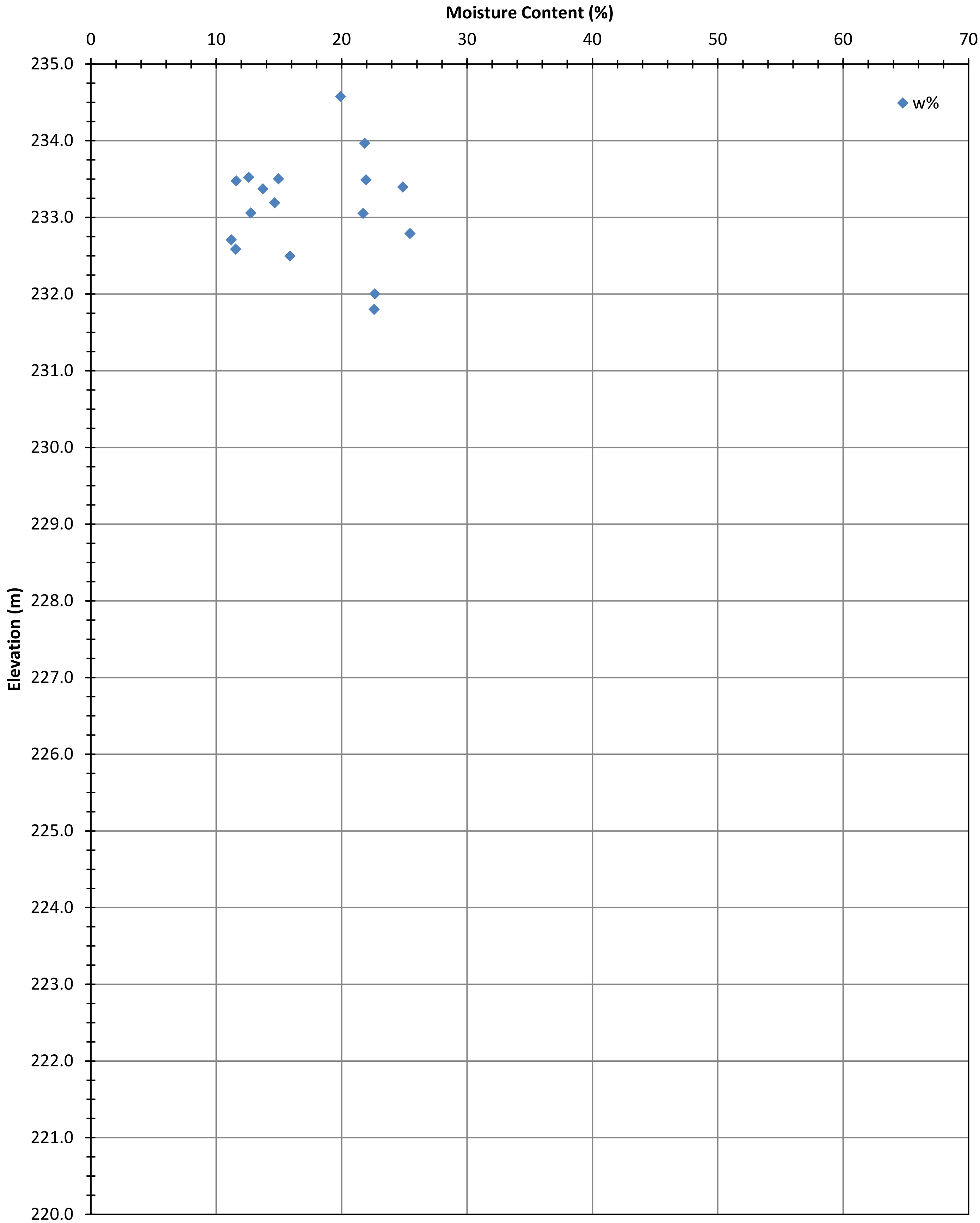
Ferry Road & Riverbend CSR - Rutland Trunk Sewer

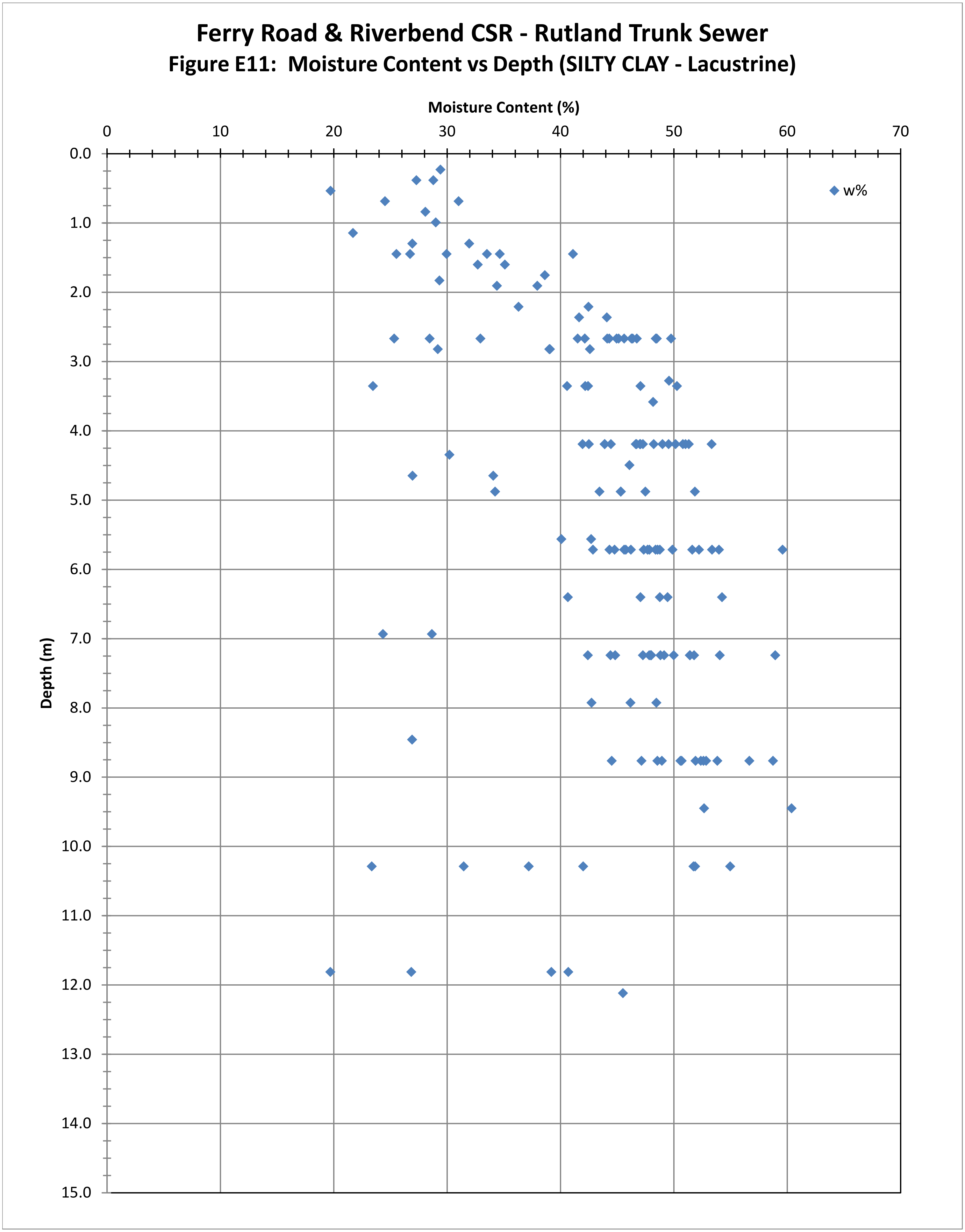
Figure E9: Moisture Content vs Depth (SILT)



Ferry Road & Riverbend CSR - Rutland Trunk Sewer

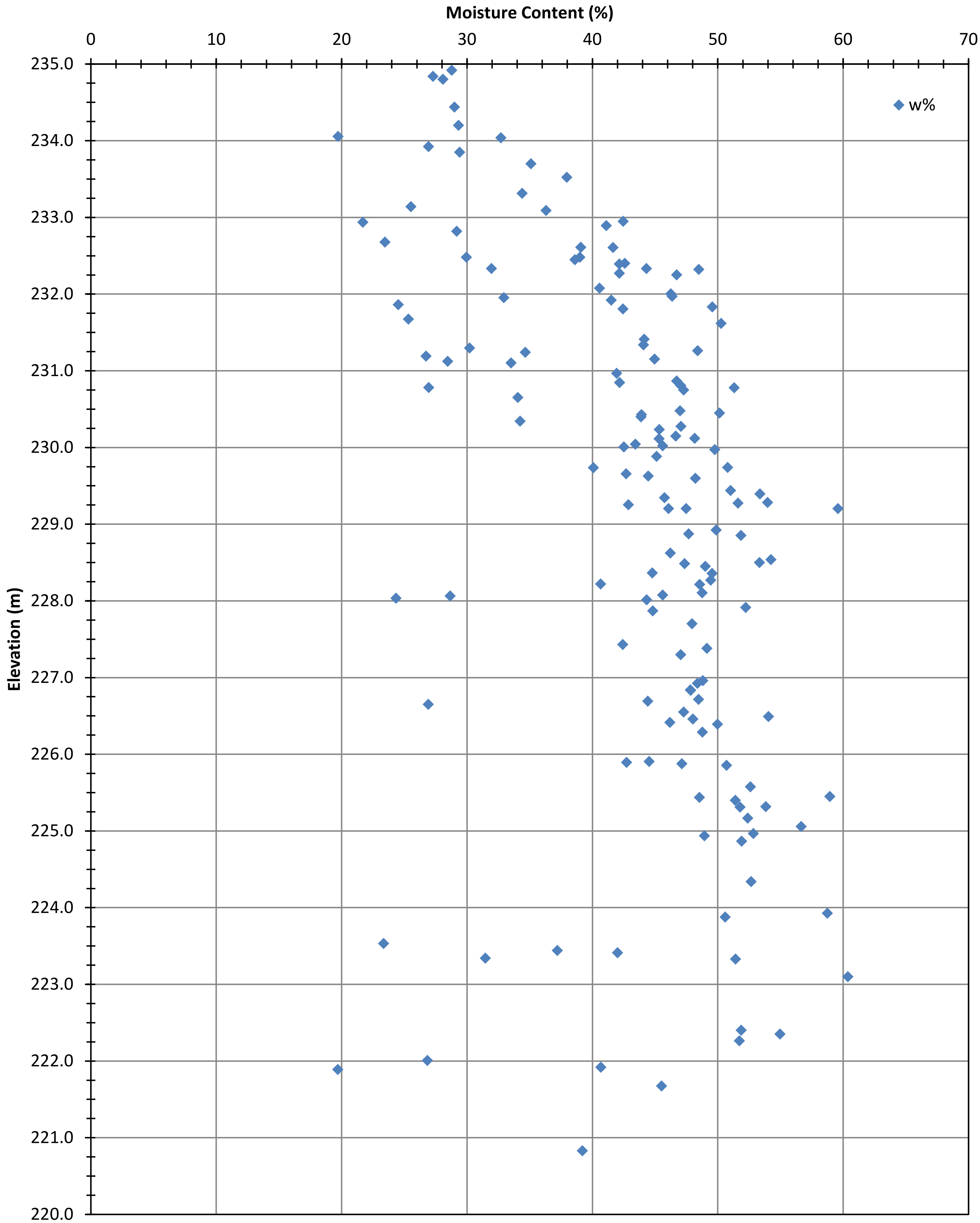
Figure E10: Moisture Content vs Elevation (SILT)

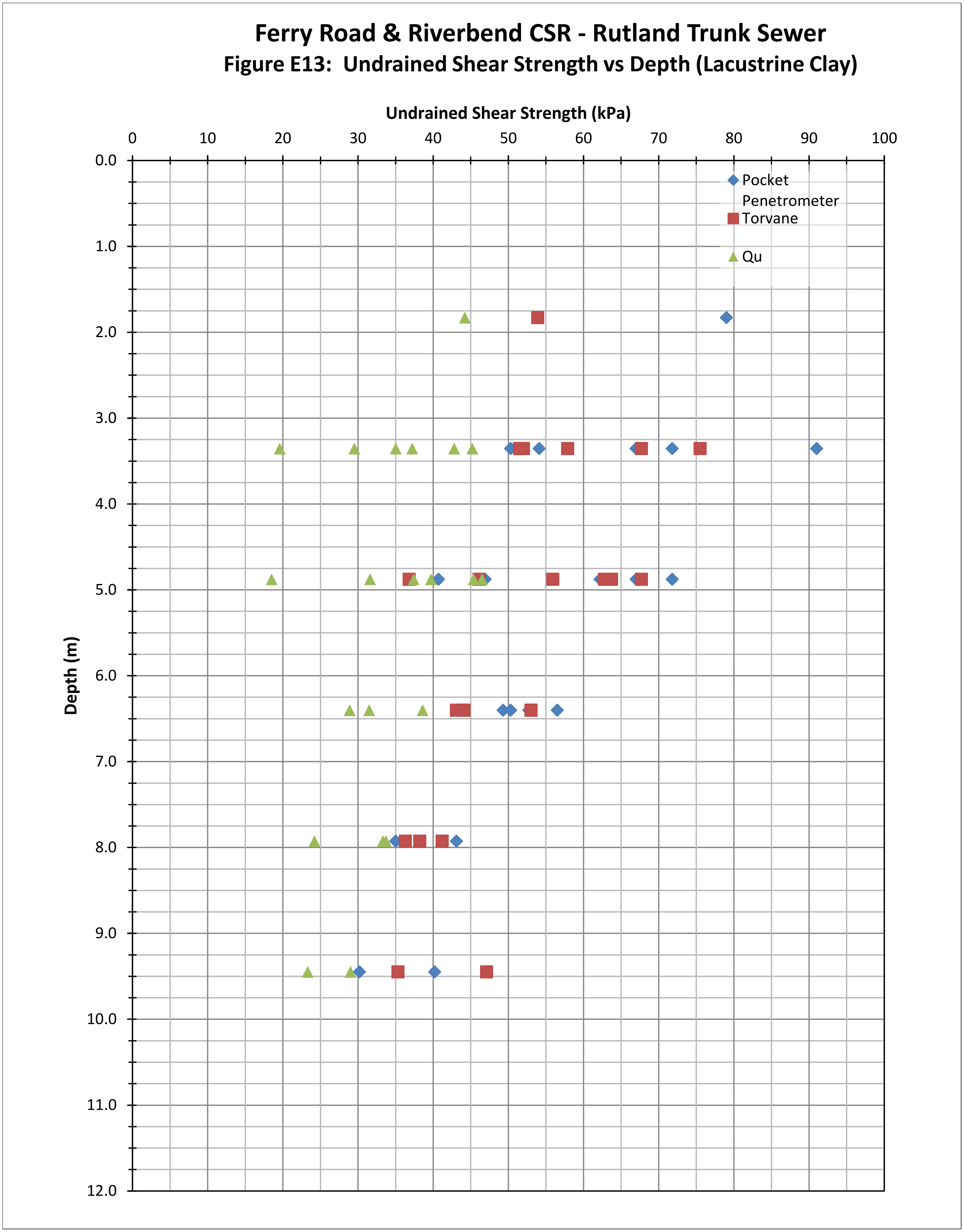



Ferry Road & Riverbend CSR - Rutland Trunk Sewer
Figure E11: Moisture Content vs Depth (SILTY CLAY - Lacustrine)
Moisture Content (%)
0
10
20
30
40
50
60
70
Depth (m)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
w%

Ferry Road & Riverbend CSR - Rutland Trunk Sewer

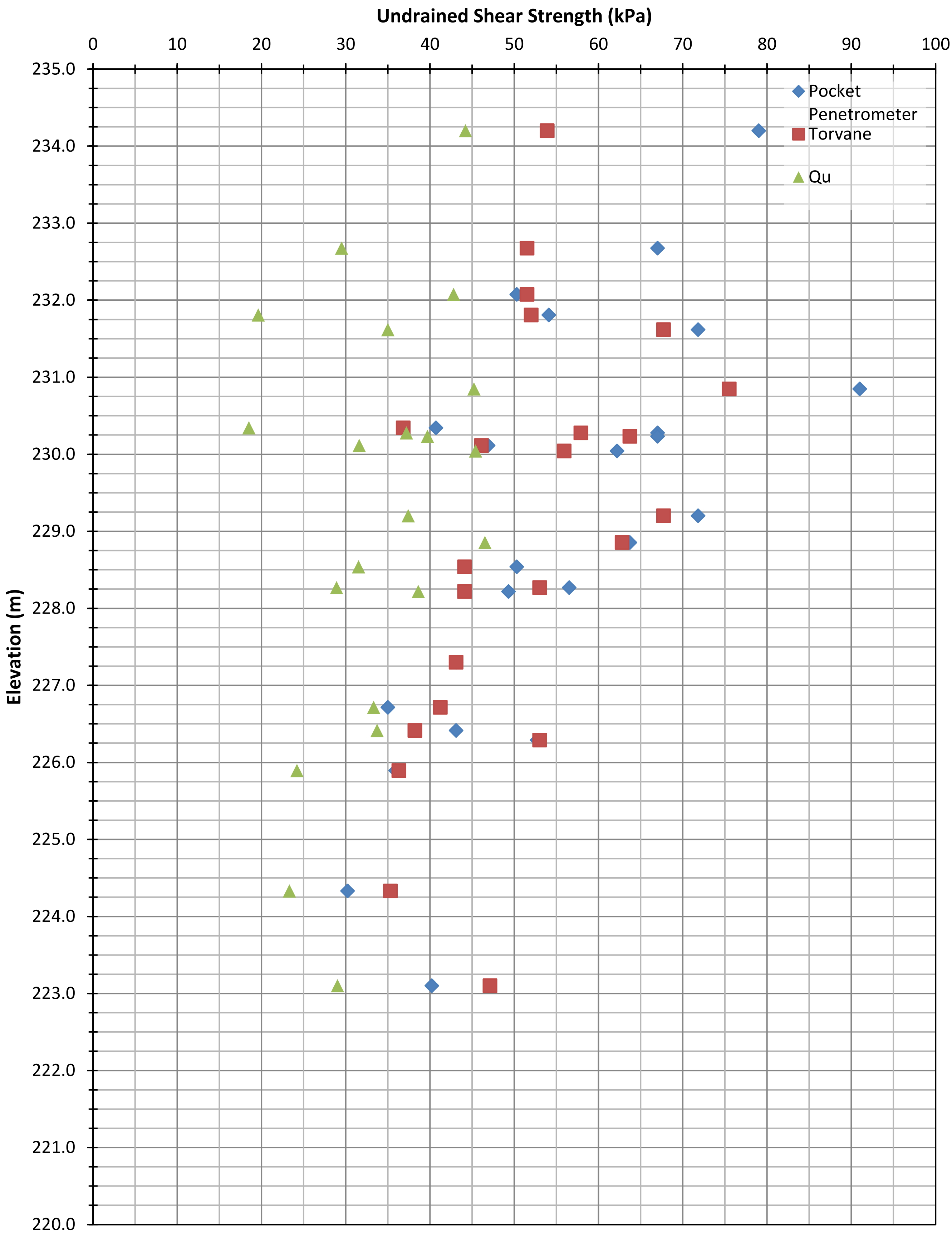
Figure E12: Moisture Content vs Elevation (SILTY CLAY - Lacustrine)




Ferry Road & Riverbend CSR - Rutland Trunk Sewer
Figure E13: Undrained Shear Strength vs Depth (Lacustrine Clay)
Undrained Shear Strength (kPa)
0
10
20
30
40
50
60
70
80
90
100
Depth (m)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
Pocket Penetrometer
Torvane
Qu

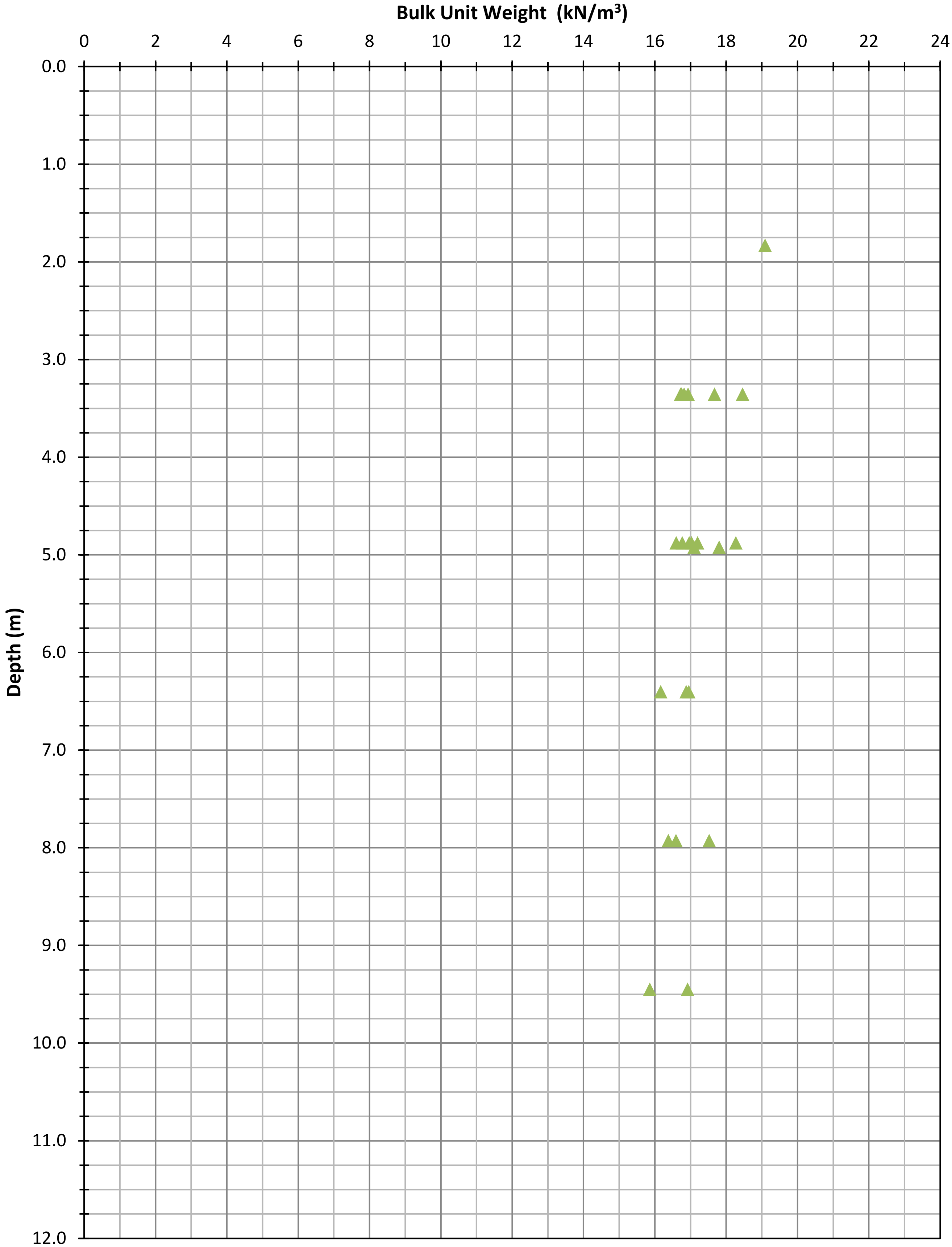
Ferry Road & Riverbend CSR - Rutland Trunk Sewer

Figure E14: Undrained Shear Strength vs Elevation (Lacustrine Clay)



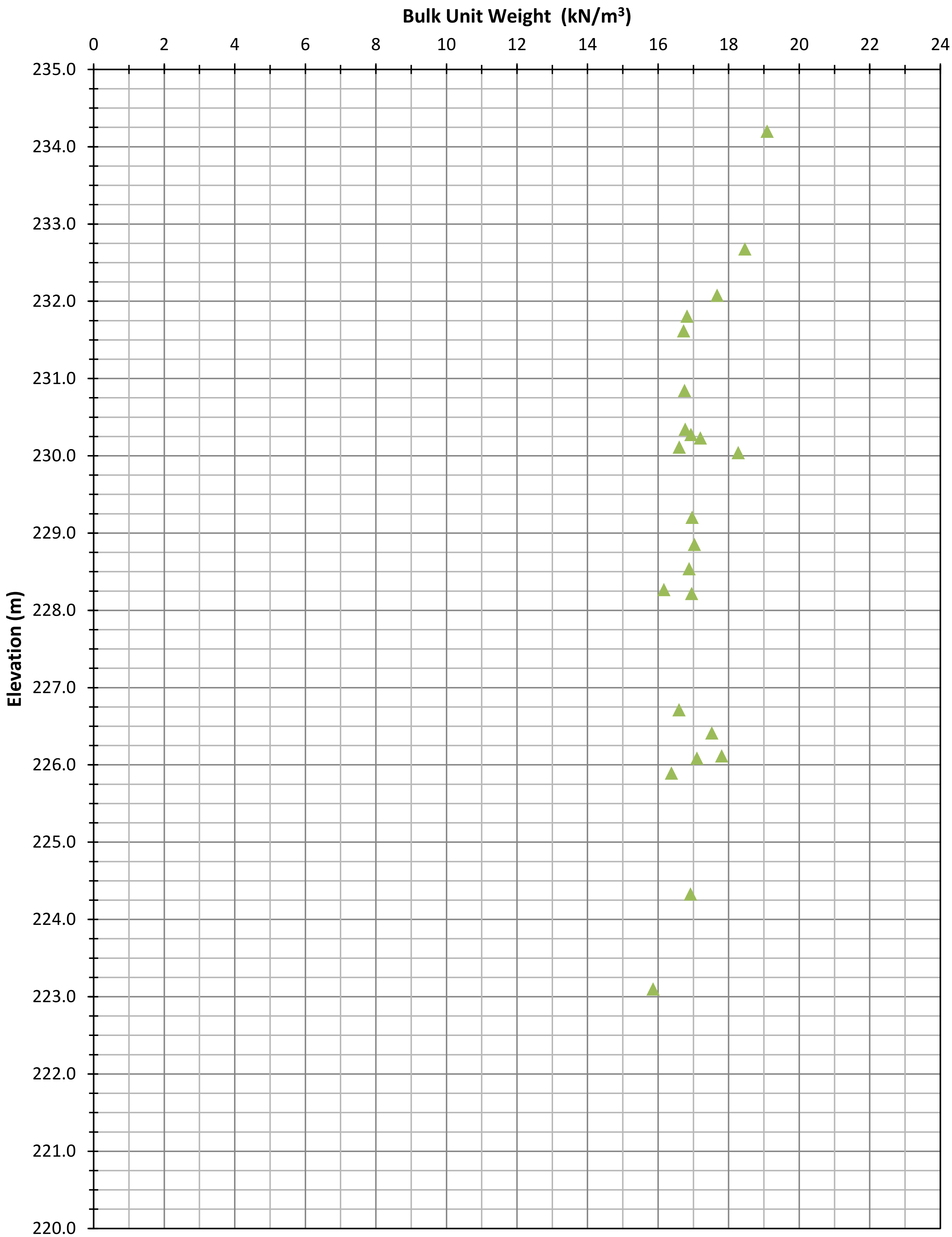
Ferry Road & Riverbend CSR - Rutland Trunk Sewer

Figure E15: Bulk Unit Weight vs Depth



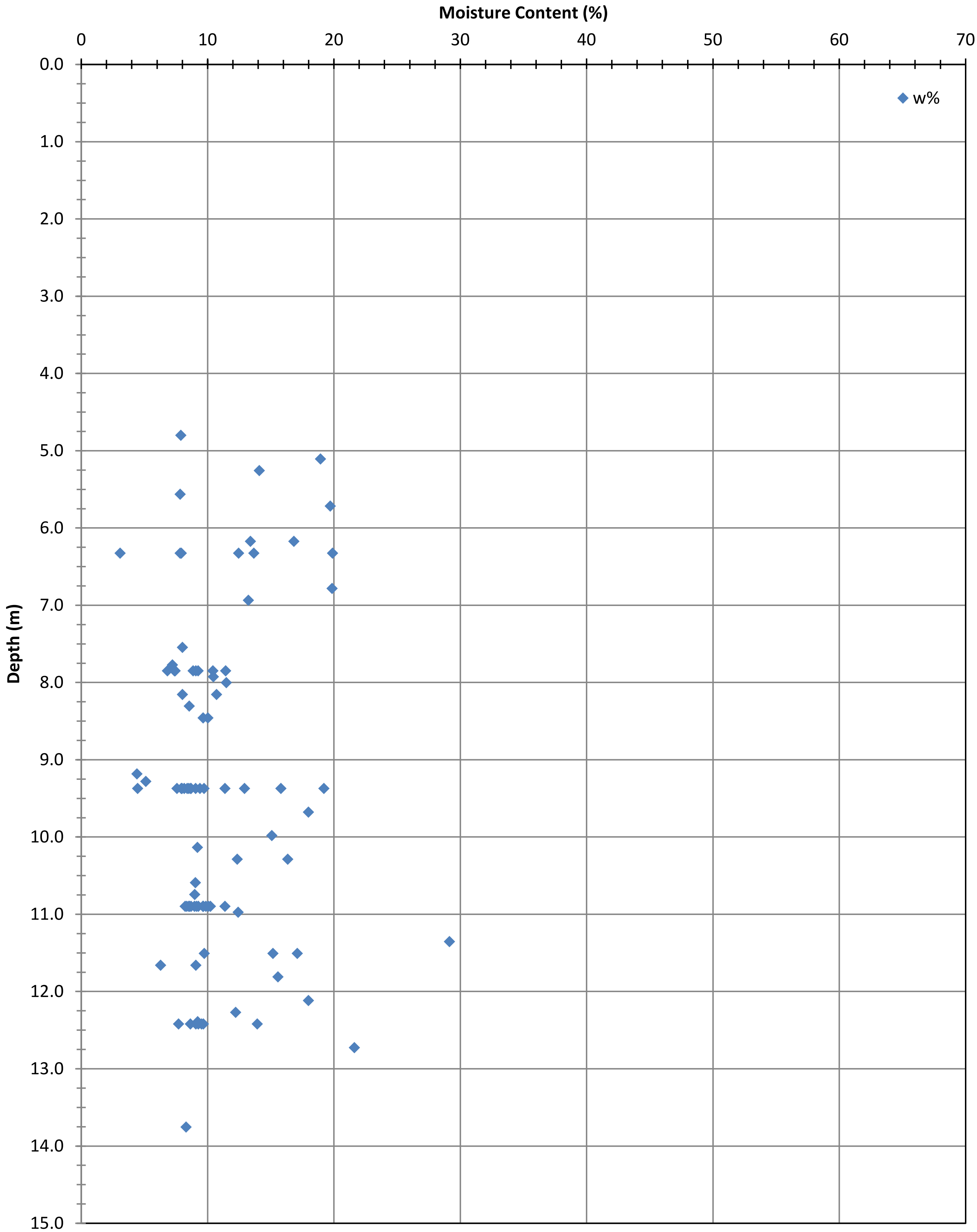
Ferry Road & Riverbend CSR - Rutland Trunk Sewer

Figure E16: Bulk Unit Weight vs Elevation



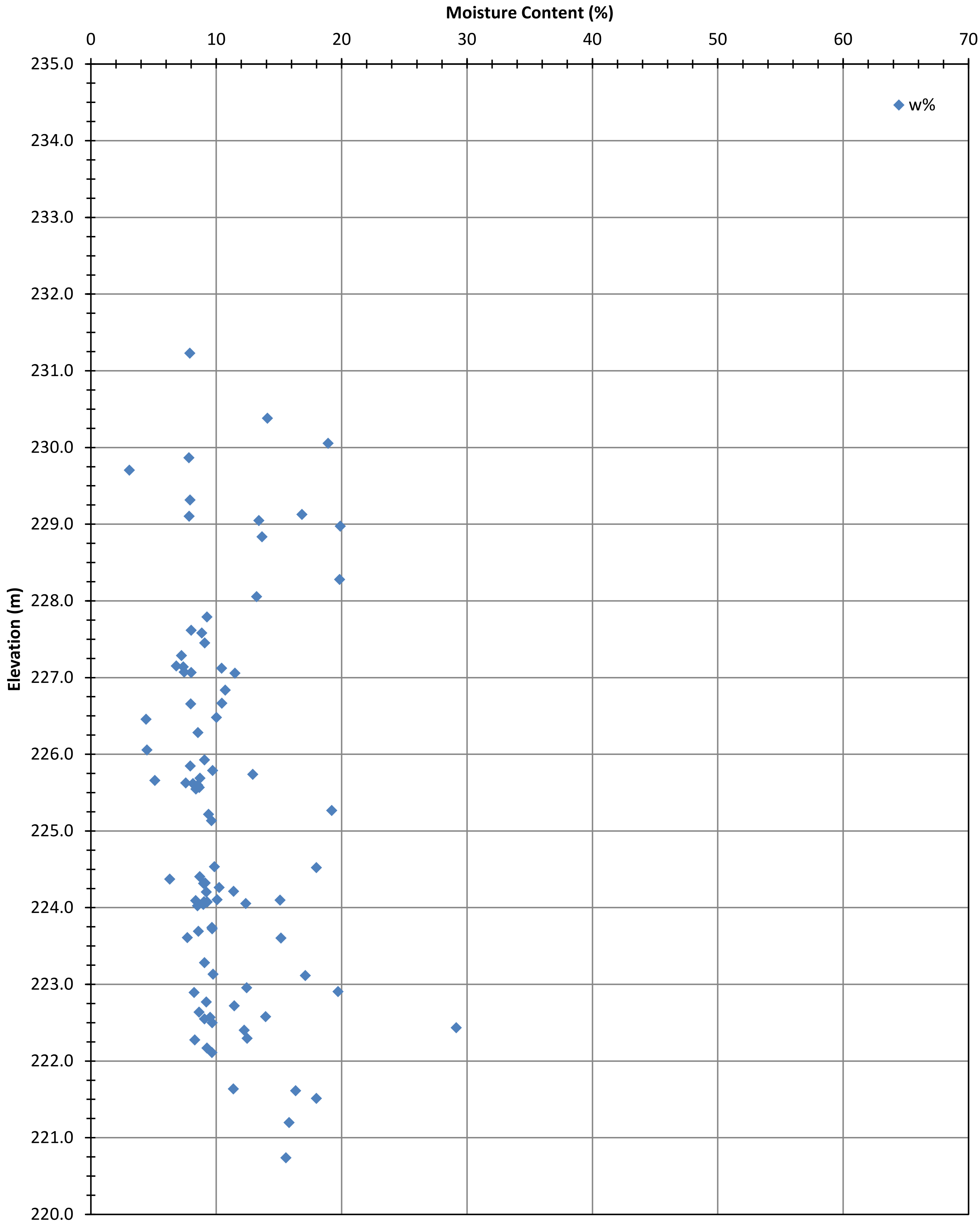
Ferry Road & Riverbend CSR - Rutland Trunk Sewer

Figure E17: Moisture Content vs Depth (Glacial Till)



Ferry Road & Riverbend CSR - Rutland Trunk Sewer

Figure E18: Moisture Content vs Elevation (Glacial Till)



GEOTECHNICAL ENGINEERS

APPENDIX F

Standard Penetration Testing Results

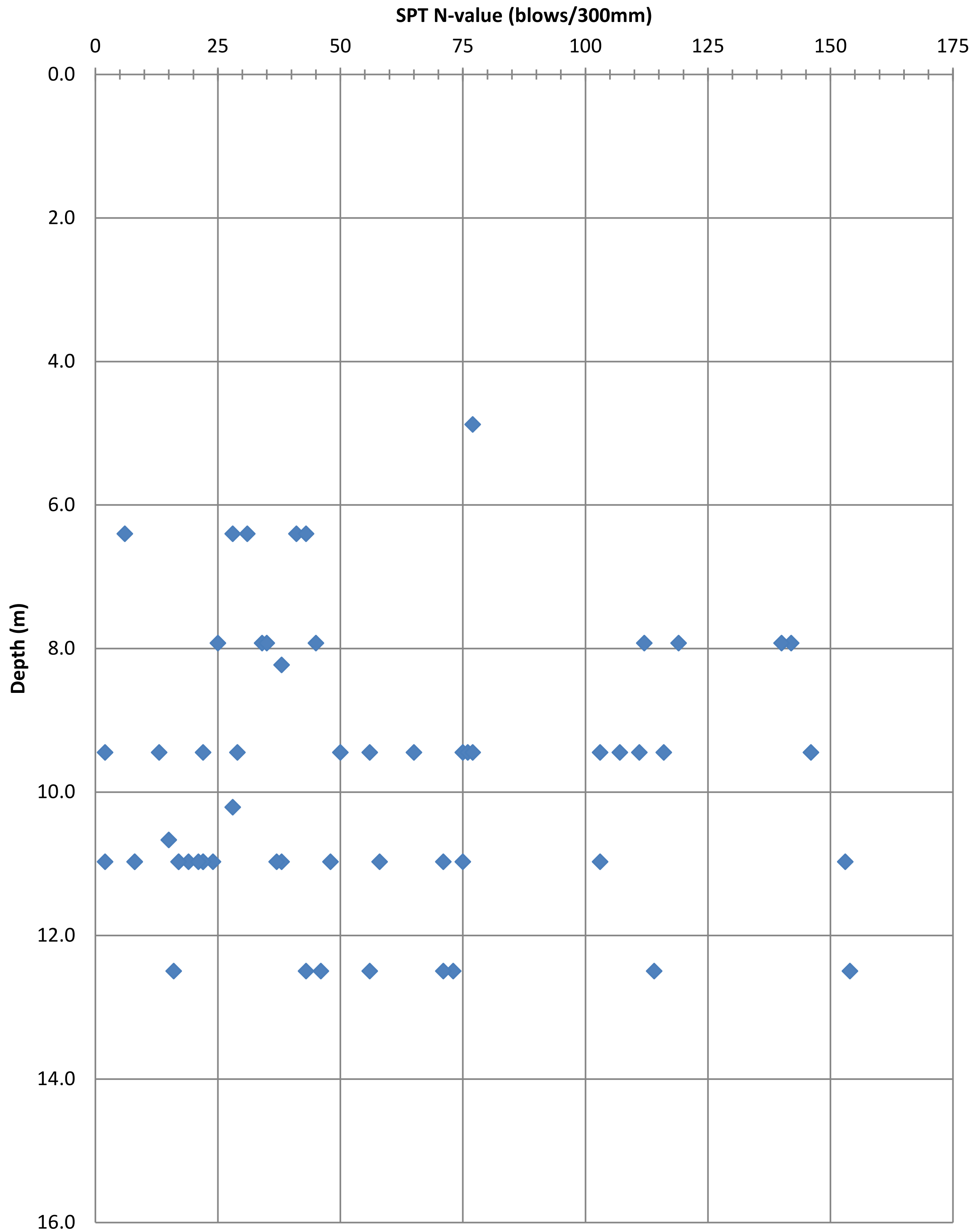
Table F1 – Summary of SPT
Figures F1 to F3

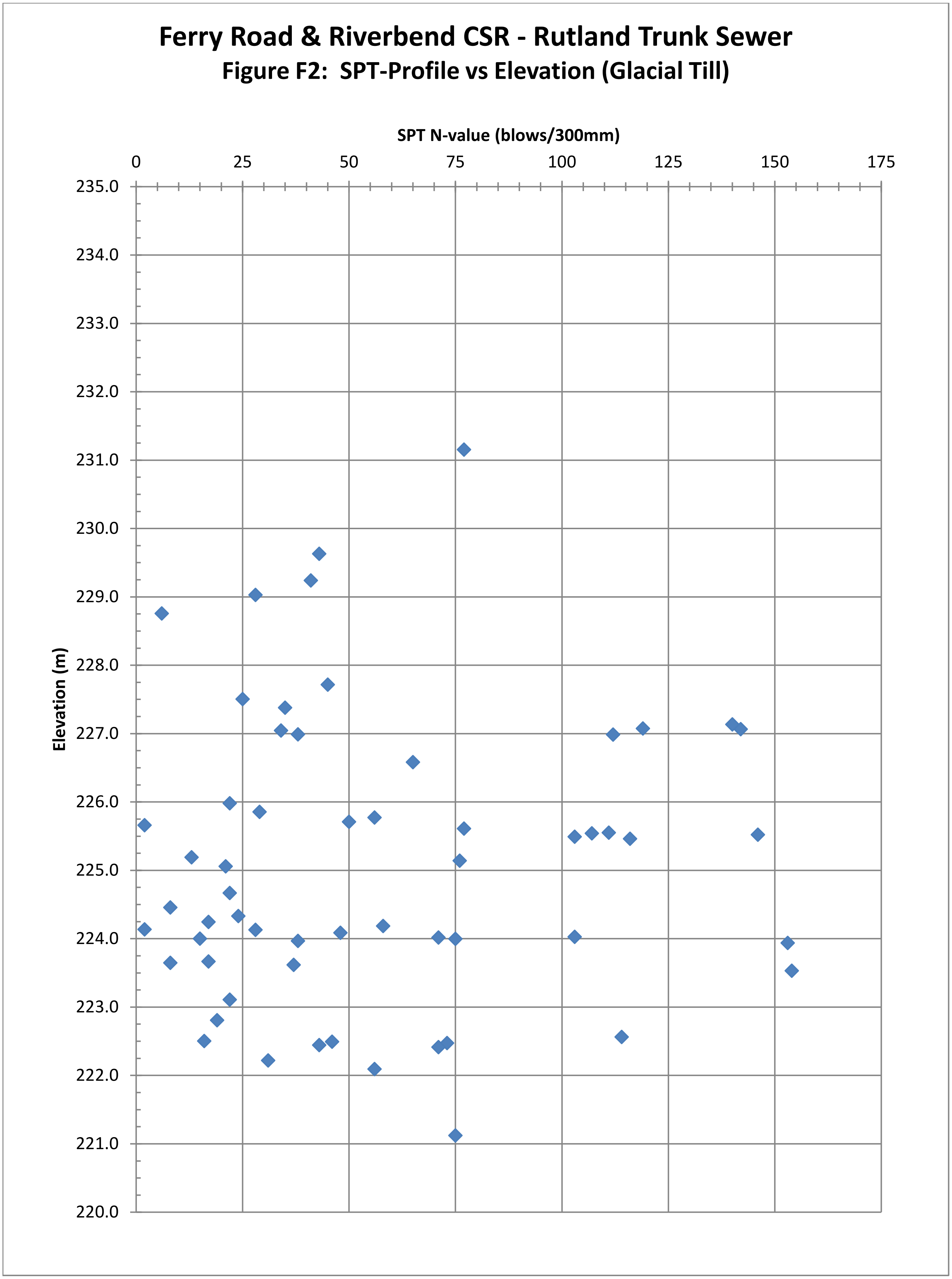
Ferry Road & Riverbend CSR - Rutland Trunk Sewer

Table F1) Summary Of Standard Penetration Testing Results

Test Hole #	Ground Elevation (m)	ID#	Soil	Depth (feet)	Depth (m)	Elev. (m)	Moisture (%)	SPT-N (blows / 300mm)	Comments
19-147	228.62	S309	Silt Till	21.0	6.4	222.2	12.5	31	
19-148	230.57	S303	Silt Till	31.0	9.4	221.1	15.8	75	
19-157	233.78	S338	Silt Till	36.0	11.0	222.8	8.2	19	
19-162	234.34	S396	Silt Till	33.5	10.2	224.1	9.2	28	
19-163	234.62	S405	Silt Till	36.0	11.0	223.6	9.7	8	
19-164	234.64	S414	Silt Till	31.0	9.4	225.2	19.2	13	
19-164	234.64	S415	Silt Till	36.0	11.0	223.7	9.7	17	
19-165	234.67	S424	Silt Till	35.0	10.7	224.0	9.0	15	
19-165	234.67	S425	Silt Till	40.0	12.2	222.5	12.2		sampler bouncing after 15 blows 150 mm
19-166	234.94	S443	Silt Till	31.0	9.4	225.5	8.7	103	
19-166	234.94	S565	Silt Till	36.0	11.0	224.0	9.0	38	tested from base of casing advancer
19-166	234.94	S567	Silt Till	41.0	12.5	222.4	9.1	43	tested from base of casing advancer
19-167	234.59	S458	Silt Till	28.0	8.5	226.1	8.5		sampler bouncing after 81 blows / 180 mm
19-167	234.59	S557	Silt Till	31.0	9.4	225.1	9.4	76	
19-167	234.59	S559	Silt Till	36.0	11.0	223.6	8.6	37	
19-167	234.59	S561	Silt Till	41.0	12.5	222.1	9.3	56	
19-168	234.97	S451	Silt Till	26.0	7.9	227.0	10.4	34	
19-168	234.97	S551	Silt Till	31.0	9.4	225.5	8.5	146	
19-168	234.97	S553	Silt Till	36.0	11.0	224.0	9.3	75	
19-168	234.97	S555	Silt Till	41.0	12.5	222.5	9.1	73	
19-169	234.91	S464	Silt Till	26.0	7.9	227.0	7.4	112	
19-169	234.91	S545	Silt Till	31.0	9.4	225.5	8.4	116	
19-169	234.91	S547	Silt Till	36.0	11.0	223.9	8.5	153	
19-169	234.91	S549	Silt Till	41.0	12.5	222.4	9.7	71	
19-170	235.00	S471	Silt Till	26.0	7.9	227.1	6.8	119	
19-170	235.00	S539	Silt Till	31.0	9.4	225.6	7.6	111	
19-170	235.00	S541	Silt Till	36.0	11.0	224.0	10.1	103	
19-170	235.00	S543	Silt Till	41.0	12.5	222.5	13.9	16	
19-171	234.99	S478	Silt Till	26.0	7.9	227.1	7.4	142	
19-171	234.99	S533	Silt Till	31.0	9.4	225.5	8.1	107	
19-171	234.99	S535	Silt Till	36.0	11.0	224.0	8.4	71	
19-171	234.99	S537	Silt Till	41.0	12.5	222.5	9.5	46	
19-172	235.06	S487	Silt Till	26.0	7.9	227.1	7.2	140	
19-172	235.06	S527	Silt Till	31.0	9.4	225.6	8.7	77	
19-172	235.06	S529	Silt Till	36.0	11.0	224.1	9.0	48	
19-172	235.06	S531	Silt Till	41.0	12.5	222.6	8.6	114	
19-173	235.16	S496	Silt Till	21.0	6.4	228.8	13.7	6	
19-173	235.16	S497	Silt Till	24.0	7.3	227.8	8.0		sampler bouncing after 50 blows 150 mm
19-173	235.16	S519	Silt Till	31.0	9.4	225.7	9.7	50	
19-173	235.16	S521	Silt Till	36.0	11.0	224.2	10.2	58	
19-173	235.16	S523	Silt Till	41.0	12.5	222.7	9.2		sampler bouncing after 29 blows 200 mm
19-239	234.08	S377	Silt Till	36.0	11.0	223.1	15.1	22	
19-240	235.11	S434	Silt Till	31.0	9.4	225.7	12.9	2	
19-240	235.11	S435	Silt Till	36.0	11.0	224.1	11.4	2	
20-244	235.22	S9	Silt Till	27.0	8.2	227.0	8.0	38	
20-244	235.22	S11	Silt Till	31.0	9.4	225.8	7.9	56	
20-244	235.22	S13	Silt Till	36.0	11.0	224.2	9.1	17	
20-245	235.31	S23	Silt Till	26.0	7.9	227.4	9.1	35	
20-245	235.31	S25	Silt Till	31.0	9.4	225.9	9.1	29	
20-245	235.31	S27	Silt Till	36.0	11.0	224.3	8.7	24	
20-246	235.43	S34	Silt Till	21.0	6.4	229.0	7.8	28	
20-246	235.43	S36	Silt Till	26.0	7.9	227.5	8.9	25	
20-246	235.43	S38	Silt Till	31.0	9.4	226.0	4.5	22	
20-246	235.43	S40	Silt Till	36.0	11.0	224.5	9.9	8	
20-247	235.64	S46	Silt Till	21.0	6.4	229.2	7.9	41	
20-247	235.64	S48	Silt Till	26.0	7.9	227.7	9.3	45	
20-247	235.64	S50	Silt Till	30.0	9.1	226.5	4.4		sampler bouncing after 32 blows 75 mm
20-247	235.64	S52	Silt Till	36.0	11.0	224.7		22	sampler blocked with stone
20-248	236.03	S56	Silt Till	16.0	4.9	231.2	7.9	77	
20-248	236.03	S57	Silt Till	21.0	6.4	229.6	3.1	43	
20-248	236.03	S59	Silt Till	25.0	7.6	228.4			sampler bouncing, no penetration
20-248	236.03	S61	Silt Till	31.0	9.4	226.6	8.0	65	
20-248	236.03	S63	Silt Till	36.0	11.0	225.1	9.6	21	
20-248	236.03	S65	Silt Till	41.0	12.5	223.5	7.7	154	
20-248	236.03	S67	Silt Till	45.0	13.7	222.3	8.3		sampler bouncing, no penetration

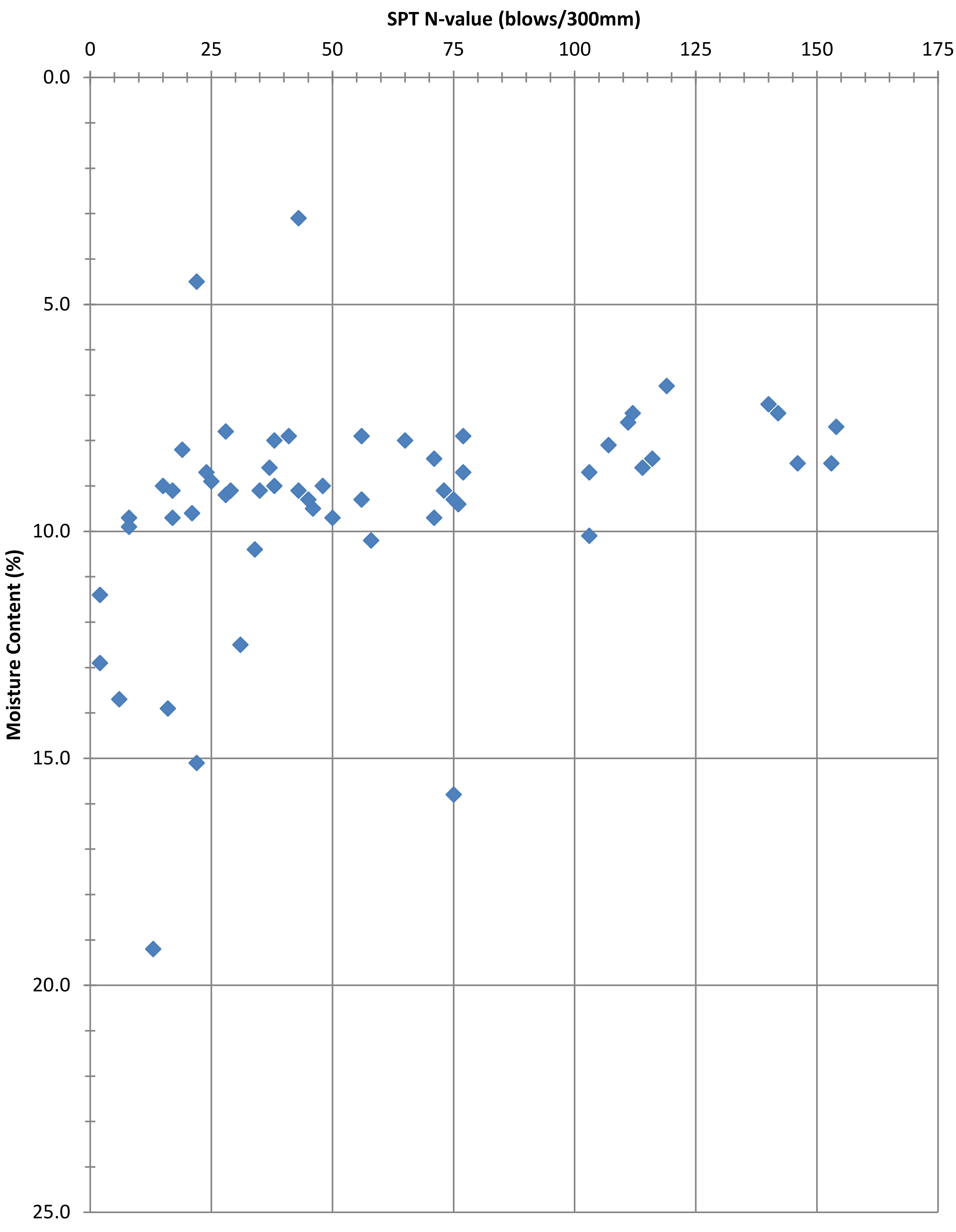
Ferry Road & Riverbend CSR - Rutland Trunk Sewer
Figure F1: SPT-Profile vs Depth (Glacial Till)




Ferry Road & Riverbend CSR - Rutland Trunk Sewer
Figure F2: SPT-Profile vs Elevation (Glacial Till)
SPT N-value (blows/300mm)
0
25
50
75
100
125
150
175
Elevation (m)
235.0
234.0
233.0
232.0
231.0
230.0
229.0
228.0
227.0
226.0
225.0
224.0
223.0
222.0
221.0
220.0

Ferry Road & Riverbend CSR - Rutland Trunk Sewer

Figure F3: SPT-Profile vs Moisture Content (Glacial Till)



DRI GEOTECHNICAL ENGINEERS

APPENDIX G

SINTEF Soil Abrasion Testing (SAT),
Cerchar Abrasivity Index (CAI) testing,
Uniaxial Compressive Strength (UCS) testing,
Petrographic Analysis

Earth Mechanics Institute
Client: Dyregrov Robinson Inc.
Project: Rutland Trunk Sewer
Date: 5/11/2021

Colorado School of Mines

Soil Abrasion Testing (SAT)
EMI # 539

Sample ID: **Sand-1**

1- Moisture condition:

Air dried	Oven dried
X	

2- Sample preparation:

Sieving	Crushing	As received
X	X	

3- Test piece hardness:

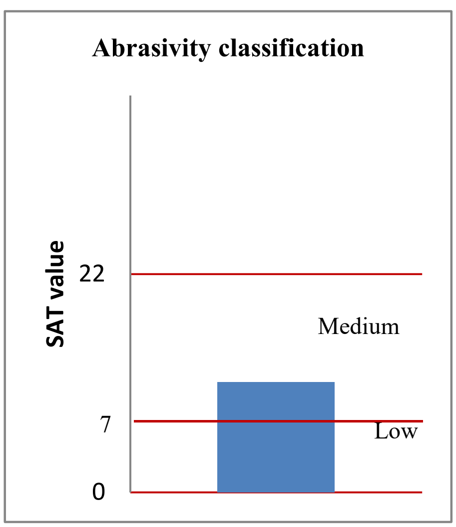
Cutter steel	Other
55(HRC)	

4- Flow rate (gr/min): 80

5- Test duration (min): 1

	Before test	After test	Weight loss
6- Weight piece 1:	39.544	39.533	0.011
Weight piece 2:	40.730	40.719	0.011
Average weight loss (gr):			0.0111

7- SAT value = 11.1



Picture of sample as tested

Notes:
Test Performed By: JD, JWD
Data Reduced By: JD

Date: 5/11/2021

Earth Mechanics Institute | **Colorado School of Mines**

Client: Dyregrov Robinson Inc.

Project: Rutland Trunk Sewer

Soil Abrasion Testing (SAT)

Date: 5/11/2021 | EMI # 539

Sample ID: **Clay-1**

1- Moisture condition:

Air dried	Oven dried
X	

2- Sample preparation:

Sieving	Crushing	As received
X	X	

3- Test piece hardness:

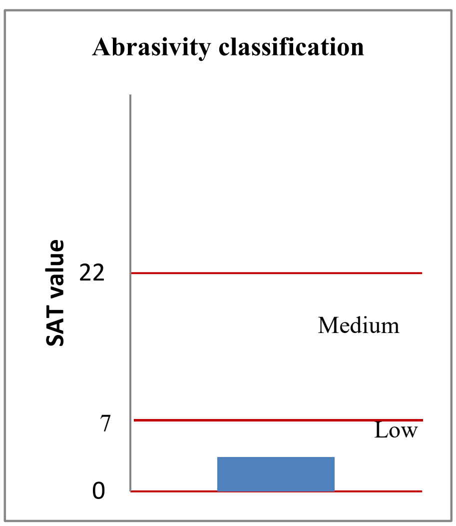
Cutter steel	Other
55(HRC)	

4- Flow rate (gr/min): 80

5- Test duration (min): 1

	Before test	After test	Weight loss
6- Weight piece 1:	42.423	42.418	0.005
Weight piece 2:	37.971	37.969	0.002
Average weight loss (gr):			0.00345

7- SAT value = 3.45



Picture of sample as tested

Notes:

Test Performed By: JD, JWD

Data Reduced By: JD

Date: 5/11/2021

Earth Mechanics Institute
Client: Dyregrov Robinson Inc.
Project: Rutland Trunk Sewer
Date: 5/11/2021

Colorado School of Mines

Soil Abrasion Testing (SAT)
EMI # 539

Sample ID: **Clay-2**

1- Moisture condition:

Air dried	Oven dried
X	

2- Sample preparation:

Sieving	Crushing	As received
X	X	

3- Test piece hardness:

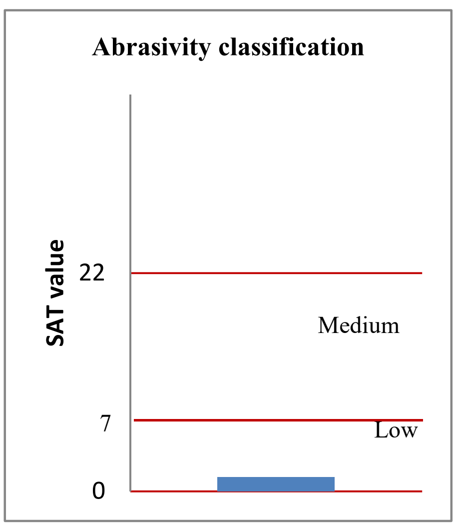
Cutter steel	Other
55(HRC)	

4- Flow rate (gr/min): 80

5- Test duration (min): 1

	Before test	After test	Weight loss
6- Weight piece 1:	43.868	43.867	0.002
Weight piece 2:	40.135	40.134	0.001
Average weight loss (gr):			0.0014

7- SAT value = 1.4



Picture of sample as tested

Notes:
Test Performed By: JD, JWD
Data Reduced By: JD

Date: 5/11/2021

Earth Mechanics Institute

Client: Dyregrov Robinson Inc.

Project: Rutland Trunk Sewer

Date: 5/11/2021

Colorado School of Mines

Soil Abrasion Testing (SAT)

EMI # 539

Sample ID: **Till-1**

1- Moisture condition:

Air dried	Oven dried
X	

2- Sample preparation:

Sieving	Crushing	As received
X	X	

3- Test piece hardness:

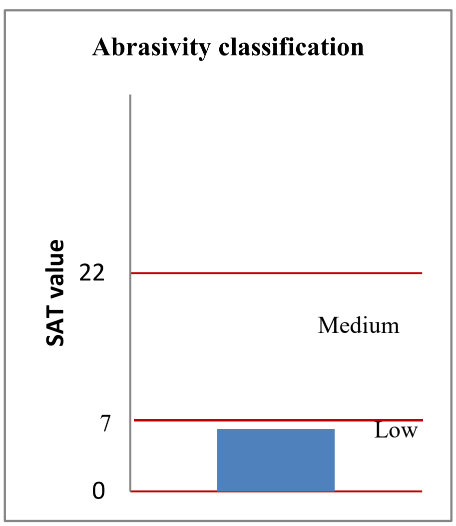
Cutter steel	Other
55(HRC)	

4- Flow rate (gr/min): 80

5- Test duration (min): 1

	Before test	After test	Weight loss
6- Weight piece 1:	44.487	44.482	0.005
Weight piece 2:	46.140	46.132	0.008
Average weight loss (gr):			0.00625

7- SAT value = 6.25



Picture of sample as tested

Notes:

Test Performed By: JD, JWD

Data Reduced By: JD

Date: 5/11/2021

Earth Mechanics Institute | **Colorado School of Mines**

Client: Dyregrov Robinson Inc.
Project: Rutland Trunk Sewer
Date: 5/11/2021

Soil Abrasion Testing (SAT)
EMI # 539

Sample ID: **Till-2**

1- Moisture condition:

Air dried	Oven dried
X	

2- Sample preparation:

Sieving	Crushing	As received
X	X	

3- Test piece hardness:

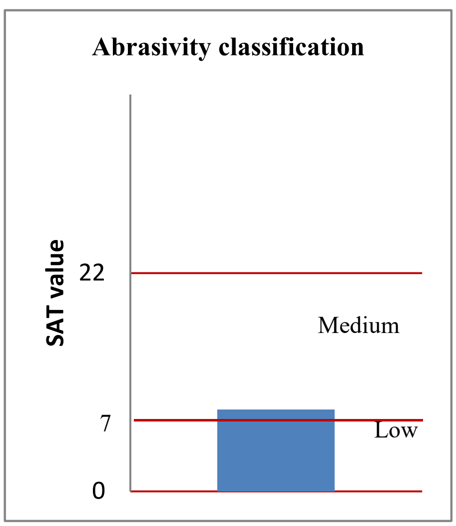
Cutter steel	Other
55(HRC)	

4- Flow rate (gr/min): 80

5- Test duration (min): 1

	Before test	After test	Weight loss
6- Weight piece 1:	42.707	42.698	0.009
Weight piece 2:	40.049	40.042	0.008
Average weight loss (gr):			0.0082

7- SAT value = 8.2



Picture of sample as tested

Notes:
Test Performed By: JD, JWD
Data Reduced By: JD

Date: 5/11/2021

Earth Mechanics Institute

Colorado School of Mines

Mining Engineering Department

Client: Dyregrov Robinson Inc

Project: Rutland Trunk Sewer

Date: 4/27/21

Cerchar Abrasivity Test

ASTM D7625

Sample ID	Rock Type	Cerchar Abrasivity Index (CAIs)*
TH-19-168, C550 @ 27'	Metamorphic	3.24
TH 19-173, C518 @ 26'	Sedimentary	3.29
TH 20-244, C8 @ 24'	Metamorphic	3.36

*** CERCHAR tests have been run on saw cut surface. No correction factor has been added to the results.**

Pictures of Sample Before and After
Cerchar Abrasivity Index

Client Name:	Dyregrov Robinson Inc	**EMI#**	539
Project Name:	Rutland Trunk Sewer	**Date:**	4/23/2021
Sample ID:	TH-19-168, C550 @ 27'		

Before

After

Pictures of Sample Before and After
Cerchar Abrasivity Index

Client Name:	Dyregrov Robinson Inc	**EMI#**	539
Project Name:	Rutland Trunk Sewer	**Date:**	4/23/2021
Sample ID:	TH 19-173, C518 @ 26'		

Before

After

Pictures of Sample Before and After
Cerchar Abrasivity Index

Client Name: Dyregrov Robinson Inc		**EMI#**	539
Project Name: Rutland Trunk Sewer		**Date:**	4/23/2021
Sample ID: TH 20-244, C8 @ 24'			

Before

After

Earth Mechanics Institute | **Colorado School of Mines**

Mining Engineering Department

Client: Dyregrov Robinson Inc

Project: Rutland Trunk Sewer

Date: 04/30/2021

Uniaxial Compressive Strength

ASTM D7012

Sample ID	Rock Type	Average Length	Average Diameter	Length to Diameter Ratio	Density	Failure Load	Uniaxial Compressive Strength: Failure Stress	Uniaxial Compressive Strength: UCS (2:1)		Notes *(Failure type)*
		(in)	(in)		(lbs/ft^3)	(lbs)	σ_c (psi)	(psi)	(MPa)	
TH 19-173, C518 @ 26'	Sedimentary	5.417	2.487	2.2	165	68,873	14,172	14,433	99.5	Non - Structural
TH 20-244, C8 @ 24'	Metamorphic	5.545	2.469	2.2	167	139,797	29,199	29,830	205.7	Non - Structural

$$UCS_{2:1correction} = \frac{\sigma_c}{0.88 + 0.222(\frac{d}{l})}$$

EARTH MECHANICS INSTITUTE

Mining Engineering Department, CSM

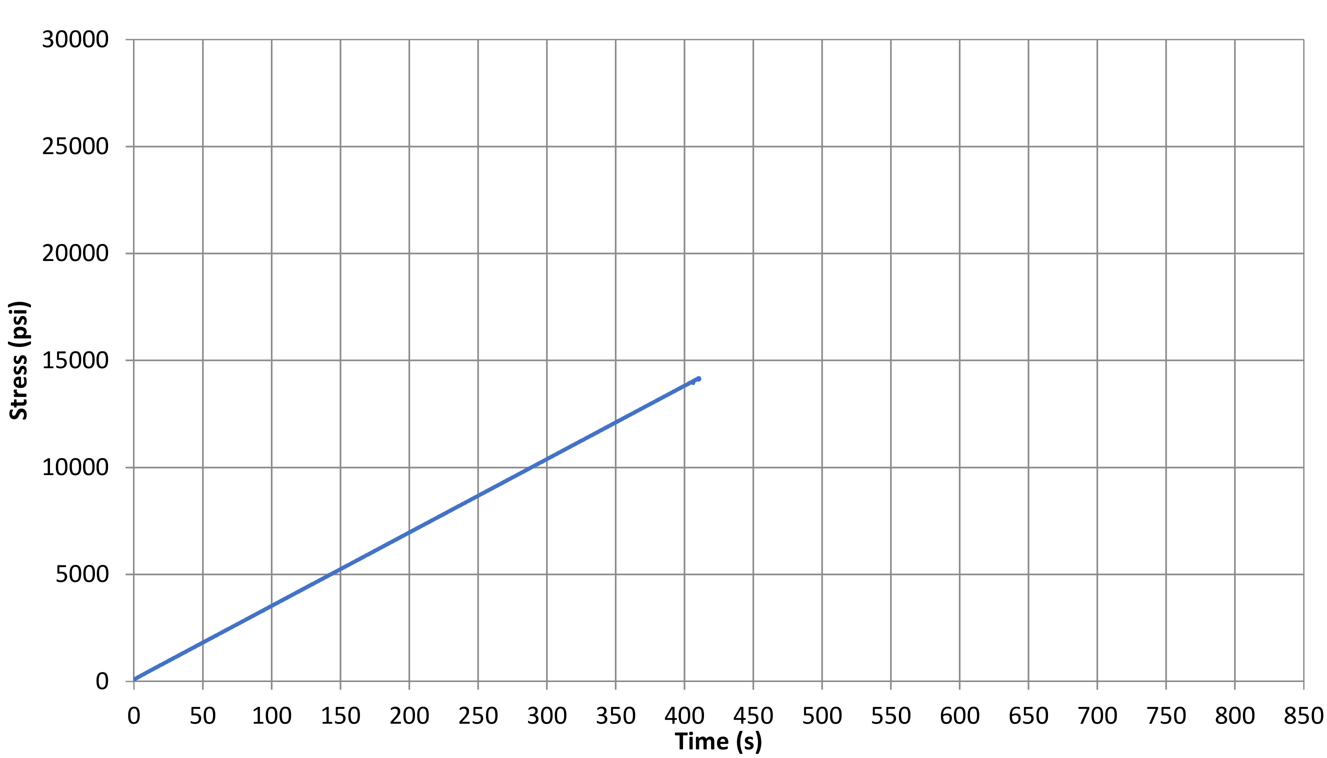
Uniaxial Compressive Strength - ASTM D7012

Client:	Dyregrob Robinson Inc.
Project:	Rutland Trunk Sewer
Location:	N/A
Rock Type:	Sedimentary
Rock Name:	N/A
Characteristics:	N/A
Test Performed By:	JD, SS
Date Tested:	4/20/2021
Data Reduced By:	MP
Date Reduced:	4/30/2021
Core ID:	TH 19-173, C518 @ 26'
File Name:	TH 19-173, C518 @ 26'_UCS
EMI Project No.:	539

Core Length		Core Diameter		L/D Ratio	Density	
in	cm	in	cm		lb/ft^3	g/cm^3
5.417	13.76	2.487	6.32	2.2	165	2.65

Failure Load	Failure Stress	UCS 2:1		Static E		Static ν	Failure Mode
lbf	psi	psi	MPa	ksi	GPa		
68,873	14,172	14,433	99.5	N/A	N/A	N/A	Non - Structural

P - Wave		S - Wave		Dynamic E		Dynamic ν
ft/s	m/s	ft/s	m/s	ksi	GPa	
N/A	N/A	N/A	N/A	N/A	N/A	N/A



EARTH MECHANICS INSTITUTE

Mining Engineering Department, CSM

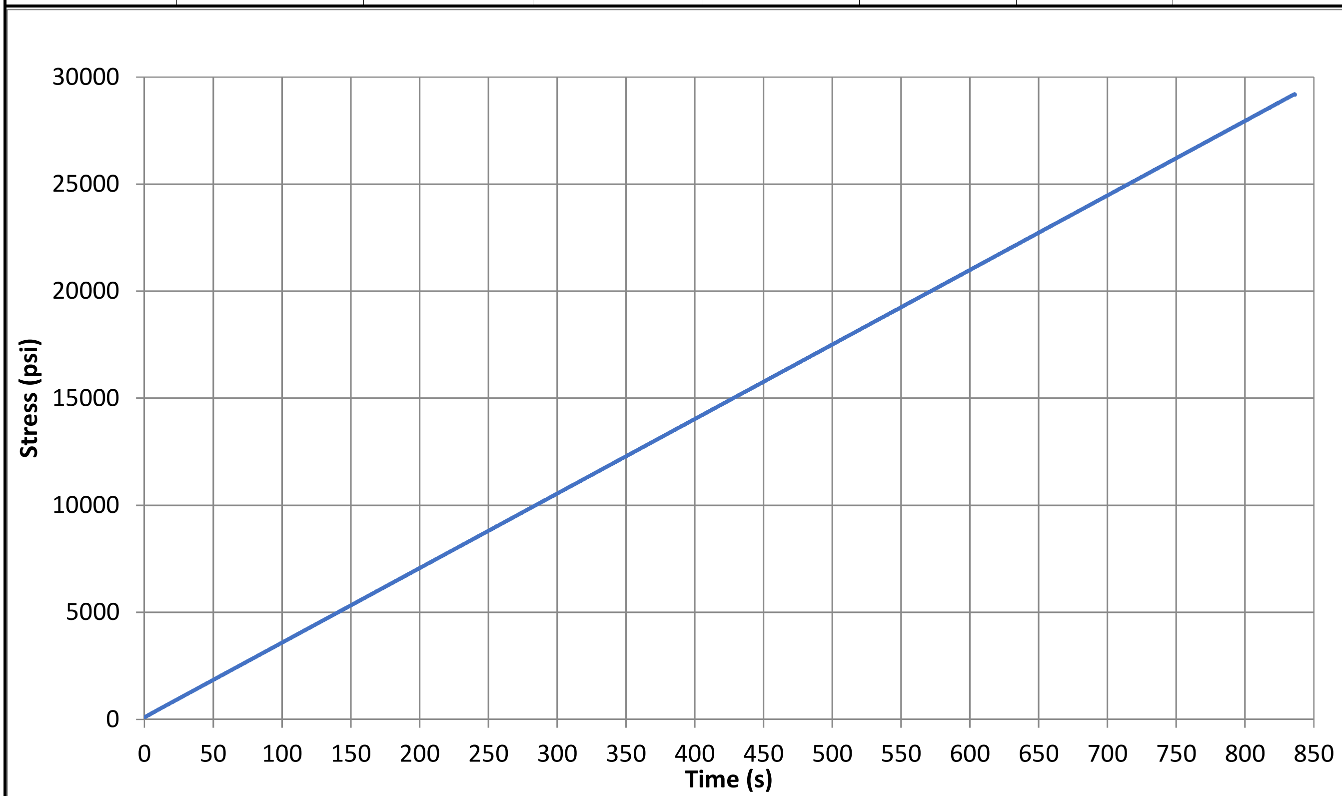
Uniaxial Compressive Strength - ASTM D7012

Client: Dyregrob Robinson Inc.
Project: Rutland Trunk Sewer
Location: N/A
Rock Type: Metamorphic
Rock Name: N/A
Characteristics: N/A
Test Performed By: JD, SS
Date Tested: 4/20/2021
Data Reduced By: MP
Date Reduced: 4/30/2021
Core ID: TH 20-244, C8 @ 24'
File Name: TH 20-244, C8 @ 24'_PP.dat
EMI Project No.: 539

Core Length		Core Diameter		L/D Ratio	Density	
in	cm	in	cm		lb/ft^3	g/cm^3
5.545	14.08	2.469	6.27	2.2	167	2.68

Failure Load	Failure Stress	UCS 2:1		Static E		Static ν	Failure Mode
lbf	psi	psi	MPa	ksi	GPa		
139,797	29,199	29,830	205.7	N/A	N/A	N/A	Non - Structural

P - Wave		S - Wave		Dynamic E		Dynamic ν
ft/s	m/s	ft/s	m/s	ksi	GPa	
N/A	N/A	N/A	N/A	N/A	N/A	N/A



Petrographic Analysis of Selected Litharenitic Loose Sand Thin Section

Prepared for:

Brent Duncan
Earth Mechanic Institute, Department of Mining Engineering
Colorado School of Mines

Prepared by:

Ryan McLin
McLin Petrographics

McLin Petrographics

McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065

Table of Contents

PETROGRAPHIC ANALYSIS

1. Introduction

The following report includes an assessment of rock type, mineralogy, and notable textural features. Rock type descriptions are accompanied by thin section photomicrographs and include five images of each sample in both plane-polarized light and crossed-polarized light and range in magnification from 2.5x, 5x, 10x, 20x, and 50x. Larger scale textural features are captured at low magnification, whereas details of the mineral matrix are characterized at the medium and high magnifications. Table 1 lists sample number, rock type and type of analyses performed. Analytical procedures are described at the end of this report.

2. Rock Types

The sedimentary rock type designation is based upon the classification schemes defined by Folk (1974). All rock types are characterized by texture or mineralogy as observed in thin section and accompanying hand sample.

Table 1. Petrologic Testing Matrix

Sample ID	Rock Type	Thin Section
539_Sand 1	Litharenitic Loose Sand	X
	TOTAL	**3**

McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065

2.2. Litharenitic Loose Sand

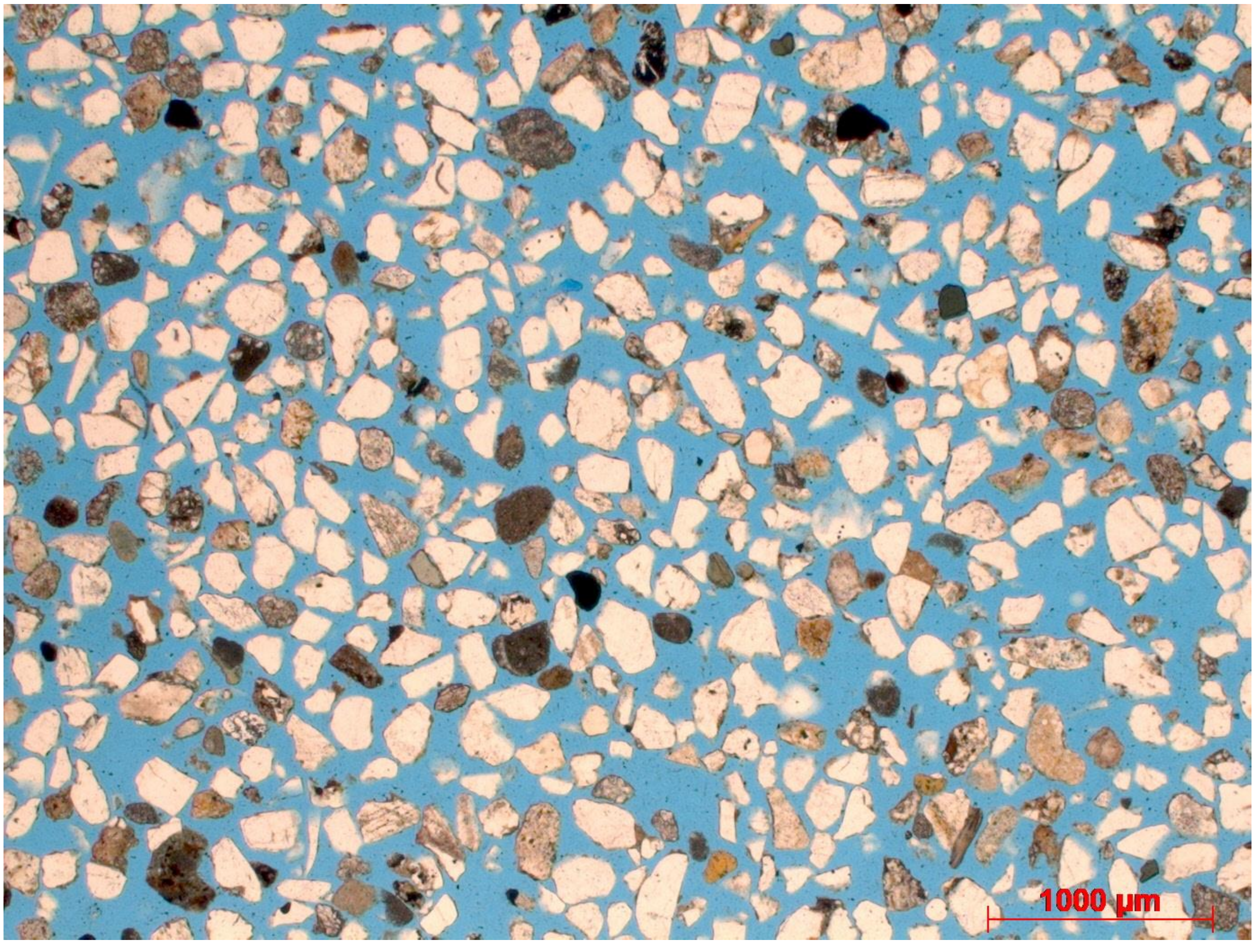
Megascopic Description: A bag of loose sand grains composed of quartz, feldspar, and rock fragments that are fine sand in size. The grains are dusty, brown in color, and likely coated with clay minerals.

Microscopic Description: The loose sand is further characterized as litharenitic (Folk, 1974) that is dominated by quartz, with subordinate amounts of rock fragments, and minor feldspar grains. Grain sizes were measured through image analysis of a sampling of grains taken from the lowest magnification image (TS_01). Results show an average grain size of fine sand according to the Wentworth (1922) grain size scale (average 223 microns; minimum 59 microns; maximum 485 microns). Grains are angular to subangular, moderately coated with clays, and moderately well sorted indicative of low textural maturity.

The mineralogy is dominated by monocrystalline quartz with minor polycrystalline quartz grains. Common sedimentary rock fragments consist of chert, limestone, and mudstone fragments. Rare glauconite pellets are also noted in thin section images TS_07 and TS_08. Uncommon igneous and metamorphic fragments are also observed. Minor feldspar grains include plagioclase and microcline variation of potassium feldspar. Clay minerals thinly coat most grains and comprise a mixture of illite, kaolinite, and chlorite imparting the dirty-brown color observed in the megascopic description. Accessories include opaque pyrite, magnetite and associated rare heavy minerals.

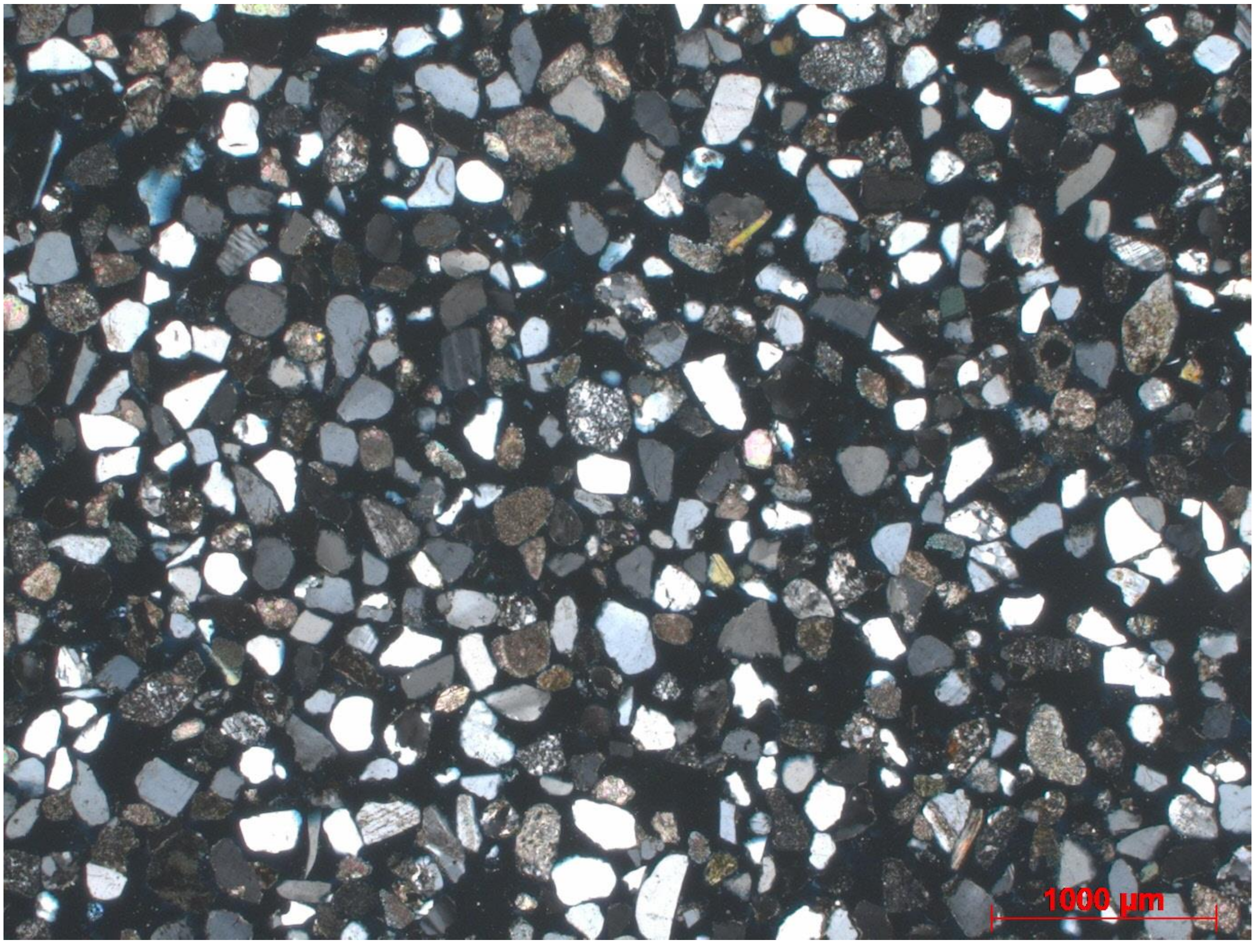
McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065

3. Thin Section Images



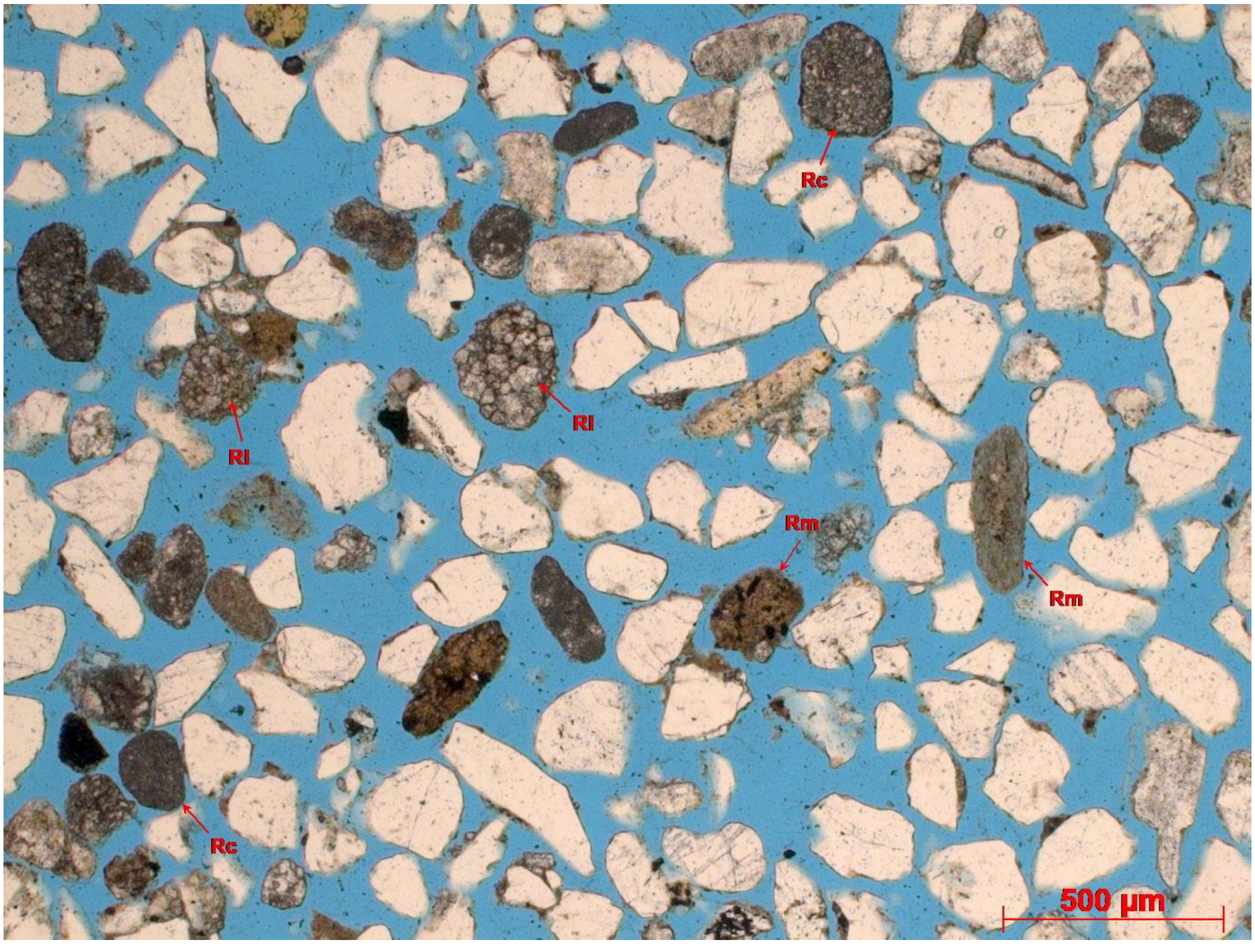
539_Sand_1_2_5x_ppl_001	Litharenitic Loose Sand

Thin Section Image 01. General overview of the loose sand shows a variety if angular to subangular sand grains that are fine sand-sized (average grain size 223 microns; minimum 59 microns; maximum 485 microns) according to the Wentworth grain size scale. Most of the grains are quartz and feldspar (white) with a subordinate amount of darker lithic fragments. Plane-polarized light. 2.5x Magnification. Field of View 5.5 mm. Scale bar = 1000 microns or 1 mm.



539_Sand_1_2_5x_xpl_002	Litharenitic Loose Sand

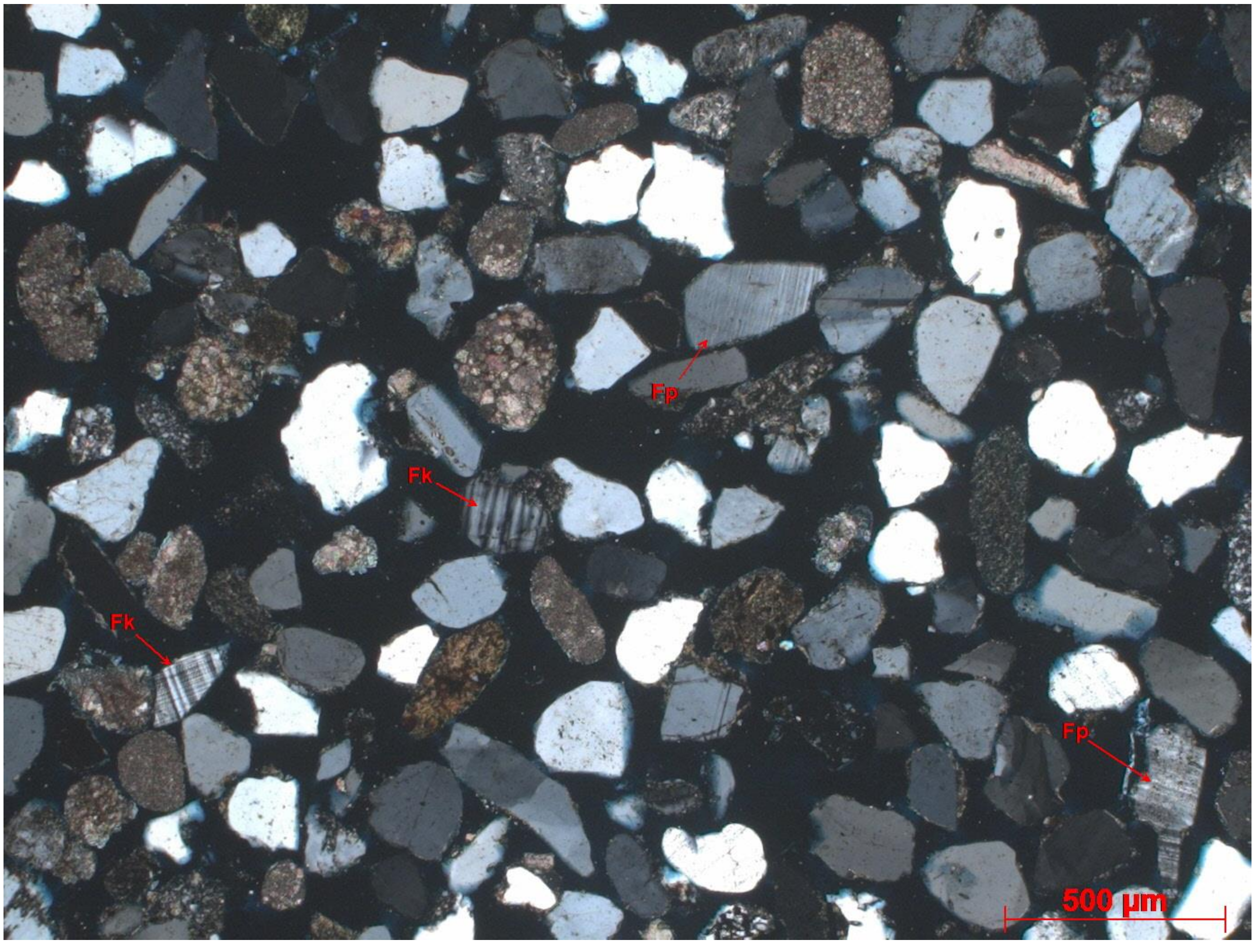
Thin Section Image 02. The same image as in TS_001 but under crossed-polarized light illustrates abundant quartz grains at various states of optical extinction from the white to gray first order interference colors. Various rock fragments include abundant chert grains from the salt-and-pepper speckled appearance of microcrystalline quartz. Other darker lithics include mudstone and carbonate fragments. Cross-polarized light. 2.5x Magnification. Field of View 5.5 mm. Scale bar = 1000 microns or 1 mm.



539_Sand_1_5x_ppl_003	Litharenitic Loose Sand

Thin Section Image 03. Greater magnification of the Litharenitic loose sand shows abundant angular grains of quartz and minor feldspar (white), with lesser amounts of darker brown to gray rock fragments. Most of the rock fragments are mudstone (Rm) or chert (Rc), but a small amount include limestone fragments (Rl) composed of sparry calcite. Plane-polarized light. 5x Magnification. Field of View 2.82 mm. Scale bar = 500 microns or 0.5 mm.

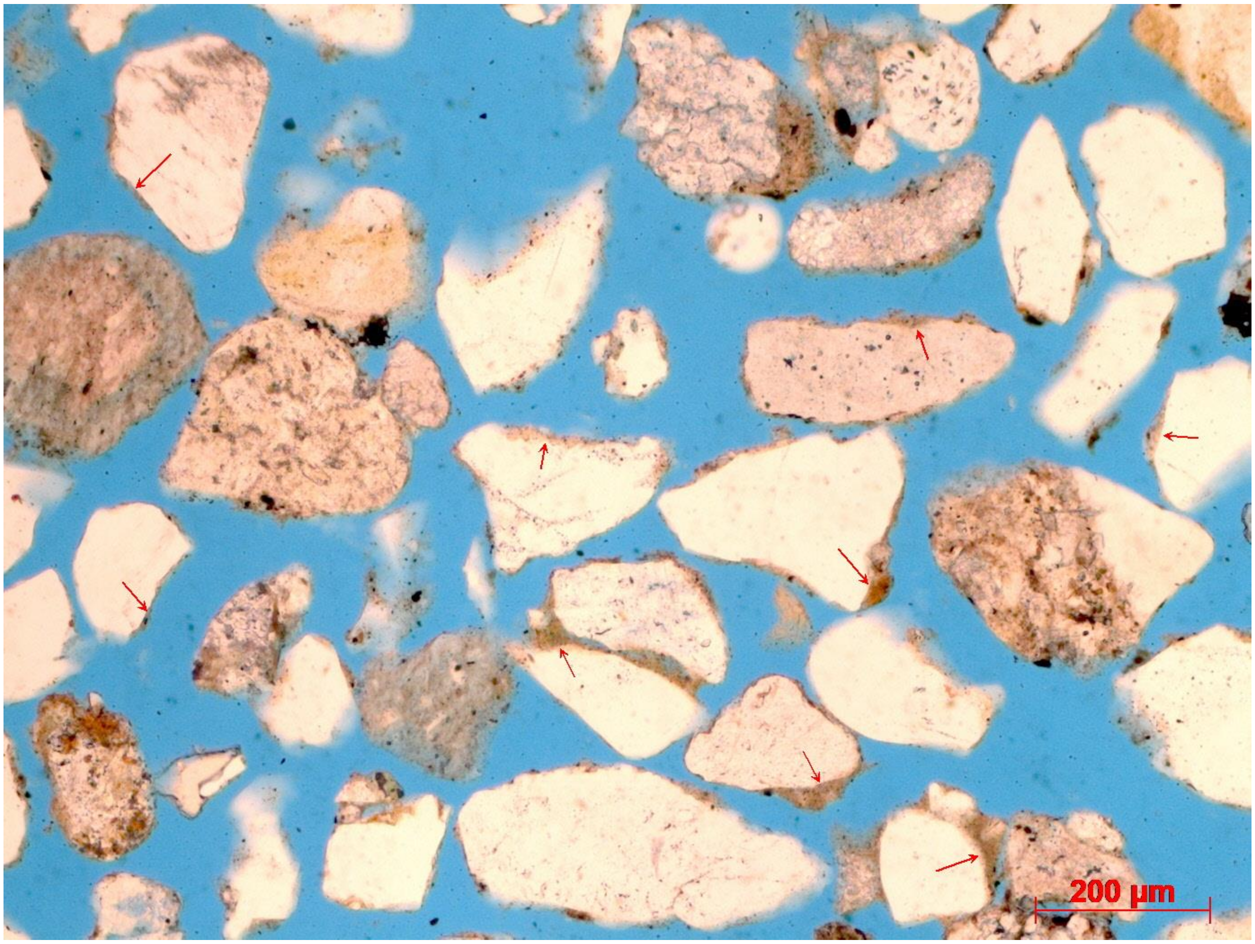
McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065



539_Sand_1_5x_xpl_004	Litharenitic Loose Sand

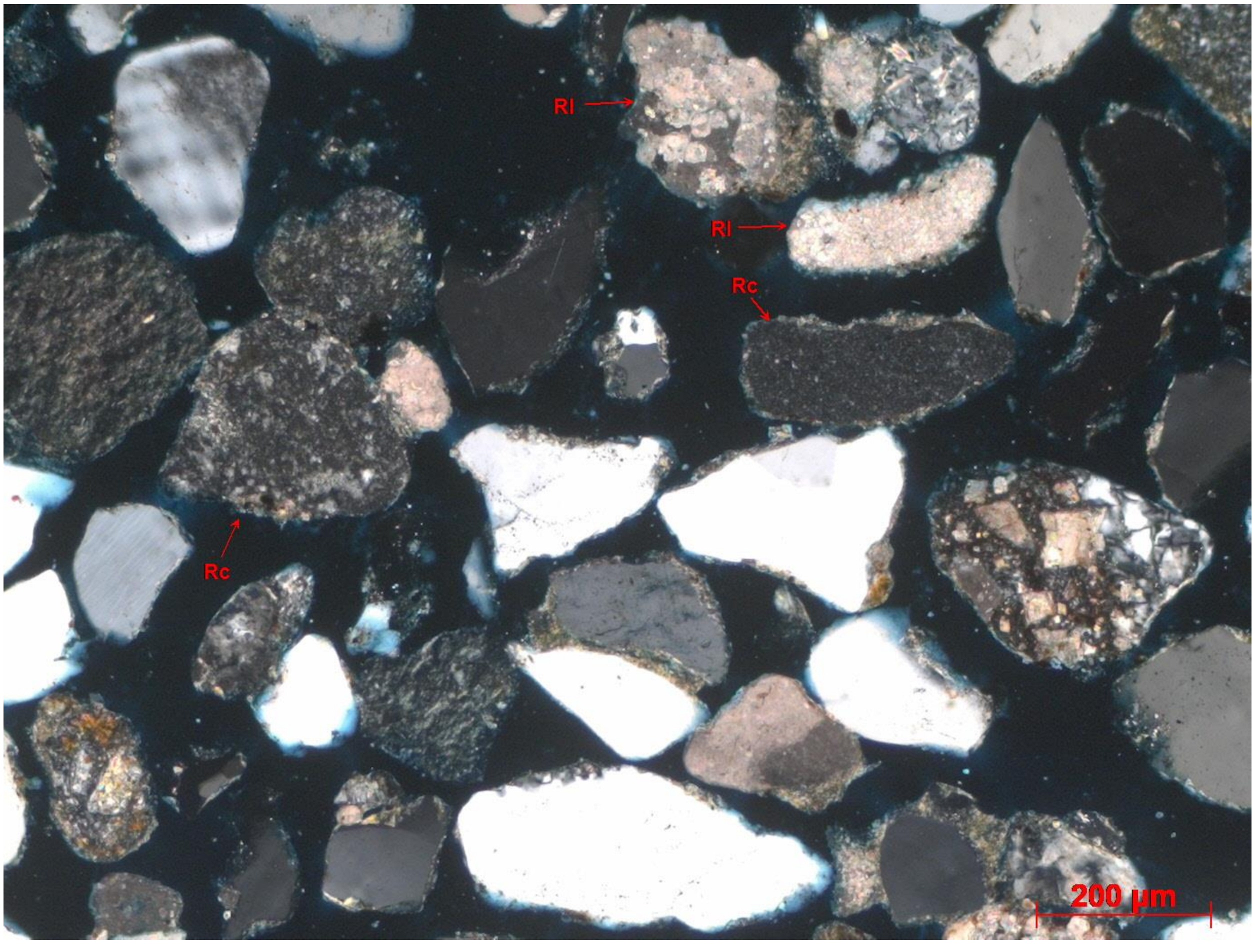
Thin Section Image 04. The same view as in TS_003 but under crossed polarized light reveals abundant angular and subangular grains dominated by quartz (white and gray). A smaller amount of feldspar grains are recognizable from their polysynthetic twinning of plagiolcase (Fp) and tartan twinning of microcline variant of potassium feldspar (Fk). The rock fragments noted in the previous image illustrate specked brown and gray colors. Cross-polarized light. 5x Magnification. Field of View 2.82 mm. Scale bar = 500 microns or 0.5 mm.

McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065



539_Sand_1_10x_ppl_005	Litharenitic Loose Sand

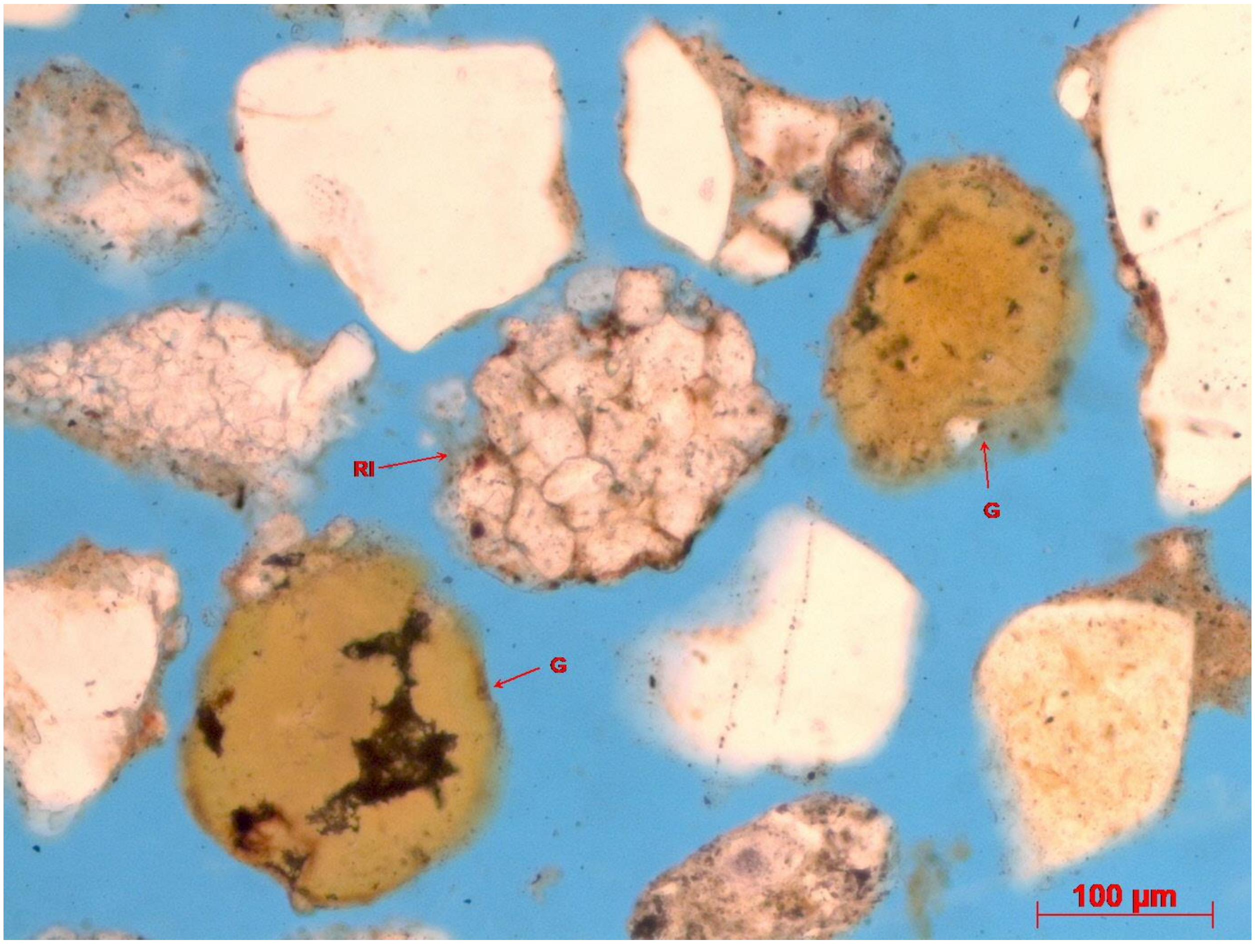
Thin Section Image 05. Closer inspection of the Litharenitic loose sand better illustrates the high angularity of the grains indication a low textural maturity of the sand. Also note the thin clay coatings on most grains (arrows) that are likely composed of illite, kaolinite, and chlorite. Plane-polarized light. 10x Magnification. Field of View 1.46 mm. Scale bar = 200 microns or 0.2 mm.



539_Sand_1_10x_xpl_006	Litharenitic Loose Sand

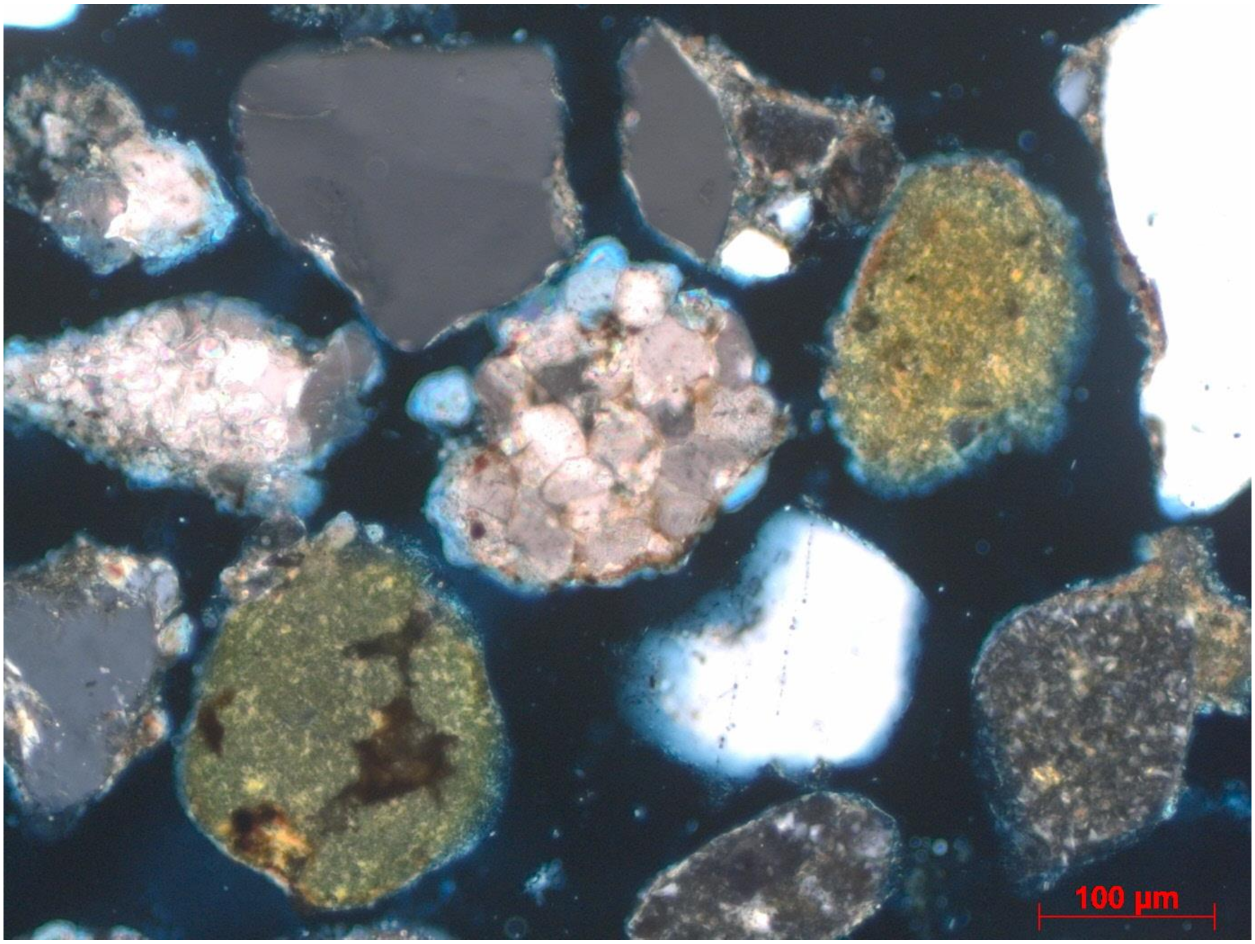
Thin Section Image 06. The same view as TS_05 but under crossed-polarized light illustrating the variety of lithic fragments from salt-and-pepper chert (Rc) to limestone fragments (Rl) that show both sparry and microcrystalline calcite. Other fragments include those of minor volcanic and metamorphic origin. Cross-polarized light. 10x Magnification. Field of View 1.46 mm. Scale bar = 200 microns or 0.2 mm.

McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065



539_Sand_1_20x_ppl_007	Litharenitic Loose Sand

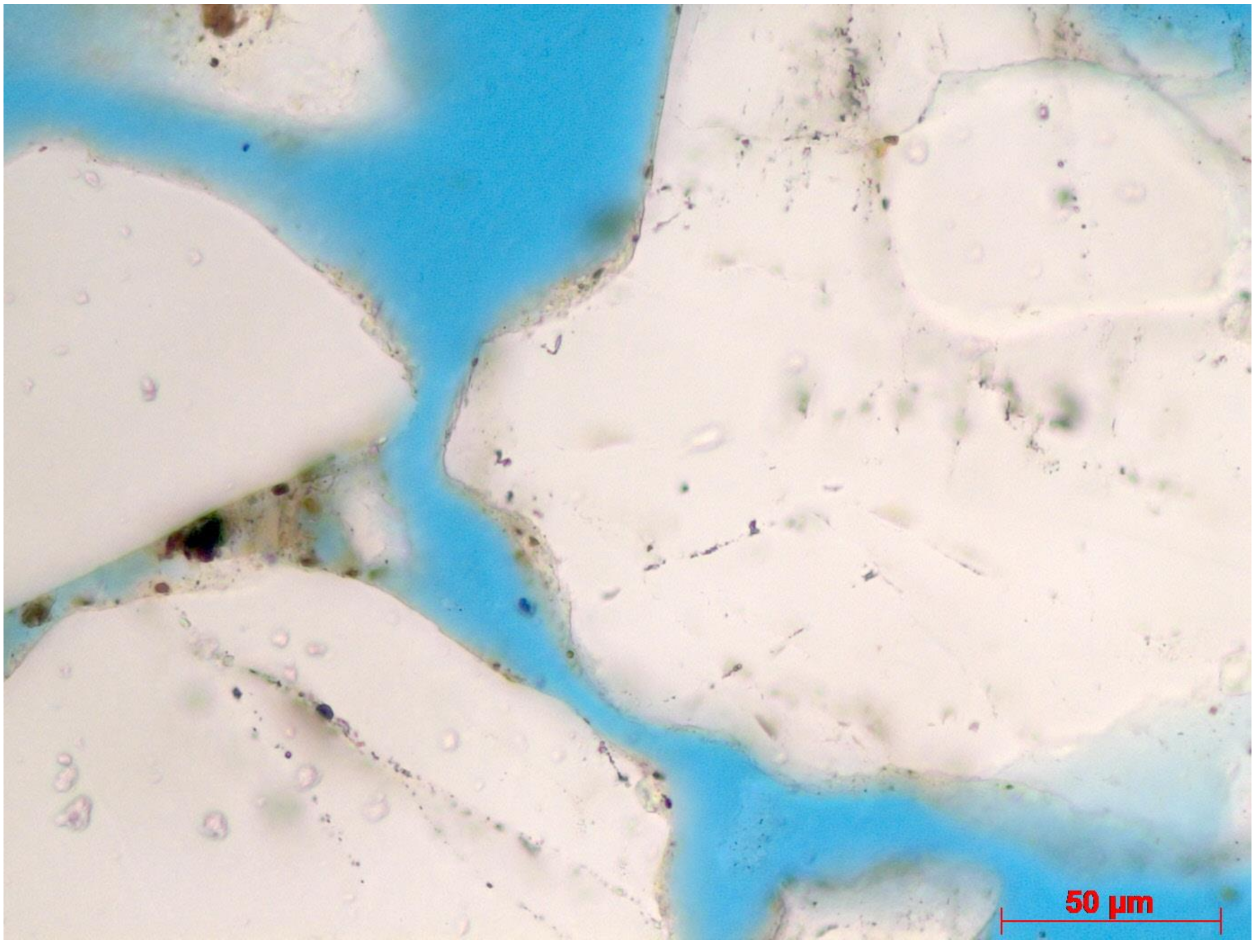
Thin Section Image 07. More magnified view of the Litharenitic loose sand illustrates two rare rounded glauconite pellets (G) between and limestone fragment (Rl) composed of sparry calcite crystals. Plane-polarized light. 20x Magnification. Field of View 0.72 mm. Scale bar = 100 microns or 0.1 mm.



539_Sand_1_20x_xpl_008	Litharenitic Loose Sand

Thin Section Image 08. The same view as in TS_07 but under crossed-polarized light better illustrates the glauconite pellets from the dull green-and-yellow speckled color. The prominent quartz grains illustrate first order white to gray interference colors at various states of optical extinction. A small chert fragment is noted at lower-right from its speckled salt-and-pepper pattern. Cross-polarized light. 20x Magnification. Field of View 0.72 mm. Scale bar = 100 microns or 0.1 mm.

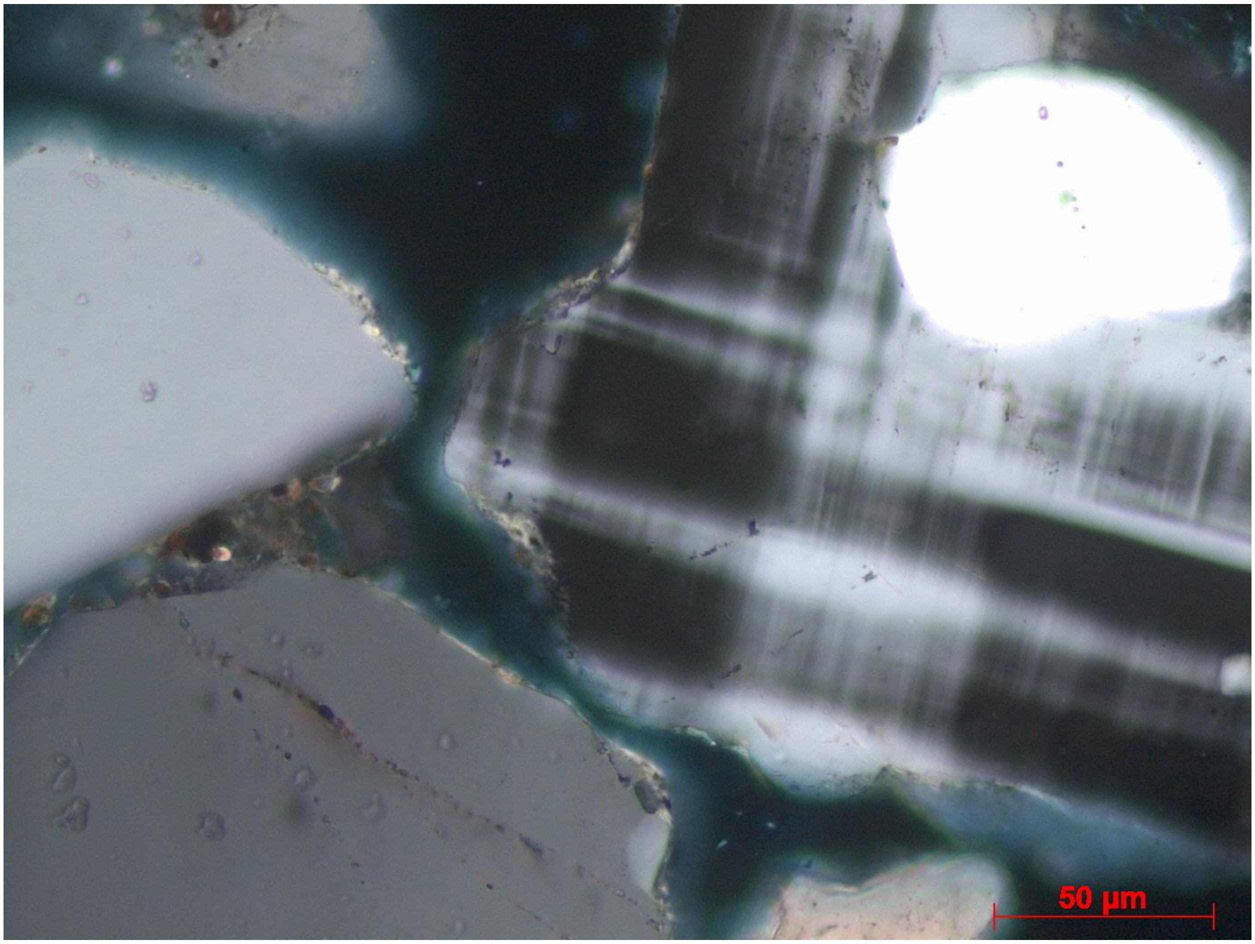
McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065



539_Sand_1_50x_ppl_009	Litharenitic Loose Sand

Thin Section Image 09. Highest magnification detail of the Litharenitic loose sand illustrates quartz and feldspar grains that are coated with a small amount of brown clays likely composed of illite, kaolinite, and chlorite. A small opaque mineral at left is likely pyrite or magnetite. Field of View 0.28 mm. Scale bar = 50 microns or 0.05 mm.

McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065



539_Sand_1_50x_xpl_010	Litharenitic Loose Sand

Thin Section Image 10. The same view as TS_09 under crossed-polarized light illustrates the tartan twinning of microcline variation of potassium feldspar. Note that the clays that coat the grains show bright white to yellow interference colors that are characteristic of illite. Cross-polarized light. 50x Magnification. Field of View 0.28 mm. Scale bar = 50 microns or 0.05 mm.

McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065

ANALYTICAL PROCEDURES

Thin Section Analysis

The loose sand sample was put into an epoxy mold, cut, surfaced, mounted to a standard (24 mm × 46 mm) thin section slide, and ground to a thickness of approximately 30 microns by National Petrographic. The samples were then shipped to Ryan McLin, sole proprietor of McLin Petrographics. The prepared thin section was examined and digitally imaged at various magnifications using a Carl Zeiss Imager.A2m polarizing binocular microscope equipped with an AxioCam MRc digital camera, UV light source, and various UV filters. Five images at increasing steps in magnification were collected in both plane-polarized light and in crossed-polarized light to observe mineral characteristics and identifying features.

BIBLIOGRAPHY

Folk, R.L., 1974, *Petrology of Sedimentary Rocks*: Hemphill Publishing Co., Austin, TX

Wentworth, C.K., 1922, A scale of grade and class terms for clastic sediments: *J. Geol*., **30**, 377-392.

McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065

Petrographic Analysis of Selected Igneous (Plutonic) and Sedimentary Rock Thin Sections

Prepared for:

Brent Duncan
Earth Mechanic Institute, Department of Mining Engineering
Colorado School of Mines

Prepared by:

Ryan McLin
McLin Petrographics

McLin Petrographics

McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065

Table of Contents

PETROGRAPHIC ANALYSIS

1. Introduction

The following report includes an assessment of rock type, mineralogy, and notable textural features. Rock type descriptions are accompanied by thin section photomicrographs and include five images of each sample in both plane-polarized light and crossed-polarized light and range in magnification from 2.5x, 5x, 10x, 20x, and 50x. Larger scale textural features are captured at low magnification, whereas details of the mineral matrix are characterized at the medium and high magnifications. Table 1 lists sample number, rock type and type of analyses performed. Analytical procedures are described at the end of this report.

2. Rock Types

Igneous rock type designations of samples that are shown in Table 1 are named according to the QAPF classification scheme (Streckeisen, 1974; La Maitre, 2002). The sedimentary rock type designation is based upon the classification schemes defined by Dunham (1962) and Write (1992). All rock types are characterized by texture or mineralogy as observed in thin section and accompanying hand sample.

Table 1. Petrologic Testing Matrix

Sample ID	**Rock Type**	**Thin Section**
TH19-168, C550@27’	Alkali-Feldspar Granite	X
TH19-173, C518@26’	Limestone (Crystalline Carbonate/Sparstone)	X
TH20-244, C8@24’	Tonalite	X
	TOTAL	**3**

2.1. Alkali-Feldspar Granite

Megascopic Description: A dense, pink, black, and gray colored, phaneritic, medium-grained, plutonic igneous rock consisting of quartz, feldspar, biotite, and muscovite.

Microscopic Description: The texture in the alkali-feldspar granite is phaneritic with individual crystals coarse enough to be seen by the unaided eye. Crystals measure between 1-5 mm and subdivide the texture into the medium grained category. The rock classification is determined using the QAPF classification of igneous rocks (Streckeisen, 1974; La Maitre, 2002). The mineralogy is dominated by polycrystalline quartz (50% by visual estimate; 52.6% modal) and alkali feldspar (40% by visual estimate; 42.1% modal). Minor minerals include plagioclase feldspar (5% by visual estimate; 5.3% modal), biotite and hornblende (4%), with rare accessories (1%) comprising of sericite, chlorite, muscovite, epidote, zircon, apatite, and tourmaline. The polycrystalline quartz is colorless, shows low relief, has a frequent wavy or undulose extinction, and exhibits low, first-order white to gray interference colors under crossed-polarized light. The alkali feldspar that is most common is microcline. Microcline is colorless, of low relief, and displays first-order gray to white interference colors under cross-polarized light. The microcline also exhibits common spindle-shaped or Scotch-plaid twinning at some orientations. It frequently includes perthite or blob-like intergrowths of sodic-plagioclase indicative of unmixing. Plagiolcase is the subordinate feldspar present in the alkali-feldspar granite and is colorless, exhibits first-order white interference colors, and has a unique polysynthetic twinning giving a striped appearance under cross-polarized light. Portions of the plagiolcase feldspar are altered to sericite, which is chemically identical to muscovite mica. Some plagioclase crystals include worm-like quartz intergrowths called myrmekite. The myrmekite is suggested to form in slowly crystallizing melts that undergo tectonic strain (Simpson & Wintsch, 1989). It is possible that the undulatory extinction of the quartz could contribute to the evidence of strain on the rock. The biotite is of particular interest in that it includes zircons and apatite crystals entrained within the mineral. In-turn, they have black pleochroic radiation halos that indicate uranium and/or thorium within the crystal lattice of the zircon or apatite crystals. The rare, high-relief epidote that was observed (Thin Section Images 5-6) is partially altered to chlorite.

2.2. Limestone (Crystalline Carbonate/Sparstone)

Megascopic Description: A dense, light gray to white in color, of low porosity, sedimentary rock consisting of calcite.

Microscopic Description: The limestone is composed primarily of finely crystalline (15-30 microns in size) sparry calcite and microcrystalline calcite or micrite thar appear interlocking in a tight matrix. The depositional texture in the limestone is unrecognizable and is therefore characterized as a crystalline carbonate according to Dunham (1962) or as a sparstone according to Write (1992), which is an obliterative category with the original fabric being overprinted by diagenesis. The minerology consists of calcite (96% by visual estimate), with minor accessories including calcareous fossil crinoid fragments (1%), fine silt-sized quartz and feldspar grains (1%), dolomite rhombs (1%), and scattered pyrite flecks and framboids (1%). There is evidence of thin organic stringers that are likely insoluble bitumen remnants and not stylolites as they do not appear to have a characteristic zig-zag form parallel to bedding indicative of pressure solution seams (since bedding cannot be recognized anyway).

2.2. Tonalite

Megascopic Description: A dense, light to dark gray and black in a salt-and-pepper appearance, phaneritic, medium-grained, plutonic igneous rock consisting of quartz, feldspar, biotite, and muscovite.

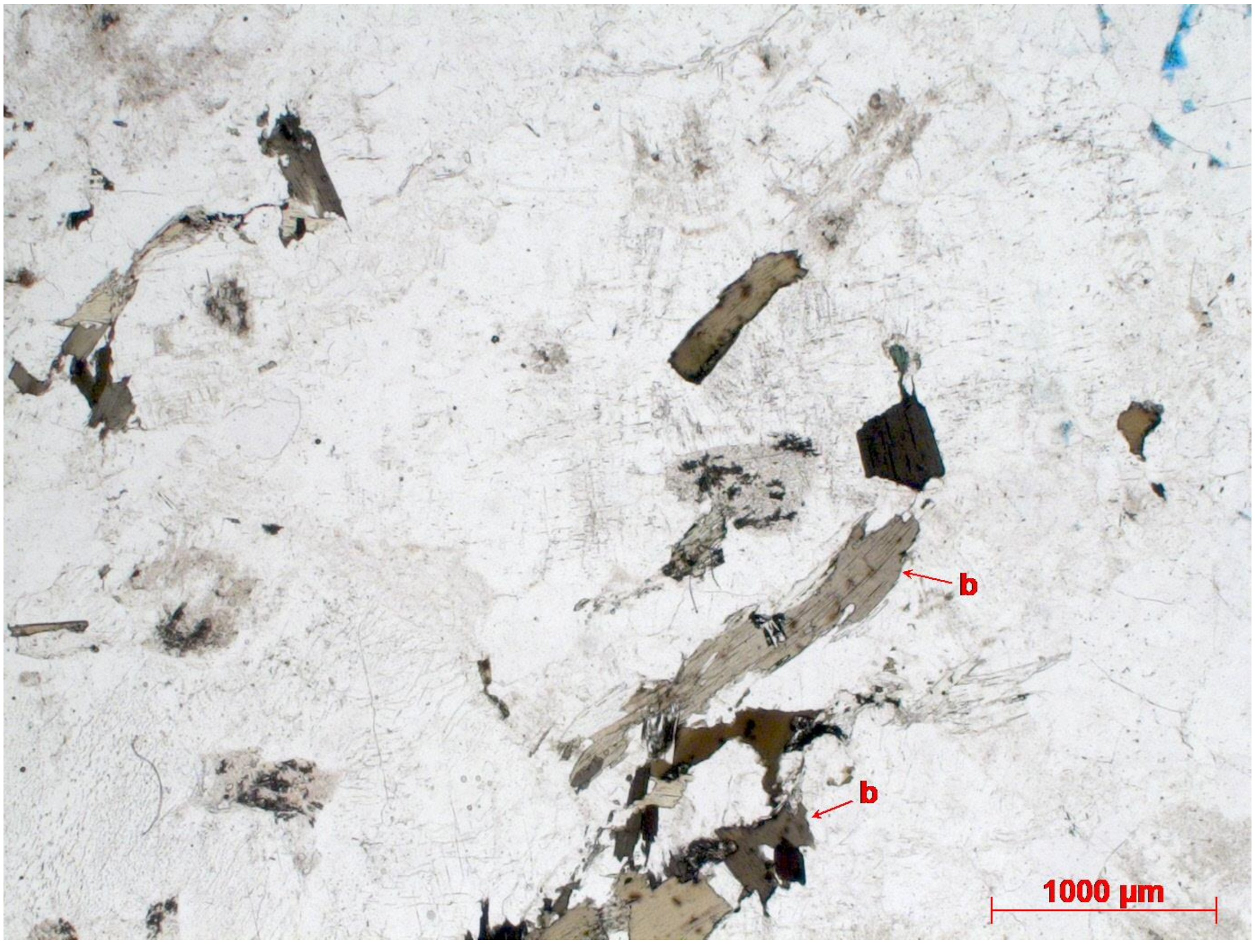
Microscopic Description: The texture in the tonalite is phaneritic with individual crystals coarse enough to be visible unaided by the human eye. Crystals measure between 1-5 mm and subdivide the texture into the medium grained category. The rock classification is determined using the QAPF classification of igneous rocks (Streckeisen, 1974; La Maitre, 2002). The mineralogy is dominated by polycrystalline quartz (45% by visual estimate; 55.6% modal), plagioclase feldspar (35% by visual estimate; 43.2% modal), biotite (12% by visual estimate), with rare microcline alkali feldspar (1% by visual estimate; 1.2% modal). Other accessories include hornblende (1%), muscovite (1%), sericite (1%), calcite (1%), olivine (1%), pyroxene (1%), and magnetite (1%). As in the alkali feldspar rock, polycrystalline quartz is the most common mineral. Quartz is colorless, shows low relief, has a frequent wavy or undulose extinction, and exhibits low, first-order white to gray interference colors under crossed-polarized light. Plagioclase feldspar is second in abundance, colorless, and exhibits first-order white interference colors, and has a unique polysynthetic twinning giving a striped appearance under cross-polarized light. Many of the

McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065

plagioclase feldspar crystals are partially altered to sericite or calcite. Biotite is the third-most common mineral in the tonalite and is light-to dark brown or green in color, pleochroic, of moderate-relief, has one excellent cleavage, and often shows mottled or bird's eye extinction under crossed-polarized light. The biotite also includes rare, low-relief apatite crystals that show small pleochroic radiation halos indicative of uranium and/or thorium in the crystal lattice. Strong interference colors range up to second-order red and pink. Olivine (Thin Section Images 25-26) is easily visible from its high-relief, and its high, second-order blue, pink, and orange interference colors.

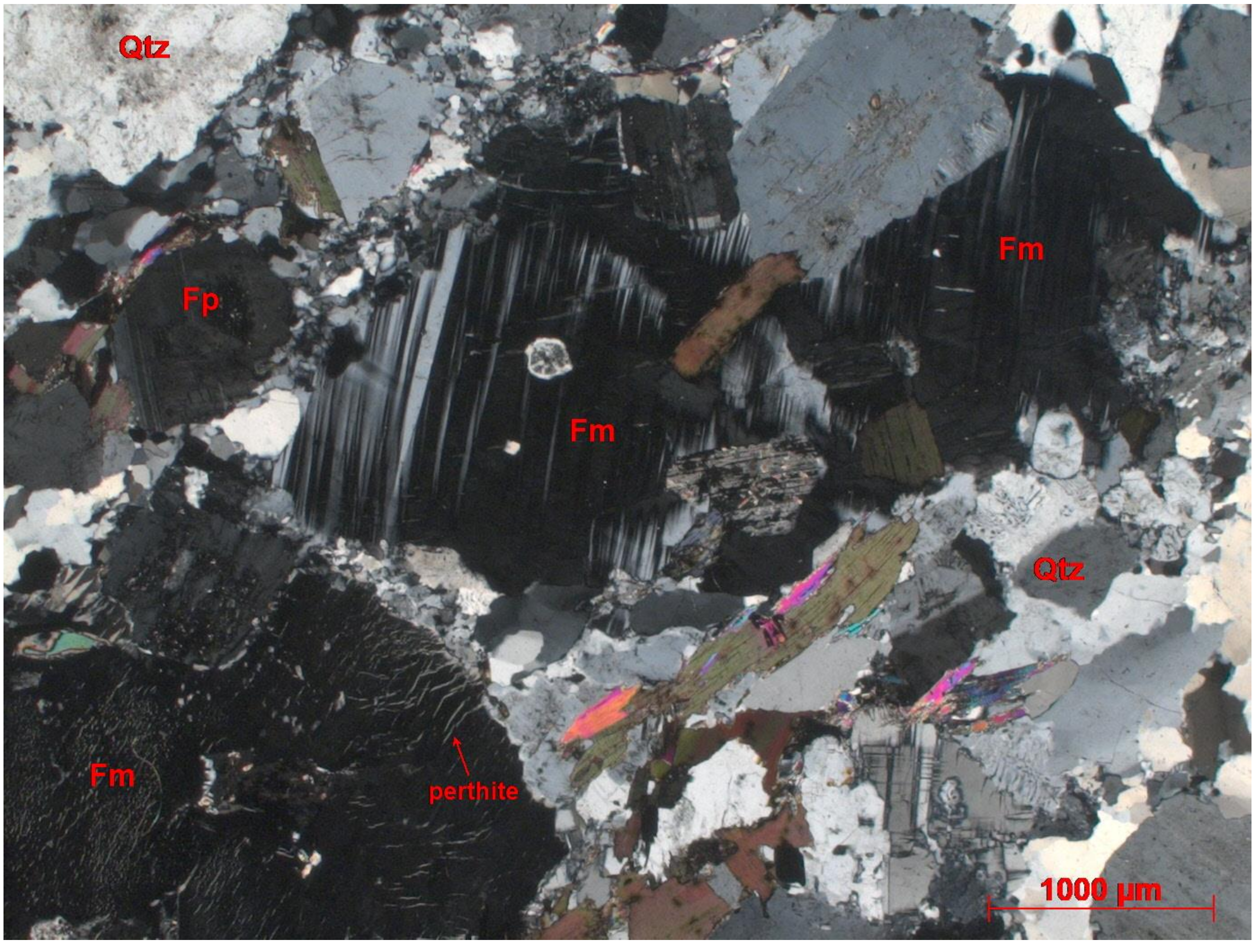
McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065

3. Thin Section Images



TH19-168_C550@27'_2_5x_ppl_001	Alkali-Feldspar Granite

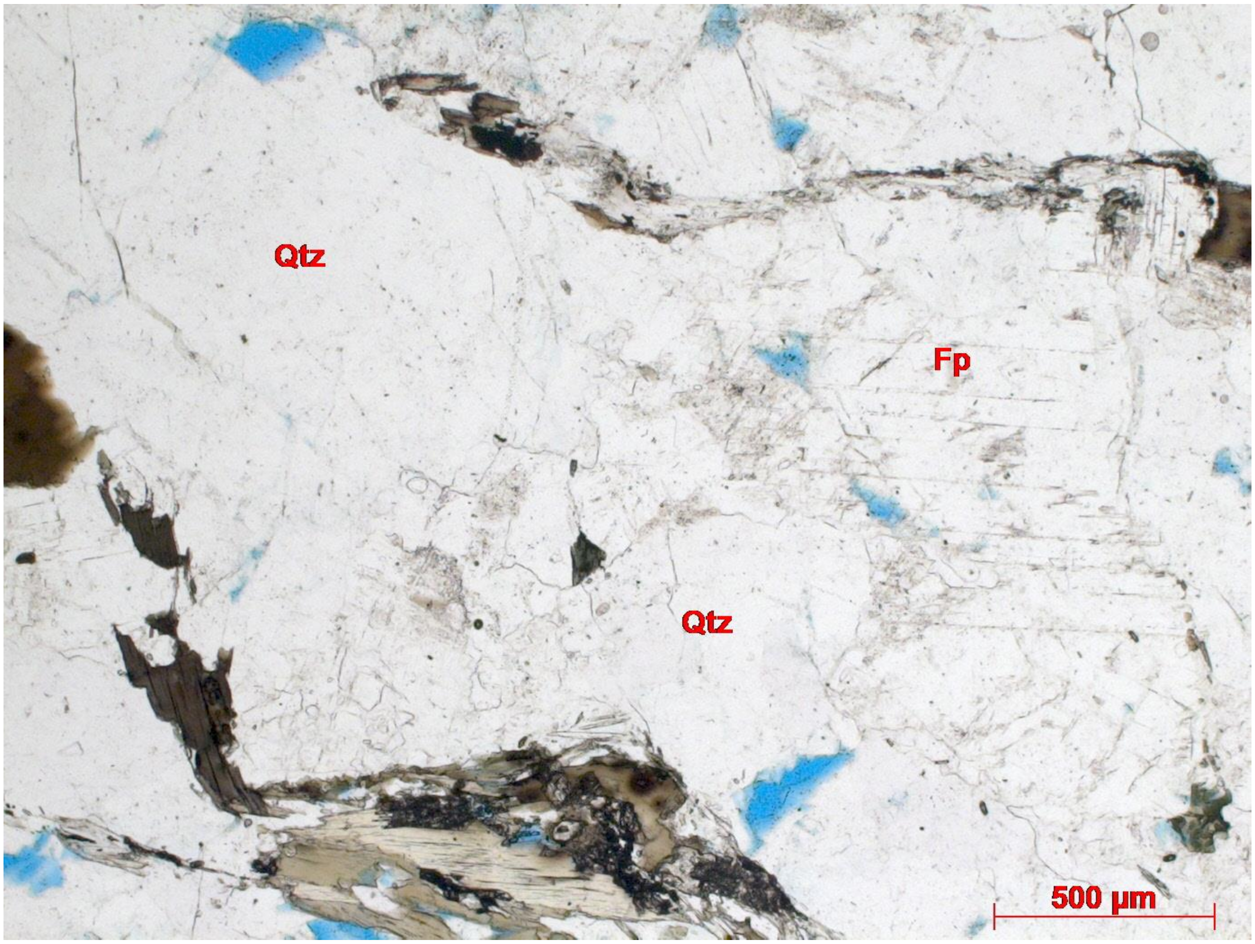
Thin Section Image 01. Alkali-Feldspar Granite taken under low magnification shows pleochroic biotite mica (b) widely scattered among coarse-grained feldspar and quartz crystals (white; low relief). Plane-polarized light. 2.5x Magnification. Field of View 5.5 mm. Scale bar = 1000 microns or 1 mm.



TH19-168_C550@27'_2_5x_xpl_002	Alkali-Feldspar Granite

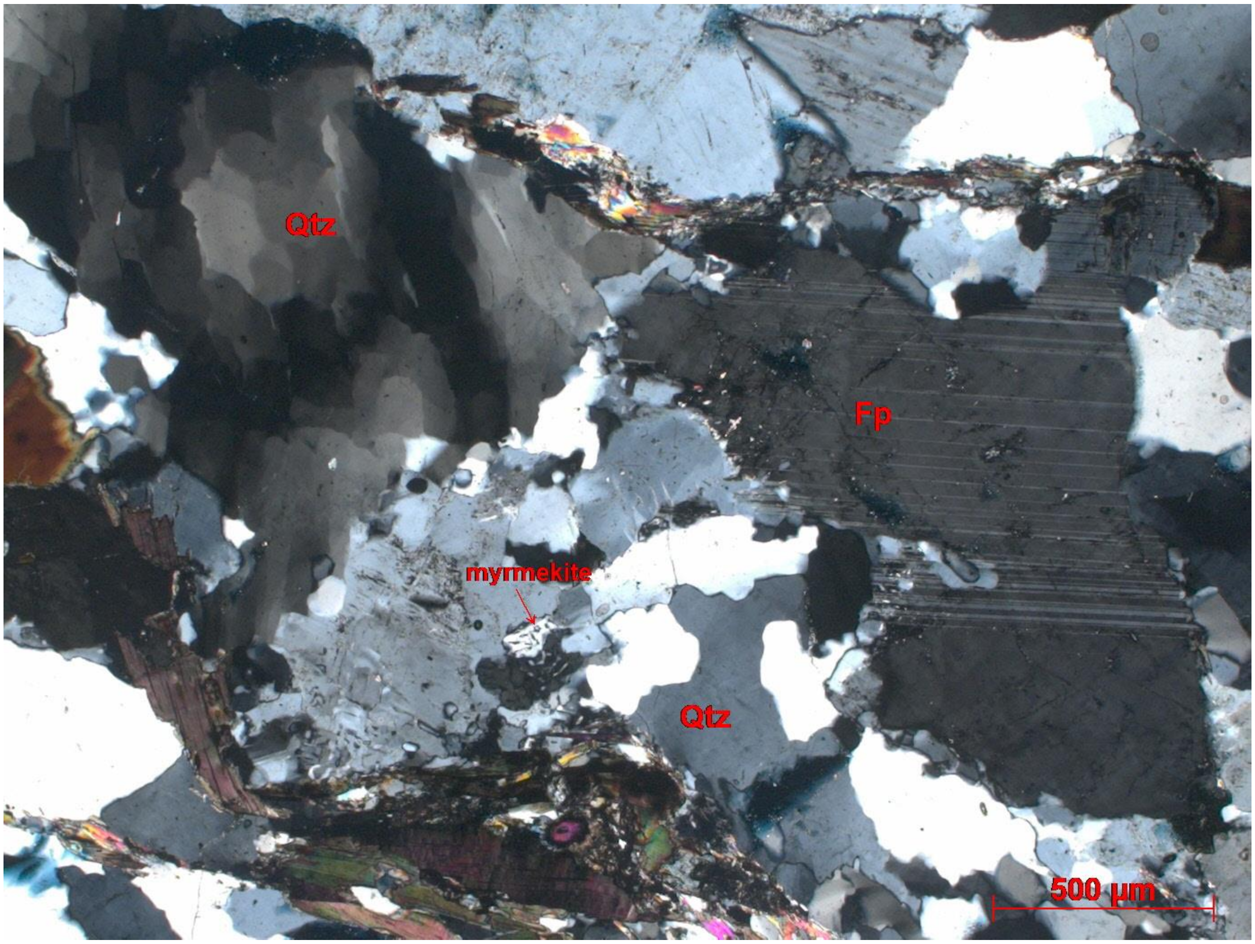
Thin Section Image 02. The same photo of the alkali-feldspar granite as TS_001 but taken under crossed polarized light illustrates crosshatch pattern of abundant K-feldspar – microcline (Fm) at various states of optical extinction. Note the worm-like perthite in the large microcline crystal at lower-left. The perthite indicates unmixing of the feldspar and exhibits sodic-plagiolcase within a potassic alkali-feldspar. Plagioclase feldspar is subordinate in abundance to alkali feldspar in the alkali-feldspar granite. Polycrystalline quartz (Qtz) is common and exhibits low first order gray to white interference colors. The biotite exhibits a wide variety of strong second-order interference colors up to pink and red. Cross-polarized light. 2.5x Magnification. Field of View 5.5 mm. Scale bar = 1000 microns or 1 mm.

McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065



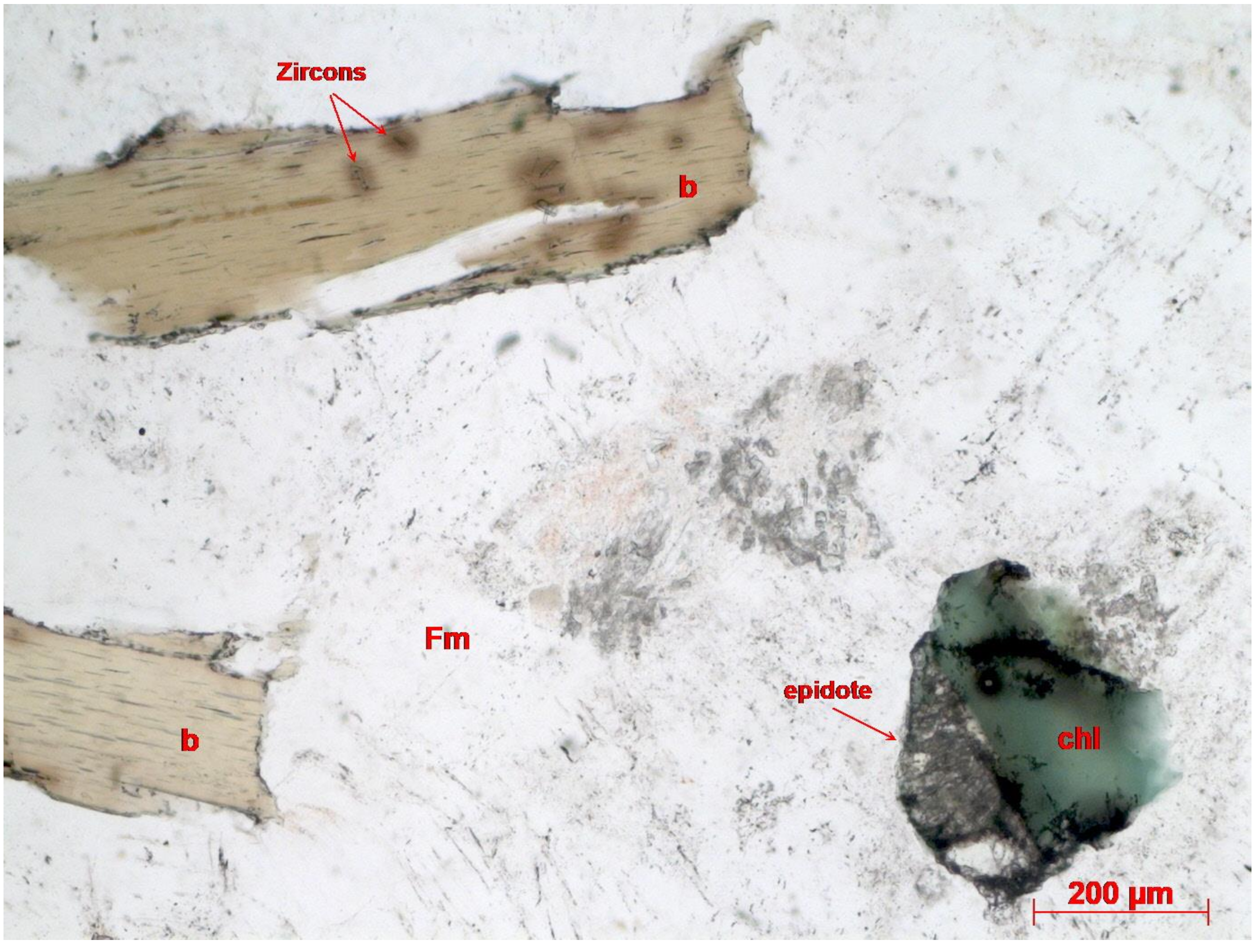
TH19-168_C550@27'_5x_ppl_003	Alkali-Feldspar Granite

Thin Section Image 03. More magnified view of the alkali-feldspar granite illustrates coarse-grained quartz crystals (Qtz) adjacent to green and brown biotite mixed with hornblende (both are pleochroic). At right is a twinned plagiolcase feldspar (Fp). Plane-polarized light. 5x Magnification. Field of View 2.82 mm. Scale bar = 500 microns or 0.5 mm.



TH19-168_C550@27'_5x_xpl_004	Alkali-Feldspar Granite

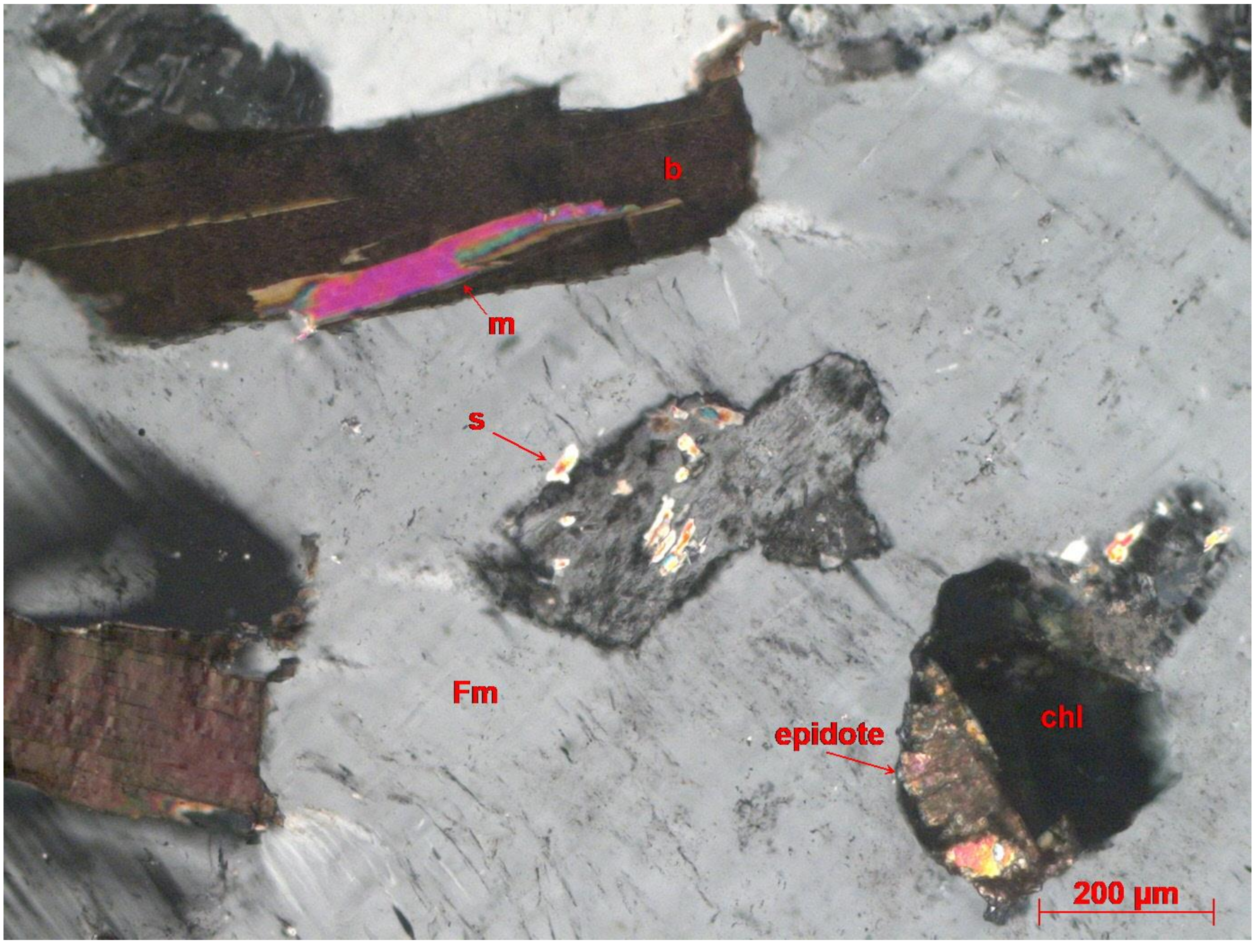
Thin Section Image 04. The same image as TS_003 but taken under crossed-polarized light better illustrates the prominence of the undulose extinction in the polycrystalline quartz (Qtz) and the polysynthetic twinning of the plagioclase feldspar (Fp). Note the small plagioclase crystal at lower-center exhibits worm-like myrmekite intergrowths of quartz. It is suggested that myrmekite occurrence is often associated with strain features in granitic rocks. The adjacent undulose extinction of the quartz crystals could also indicate tectonic strain in addition to the myrmekite formation during cooling of the magma body. Cross-polarized light. 5x Magnification. Field of View 2.82 mm. Scale bar = 500 microns or 0.5 mm.



TH19-168_C550@27'_10x_ppl_005	Alkali-Feldspar Granite

Thin Section Image 05. Greater magnification view of the alkali-feldspar granite exhibits smaller crystals of biotite (b) and a rare epidote (high-relief) hosted by a larger microcline variation of alkali-feldspar (Fm; white, low-relief). Note the small zircons hosted by the biotite. They, in turn, show pleochroic radiation halos likely from uranium or thorium in the crystal. Note the epidote is almost entirely altered to green chlorite (chl). Plane-polarized light. 10x Magnification. Field of View 1.46 mm. Scale bar = 200 microns or 0.2 mm.

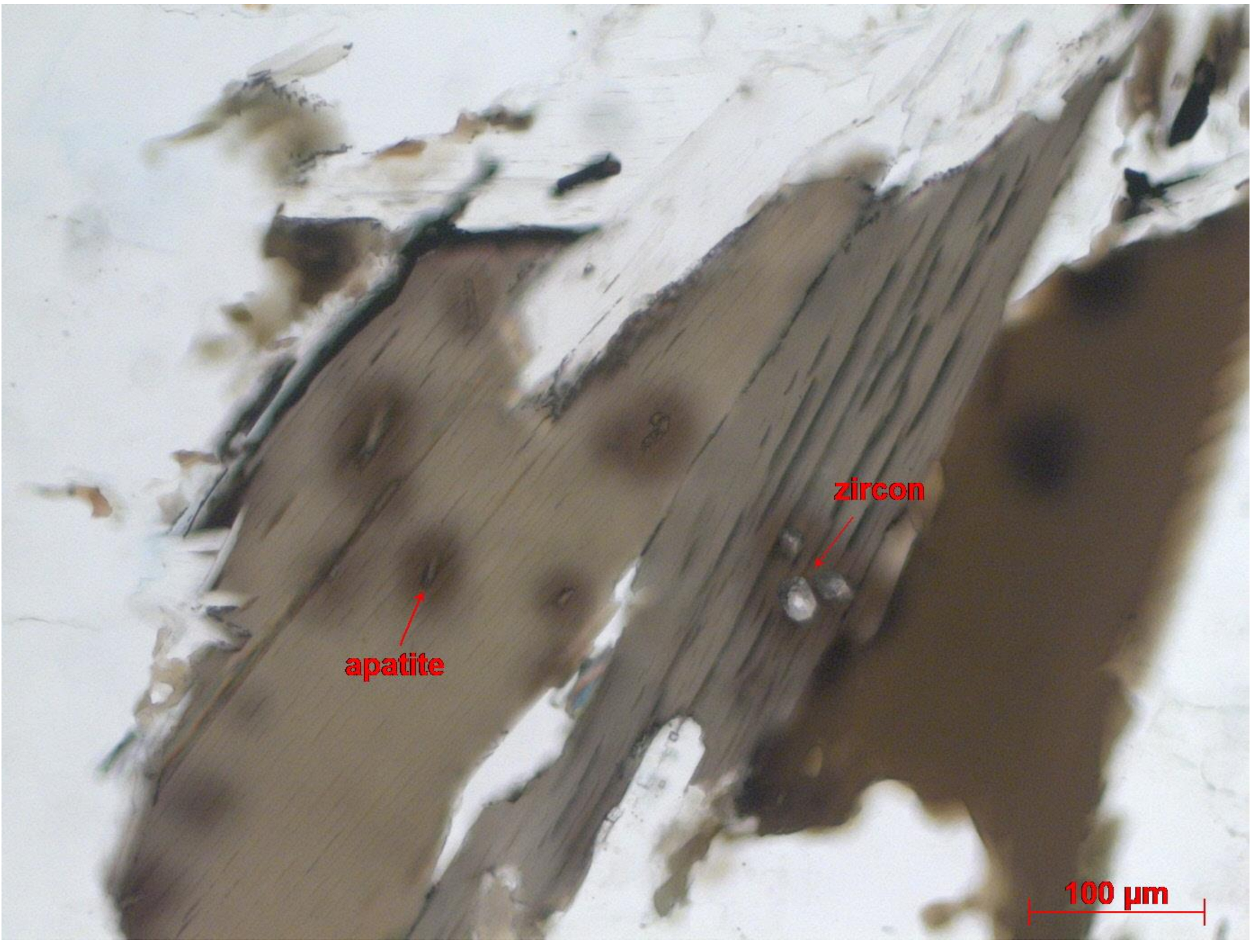
McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065



TH19-168_C550@27'_10x_xpl_006	Alkali-Feldspar Granite

Thin Section Image 06. The same view as in TS_005 but taken under crossed-polarized light to emphasize the birds-eye extinction of the biotite and the upper third-order interference colors of the epidote that is partially altered to chlorite. A low-relief muscovite mica (m) overlaps the biotite at top. At center is a plagiolcase feldspar inclusion that is partially altered to bright sericite (s). All these smaller mineral crystals are enclosed in a larger microcline alkali-feldspar (Fm). Cross-polarized light. 10x Magnification. Field of View 1.46 mm. Scale bar = 200 microns or 0.2 mm.

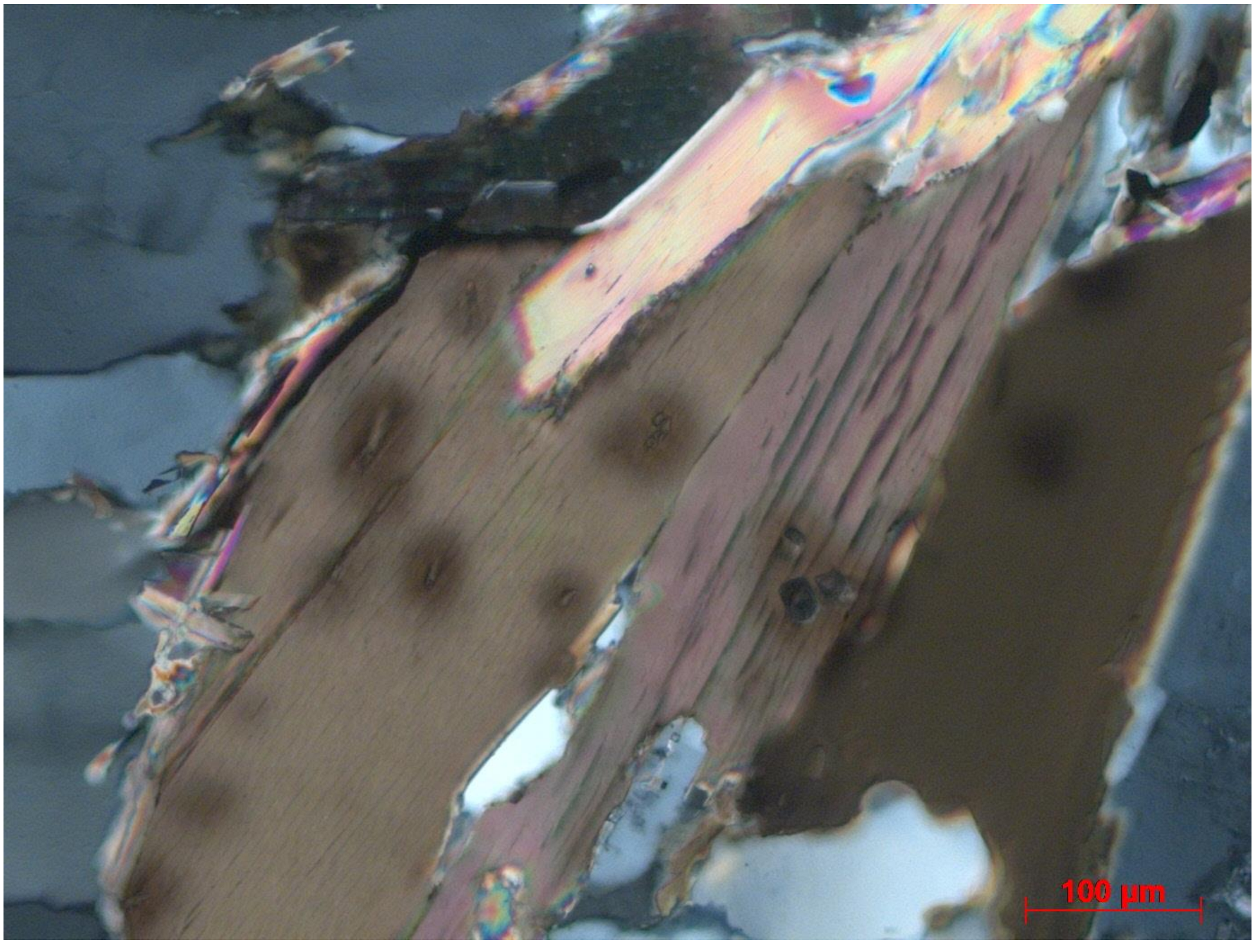
McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065



TH19-168_C550@27'_20x_ppl_007	Alkali-Feldspar Granite

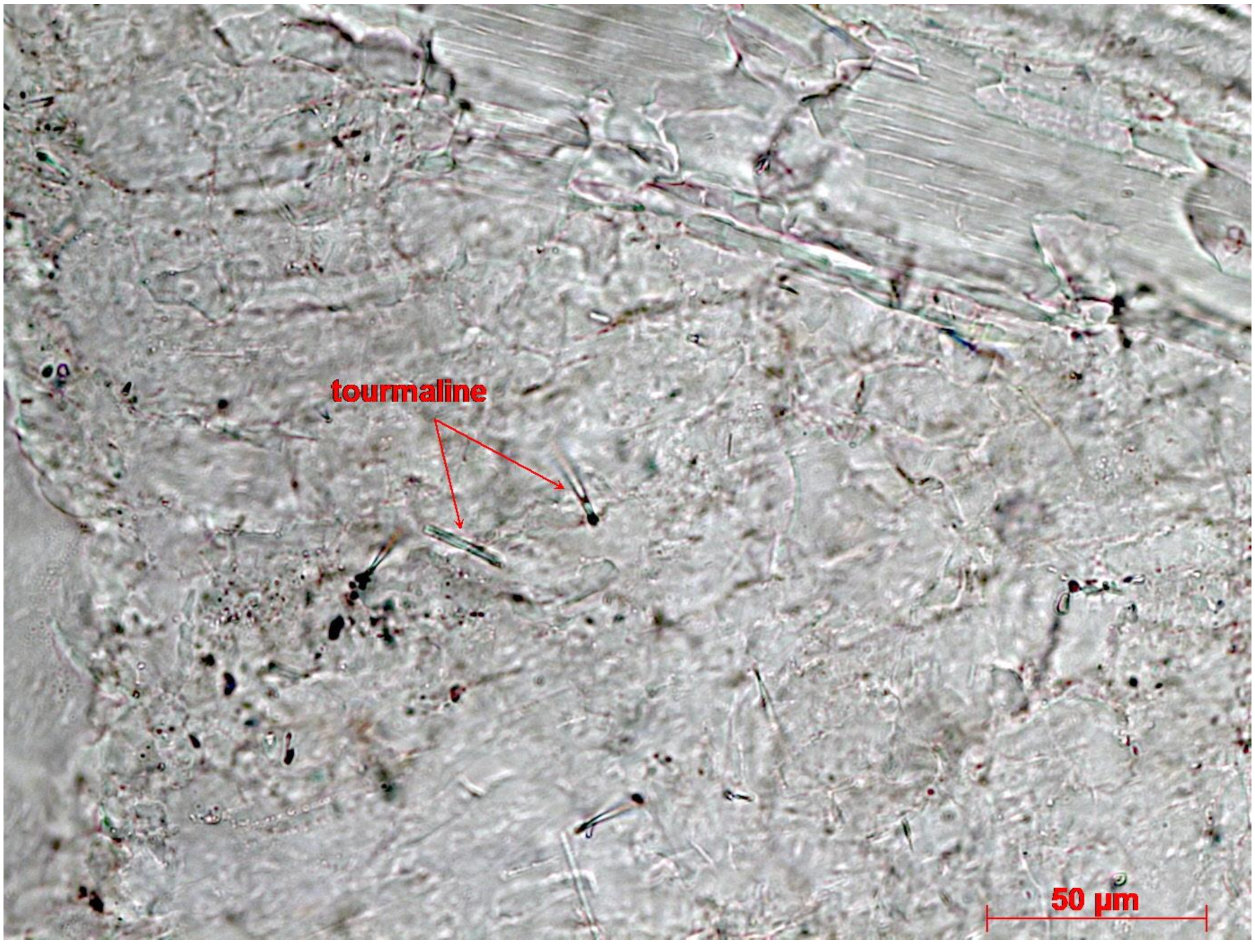
Thin Section Image 07. Detailed view of the alkali-feldspar granite emphasizes a pleochroic biotite crystal that is medium-to-dark brown and hosts smaller crystals of zircons and apatite crystals. Note the zircons have high relief, whereas the apatite crystals are lower in relief. Both exhibit dark radiation halos indicative of uranium and/or thorium in the crystal lattice. Plane-polarized light. 20x Magnification. Field of View 0.72 mm. Scale bar = 100 microns or 0.1 mm.

McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065



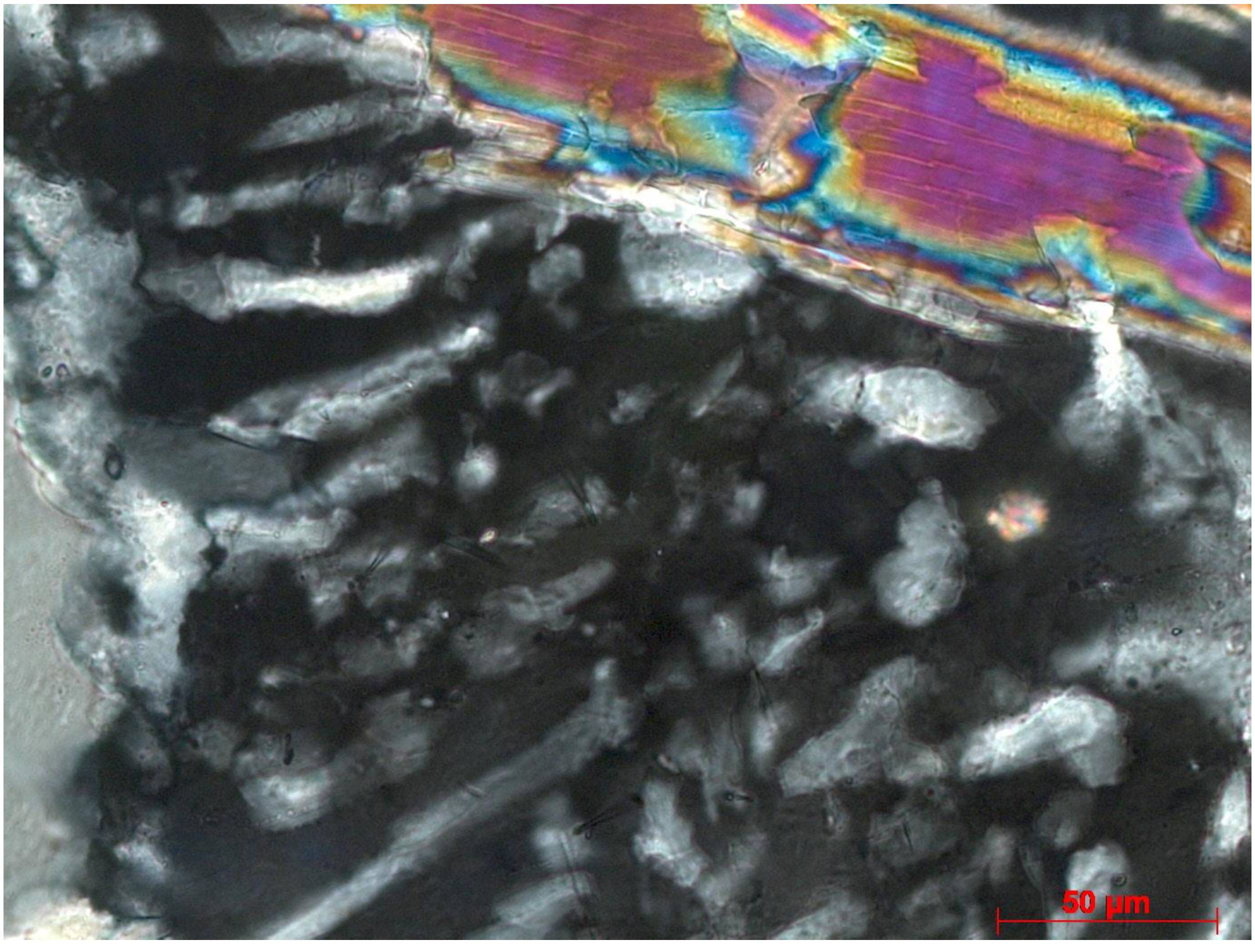
TH19-168_C550@27'_20x_xpl_008	Alkali-Feldspar Granite

Thin Section Image 08. The same view of TS_007 but under crossed-polarized light illustrates the strong interference colors of the brown biotite that range up to second-order pink and red. Crossed-polarized light. 20x Magnification. Field of View 0.72 mm. Scale bar = 100 microns or 0.1 mm.



TH19-168_C550@27'_50x_ppl_009	Alkali-Feldspar Granite

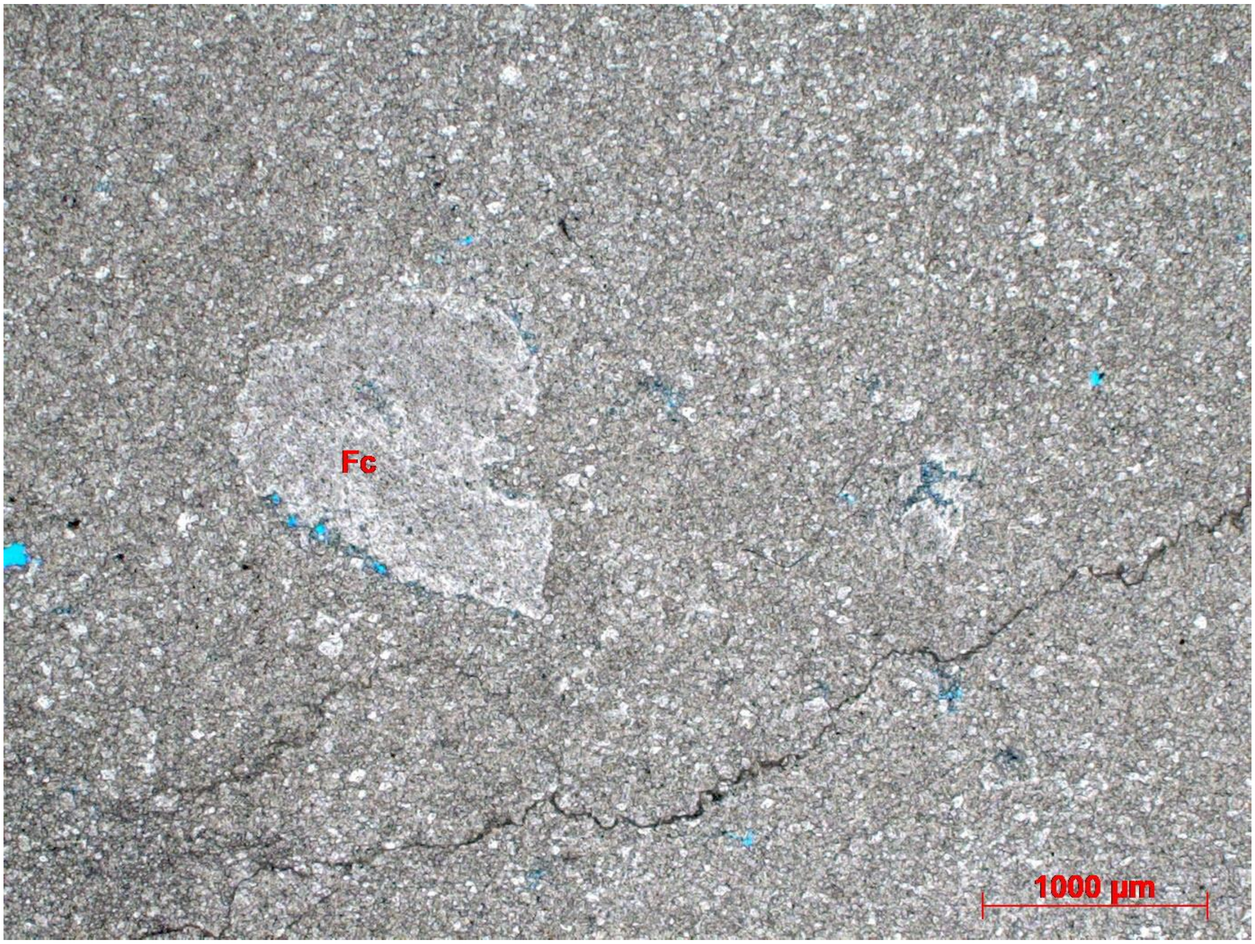
Thin Section Image 09. Highest magnification view of the alkali-feldspar granite exhibits prismatic green tourmaline crystals that are hosted by a plagiolcase feldspar crystal with associated myrmekite intergrowths of quartz. Plane-polarized light. 50x Magnification. Field of View 0.28 mm. Scale bar = 50 microns or 0.05 mm.



TH19-168_C550@27'_50x_xpl_010	Alkali-Feldspar Granite

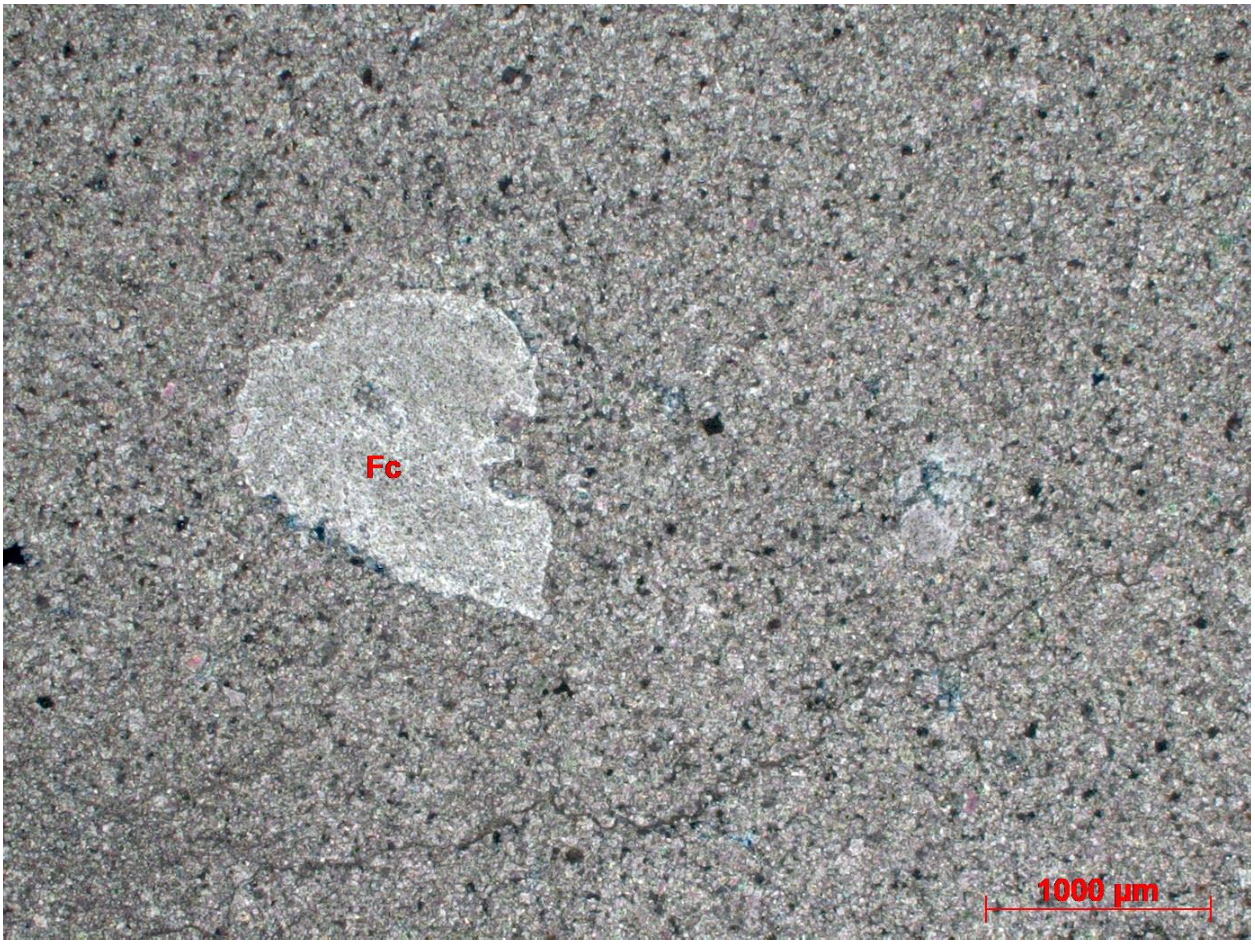
Thin Section Image 10. The same image as TS_009 but under crossed-polarized light exhibits the worm-like myrmekite of quartz intergrowths (white) against the host plagiolcase feldspar (currently optically extinct). Note the muscovite mica at top that exhibits bright second order interference colors of blue, green, yellow, and red. Cross-polarized light. 50x Magnification. Field of View 0.28 mm. Scale bar = 50 microns or 0.05 mm.

McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065



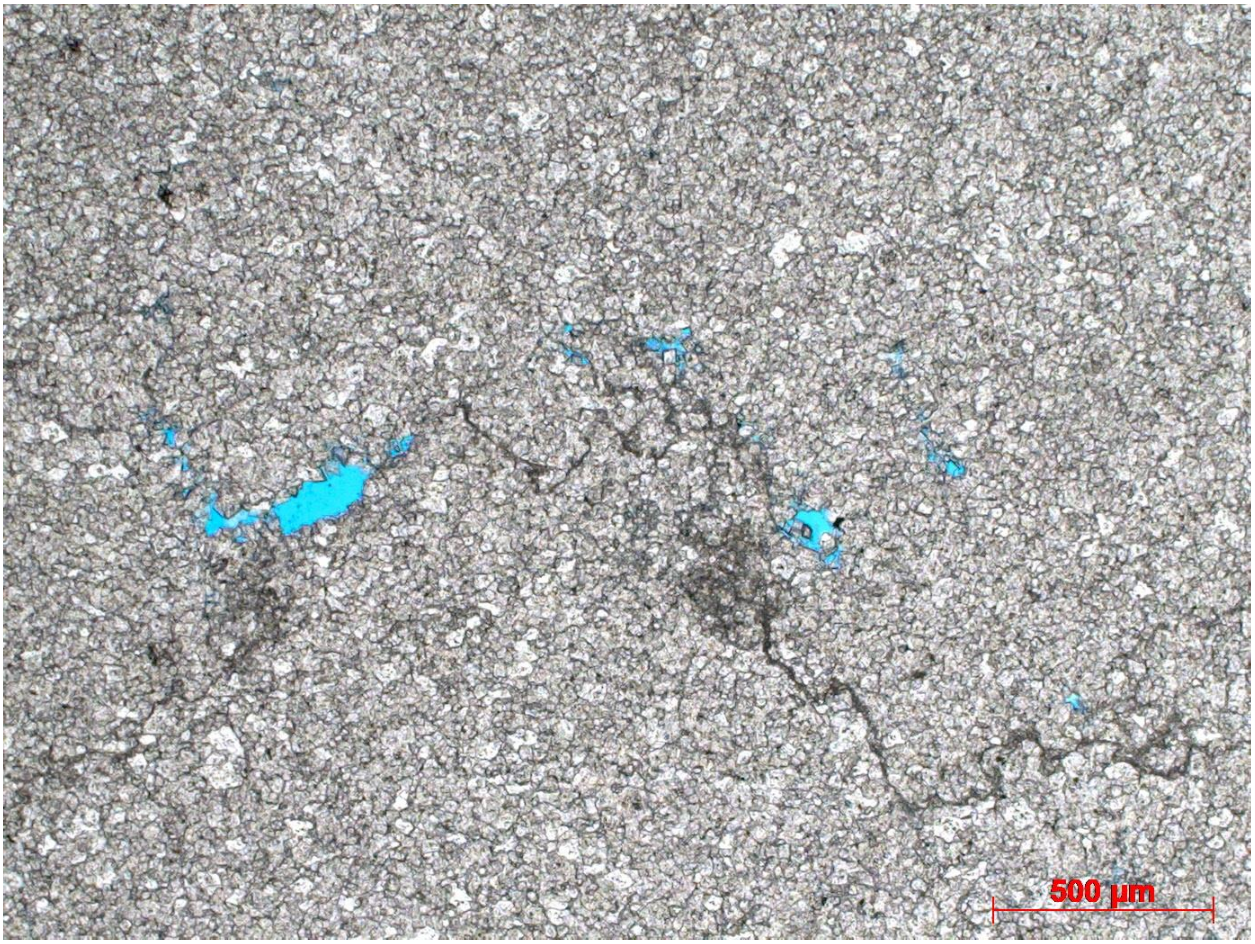
TH19-173_C518@26'_2_5x_ppl_011	Limestone (Crystalline Carbonate/Sparstone)

Thin Section Image 11. General overview of a limestone. Depending upon the classification scheme, this rock can be classified as a crystalline carbonate (Dunham, 1962) or as a sparstone (Write, 1992). The matrix is composed of interlocking calcite crystals that range in size from 15-30 microns (finely crystalline). A minor amount of calcareous shell fragments includes broken pieces of crinoid plates (Fc). At bottom are thin black stringers that are interpreted to be insoluble bitumen or some form or organic matter and not stylolites. Plane-polarized light. 2.5x Magnification. Field of View 5.5 mm. Scale bar = 1000 microns or 1 mm.



TH19-173_C518@26'_2_5x_xpl_012	Limestone (Crystalline Carbonate/Sparstone)

Thin Section Image 12. The same image as in TS_011 but under crossed-polarized light illustrates abundant interlocking calcite crystals, the crinoid plate fragment (Fc), and the organic stringers at the bottom of the image. Cross-polarized light. 2.5x Magnification. Field of View 5.5 mm. Scale bar = 1000 microns or 1 mm.



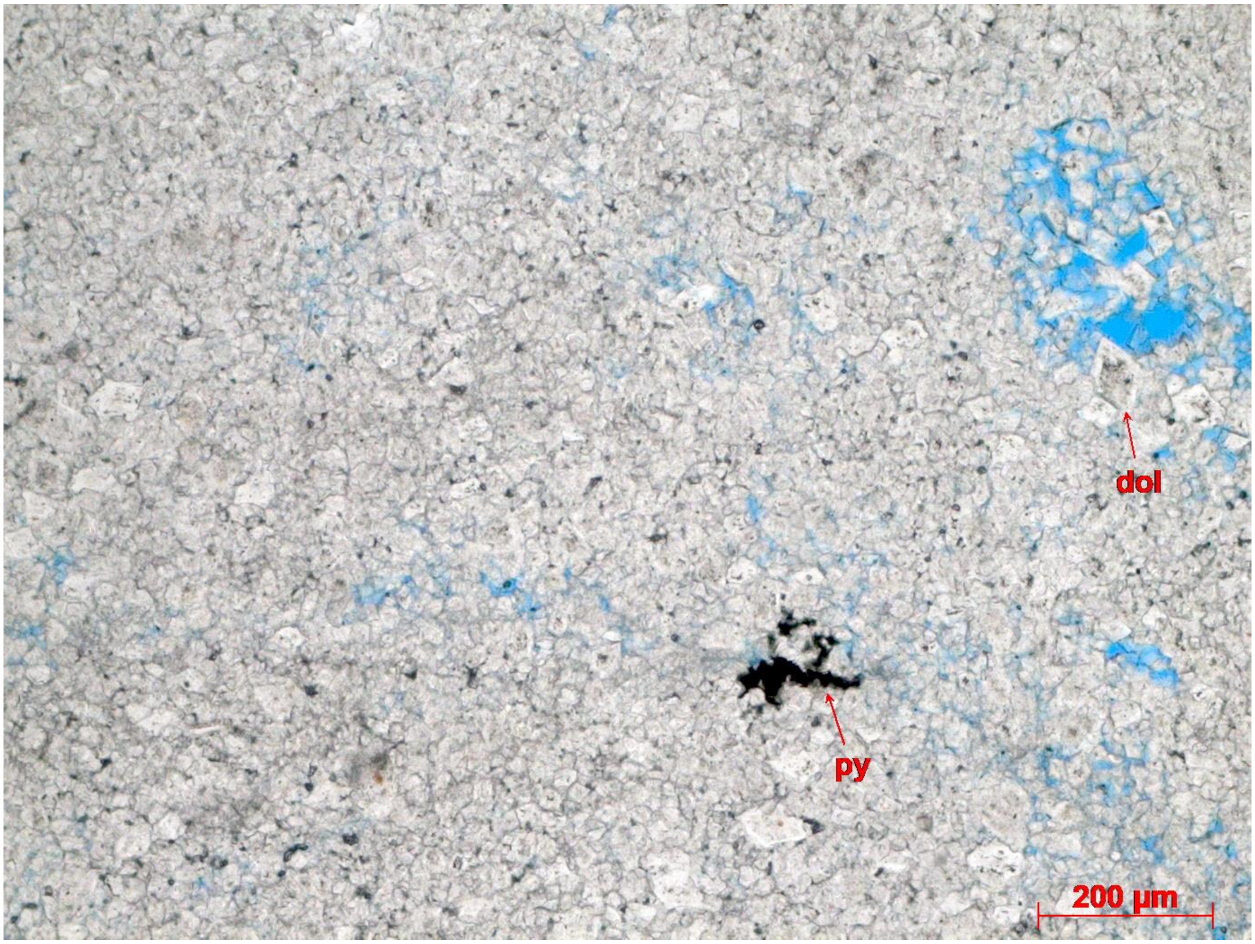
TH19-173_C518@26'_5x_ppl_013	Limestone (Crystalline Carbonate/Sparstone)

Thin Section Image 13. Greater magnification of the limestone shows sparry calcite cement crystals that are finely crystalline that are cemented together into an interlocking matrix. Note the porous vugs that show the blue dye added to the thin section epoxy. At center and lower right are more of the organic stringers mentioned previously. Plane-polarized light. 5x Magnification. Field of View 2.82 mm. Scale bar = 500 microns or 0.5 mm.

McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065

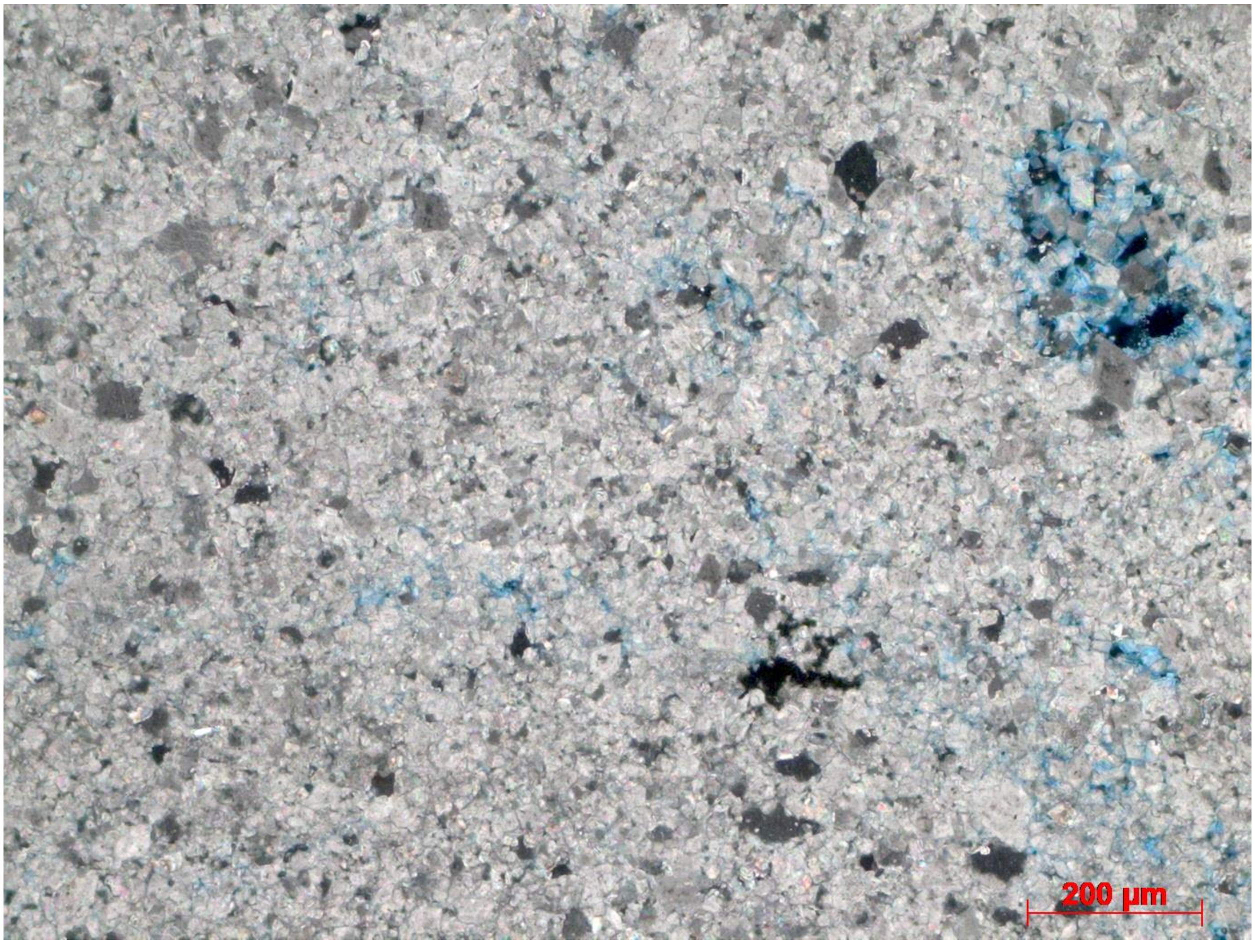
TH19-173_C518@26'_5x_xpl_014	Limestone (Crystalline Carbonate/Sparstone)

Thin Section Image 14. The same view as in TS_013 but under crossed-polarized light better illustrates the high order, white-edged interference colors of calcite. The vuggy areas will appear isotropic from the background glass slide. Cross-polarized light. 5x Magnification. Field of View 2.82 mm. Scale bar = 500 microns or 0.5 mm.



TH19-173_C518@26'_10x_ppl_015	Limestone (Crystalline Carbonate/Sparstone)

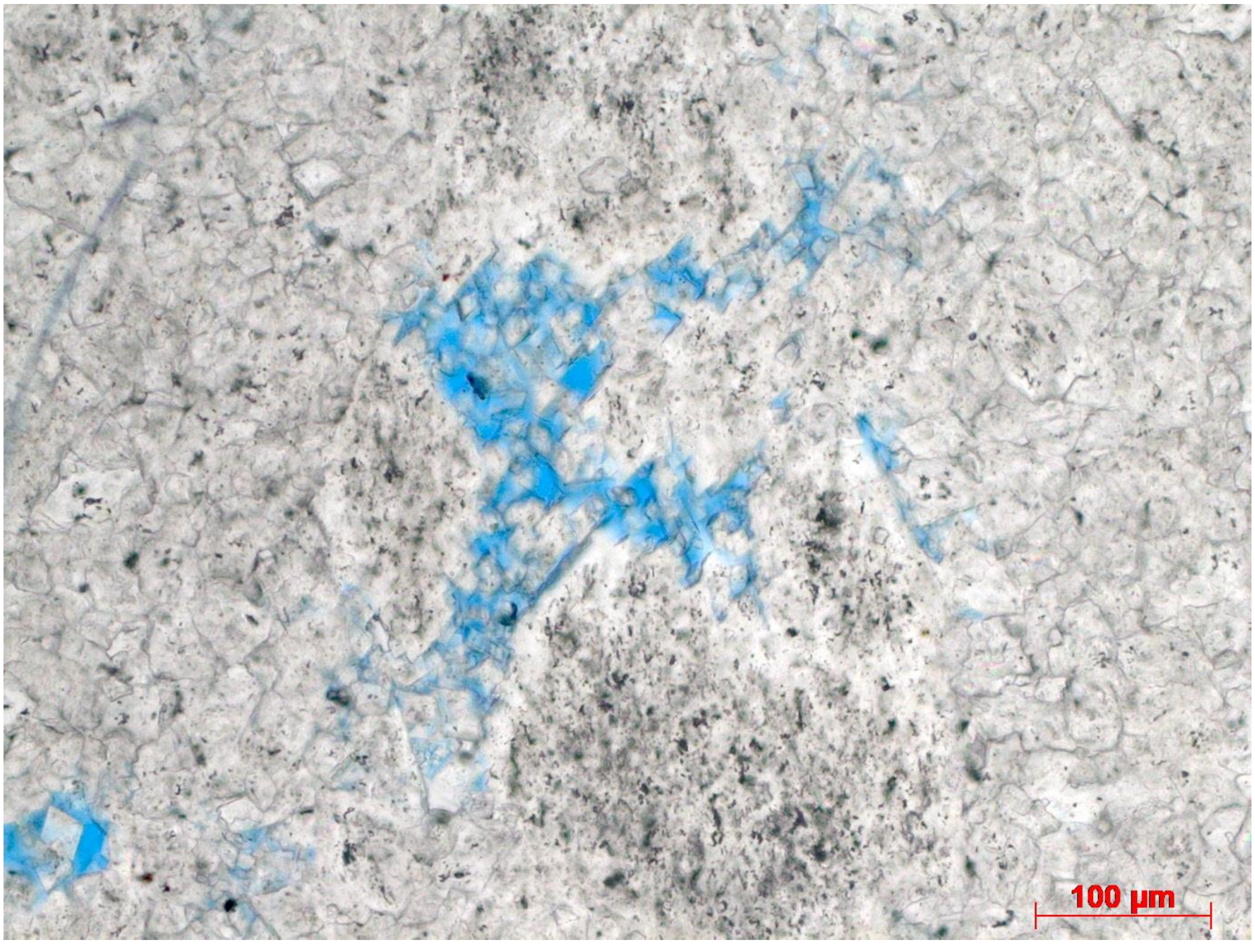
Thin Section Image 15. Higher magnification of the limestone shows the matrix of interlocking sparry calcite that hosts minor minerals such as opaque pyrite (py) and zoned dolomite rhombohedral crystals (dol). Plane-polarized light. 10x Magnification. Field of View 1.46 mm. Scale bar = 200 microns or 0.2 mm.



TH19-173_C518@26'_10x_xpl_016	Limestone (Crystalline Carbonate/Sparstone)

Thin Section Image 16. The same view as TS_015 but under crossed-polarized light better illustrates the high-order interference colors, the variable relief, and the rhombohedral cleavage of the calcite. Cross-polarized light. 10x Magnification. Field of View 1.46 mm. Scale bar = 200 microns or 0.2 mm.

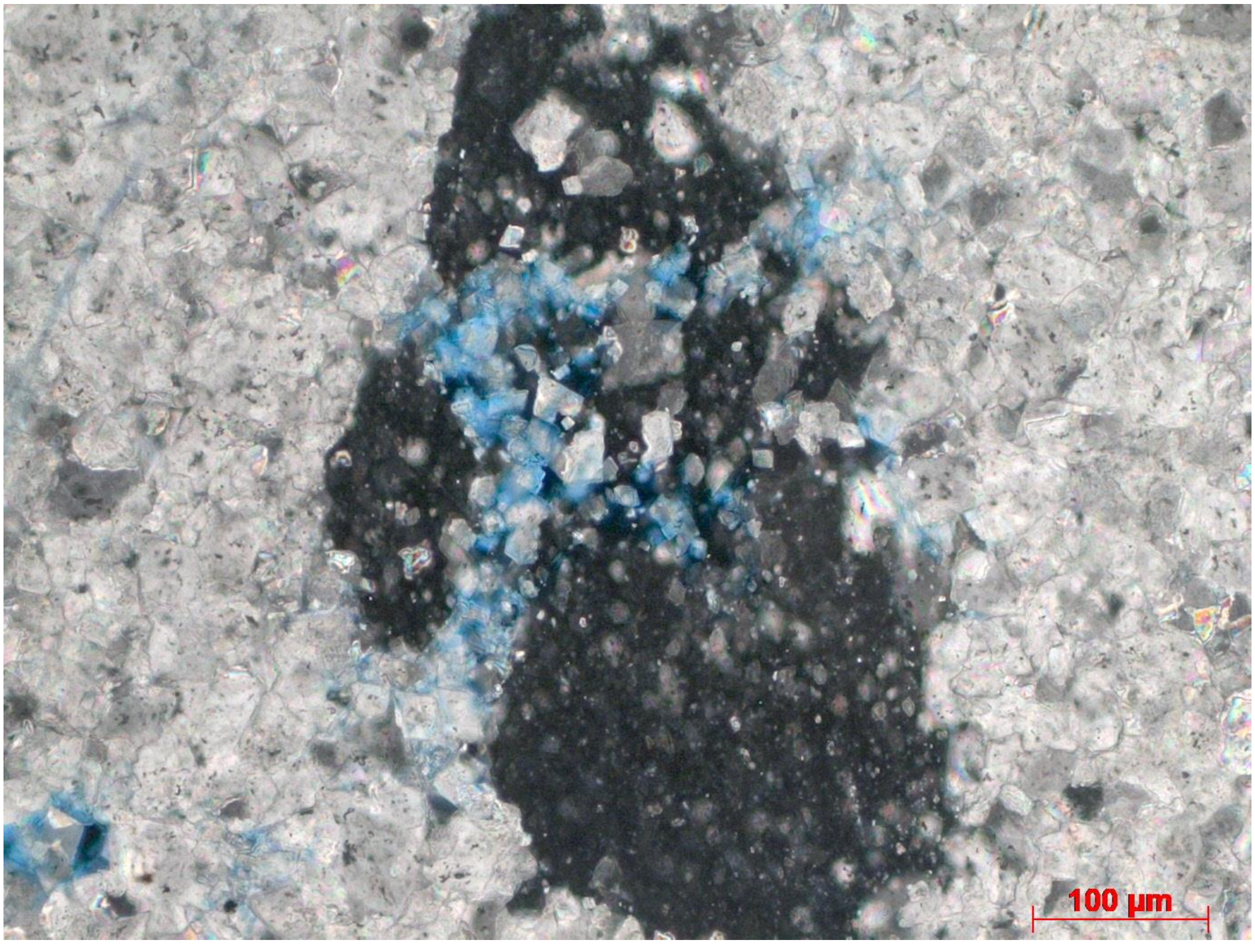
McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065



TH19-173_C518@26'_20x_ppl_017	Limestone (Crystalline Carbonate/Sparstone)

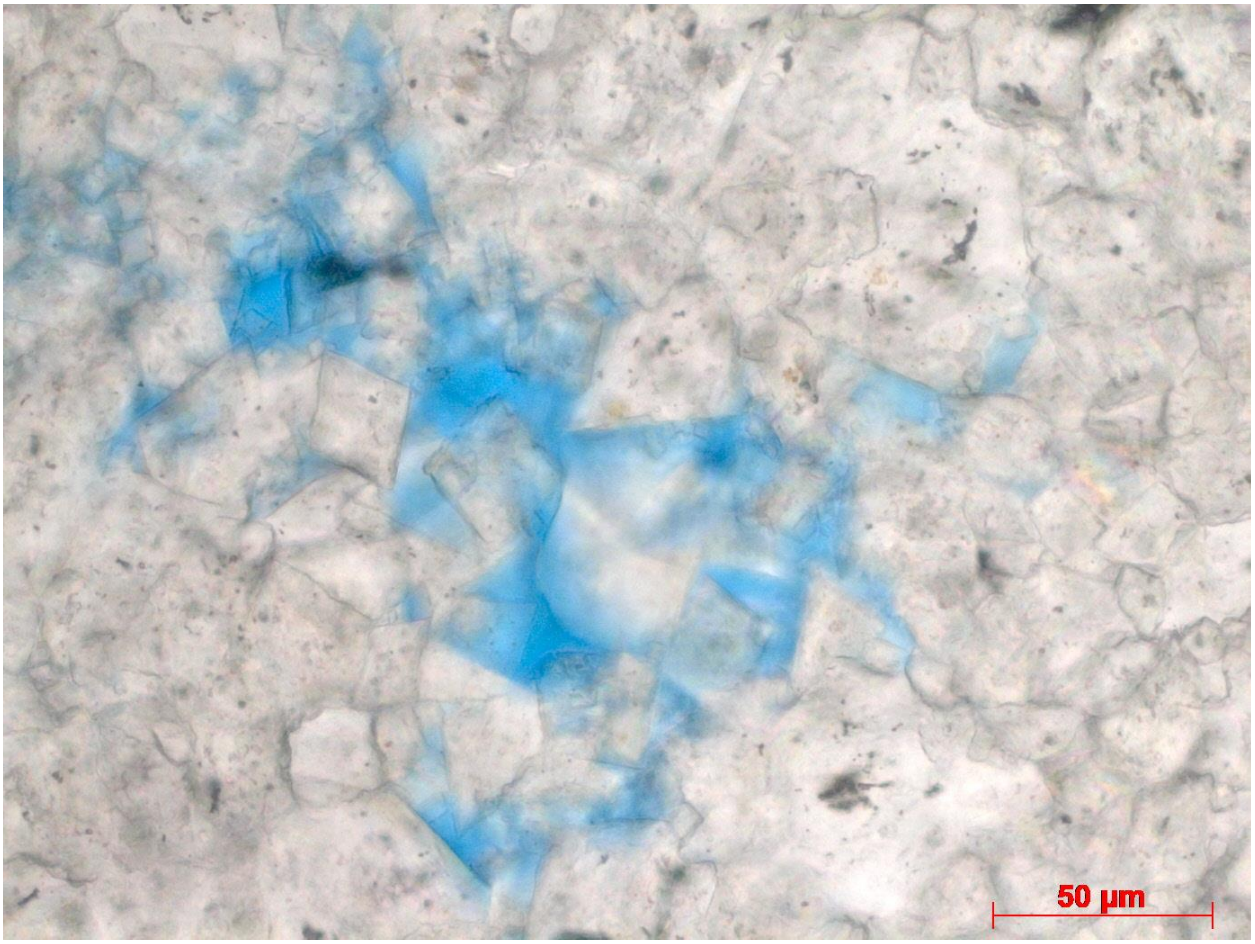
Thin Section Image 17. Closer inspection of the limestone centers upon a partially dissolved fossil fragment or rip-up class that exhibits intraparticle porosity as shown from the partially dissolved rhombohedral crystal shapes and blue-dye background. Plane-polarized light. 20x Magnification. Field of View 0.72 mm. Scale bar = 100 microns or 0.1 mm.

McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065



TH19-173_C518@26'_20x_xpl_018	Limestone (Crystalline Carbonate/Sparstone)

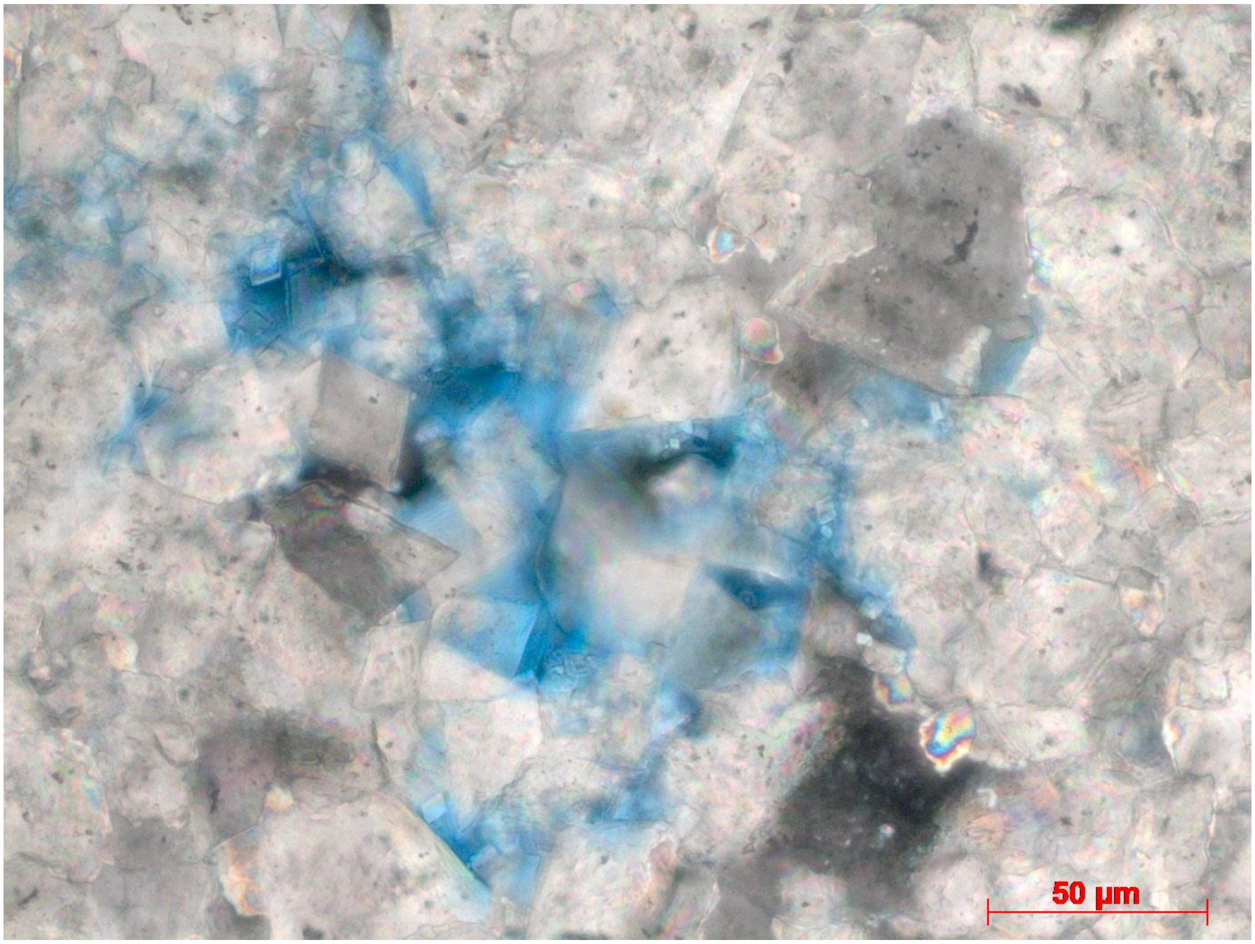
Thin Section Image 18. The same view as in TS_017 but under crossed-polarized light better illustrates the unit extinction of the unidentified fragment, possible a crinoid plate. Note the finely crystalline calcite crystals that appear in front of the crinoid plate in the third dimension and are smaller than the 30-micron thickness of the slide. Cross-polarized light. 20x Magnification. Field of View 0.72 mm. Scale bar = 100 microns or 0.1 mm.



TH19-173_C518@26'_50x_ppl_019	Limestone (Crystalline Carbonate/Sparstone)

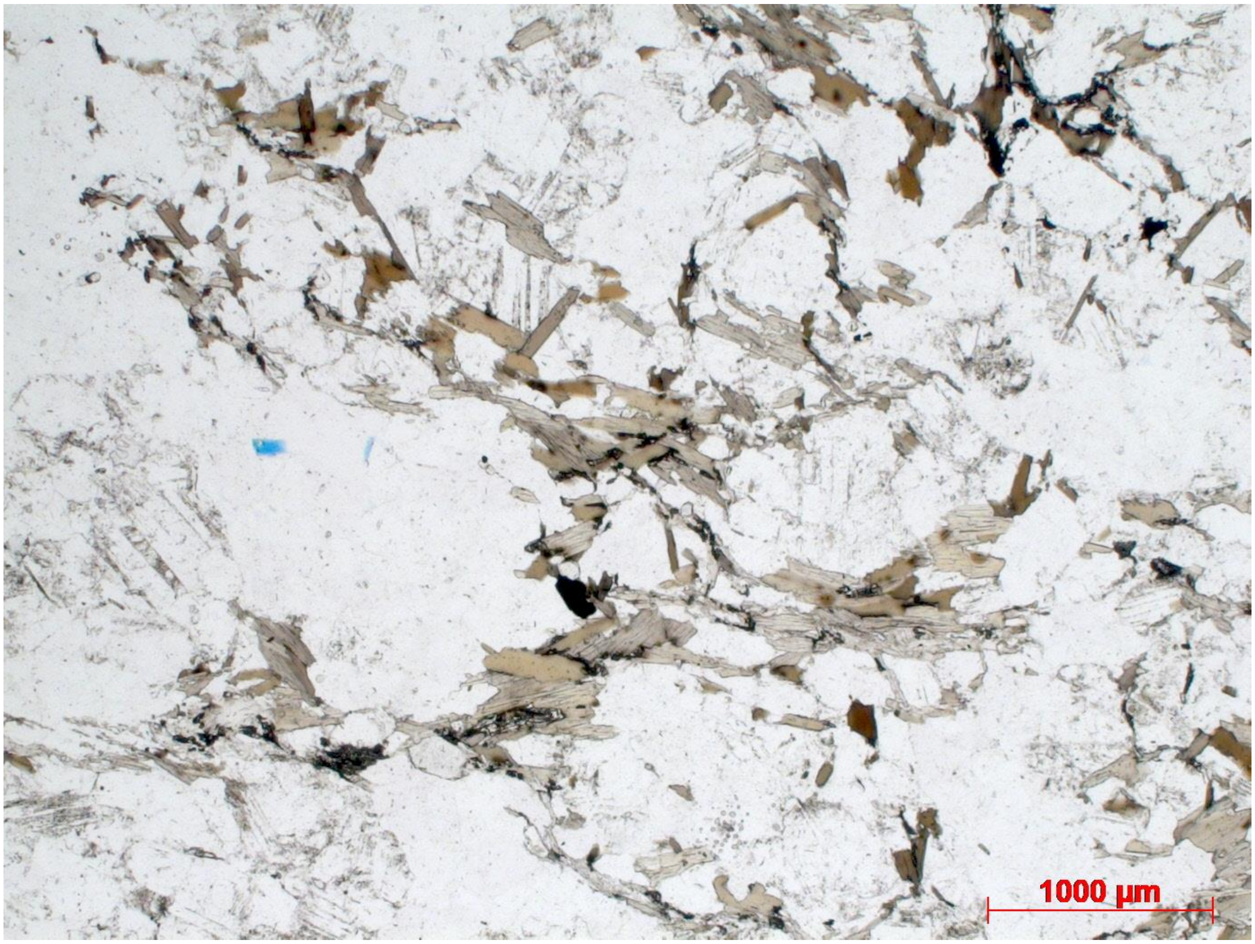
Thin Section Image 19. Highest magnification detail of the limestone focusses on a vuggy intercrystalline pore space between sharp, euhedral crystals of sparry calcite. Plane-polarized light. 50x Magnification. Field of View 0.28 mm. Scale bar = 50 microns or 0.05 mm.

McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065



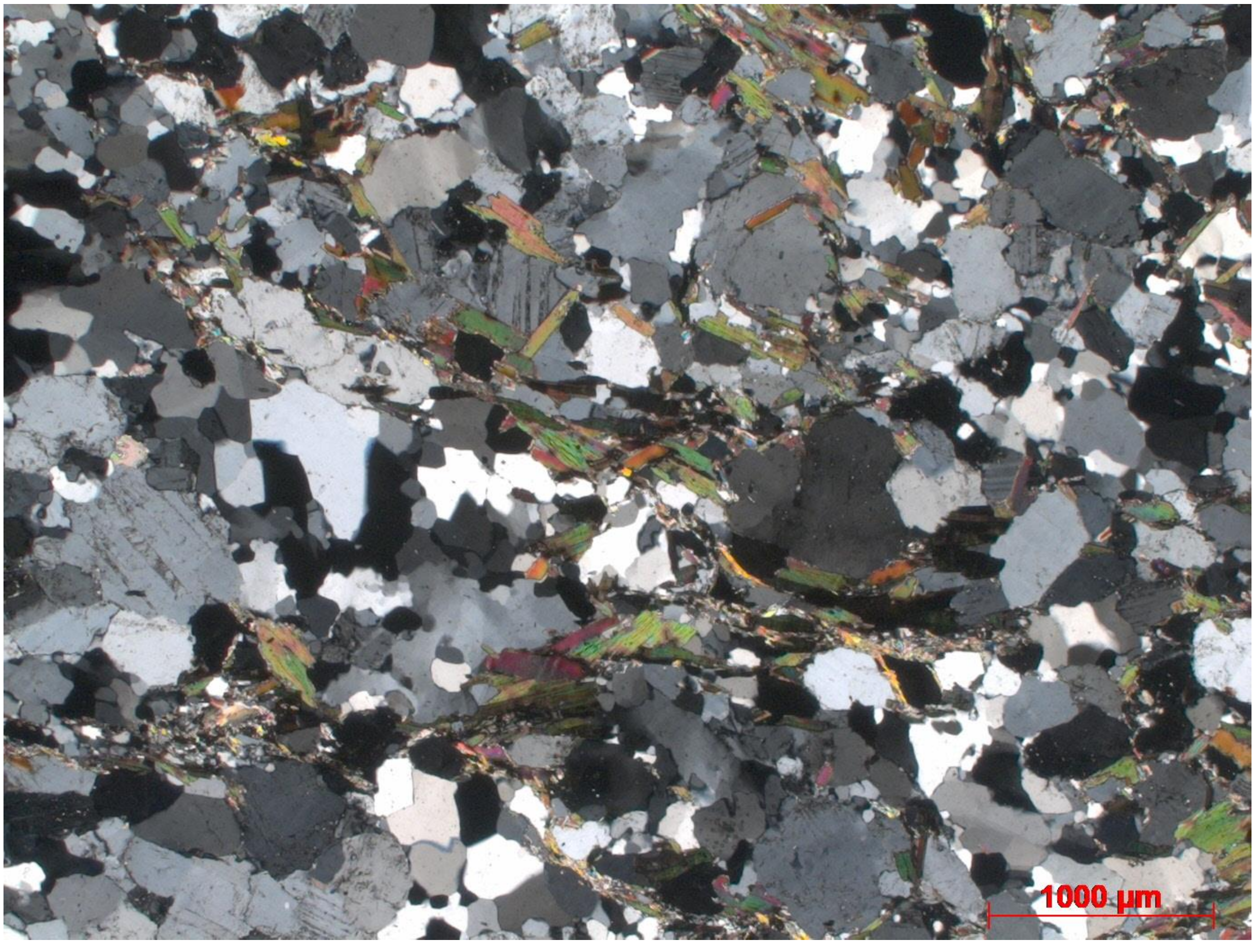
TH19-173_C518@26'_50x_xpl_020	Limestone (Crystalline Carbonate/Sparstone)

Thin Section Image 20. The same view as TS_019 under crossed-polarized light illustrates the extreme birefringence, rhombohedral cleavage, and high-order interference colors of the calcite crystals. Cross-polarized light. 50x Magnification. Field of View 0.28 mm. Scale bar = 50 microns or 0.05 mm.



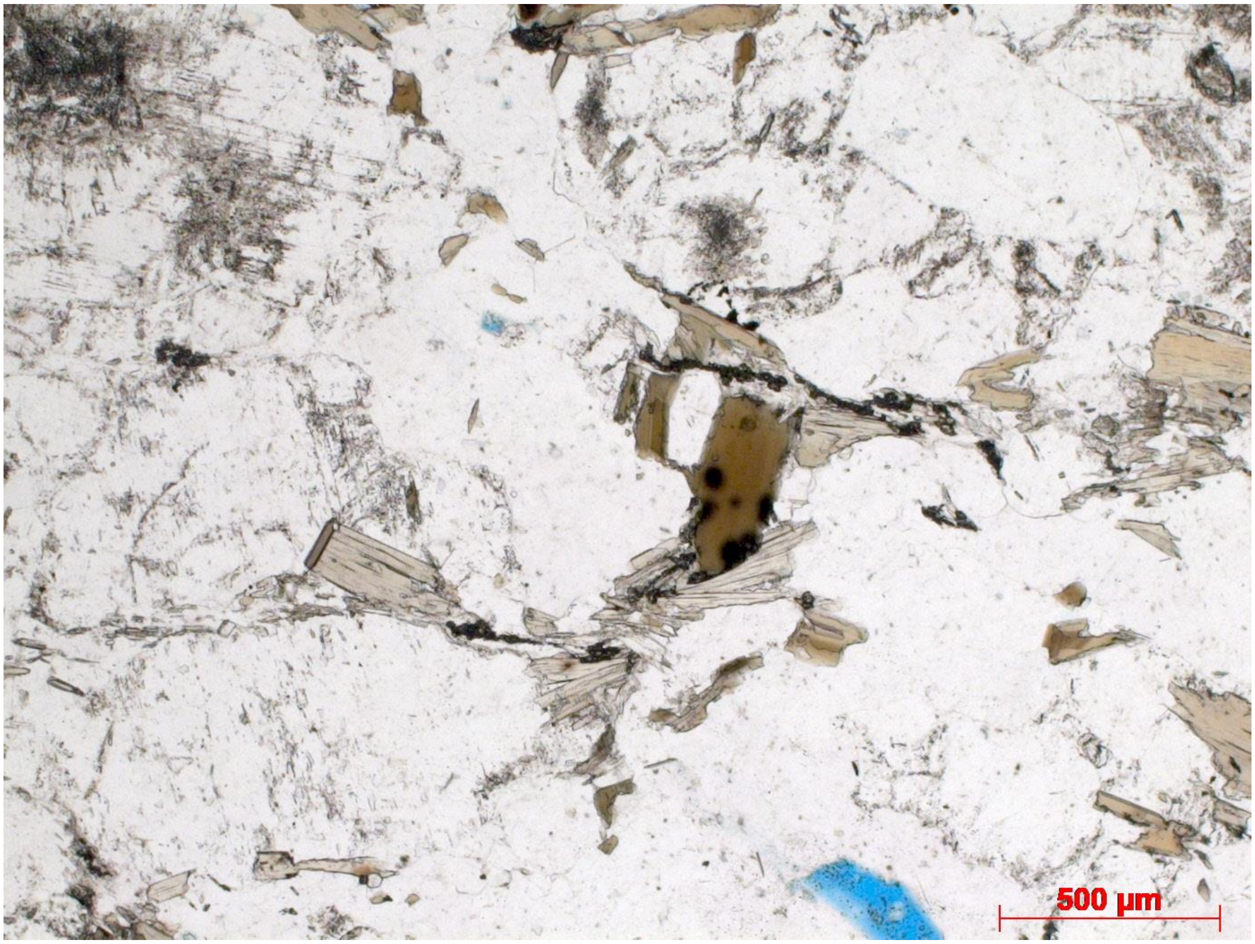
TH20-244_C8@24'_2_5x_ppl_021	Tonalite

Thin Section Image 21. Low magnification overview of a tonalite shows an abundant amount of pleochroic biotite with subordinate hornblende (light to dark brown) among fine to medium-grained polycrystalline quartz and plagiolcase feldspar (white; low relief) Plane-polarized light. 2.5x Magnification. Field of View 5.5 mm. Scale bar = 1000 microns or 1 mm.



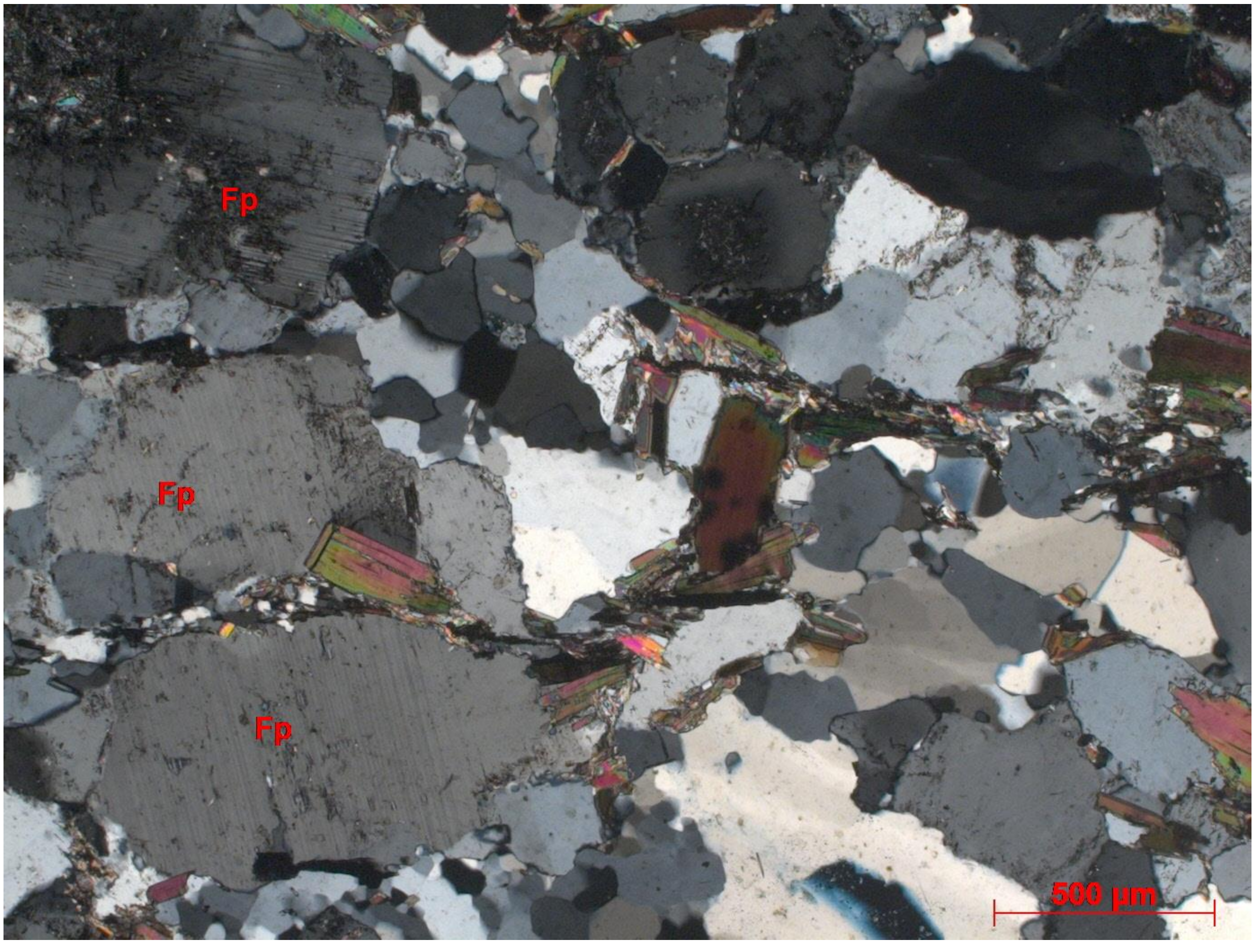
TH20-244_C8@24'_2_5x_xpl_022	Tonalite

Thin Section Image 22. The same view as in TS 21 but under crossed polarized light better illustrates the abundant polycrystalline quartz (45% by visual estimate) from the low-first order grey and white interference colors and undulose extinction. Plagioclase feldspar is also common, but in lesser amounts (35% by visual estimate). Biotite (15% by visual estimate) is widespread and exhibits strong birefringence with up to middle third-order interference colors of yellow, green, pink, and red. Cross-polarized light. 2.5x Magnification. Field of View 5.5 mm. Scale bar = 1000 microns or 1 mm.



TH20-244_C8@24'_5x_ppl_023	Tonalite

Thin Section Image 23. More magnified view of the tonalite exhibits fine to medium-grained polycrystalline quartz and plagioclase feldspar (white; low relief), abundant biotite and lesser amounts of hornblende. Note the biotite crystal at center hosts radioactive apatite and zircon crystals from the black radiation halos. Plane-polarized light. 5x Magnification. Field of View 2.82 mm. Scale bar = 500 microns or 0.5 mm.



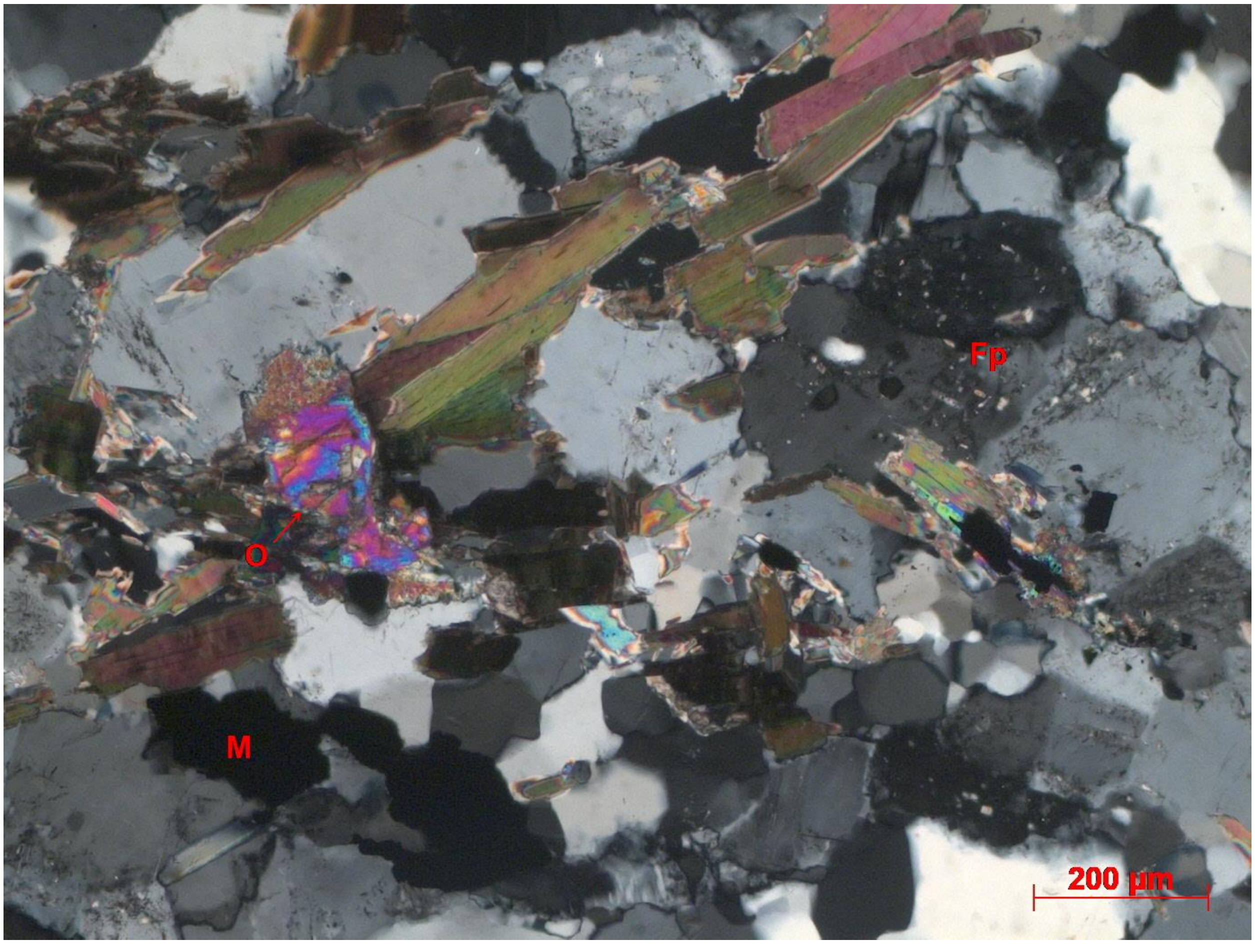
TH20-244_C8@24'_5x_xpl_024	Tonalite

Thin Section Image 24. The same view as the previous image but under crossed-polarized light shows abundant polycrystalline quartz crystals (white to gray interference colors; undulose extinction) among common biotite and subordinate hornblende (pink and green interference colors; birds eye extinction). At left are two plagioclase feldspar grains (Fp) identified from their characteristic polysynthetic twinning. Cross-polarized light. 5x Magnification. Field of View 2.82 mm. Scale bar = 500 microns or 0.5 mm.

McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065

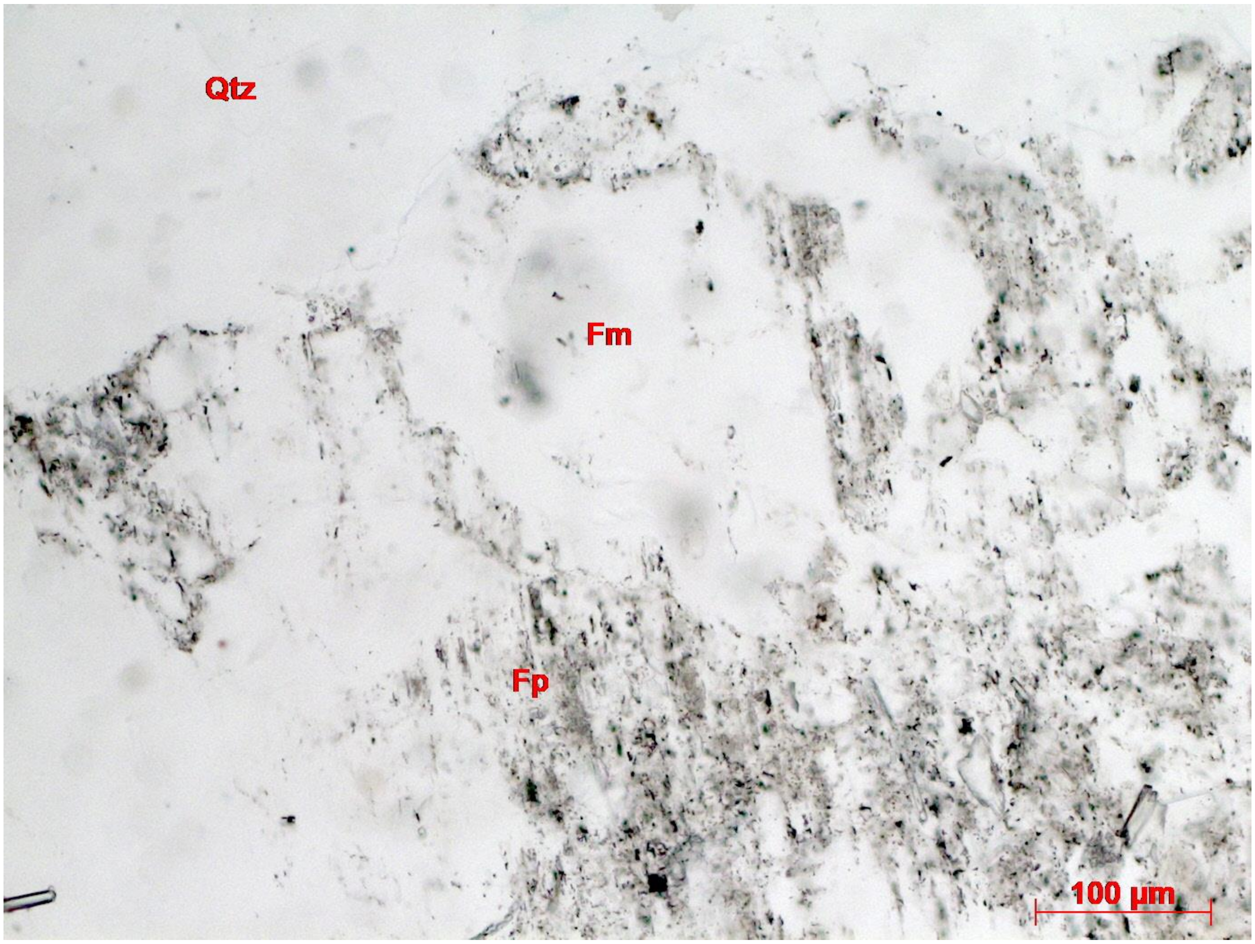
TH20-244_C8@24'_10x_ppl_025	Tonalite

Thin Section Image 25. Medium magnification view of the tonalite shows abundant crystals of white polycrystalline quartz and plagiolcase feldspar that host subordinate amounts of light to dark-brown biotite and hornblende. Other accessory minerals include opaque magnetite (M), high-relief olivine (O), and rare apatite crystals enclosed in biotite (arrow). Plane-polarized light. 10x Magnification. Field of View 1.46 mm. Scale bar = 200 microns or 0.2 mm.



TH20-244_C8@24'_10x_xpl_026	Tonalite

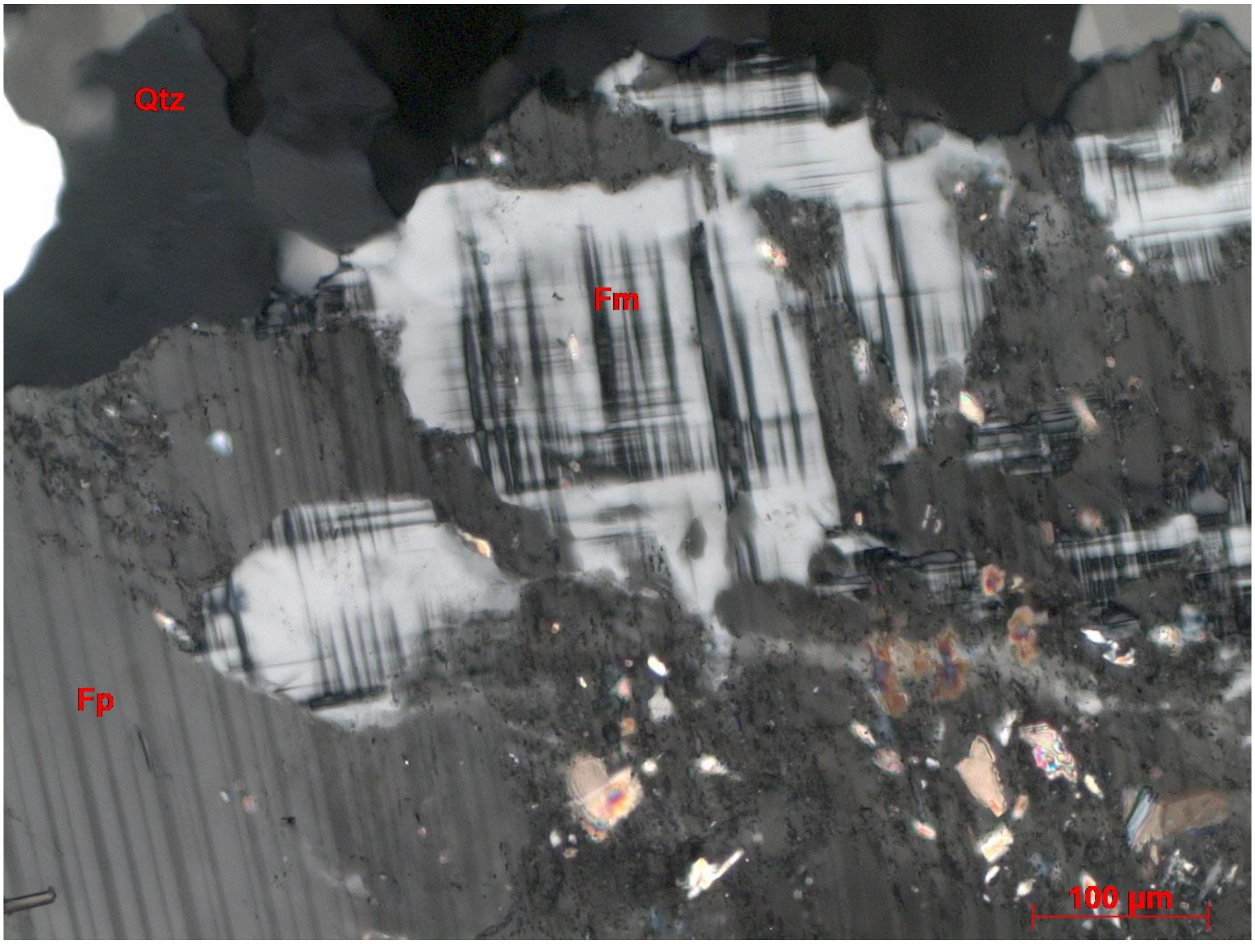
Thin Section Image 26. The same image as in TS25 but under crossed-polarized light illustrates the high second-order blue, pink, and orange interference colors of the olivine (O) and the abundant polycrystalline quartz (white to gray) and biotite (green to pink). A plagioclase feldspar at right (Fp) exhibits partial replacement by bright sericite. Cross-polarized light. 10x Magnification. Field of View 1.46 mm. Scale bar = 200 microns or 0.2 mm.



TH20-244_C8@24'_20x_ppl_027	Tonalite

Thin Section Image 27. Highly magnified view of the tonalite illustrates a microcline variation of alkali-feldspar (Fm) that is replaced by plagiolcase feldspar (Fp). The plagiolcase, in-turn, is partially replaced by sericite and calcite cement (dark gray flecks). At top is polycrystalline quartz (Qtz). Plane-polarized light. 20x Magnification. Field of View 0.72 mm. Scale bar = 100 microns or 0.1 mm.

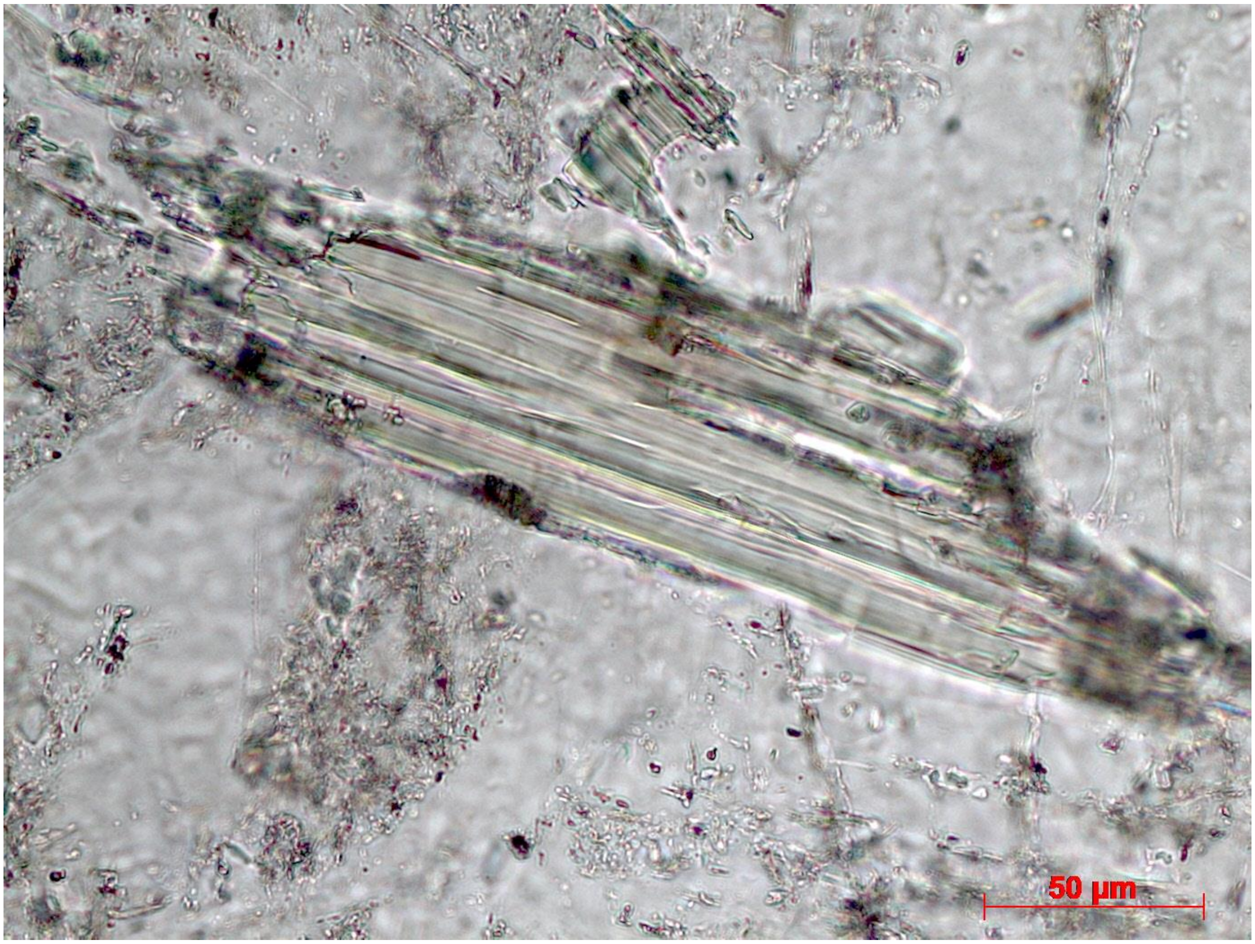
McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065



TH20-244_C8@24'_20x_xpl_028	Tonalite

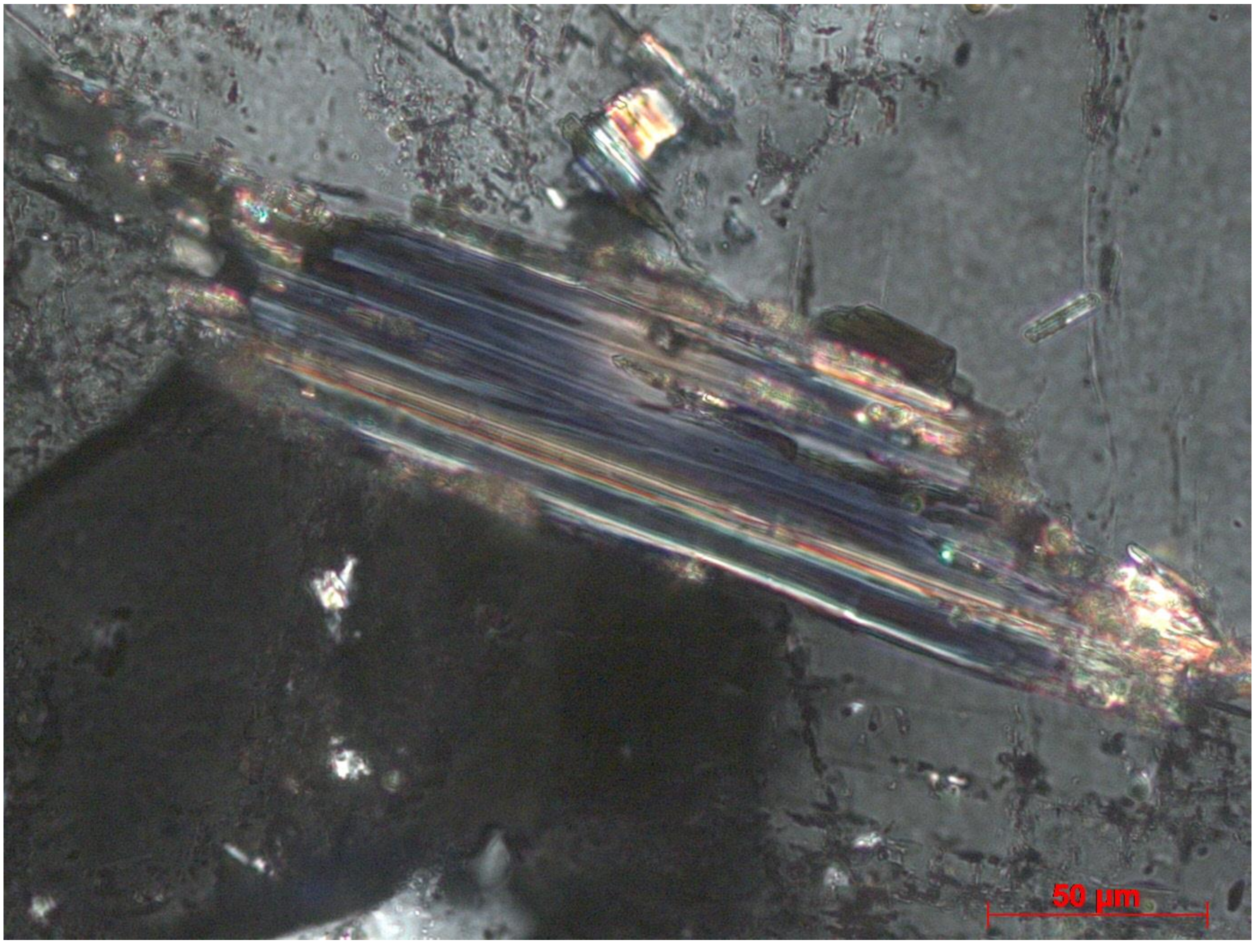
Thin Section Image 28. The same image as TS27 but under crossed-polarized light better illustrates the difference in the microcline (Fm) and the plagiolcase (Fp). Polycrystalline quartz (Qtz) is adjacent to the feldspar. Accessory calcite and sericite are rare and partially replaces the plagioclase (bright interference colors). Cross-polarized light. 20x Magnification. Field of View 0.72 mm. Scale bar = 100 microns or 0.1 mm.

McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065



TH20-244_C8@24'_50x_ppl_029	Tonalite

Thin Section Image 29. Highest magnification view of the tonalite emphasizes a light green pleochroic hornblende crystal adjacent to polycrystalline quartz crystals (white). Plane-polarized light. 50x Magnification. Field of View 0.28 mm. Scale bar = 50 microns or 0.05 mm.



TH20-244_C8@24'_50x_xpl_030	Tonalite

Thin Section Image 30. The same view as TS29 but under crossed-polarized light illustrates the hornblende crystal from the deep blue interference colors (middle second-order). Cross-polarized light. 50x Magnification. Field of View 0.28 mm. Scale bar = 50 microns or 0.05 mm.

ANALYTICAL PROCEDURES

Thin Section Analysis

Core samples were cut, surfaced, mounted to standard (24 mm × 46 mm) thin section slides, and ground to a thickness of approximately 30 microns by National Petrographic. The samples were then shipped to Ryan McLin, sole proprietor of McLin Petrographics. The prepared thin sections were examined and digitally imaged at various magnifications using a Carl Zeiss Imager.A2m polarizing binocular microscope equipped with an AxioCam MRc digital camera, UV light source, and various UV filters. Five images at increasing steps in magnification were collected for each thin section in both plane-polarized light and in crossed-polarized light to observe mineral characteristics and identifying features.

BIBLIOGRAPHY

Dunham, R.J., 1962. Classification of carbonate rocks according to depositional texture. In: Classification of Carbonate Rocks (Ed. W.E. Ham), Am. Assoc. Pet. Geol. Mem., 1, 108–121.

Le Maitre, R. W. (ed.) 2002. Igneous Rocks. A Classification and Glossary of Terms. Recommendations of the International Union of Geological Sciences Sub commission on the Systematics of Igneous Rocks, 2nd ed. xvi + 236 pp. Cambridge, New York, Melbourne

Simpson, C., and Wintsch, R.P., 1989. Evidence for deformation-induced K-feldspar replacement by myrmekite: Journal of Metamorphic Geology, v. 7, p. 261–275, https://doi.org/10.1111/j.1525-1314.1989.tb00588.x.

Streckeisen, A., 1974. Classification and Nomenclature of Plutonic Rocks. Geologische Rundschau, 63, 773-786.

Wright, V.P, 1992. A revised classification of limestones. In: Sedimentary Geology v.76, Issues 3–4, March 1992, 177-185

McLin Petrographics
1034 Daria Dr
Houston, TX 77079
832-349-5065

APPENDIX H

Ferry Road and Riverbend CSR – Rutland Trunk Sewer - Geophysical Survey
(Tetra Tech July 26, 2021, Issued for Use)

TETRA TECH

July 26, 2021

ISSUED FOR USE
FILE: ENG.GEOP03198-03
Via Email: Kirby.McRae@tetratech.com

Tetra Tech Inc.
400, 161 Portage Avenue
Winnipeg, MB R3B 0Y4

Attention: Kirby McRae, P.Eng., Senior Design Lead

Subject: Ferry Road and Riverbend CSR – Rutland Trunk Sewer – Geophysical Survey
Winnipeg, MB

1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) was retained by the City of Winnipeg to conduct geophysical profiling along Rutland Street for the proposed Ferry Road and Riverbend Combined Sewer Relief (CSR) tunnel in Winnipeg, MB. Previous geotechnical investigations and sewer projects in the area have identified the likelihood of hard glacial tills being encountered along an 800 m section of the alignment between Bruce Avenue and Silver Avenue.

Geophysical seismic data was collected along approximately 2 km of the alignment, including the noted 800 m section, in order to identify the location and elevation of harder subsurface material that could be problematic for tunnelling construction.

2.0 SEISMIC METHODOLOGY

2.1 Seismic Methodology

Two different seismic methods were utilized for this project: seismic refraction and multi-channel analysis of surface waves (MASW). Both data sets can be collected at the same time but use different properties of seismic wave train record.

Seismic refraction investigations rely on the generation of acoustic waves from a source and measurement of the ground response using acoustic receivers, called geophones, at a known geometry. The relative geometry of the source and receiver locations are known and can be related to the travel time of the acoustic wave travelling to each receiver. By identifying the first arrival of the compression (P-) wave, a modelled velocity cross-section can be generated.

Multichannel analysis of surface waves (MASW) is an alternate seismic technique based on the measurement of surface waves, specifically the dispersion characteristics of retrograde motion Rayleigh waves as these waves travel past the geophones. MASW data is analyzed by phase velocity-frequency based transformation. The dispersion curves are interpreted and solved through a least squares modelling process to obtain a one-dimensional vertical model of the average shear wave (S-wave) velocity across the seismic line at various depths, at each spread location. The MASW source can either be an active source (such as a sledgehammer striking a metal plate) or a passive source (such as ambient site noise caused by construction activities or traffic). MASW is often collected at

Tetra Tech Canada Inc.
14940 - 123 Avenue
Edmonton, AB T5V 1B4 CANADA
Tel 780.451.2121 Fax 780.454.5688

the same time as refraction data and provides additional information along the profile to assist with interpretation of the refraction data.

A detailed description of seismic refraction and MASW methodology, including limitations, is included in Appendix B.

3.0 DATA COLLECTION

Seismic data was collected by David McBean, P.Geo. (Alberta), and Jordan Augruso, P.Geo. (Alberta), between August 16 and August 18, 2020. The seismic system used for the survey was a Geometrics' 24-channel seismograph with 4.5 Hz geophones at a 1 m spacing. A sledgehammer striking a metal plate was used as the seismic source. Data was collected using an off-end shot location of 10 m.

The geophones were mounted on a landstreamer, with ground coupling achieved through a metal plate. This setup allows the geophones to be moved along the line efficiently, increasing the speed of data collection. The survey setup is shown below in Photo 1.

Photo 1 – Landstreamer setup

Data was collected along a profile approximately 2 km in length, extending from the Assiniboine River at the south end of the alignment to the Winnipeg James Armstrong Richardson International Airport at the north end. Seismic data was collected at 5 m increments along the profile. No data was collected on active roadways; therefore, the seismic profile contains four gaps in data coverage at Portage Avenue, Bruce Avenue, Ness Avenue, and Silver Avenue. Figure 1 provides a plan view site map of the survey area.

Data was collected adjacent to Rutland Street, which remained open to traffic at the time of the survey. The noted avenues along the survey alignment likewise remained open to traffic at the time of the survey. The field crew timed collection of individual seismic data files to occur when there was minimal adjacent traffic, or when traffic was paused at stop lights, but in busier areas such as at between Bruce Avenue and Silver Avenue, roadway traffic did contribute noise to the dataset.

Geophone locations were surveyed by Tetra Tech using an RTK GPS system to provide position and elevation information.

4.0 DATA PROCESSING

4.1 Refraction

The data was processed using Geometrics' SeisImager seismic processing software. The software was used to filter and gain the data, select the first arrivals, and assign layers to the travel times and perform a time-term inversion. The results from the time-term inversion were used as the initial model for tomographic inversions.

Due to traffic noise, the refraction seismic data had a low signal to noise ratio in some locations, making it challenging to pick the P-wave first arrivals. In these areas, MASW was used as the primary method for interpretation.

4.2 MASW

The data was also processed using MASW methods, which involves creating a plot of the phase velocity vs. frequency, called a dispersion image. By selecting the highest amplitude energy at the lowest phase velocities (the fundamental mode), a dispersion curve is determined. In general, the data was sell-suited to the MASW method and yielded a well-defined phase dispersion curve. The MASW data was processed and inverted in Kansas Geological Survey's SurfSeis software. The back calculation of shear wave (S-wave) velocity was performed using an iterative inversion least-squares approach. MASW is less sensitive to background noise, well-suited in urban environments and works well in unconsolidated soils.

5.0 RESULTS AND INTERPRETATION

Figures 2 and 3 provide an interpreted seismic profile along the surveyed alignment. In general, the seismic data agrees well with the available borehole information along the entire alignment. Primarily the modelled S-wave velocity was used to map the till interface, with P-wave velocities being used to help refine the interpretation in non-traffic areas.

The modelled S-wave contours have been shown on the figures along with an interpreted top of till interface, simplified borehole data, and proposed tunnel elevation. Locations along the alignment where either no data was collected (for example on roadways), or where the data quality and thus confidence in the data was poor have been shown as dashed lines (inferred).

The till interface fits well with a modelled S-wave velocity of between 190 m/s to 250 m/s and a modelled P-wave velocity of 1,000 m/s. The S-wave velocity used for the till interface changes as one moves north, away from the Assiniboine River. Since till is a geological deposition description, the actual composition of the material can, and does, change over the course of the alignment both in terms of material composition, density (N blow counts), and water content, which will affect seismic velocities.

From approximately 50 m north of the Assiniboine River (profile chainage 0 m) to the running track in Bourkevale Park (profile chainage 220 m), the till interface correlates better with a higher modelled S-wave velocity (220 m/s to 250 m/s) than the rest of the alignment. This could be due to the higher silt and less clay composition in the till relative to the rest of the alignment.

Over the running track (profile chainage 250 m) to Portage Avenue, the till is interpreted to be at its deepest point, over 12 m from surface, and is close to the modelling extent of the data. The engineered surface of the track does change the dispersion behavior of the surface waves and there is evidence of a velocity reversal (fast layer over a slow layer) in the refraction data that prevents accurate depth modelling from the refraction data set. The till interface correlates better with a modelled S-wave velocity of approximately 200 m/s.

From Portage Avenue to the end of the alignment past Silver Avenue, the till interface correlates well with a slower modelled S-wave velocity between 190 m/s and 200 m/s. The till interface elevation is shown as a gradual ascent, with several localized crests and troughs, to a high point around profile chainage 1,900 m past Silver Avenue. The till interface is at its shallowest point of only about 4 m from the surface at this furthest surveyed chainage.

6.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of City of Winnipeg and their agents. Tetra Tech Canada Inc. (operating as Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than City of Winnipeg or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on Use of this Document attached in the Appendix or Contractual Terms and Conditions executed by both parties.

7.0 CLOSURE

We trust this document meets your present requirements. If you have any questions or comments, please contact the undersigned.

Tetra Tech Canada Inc.

PROVINCE OF MANITOBA
N. S. PARRY
Member
34186G
REGISTERED PROFESSIONAL GEOSCIENTIST

July 26, 2021

Prepared by:
Patrick Finlay, P.Geoph.
Manager, Senior Geophysicist
Engineering & Environmental Geophysics
Direct Line: 587.460.3506
Patrick.Finlay@tetratech.com

Reviewed by:
Neil Parry, P.Geo., MBA
Director, Geospatial Imaging, Geophysicist
Engineering & Environmental Geophysics
Direct Line: 587.460.3598
Neil.Parry@tetratech.com

/sd

ENGINEERS
GEOSCIENTISTS
MANITOBA

Certificate of Authorization
Tetra Tech Canada Inc.
No. 6499

FIGURES

LEGEND

SEISMIC READING LOCATION

BOREHOLE

0+000 TUNNEL PATH CHAINAGE

TUNNEL PATH

SCALE 1:7,500
NAD83
UTM z14

CLIENT

Winnipeg

TETRA TECH

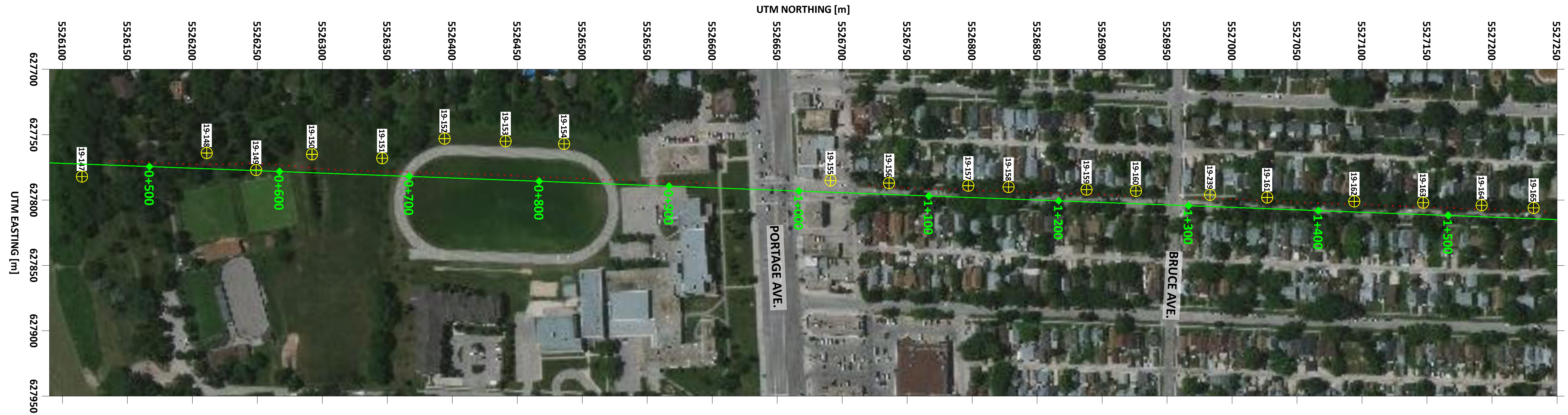
Ferry Rd. & Riverbend CSR Rutland Trunk Sewer

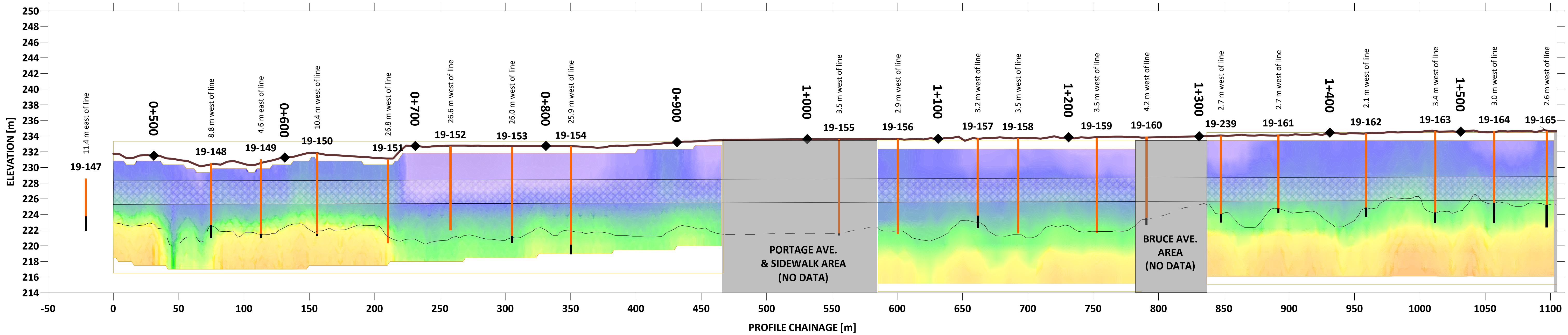
Seismic Data Coverage Overview Map

PROJECT NO.	DWN	CKD	APVD	REV
ENG.GEOP03198-03	JA	PF	PF	1

OFFICE	DATE
EBA.EDM	May 28, 2021

Figure 1





LEGEND

- ◆ TUNNEL CHAINAGE MARKER
- PROPOSED TUNNEL LOCATION
- BOREHOLE RESULT - NON-TILL MATERIAL
- BOREHOLE RESULT - TILL MATERIAL
- NO GEOPHYSICAL DATA
- GROUND SURFACE
- INTERPRETED TILL INTERFACE (FROM GEOPHYSICAL AND BOREHOLE RESULTS)
- INTERPRETED TILL INTERFACE (INFERRED)

PLAN MAP SCALE 1:3000

PROFILE SCALE 1:3,000
VE = 6

MODELLED S-WAVE VELOCITY [m/s]

0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420

CLIENT

Winnipeg

TETRA TECH

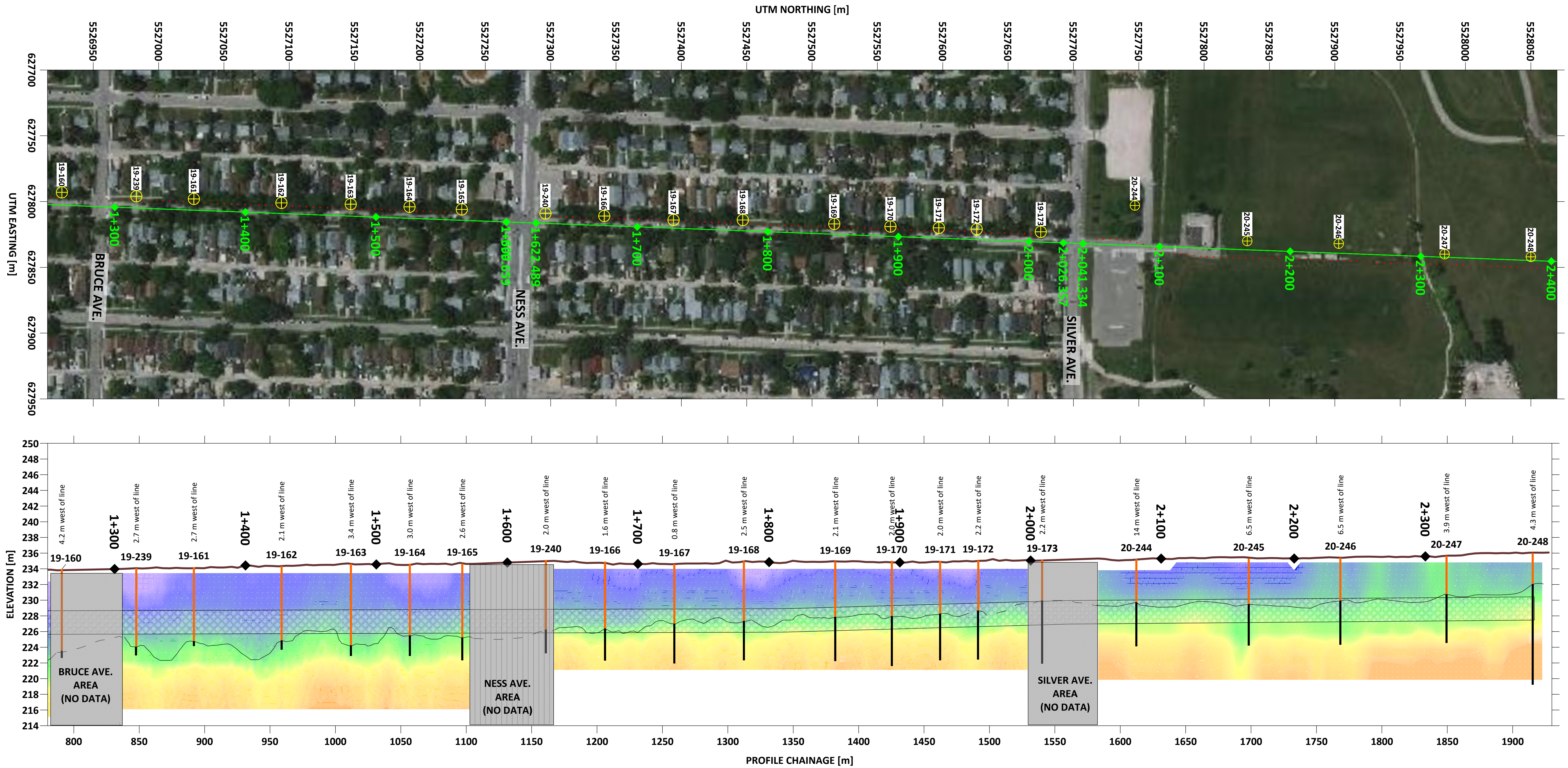
Ferry Rd. & Riverbend CSR Rutland Trunk Sewer

Interpreted Seismic Profile Segment 1

PROJECT NO.	DWN	CKD	APVD	REV
ENG.GEOP03198-03	JA	PF	PF	0

OFFICE	DATE
EBA-EDM	October 06, 2020

Figure 2



LEGEND

- ◆ TUNNEL CHAINAGE MARKER
- APPROX. PROPOSED TUNNEL LOCATION
- BOREHOLE RESULT - NON-TILL MATERIAL
- BOREHOLE RESULT - TILL MATERIAL
- NO GEOPHYSICAL DATA
- GROUND SURFACE
- INTERPRETED TILL INTERFACE (FROM GEOPHYSICAL AND BOREHOLE RESULTS)
- INTERPRETED TILL INTERFACE (INFERRED)

PLAN MAP SCALE 1:3000

PROFILE SCALE 1:3,000
VE = 6

MODELLED S-WAVE VELOCITY [m/s]

0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420

CLIENT

Winnipeg

TETRA TECH

Ferry Rd. & Riverbend CSR Rutland Trunk Sewer

Interpreted Seismic Profile Segment 2

PROJECT NO.	DWN	CKD	APVD	REV
ENG.GEOP03198-03	JA	PF	PF	1

OFFICE	DATE
EBA-EDM	May 28, 2021

Figure 3

APPENDIX A

TETRA TECH'S LIMITATIONS ON USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

GEOPHYSICAL

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

The Professional Document is intended for the sole use of TETRA TECH's Client (the "Client") as specifically identified in the TETRA TECH Services Agreement or other Contractual Agreement entered into with the Client (either of which is termed the "Contract" herein). TETRA TECH does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the Client, unless authorized in writing by TETRA TECH.

Any unauthorized use of the Professional Document is at the sole risk of the user. TETRA TECH accepts no responsibility whatsoever for any loss or damage where such loss or damage is alleged to be or, is in fact, caused by the unauthorized use of the Professional Document.

Where TETRA TECH has expressly authorized the use of the Professional Document by a third party (an "Authorized Party"), consideration for such authorization is the Authorized Party's acceptance of these Limitations on Use of this Document as well as any limitations on liability contained in the Contract with the Client (all of which is collectively termed the "Limitations on Liability"). The Authorized Party should carefully review both these Limitations on Use of this Document and the Contract prior to making any use of the Professional Document. Any use made of the Professional Document by an Authorized Party constitutes the Authorized Party's express acceptance of, and agreement to, the Limitations on Liability.

The Professional Document and any other form or type of data or documents generated by TETRA TECH during the performance of the work are TETRA TECH's professional work product and shall remain the copyright property of TETRA TECH.

The Professional Document is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of TETRA TECH. Additional copies of the Document, if required, may be obtained upon request.

1.2 ALTERNATIVE DOCUMENT FORMAT

Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Both electronic file and/or hard copy versions of TETRA TECH's Instruments of Professional Service shall not, under any circumstances, be altered by any party except TETRA TECH. TETRA TECH's Instruments of Professional Service will be used only and exactly as submitted by TETRA TECH.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of TETRA TECH.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by persons other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary investigation and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to investigate, address, or consider and has not investigated, addressed, or considered any environmental or regulatory issues associated with the development of the site.

1.8 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgemental in nature as to both type and condition. TETRA TECH does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

1.9 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

1.10 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. TETRA TECH does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

1.11 SURFACE WATER AND GROUNDWATER CONDITIONS

Surface and groundwater conditions mentioned in this report are those observed at the times recorded in the report. These conditions vary with geological detail between observation sites; annual, seasonal and special meteorological conditions; and with development activity. Interpretation of water conditions from observations and records is judgmental and constitutes an evaluation of circumstances as influenced by geology, meteorology and development activity. Deviations from these observations may occur during the course of development activities.

APPENDIX B

SURVEY METHODOLOGIES AND LIMITATIONS

SURVEY METHODOLGIES AND LIMITATIONS

Seismic Refraction Methodology

Seismic investigations rely on the generation of acoustic waves from a source and measurement of the ground response using acoustic receivers, or geophones, at a known geometry. The relative geometry of the source and receivers are known and can be related to the time it takes for the acoustic wave to travel to each receiver. By identifying the first arrival times of the compression (P-) wave, a modelled velocity cross-section can be generated, thereby obtaining the modelled P-wave velocities along the cross-section.

The seismic refraction method is based on acoustic behavior controlled by Snell's Law and results in a cross-section model by analyzing the first arrival time of acoustic waves as received over an array of geophones. Where the apparent velocity of the first arrival wave changes (identified by a change in slope of the first arrival time versus geophone distance), a change in layer type and velocity can be identified.

Refractions can only occur at layer interfaces where velocities increase with depth. In situations where velocities decrease with depth, the lower velocity layer cannot be reliably modelled.

Seismic Refraction Limitations

Inverse Modelling – The inverse modelling process can produce many different valid, geologically realistic models that satisfy the initial conditions. The models used in this data analysis are considered the best models at the time of reporting based upon other available geophysical data and borehole data collected, as well as site observations.

Vertical Resolution – Layers with a vertical dimension that are small relative to the geophone spacing may not be detected due to insufficient horizontal sampling.

Hidden Layers – Governed by Snell's Law, the seismic refraction method can only resolve lithological layers if the velocities of the layers increase with depth. Sometimes this assumption is violated and results in 'hidden' or 'blind' layers that are low velocity layers between two higher velocity layers, or equally, layers that are too thin to be resolved given the velocity contrast present and the geophone geometry used.

Multichannel Analysis of Surface Waves (MASW) Methodology

When a stress is applied to an elastic body (such as a hammer hitting the ground), the corresponding strain propagates outwards as an elastic wave. There are two principal types of elastic waves: body and surface waves. Body waves consist of compressional or P- (primary) waves and S- (shear) waves. The velocities of P- and S-waves (Vp and Vs, respectively), are related to the bulk elastic properties and density of the material. Shear wave velocity is an important parameter that is directly proportional to the shear modulus of a material. It is a measure of stiffness (or rigidity) of that material and is a parameter often used in geotechnical engineering.

In addition to body waves that travel through an elastic medium, there are waves that travel only along the boundary of an elastic solid. There are two common types of surface waves in solids: Rayleigh waves (or ground roll) and Love waves. Rayleigh waves are of interest as their velocity behaviour is controlled by the shear strength of the material supporting the ground roll movement. Rayleigh waves are easily generated and constitute the majority of measurable seismic energy under normal ground conditions. Rayleigh waves have characteristic properties in that they travel in an elliptical retrograde motion in the vertical plane as they propagate along the surface of the elastic medium. The velocity of Rayleigh waves approximates 0.9Vs and can therefore be used to estimate the shear velocities of materials. Geophones are used to record the Rayleigh waves by measuring the vertical particle displacement at the ground surface.

In a layered medium, surface waves have dispersion properties that are not observed with body waves. Dispersion occurs as a result of surface waves being comprised of different wavelengths propagating at different velocities. The propagation velocity of each wavelength is called phase velocity. By analyzing the differing phase velocity characteristics at different frequencies, a dispersion curve can be generated. Short wavelengths have shallow penetration depths, while longer ones have deeper penetration. Therefore, analysis of the fundamental wave energy distribution of the dispersion curve maps a profile of near-surface shear wave velocities. The entire MASW technique thus consists of three fundamental steps: acquisition of ground roll data; imaging of the dispersion curves; and inversion (or back calculation) of shear wave velocities from the interpreted dispersion curves, thus obtaining stiffness parameters.

The end result of a MASW survey is a one-dimensional sounding, providing stiffness parameters at discrete locations, roughly analogous to a series of penetrometer measurements. Although the MASW technique makes use of the lateral dispersion of velocities along the surface (and thus is not a true point measurement), it is assumed to represent a point measurement that is representative of the soil conditions in the immediate vicinity of the array. In areas where a two-dimensional profile is required, a series of constant-offset one-dimensional soundings can be collected and processed together to build up a two-dimensional cross-section of shear wave velocities.

MASW Limitations

Due to the mathematical nature of inverse models, many possible models can satisfy the initial conditions and be considered equally correct in the absence of other data. In this case, the models chosen were deemed to be the optimal models given the available information. Therefore, modelling parameters were selected based on the expected lithology in the region of the survey. The models presented are considered reasonable, given the information available at this time, and represent the simplest interpretation that provides a good match to the measured field values. Other models with different layer thicknesses and seismic parameters may result in similar matches of the modelled data with the field data.

In geophysical modelling, the representation of the deepest layer of the model is referred to as a half-space. For this layer, only the top boundary is defined and the layer is treated mathematically as extending infinitely into the earth. The half-space is considered homogeneous and isotropic. In reality, there are subsequent seismic layers in the earth beyond the last model layer; however, due to geometric limitations of the survey and in situ contrasts between differing layers, they cannot be defined. As long as the seismic properties of the material beneath the final model layer do not differ substantially from those of the final model layer itself, the half-space approximation is considered to be mathematically sound, and the seismic model layers are considered to be a reasonable approximation of the seismic layers within the limits of the survey.

Topography – One of the assumptions of MASW theory is that the entirety of the array is in the same plane. This assumption has to do with the fact that one is measuring time differences with the use of geometry. As long as the changes in topography along the array's plane are less than 10 percent of the total line length, this holds true. Changes in topography did not exceed 10 percent of the total line length for the MASW profile at this site.

Fundamental Mode – An assumption used in the software is that the fundamental mode of the dispersion image is used for analysis. This mode can, at times, be difficult to pick out. It should be reviewed on a shot-by-shot basis to ensure correct interpretation as was done in this evaluation.

Layer Resolution/Aliasing – When spectra with poor low-frequency components are used in data collection over an area with stiff soils, a gradation of shear-wave velocities may be modelled where a sharp interface exists. This is due to the aliasing of these boundaries at depth as the lower frequency waves have too long of a wavelength to distinguish sudden boundaries.

Data Density – As with most surveys, data density should be considered when reviewing the results. Geophone spacing and survey methodology was recorded, reported on, and used in the interpretation process.

Data Coverage/Resolution – There are limitations on vertical resolution and maximum depth based on survey design and site conditions. The minimum vertical resolution (thus minimum depth of investigation) is directly proportional to the geophone interval and the highest frequencies generated by the source (and recorded by the receivers), while the theoretical maximum depth of investigation is proportional to the spread length between the first and last geophone, and the lowest frequencies generated by the source. Thus, maximum and minimum depths of investigation may vary between profiles collected with the same parameters and setups at the same site, because an impulsive, human-driven source, such as the one used in this project, does not guarantee a specific frequency content.

DRI GEOTECHNICAL ENGINEERS

APPENDIX I

Ferry Road Piezometer Hydraulic Conductivity Testing
(Tetra Tech Internal Memo June 11, 2021)

TETRA TECH

INTERNAL MEMO

ISSUED FOR USE

To:	Kirby McRae	**Date:**	June 11, 2021
c:		**Memo No.:**	
From:	Brent Horning	**File:**	705-1000120300, Task 600.02
Subject:	Ferry Road Piezometer Hydraulic Conductivity Testing		

1.0 PROJECT BACKGROUND

In order to assess the potential for groundwater inflow into proposed future excavation works for a water and sewer line replacement, hydraulic conductivity analyses were performed at six (6) locations using the piezometers previously installed for geotechnical investigation of the proposed routing. These piezometers were installed along Rutland Street, running north from the Assiniboine River to Silver Avenue. A site plan showing the approximate piezometer locations is provided as Figure 1, attached.

The piezometers consist of 25 mm diameter PVC casings with 300 mm long perforated sections. Five of the piezometers were installed in the overburden, either a soft clay or silt till, at depths of 6.7 m below grade (mbg) to 11.2 mbg. The sixth piezometer was installed in the carbonate bedrock at a depth of 15.5 m below grade. Details relating to the screen section placement are provided in Table 1, attached. Borehole logs showing the stratigraphy encountered and the well construction as prepared by Dyregrov Robinson are included in Appendix A.

2.0 METHODOLOGY

On May 25 and 26, 2020, falling head slug tests were performed on each of the six piezometers, as described below.

- The static water level was measured using an electronic water level meter in relation to top of casing.
- A data logging pressure transducer set to record at two second intervals was placed approximately 0.5 m below the static water level.
- Approximately 4 L of clean tap water was poured into the well casing to create a sudden increase in the water level in the piezometer
- The rate of water drainage through the well screen to restore the water level to its original elevation was recorded by the pressure transducer and confirmed by periodic manual measurements.
- The transducer record was analysed using the AquiferTest Pro software to produce a hydraulic conductivity value for the materials adjacent to the well screen in each location.

Tetra Tech Canada Inc.
400-161 Portage Avenue East
Winnipeg, MB R3B 0Y4
Tel 204.954.6800 Fax 204.988.0546

3.0 FIELD OBSERVATIONS

Measurement of static water levels in the piezometers completed in the overburden found the water levels to be between 3.25 mbg and 3.53 mbg near the Assiniboine River shoreline, and between 6.45 mbg and 6.94 mbg further inland. Calculation of the associated groundwater elevations showed a variation of between 228.66 m above sea level (ASL) in the northern most piezometer (TH19-240) and 225.37 m ASL in the southern piezometer (TH19-147). The associated groundwater flow direction in the overburden unit is therefore anticipated to be southerly.

The groundwater in the bedrock piezometer (TH19-173) was measured as 7.65 mbg, with a calculated elevation of 227.51 m ASL. With only one measurement point, the potential groundwater flow direction in the carbonate bedrock cannot be determined. It is however noted that the water level in the bedrock is at a lower elevation that the water level in the closest overburden piezometer (TH19-240), suggesting a downward groundwater flow direction between these units.

Depth to groundwater measurements and calculated groundwater elevations are presented in Table 1, attached.

Upon introduction of the clean water into the piezometer casing it was noted that the water dissipated relatively quickly in each of the six piezometers, confirming that the water was being forced out into the surrounding water bearing unit adjacent to the screen section. Review of the piezometer construction details showed that for four of the six piezometers, the static water level was above any sand backfill installed around the screen section, ensuring it was saturated prior to the introduction of water into the piezometer. For the two piezometers located closest to the river (TH19-147 and TH19-148), the sand backfill extended above the static water level, suggesting the possibility that some of the water being introduced in to the casing would infill the sand fill, possibly influencing the initial results of the hydraulic conductivity assessment.

4.0 FALLING HEAD TEST ANALYSIS

Based on the well construction and stratigraphic conditions present, the Hvorselv method of hydraulic conductivity analysis was considered to be appropriate. This method involves the plotting the rate of variation in water level recovery over time in an effort to produce a straight-line semi-log plot. The water level recovery plots are provided in Appendix B. A summary of the resulting hydraulic conductivity values is included in Table 1.

Review of the groundwater level recovery curves found each of the five piezometers completed in the overburden to show a relative consistent pattern with at least two notable recovery stages. The initial straight line portion, extending over between 2 minutes and 10 minutes following water addition is considered to be representative of the hydraulic conductivity of the unit adjacent to the screen section. The secondary straight line portion of the slope is representative of the presence of a boundary condition, most commonly a hydraulic connection with adjacent stratigraphic units. For those two piezometers in which initial saturation of the sand pack adjacent to the piezometer was possibly anticipated (TH19-147 and TH19-148), some initial curve variation was noted, but was of limited duration so is not expected to have impacted the hydraulic conductivity value calculations.

In four of the five overburden piezometers, the initial hydraulic conductivity values were relatively consistent, ranging in value from 3.6×10^{-6} m/s to 8.9×10^{-6} m/s. In the fifth overburden piezometer (TH19-240, located furthest inland), the hydraulic conductivity was lower, with a value of 8.0×10^{-7} m/s. All of these values are consistent with a primarily silt with sand soil condition, as reported in the borehole logs.

In each of the five piezometers completed in the overburden, the secondary slope is representative of an increased hydraulic conductivity. Again the range of hydraulic conductivity is fairly consistent in four of the piezometers, being between 1.3×10^{-5} m/s to 3.6×10^{-5} m/s. The conductivity in the northern most piezometer (TH19-240) is again notable lower at 2.5 x 10^{-6} m/s. These values are still consistent with a silt with sand, but would suggest an increasing sand content.

Review of the groundwater level recovery plot for the piezometer completed in the bedrock (TH19-173) shows a single straight line plot, terminating upon recovery to the original static water level. The calculated hydraulic conductivity of the carbonate bedrock in this location is 3.2 x 10^{-5} m/s, consistent with a fractured or karstic carbonate rock condition, as noted in the associated borehole log.

5.0 DISCUSSION/ CONCLUSIONS

Hydraulic conductivity testing of the piezometers installed in the overburden suggests that these soils show a variable hydraulic conductivity due to interconnectivity between layers or over lateral extension. The hydraulic conductivities in the saturated overburden extending from the Assiniboine River northward to at least Bruce Avenue, showed an initial average hydraulic conductivity of 6.0 x 10^{-6} m/s, increasing to an average of 2.5 x 10^{-5} m/s. In the vicinity of Ness avenue, the overburden showed a lower hydraulic conductivity of 8.0 x 10^{-7} m/s to 2.5 x 10^{-6} m/s.

The higher range of secondary hydraulic conductivity values for the overburden units is similar to that calculated for the carbonate bedrock unit (3.2 x 10^{-5} m/s), suggesting this may be the source of the boundary condition observed in each of the overburden falling head tests.

6.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of the City of Winnipeg and their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than the City of Winnipeg, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on the Use of this Document attached in the Appendix or Contractual Terms and Conditions executed by both parties.

7.0 CLOSURE

We trust this memo meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.

705-1000120300-MEM-V0001-01
705-1000120300-MEM-V0001-01
705-1000120300-MEM-V0001-01
705-1000120300-MEM-V0001-01
705-1000120300-MEM-V0001-01

Prepared by:
Brent Horning, P.Eng.
Sr. Environmental Engineer
Direct Line: 204.954.6860
Email: Brent.Horning@tetratech.com

705-1000120300-MEM-V0001-01
705-1000120300-MEM-V0001-01
705-1000120300-MEM-V0001-01
705-1000120300-MEM-V0001-01
705-1000120300-MEM-V0001-01

Reviewed by:
Ryan Wizbicki, P.Eng.
Manager – Environmental Services
Direct Line: 204.954.6930
Email: Ryan.Wizbicki@tetratech.com

BH/
Attachments

PROVINCE OF MANITOBA
B.K.
HORNING
Member
7802
Jun 14/21
REGISTERED PROFESSIONAL ENGINEER

ENGINEERS
GEOSCIENTISTS
MANITOBA
Certificate of Authorization
Tetra Tech Canada Inc.
No. 6499

FIGURES

REFERENCE DRAWINGS: MAPQUEST street map

NO.	DATE	DESCRIPTION	ISSUED BY

REVISIONS / ISSUE

TETRA TECH

CLIENT: THE CITY OF WINNIPEG

AUTHORIZED BY:

DATE 11-06-2021

CLIENT DRAWING NO.

DRAWING DESCRIPTION

FIGURE 1: GENERAL PIEZOMETER LOCATION PLAN
FERRY ROAD PIEZOMETER HYDRAULIC CONDUCTIVITY TESTING

DESIGNED BY: BKH	DRAWN BY: BKH	DRAWING NO.	REV.
REVIEWED BY:	SCALE: As Shown	705-10001203A00-SKT-V0005	00

TABLES

Table 1
Summary of Hydraulic Conductivty Test Results
Ferry Road Piezometer Hydraulic Conductivity Testing
City of Winnipeg

Piezometer No.	Ground Surface Elevation [a]	Screen Section Depth		Material Adjacent to Screen Section	Static Water Level [b]		Initial Hydraulic Conductivity	Secondary Hydraulic Conductivity
	m Above Sea Level	m below grade	m Above Sea Level		m below grade	m Above Sea Level	m/ sec	m/ sec
TH19-147	228.619	6.1 - 6.4	222.2 - 222.5	Silt (Till)	3.25	225.37	7.0×10^{-6}	3.0×10^{-5}
TH19-148	230.566	6.1 - 6.4	224.2 - 224.5	Clay (Alluvial) underlain by Sand (alluvial)	3.53	227.04	3.6×10^{-6}	3.6×10^{-5}
TH19-155	233.629	12.0 - 12.3	221.3 - 221.6	Silt (Till)	6.59	227.04	4.5×10^{-6}	1.3×10^{-5}
TH19-173	235.159	15.2 - 15.5	219.7 - 220.0	Bedrock (Dolomite)	7.65	227.51	3.2×10^{-5}	Not Present
TH19-239	234.083	10.7 - 11.0	223.1 - 223.4	Silt (Till)	6.94	227.14	8.9×10^{-6}	2.2×10^{-5}
TH19-240	235.111	9.1 - 9.4	225.7 - 226.0	Silt (Till)	6.45	228.66	8.0×10^{-7}	2.5×10^{-6}

Note: [a] Elevations based on Dyregrov Robinson Inc. well logs.
[b] Water levels measured on May 25 and 26, 2020.

APPENDIX A

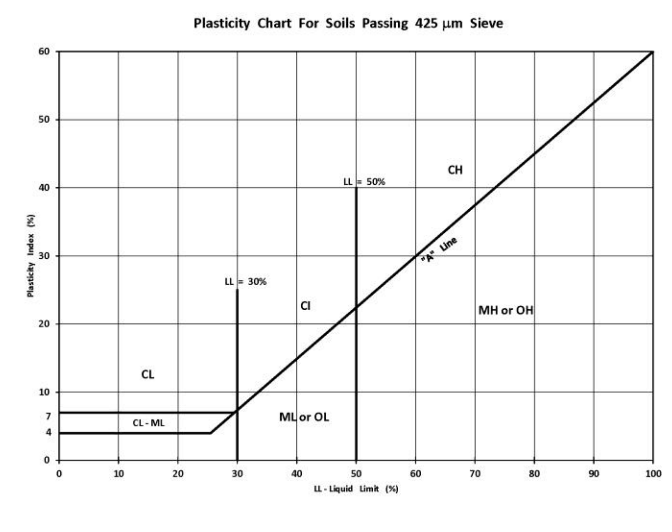
DYREGROV ROBINSON BOREHOLE LOGS

EXPLANATION OF TERMS & SYMBOLS

Description				TH Log Symbols	USCS Classification	Laboratory Classification Criteria			
						Fines (%)	Grading	Plasticity	Notes
COARSE GRAINED SOILS	GRAVELS (More than 50% of coarse fraction of gravel size)	CLEAN GRAVELS (Little or no fines)	Well graded gravels, sandy gravels, with little or no fines		GW	0-5	$C_U > 4$ $1 < C_C < 3$		Dual symbols if 5-12% fines. Dual symbols if above “A” line and $4<W_P<7$ $C_U = \frac{D_{60}}{D_{10}}$ $C_C = \frac{(D_{30})^2}{D_{10} x D_{60}}$
			Poorly graded gravels, sandy gravels, with little or no fines		GP	0-5	Not satisfying GW requirements		
		DIRTY GRAVELS (With some fines)	Silty gravels, silty sandy gravels		GM	> 12		Atterberg limits below “A” line or $W_P<4$	
			Clayey gravels, clayey sandy gravels		GC	> 12		Atterberg limits above “A” line or $W_P<7$	
	SANDS (More than 50% of coarse fraction of sand size)	CLEAN SANDS (Little or no fines)	Well graded sands, gravelly sands, with little or no fines		SW	0-5	$C_U > 6$ $1 < C_C < 3$		
			Poorly graded sands, gravelly sands, with little or no fines		SP	0-5	Not satisfying SW requirements		
		DIRTY SANDS (With some fines)	Silty sands, sand-silt mixtures		SM	> 12		Atterberg limits below “A” line or $W_P<4$	
			Clayey sands, sand-clay mixtures		SC	> 12		Atterberg limits above “A” line or $W_P<7$	
FINE GRAINED SOILS	SILTS (Below ‘A’ line negligible organic content)	$W_L<50$	Inorganic silts, silty or clayey fine sands, with slight plasticity		ML			Classification is Based upon Plasticity Chart	
		$W_L>50$	Inorganic silts of high plasticity		MH				
	CLAYS (Above ‘A’ line negligible organic content)	$W_L<30$	Inorganic clays, silty clays, sandy clays of low plasticity, lean clays		CL				
		$30<W_L<50$	Inorganic clays and silty clays of medium plasticity		CI				
		$W_L>50$	Inorganic clays of high plasticity, fat clays		CH				
	ORGANIC SILTS & CLAYS (Below ‘A’ line)	$W_L<50$	Organic silts and organic silty clays of low plasticity		OL				
		$W_L>50$	Organic clays of high plasticity		OH				
HIGHLY ORGANIC SOILS			Peat and other highly organic soils		Pt	Von Post Classification Limit		Strong colour or odour, and often fibrous texture	

	Asphalt		Glacial Till		Bedrock (Igneous)
	Concrete		Clay Shale		Bedrock (Limestone)
	Fill				Bedrock (Undifferentiated)

DYREGROV ROBINSON INC.
CONSULTING GEOTECHNICAL ENGINEERS



FRACTION		**PARTICLE SIZE** (mm)	
		Min.	Max.
Boulders		>300	
Cobbles		75	300
Gravel	Coarse	19	75
	Fine	4.75	19
Sand	Coarse	2.0	4.75
	Medium	0.425	2.0
	Fine	0.075	0.425
Silt (non-plastic) or Clay (plastic)		< 0.075 mm	

RELATIVE PROPORTIONS (by weight)	
Percent	Descriptor
>35%	main fraction
35 - 50	"and"
20 – 35	Adjective e.g. silty, clayey
10 – 20	"some"
1 - 10	"trace"

Soil Classification Example

Clay 50% (main fraction), Silt 25%, Sand 17%, Gravel 8%

Clay – silty, some sand, trace gravel

TERMS and SYMBOLS

Laboratory and field tests are identified as follows:

Unconfined Comp.: undrained shear strength (kPa or psf) derived from unconfined compression testing.

Torvane: undrained shear strength (kPa or psf) measured using a Torvane

Pocket Pen.: undrained shear strength (kPa or psf) measured using a pocket penetrometer.

Unit Weight bulk unit weight of soil or rock (kN/m^3 or pcf).

SPT – N Standard Penetration Test: The number of blows (N) required to drive a 51 mm O.D. split barrel sampler 300 mm into the soil using a 63.5 kg hammer with a free fall drop height of 760 mm.

DCPT Dynamic Cone Penetration Test. The number of blows (N) required to drive a 50 mm diameter cone 300 mm into the soil using a 63.5 kg hammer with a free fall drop height of 760 mm.

M/C insitu soil moisture content in percent

PL Plastic limit, moisture content in percent

LL Liquid limit, moisture content in percent

The undrained shear strength (Su) of cohesive soil is related to its consistency as follows:

Su (kPa)	Su (psf)	CONSISTENCY
<12	250	very soft
12 – 25	250 – 525	soft
25 – 50	525 – 1050	firm
50 – 100	1050 – 2100	stiff
100 – 200	2100 – 4200	very stiff
200	4200	hard

The SPT - N of non-cohesive soil is related to compactness condition as follows:

N – Blows / 300 mm	COMPACTNESS
0 - 4	very loose
4 - 10	loose
10 - 30	compact
30 - 50	dense
50 +	very dense

References:

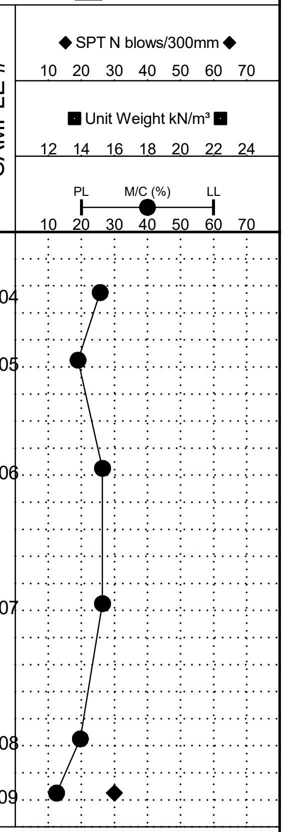
ASTM D2487 – Classification of Soils For Engineering Purposes (Unified Soil Classification System)

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

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-147**
LOCATION: UTM 14U: 5526115 m N, 627781 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill Rig w/125 mm SS & 200mm HS Augers	ELEVATION (m): 228.619

SAMPLE TYPE	GRAB	SHELBY TUBE	SPLIT SPOON	BULK	NO RECOVERY	CORE
BACKFILL TYPE	BENTONITE	GRAVEL	SLOUGH	GROUT	CUTTINGS	SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
228.619 – 226.2	0 – 2.4	CLAY (ALLUVIAL) - silty, trace sand - brown - dry to moist - intermediate plasticity - some silt below 1 m	GRAB GRAB	G304 G305
226.2 – 223.8	2.4 – 4.9	SILT (ALLUVIAL) - some clay, some sand - brown - moist, loose - grey and wet below 4 m	GRAB GRAB	G306 G307
223.8 – 221.9	4.9 – 6.7	SILT (TILL) - trace sand, trace gravel - grey, wet, loose - compact and moist below 5.5 m - dense at 6 m	GRAB SPLIT SPOON	G308 S309



END OF TEST HOLE AT 6.7 m IN SILT(TILL) (AUGER REFUSAL)
NOTES:
1. Some sloughing and seepage observed at 4 m.
2. After drilling to 5.8 m, hole caved to 4 m.
Switched to hollow stem (HS) augers at 5.8 m.
3. 25 mm PVC Standpipe piezometer w/ Cassagrande tip installed 6.7 m b/l grade.
Top of pipe (T.O.P) 0.91 m above grade.

Water levels:
September 23, 2019: 3.93 m below T.O.P. - Ground water elevation - 225.60 m
November 13, 2019: 2.70 m below T.O.P. - Ground water elevation - 226.83 m

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

LOGGED BY: CR	COMPLETION DEPTH: 6.71 m
REVIEWED BY: DRAFT	COMPLETION DATE: 30-7-19
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-148**
LOCATION: UTM 14U: 5526210 m N, 627763 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill Rig w/125 mm SS & 200mm HS Augers	ELEVATION (m): 230.566

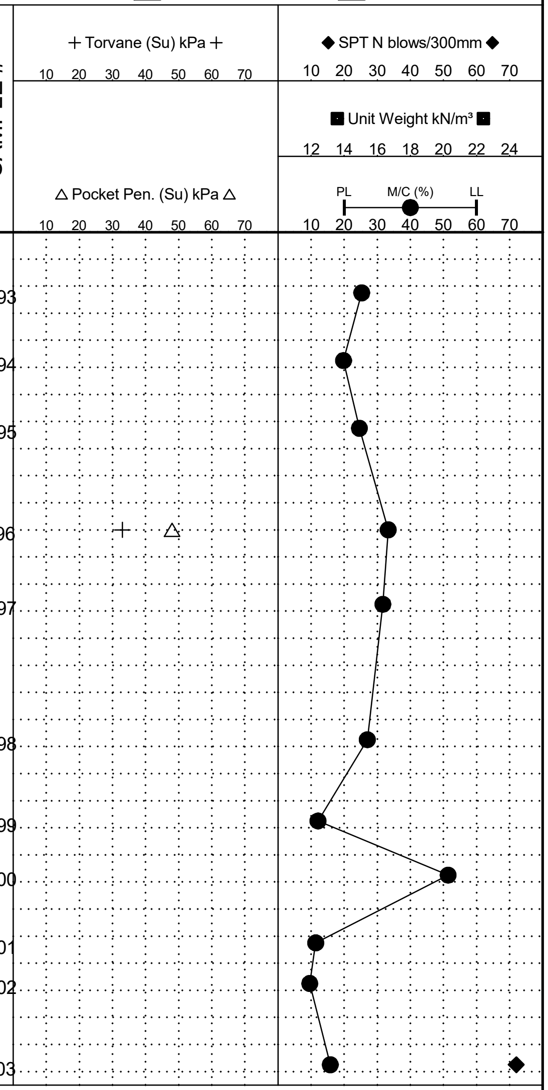
SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
		TOPSOIL (150 mm thick) - black, dry		
		CLAY (Alluvial) - some silt to silty - black with trace organics to 1.5 m - dry to moist	GRAB	G293
		- brown below 1.5 m - moist, stiff bvecoming firm below 3 m - intermediate to high plasticity (variable)	GRAB	G294
			GRAB	G295
			SHELBY TUBE	T296
			GRAB	G297
		- wet sand lense at 5.2 m - grey, wet, soft below 5.2 m	GRAB	G298
		SAND (Alluvial) - brown, wet, loose, coarse grained	GRAB	G299
		CLAY (Glaciolacustrine) - silty - grey - moist, firm to stiff, high plasticity	GRAB	G300
		SILT (TILL) - trace sand, trace gravel - grey, wet, loose becoming moist and dense to very dense at 9 m	GRAB	G301
			GRAB	G302
			SPLIT SPOON	S303

Elevation scale (m): 230, 229, 228, 227, 226, 225, 224, 223, 222, 221

Depth scale (m): 1, 2, 3, 4, 5, 6, 7, 8, 9



END OF TEST HOLE AT 9.6 m IN SILT(TILL) (AUGER REFUSAL)

NOTES:
1. Some sloughing and seepage observed.
2. After drilling to 8.8 m, hole caved to 5 m.
   Switched to hollow stem (HS) augers at 8.8 m.
4. 25 mm PVC Standpipe piezometer w/ Cassagrande tip installed 6.4 m b/l grade.
Top of pipe (T.O.P) 0.05 m below grade.
Water levels:
September 23, 2019: 4.13 m below T.O.P. - Ground water elevation at 226.436 m
November 13, 2019: 3.52 m below T.O.P. - Ground water elevation at 227.046 m

BH GEOTECH PLOTS-AUGUST 2013 143691.7_RUTLAND TRUNK_GINT.GPJ DATA TEMPLATE - AUGUST 2, 2013.GDT 26-2-20

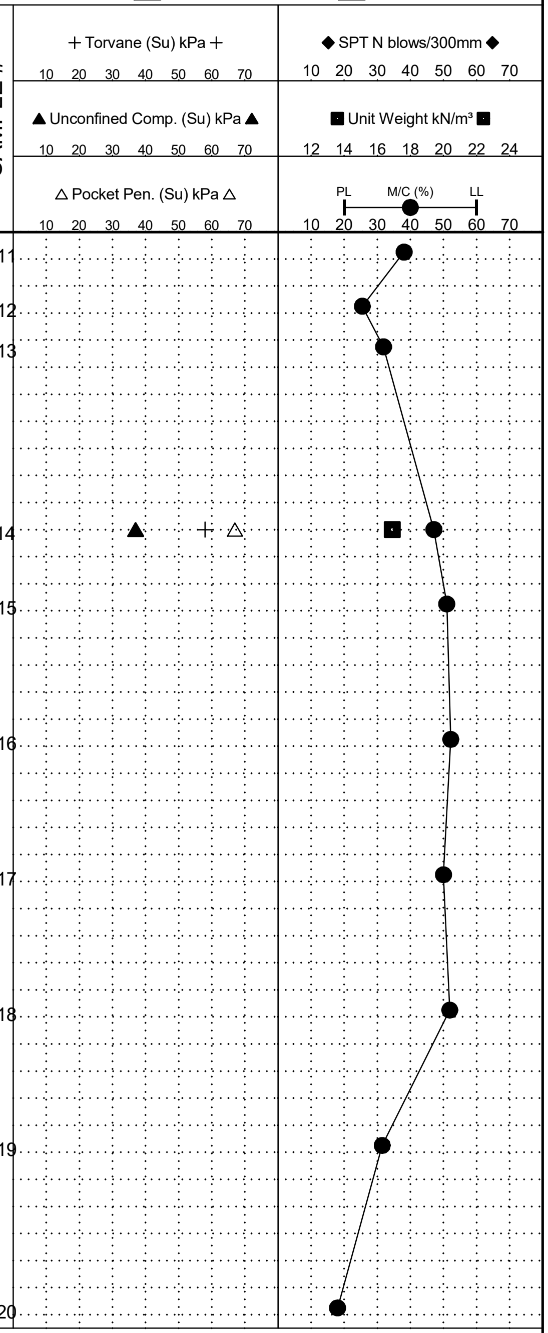
DYREGROV ROBINSON INC. Consulting Geotechnical Engineers	LOGGED BY: CR	COMPLETION DEPTH: 9.60 m
	REVIEWED BY: DRAFT	COMPLETION DATE: 29-7-19
	PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-155**
LOCATION: UTM 14U: 5526690 m N, 627784 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS Augers	ELEVATION (m): 233.629

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
		CONCRETE (130 mm thick) - sidewalk	GRAB	G311
233		CLAY - silty, trace organics - black, moist, stiff, high plasticity	GRAB	G312
	1	SILT - brown, moist, loose	GRAB	G313
232	2	CLAY - silty - mottled brown and grey - moist, stiff, high plasticity - trace silt inclusions		
231–230	3		SHELBY TUBE	T314
229	4		GRAB	G315
228	5–6	- grey below 5.5 m	GRAB	G316
227–226	7		GRAB	G317
225	8–9		GRAB	G318
224–223	10	- trace till inclusions, trace gravel below 10.4	GRAB	G319
222	11–12	SILT (TILL) - trace sand, trace gravel, grey, wet, loose	GRAB	G320



END OF TEST HOLE AT 12.3 m IN SILT(TILL)
NOTES:
1. No sloughing or seepage observed during drilling.
2. 25 mm PVC Standpipe piezometer w/ Cassagrande tip installed 12.3 m b/l grade.
Top of pipe (T.O.P) 0.075 m below grade.
Water levels:
September 23, 2019: 7.27 m below T.O.P. - Ground water elevation at 226.284 m
November 13, 2019: 5.10 m below T.O.P. - Ground water elevation at 228.454 m

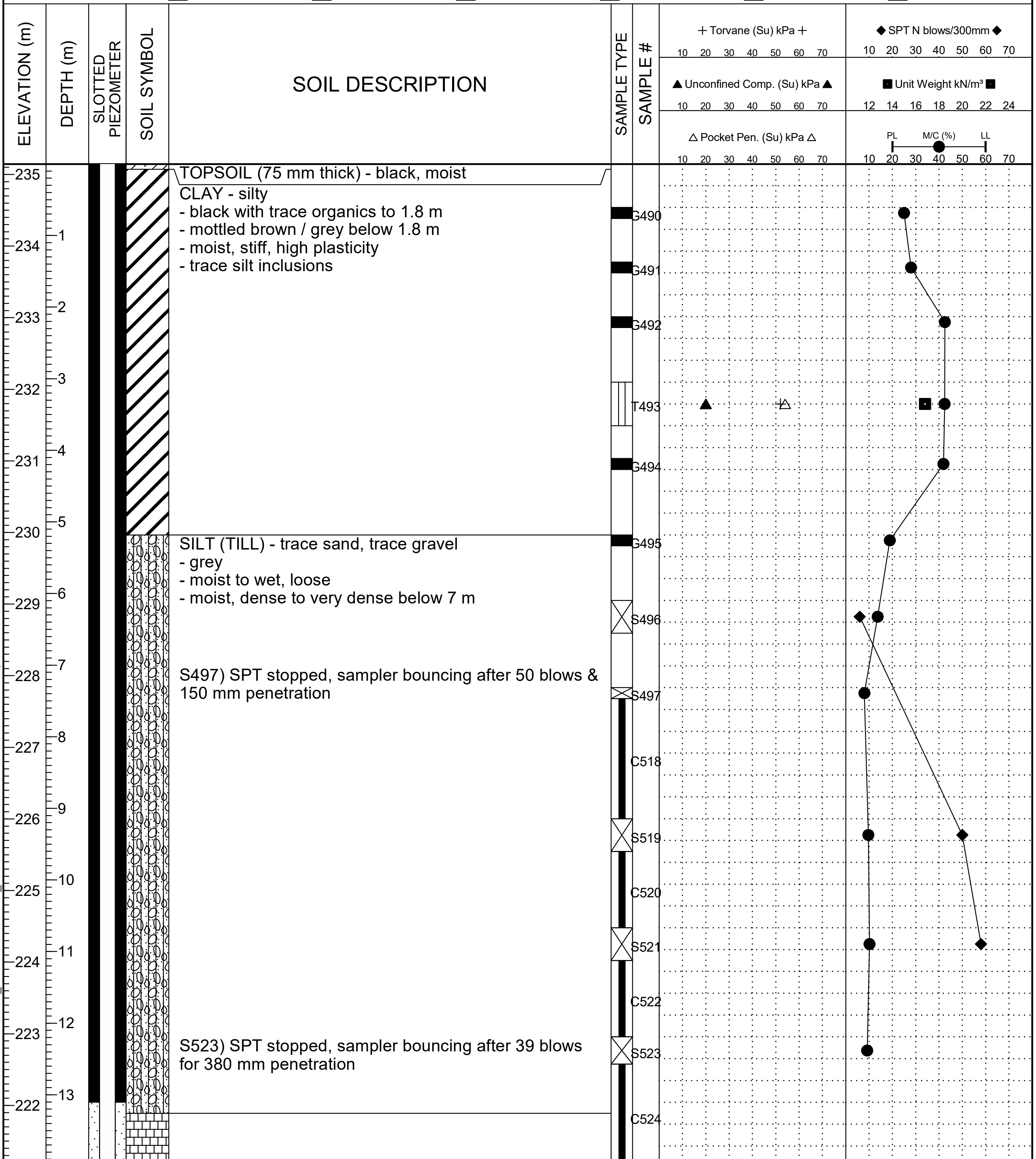
DYREGROV ROBINSON INC. Consulting Geotechnical Engineers	LOGGED BY: CR	COMPLETION DEPTH: 12.34 m
	REVIEWED BY: DRAFT	COMPLETION DATE: 30-7-19
	PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-173**
LOCATION: UTM 14U: 5527675 m N, 627822 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER MP8 Drill w/125 mm SS Augers & HQ coring	ELEVATION (m): 235.159

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE #
235	0	TOPSOIL (75 mm thick) - black, moist	
		CLAY - silty - black with trace organics to 1.8 m - mottled brown / grey below 1.8 m - moist, stiff, high plasticity - trace silt inclusions	G490, G491, G492, T493, G494
230	5.2	SILT (TILL) - trace sand, trace gravel - grey - moist to wet, loose - moist, dense to very dense below 7 m	G495, S496
		S497) SPT stopped, sampler bouncing after 50 blows & 150 mm penetration	S497, C518, S519, C520, S521, C522
		S523) SPT stopped, sampler bouncing after 39 blows for 380 mm penetration	S523
	13.2		C524



DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

LOGGED BY: CR	COMPLETION DEPTH: 15.54 m
REVIEWED BY: DRAFT	COMPLETION DATE: 15-8-19
PROJECT ENGINEER: Gil Robinson	

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-173**
LOCATION: UTM 14U: 5527675 m N, 627822 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER MP8 Drill w/125 mm SS Augers & HQ coring	ELEVATION (m): 235.159

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SLOTTED PIEZOMETER	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	+ Torvane (Su) kPa + 10 20 30 40 50 60 70 / ▲ Unconfined Comp. (Su) kPa ▲ 10 20 30 40 50 60 70 / △ Pocket Pen. (Su) kPa △ 10 20 30 40 50 60 70	◆ SPT N blows/300mm ◆ 10 20 30 40 50 60 70 / ■ Unit Weight kN/m³ ■ 12 14 16 18 20 22 24 / PL M/C (%) LL 10 20 30 40 50 60 70
221 220	15			BEDROCK - Red River Formation, Upper Fort Garry Member (dolomite) - poor to good quality, good below 14 m - whitish grey color, strong to very strong - horizontal and vertical fractures - close to moderately close discontinuity spacing - gapped to open joint apeture, evidence of water flow (Class 3) - 3 mm thick clay filling at 13.7 m and 13.9 m - trace small vugs (< 0.5mm) *continued from previous page*	CORE	C525		

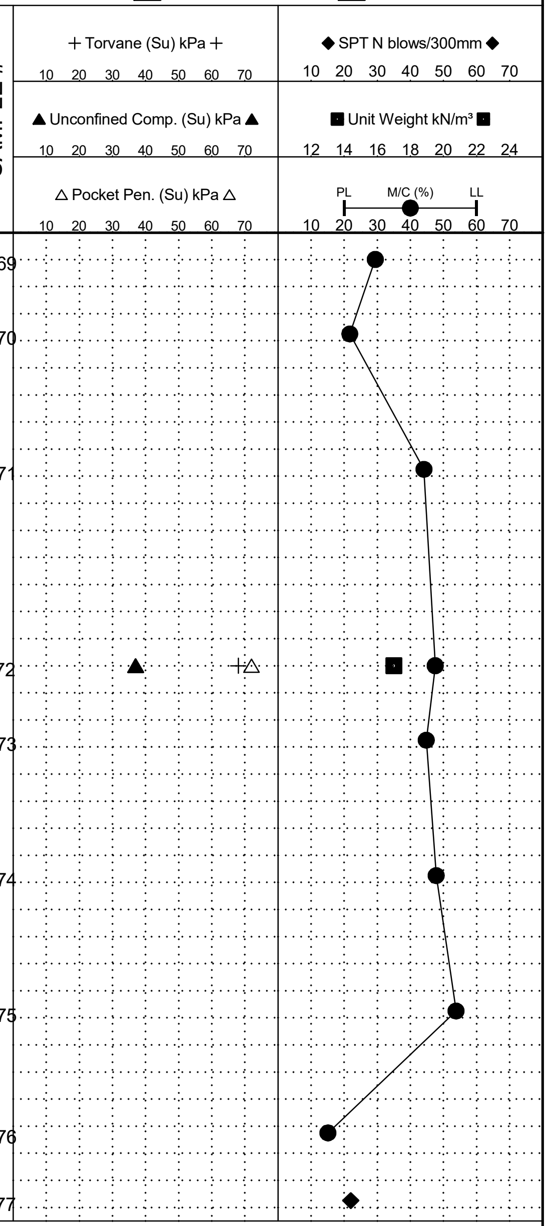
END OF TEST HOLE AT 15.5 m IN BEDROCK
Notes:
1. No sloughing or seepage observed during driling with augers.
2. Upon completion of drilling with augers, test hole open to 7.5 m b/l grade, dry.
3. Auger refusal occured at 7.5 m, switched to HQ coring with casing advancer.
4. 25 mm PVC Standpipe piezometer w/ Cassagrande tip installed 15.5 m b/l grade.
Top of pipe (T.O.P) 0.05 m below grade.
Water levels:
September 23, 2019: 8.43 m below T.O.P. - Ground water elevation at 226.679 m
November 13, 2019: 6.44 m below T.O.P. - Ground water elevation at 228.669 m

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-239**
LOCATION: UTM 14U: 5526983 m N, 627796 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS Augers	ELEVATION (m): 234.083

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
	0	CONCRETE (125 mm thick)		
		SAND and GRAVEL (FILL, 100 mm thick) - brown	GRAB	G369
		CLAY - silty, trace organics - black, moist, stiff, high plasticity		
233	1		GRAB	G370
		SILT - brown, moist to wet, loose		
		CLAY - silty - mottled brown and grey - moist, stiff, high plasticity - trace silt inclusions		
232	2			
			GRAB	G371
231	3			
230	4			
229	5		SHELBY TUBE	T372
			GRAB	G373
228	6	- grey below 6 m		
227	7		GRAB	G374
226	8			
225	9		GRAB	G375
224	10	SILT (TILL) - trace sand, trace gravel - grey, wet, loose becoming compact with depth	GRAB	G376
223	11		SPLIT SPOON	S377



END OF TEST HOLE AT 11.2 m IN SILT(TILL) (AUGER REFUSAL)
NOTES:
1. Some sloughing and seepage observed silt layer 0.6 m.
2. Upon completion of drilling, test hole open to 11 m b/l grade, water level 7.9 m b/l grade.
4. 25 mm PVC Standpipe piezometer w/ Cassagrande tip installed 11 m b/l grade.
Top of pipe (T.O.P) 0.05 m below grade.
Water levels:
September 23, 2019: 7.66 m below T.O.P. - Ground water elevation at 226.373 m
November 13, 2019: 5.50 m below T.O.P. - Ground water elevation at 228.533 m

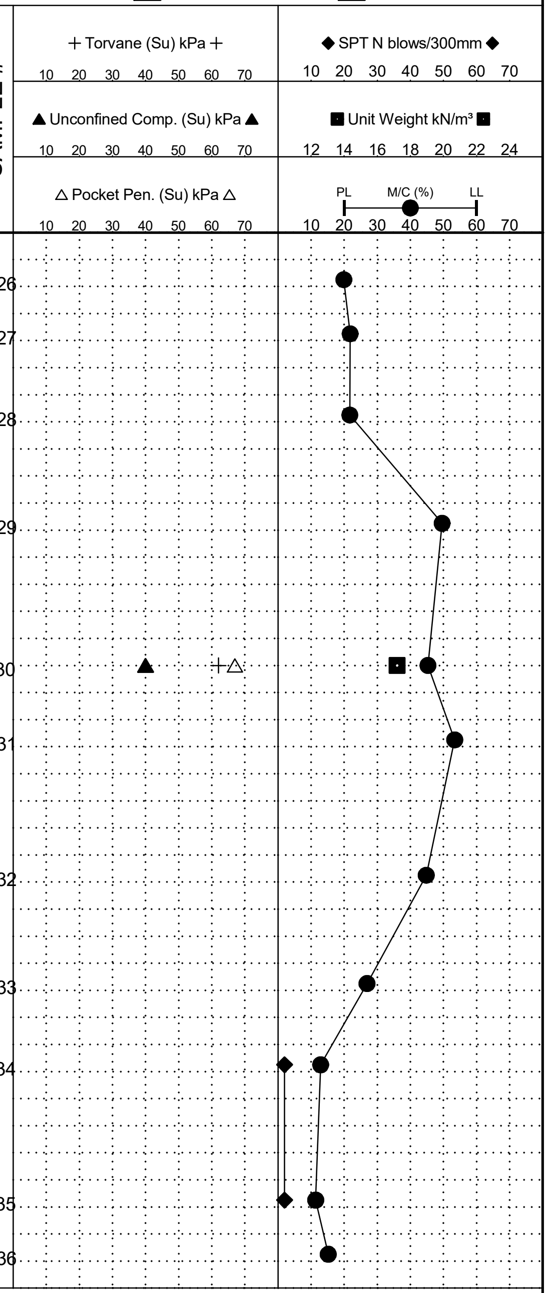
DYREGROV ROBINSON INC. Consulting Geotechnical Engineers	LOGGED BY: CR	COMPLETION DEPTH: 11.13 m
	REVIEWED BY: DRAFT	COMPLETION DATE: 1-8-19
	PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Ferry Rd. & Riverbend CSR - Rutland Trunk Sewer	CLIENT: Tetra Tech Canada Inc.	TEST HOLE NO: **19-240**
LOCATION: UTM 14U: 5527295 m N, 627808 m E		PROJECT NO.: 143691
CONTRACTOR: Paddock Drilling Ltd.	METHOD: ACKER SS Drill w/125 mm SS Augers	ELEVATION (m): 235.111

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
235	0	CLAY - silty, trace organics - black, moist, stiff		
		SILT - brown - moist, loose	GRAB	G426
234	1		GRAB	G427
233	2		GRAB	G428
		CLAY - silty - mottled brown and grey - moist, stiff, high plasticity - trace silt inclusions		
232	3		GRAB	G429
231	4			
230	5	- trace sand, trace gravel below 5 m	SHELBY TUBE	T430
		- grey, wet below 5.5 m	GRAB	G431
229	6			
228	7		GRAB	G432
227	8		GRAB	G433
226	9	SILT (TILL) - trace clay, trace sand, trace gravel - grey - wet, loose	SPLIT SPOON	S434
225	10			
224	11		SPLIT SPOON	S435
		- SPT attempted after refusal, no penetration sampler bouncing	GRAB	G436



END OF TEST HOLE AT 11.2 m IN SILT(TILL) (AUGER REFUSAL)

NOTES:

1. Sloughing observed from silt till layer below 9.4 m.
2. No seepage observed during drilling.
3. Upon completion of drilling test hole open to 9.4 m, dry.
4. 25 mm PVC Standpipe piezometer w/ Cassagrande tip installed 9.4 m b/l grade.

Top of pipe (T.O.P) 0.05 m below grade.

Water levels:

September 23, 2019: 8.45 m below T.O.P. - Ground water elevation at 226.611 m

November 13, 2019: 7.80 m below T.O.P. - Ground water elevation at 227.261 m

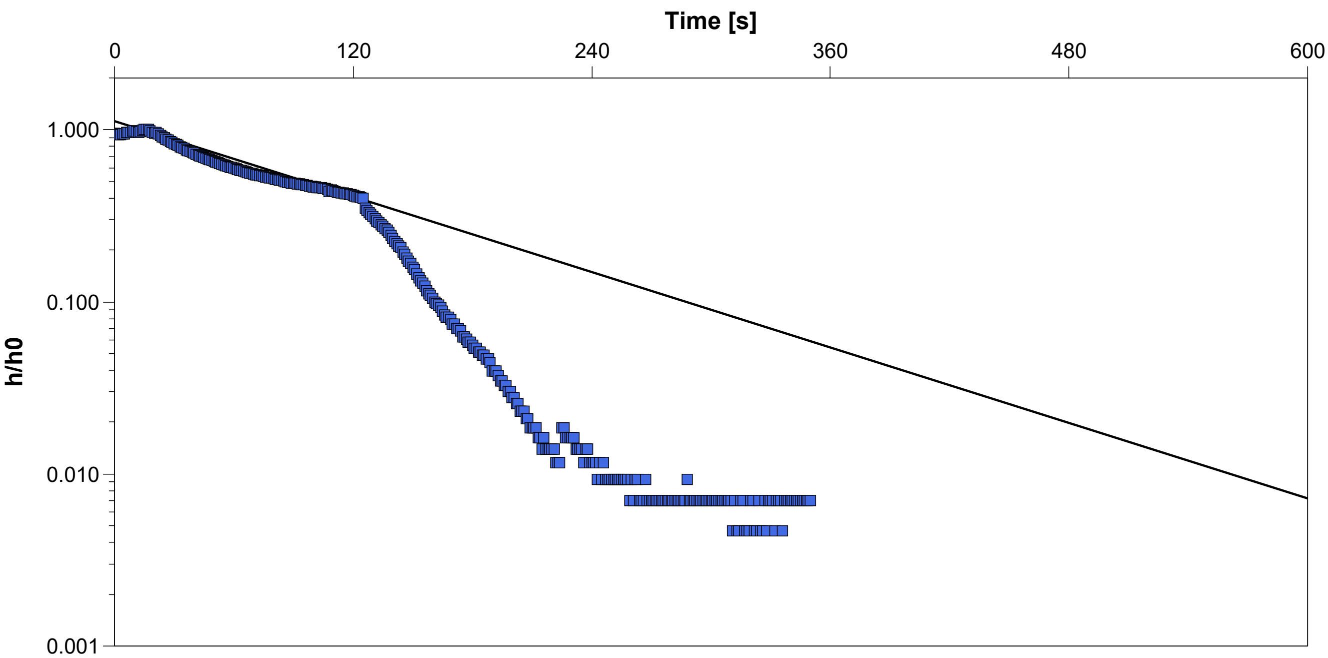
DYREGROV ROBINSON INC. Consulting Geotechnical Engineers	LOGGED BY: CR	COMPLETION DEPTH: 11.89 m
	REVIEWED BY: DRAFT	COMPLETION DATE: 2-8-19
	PROJECT ENGINEER: Gil Robinson	Page 1 of 1

APPENDIX B

HYDRAULIC CONDUCTIVITY GRAPHS

Slug Test Analysis Report	
TETRA TECH	Project: Ferry Road Sewer Line Upgrade
	Number: 705-1000120300
	Client: City of Winnipeg

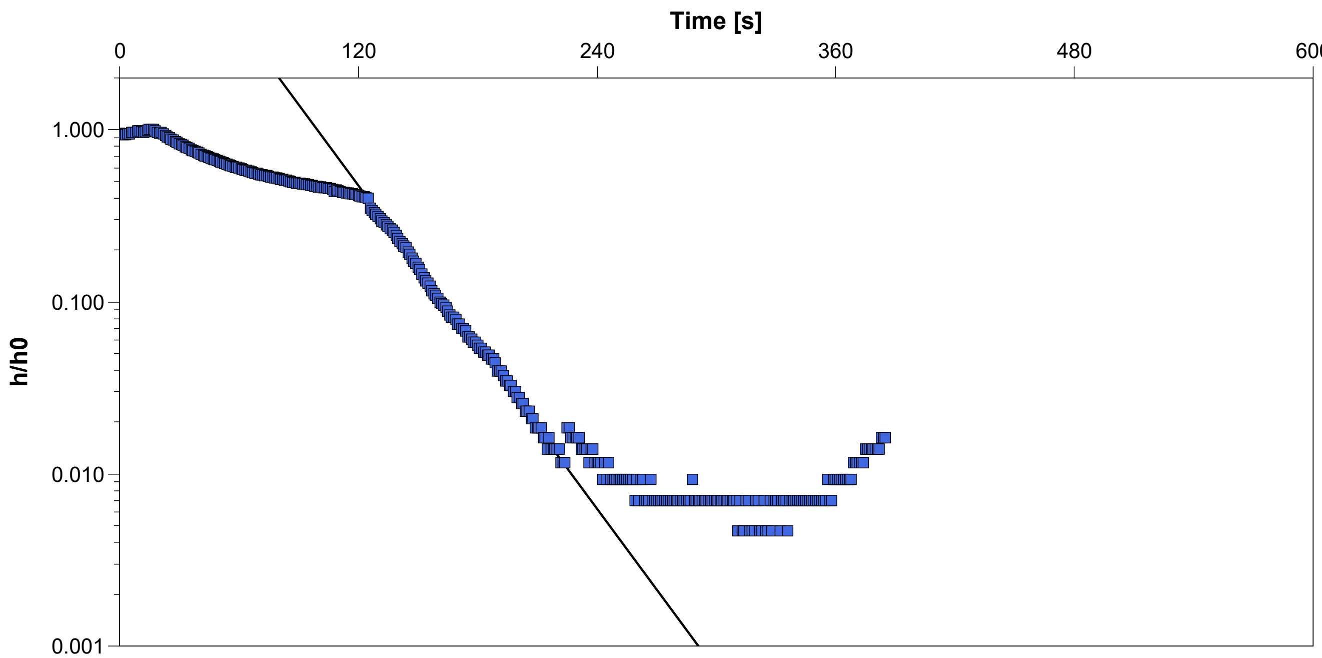
Location: Ferry Road, Winnipeg	Slug Test: TH19-147 Falling Head	Test Well: TH19-147
Test Conducted by: M. Randell		Test Date: 2020-05-25
Analysis Performed by:	TH19-147 Falling Head	Analysis Date: 2020-07-21
Aquifer Thickness: 10.00 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
TH19-147	7.00×10^{-6}	

TETRA TECH		**Slug Test Analysis Report**
		Project: Ferry Road Sewer Line Upgrade
		Number: 705-1000120300
		Client: City of Winnipeg
Location: Ferry Road, Winnipeg	Slug Test: TH19-147 Falling Head	Test Well: TH19-147
Test Conducted by: M. Randell		Test Date: 2020-05-25
Analysis Performed by:	TH19-147 Falling Head- Secondary	Analysis Date: 2020-06-11
Aquifer Thickness: 10.00 m		

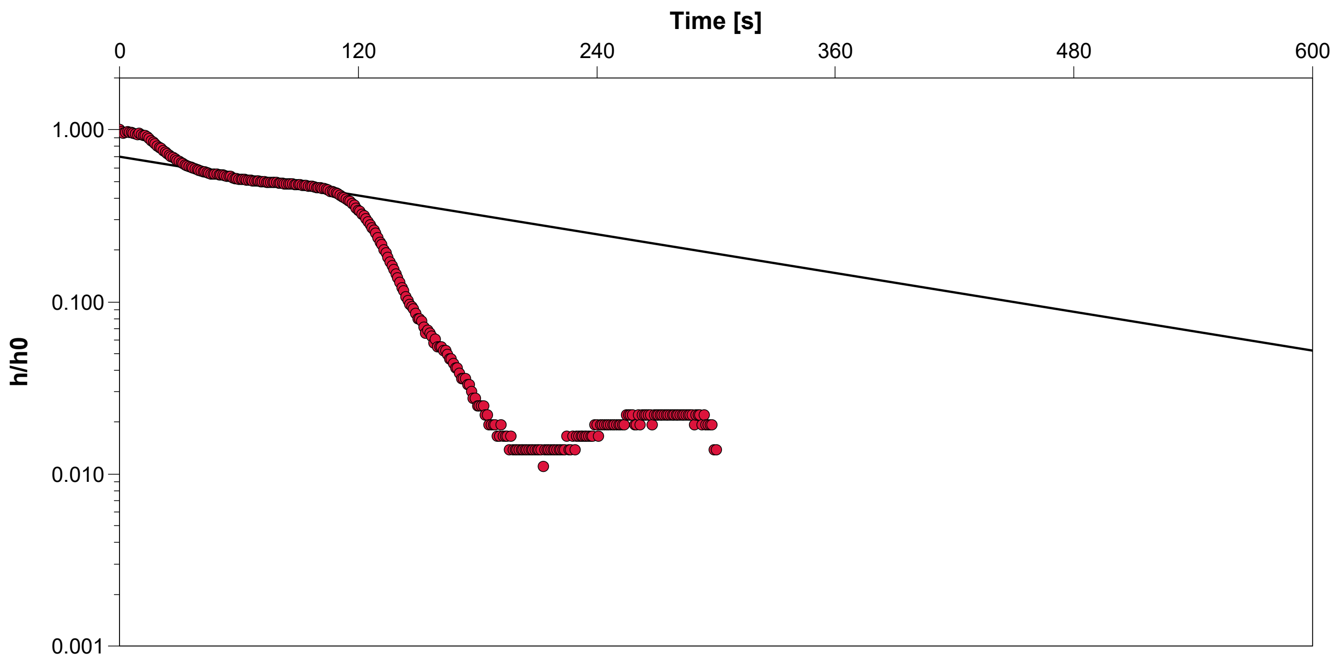


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
TH19-147	3.00×10^{-5}	

Slug Test Analysis Report	
	Project: Ferry Road Sewer Line Upgrade
	Number: 705-1000120300
	Client: City of Winnipeg

Location: Ferry Road, Winnipeg	Slug Test: TH19-148 falling Head	Test Well: TH19-148
Test Conducted by:		Test Date: 2020-06-11
Analysis Performed by:	TH19-148 Falling Head	Analysis Date: 2020-07-21
Aquifer Thickness: 10.00 m		

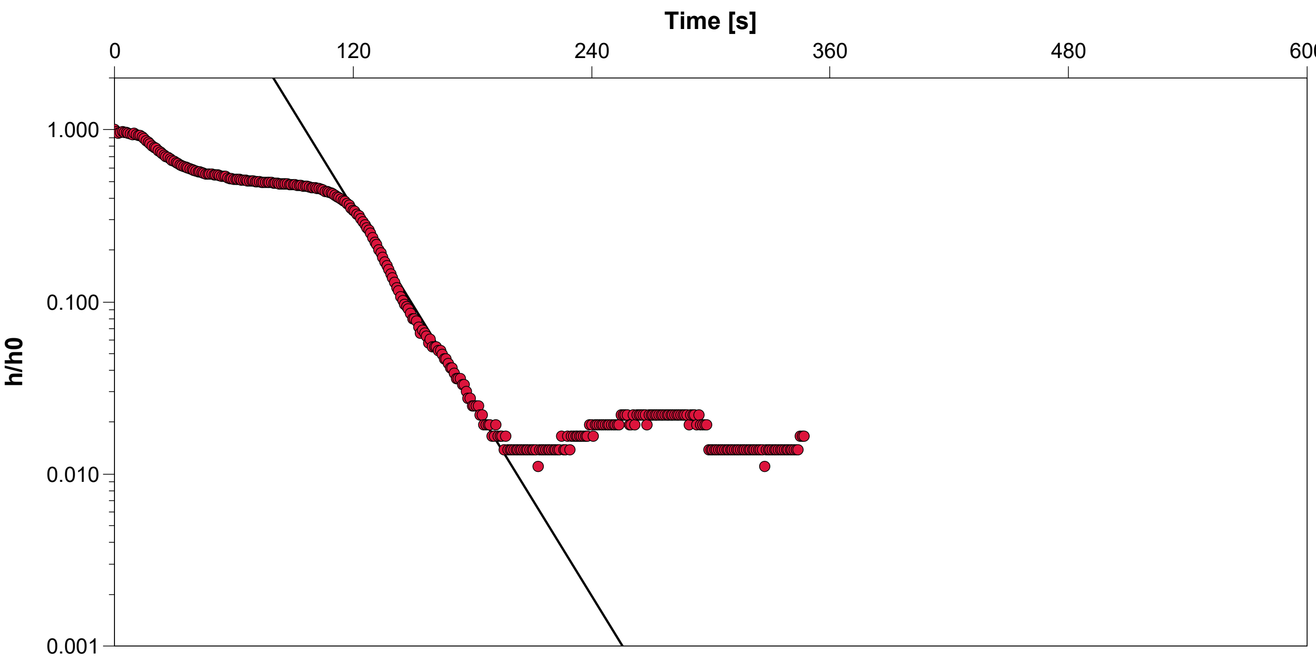


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
TH19-148	3.60×10^{-6}	

TETRA TECH	**Slug Test Analysis Report**
	Project: Ferry Road Sewer Line Upgrade
	Number: 705-1000120300
	Client: City of Winnipeg

Location: Ferry Road, Winnipeg	Slug Test: TH19-148 falling Head	Test Well: TH19-148
Test Conducted by:		Test Date: 2020-06-11
Analysis Performed by:	TH19-148 Falling Head - Secondary	Analysis Date: 2020-06-11
Aquifer Thickness: 10.00 m		

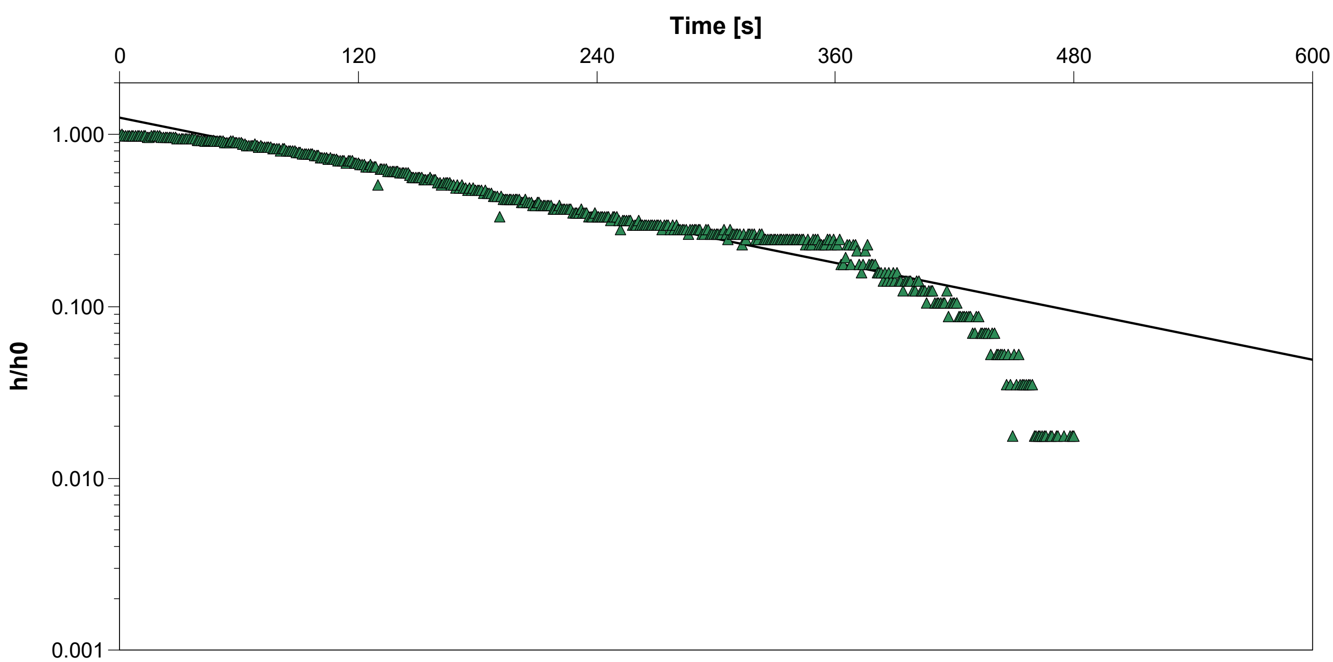


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
TH19-148	3.60×10^{-5}	

TETRA TECH	**Slug Test Analysis Report**
	Project: Ferry Road Sewer Line Upgrade
	Number: 705-1000120300
	Client: City of Winnipeg

Location: Ferry Road, Winnipeg	Slug Test: TH19-155 All Data	Test Well: TH19-155
Test Conducted by: M. Randell		Test Date: 2020-05-25
Analysis Performed by:	TH18-155 Falling Head	Analysis Date: 2020-07-21
Aquifer Thickness: 10.00 m		

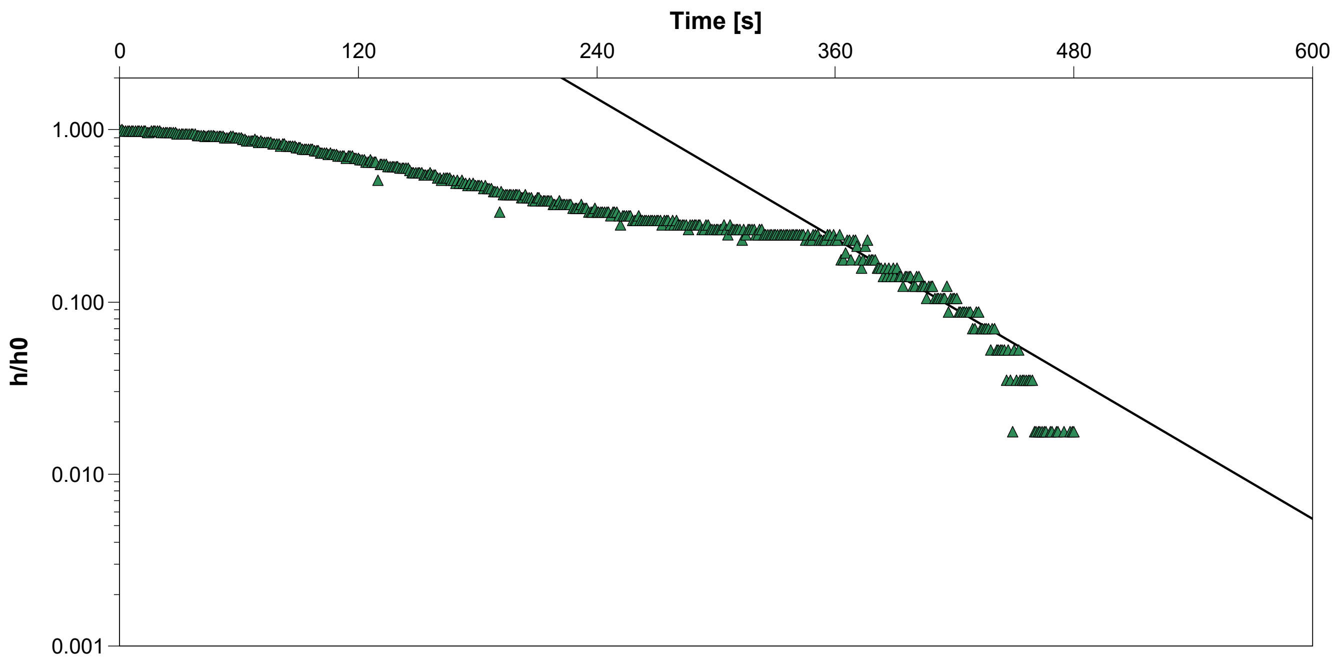


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
TH19-155	4.50×10^{-6}	

Slug Test Analysis Report	
Project: Ferry Road Sewer Line Upgrade	
Number: 705-1000120300	
Client: City of Winnipeg	

Location: Ferry Road, Winnipeg	Slug Test: TH19-155 All Data	Test Well: TH19-155
Test Conducted by: M. Randell		Test Date: 2020-05-25
Analysis Performed by:	TH19-155 Falling Head - Secondary	Analysis Date: 2020-07-21
Aquifer Thickness: 10.00 m		

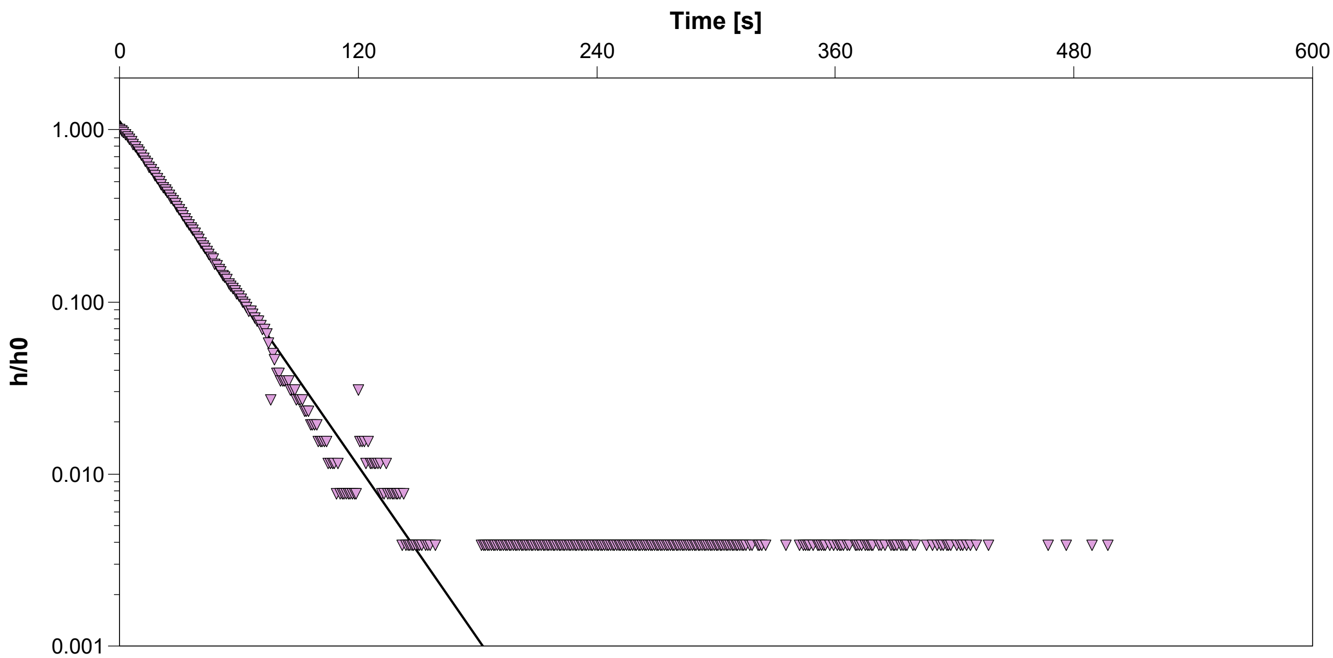


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
TH19-155	1.30×10^{-5}	

TETRA TECH	**Slug Test Analysis Report**
	Project: Ferry Road Sewer Line Upgrade
	Number: 705-1000120300
	Client: City of Winnipeg

Location: Ferry Road, Winnipeg	Slug Test: TH19-173 falling 1	Test Well: TH19-173
Test Conducted by:		Test Date: 2020-06-11
Analysis Performed by:	TH19-173 Falling Head	Analysis Date: 2020-06-11
Aquifer Thickness:		



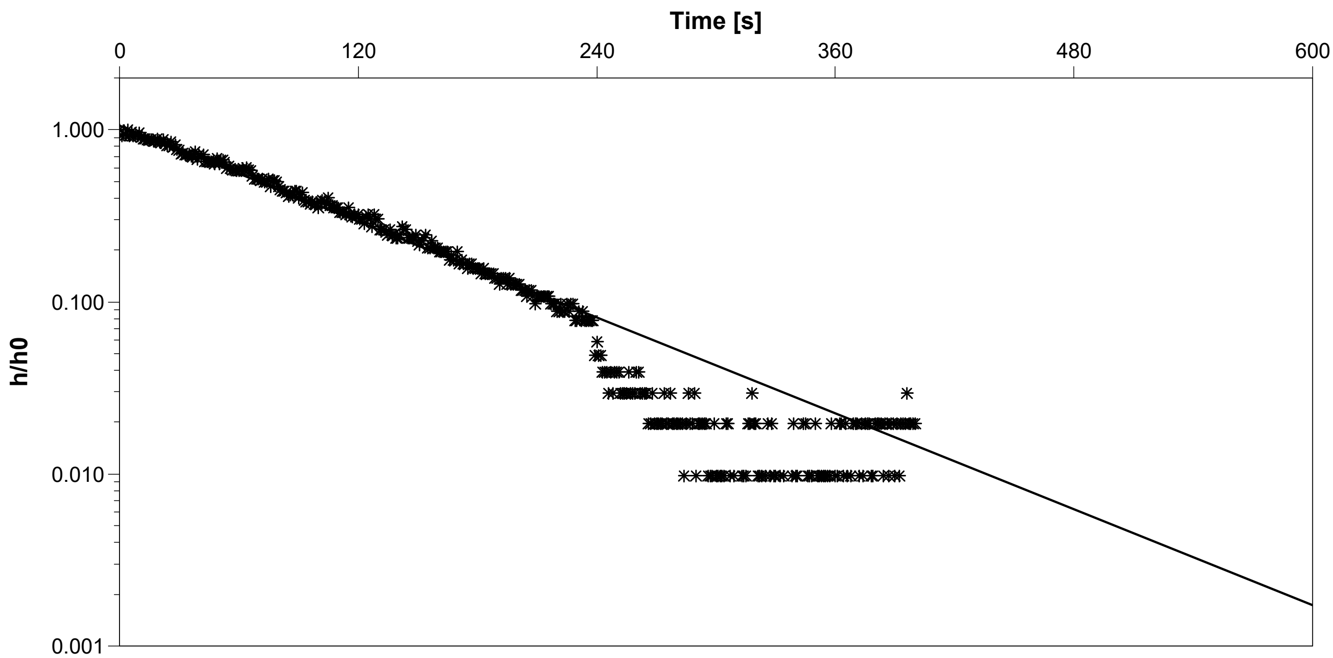
Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
TH19-173	3.20×10^{-5}	

Slug Test Analysis Report

Project:	Ferry Road Sewer Line Upgrade
Number:	705-1000120300
Client:	City of Winnipeg

Location: Ferry Road, Winnipeg	Slug Test: TH19-239 Falling	Test Well: TH19-239
Test Conducted by:		Test Date: 2020-06-11
Analysis Performed by:	TH19-239 Falling Head	Analysis Date: 2020-06-11
Aquifer Thickness: 10.00 m		



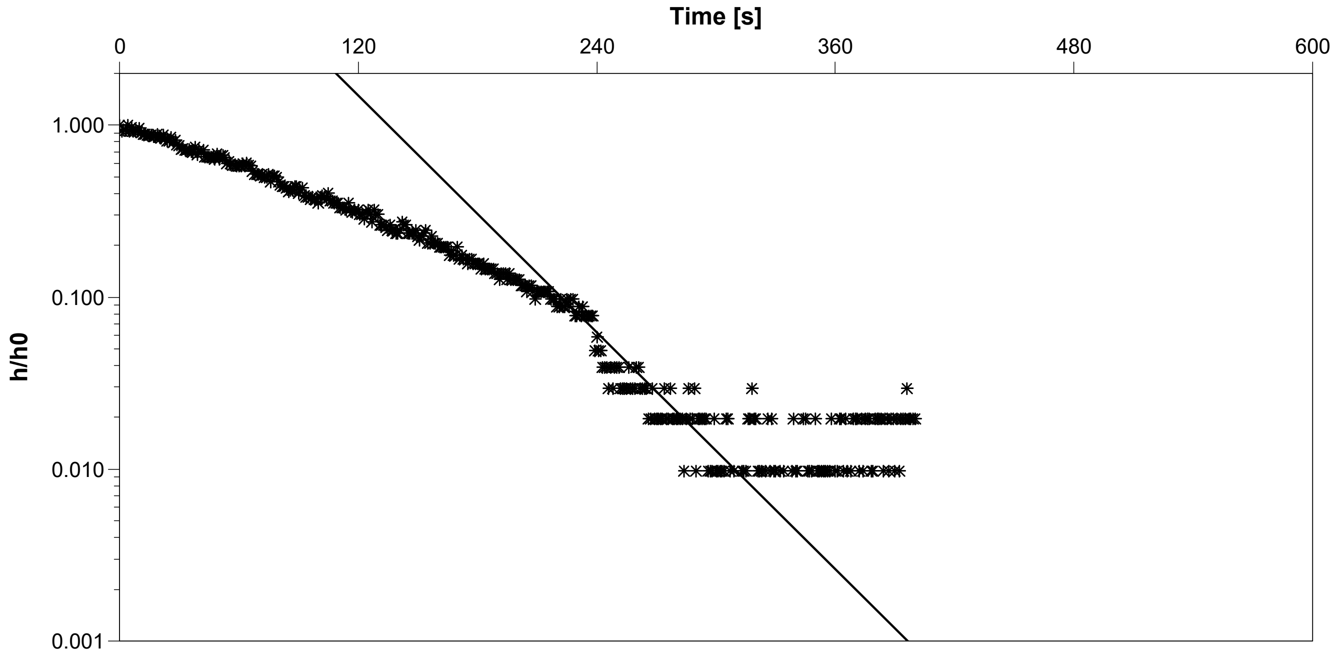
Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
TH19-239	8.90×10^{-6}	

Slug Test Analysis Report

Project:	Ferry Road Sewer Line Upgrade
Number:	705-1000120300
Client:	City of Winnipeg

Location: Ferry Road, Winnipeg	Slug Test: TH19-239 Falling	Test Well: TH19-239
Test Conducted by:		Test Date: 2020-06-11
Analysis Performed by:	TH19-239 Falling - Secondary	Analysis Date: 2020-07-22
Aquifer Thickness: 10.00 m		

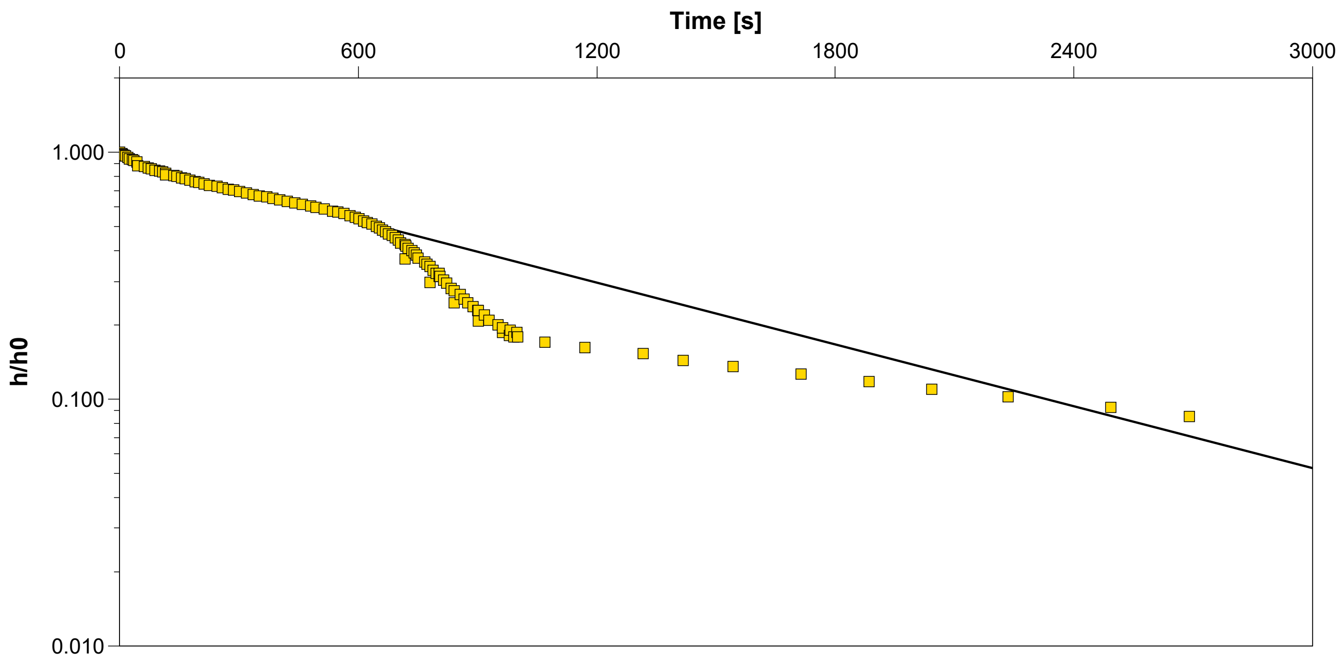


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
TH19-239	2.20×10^{-5}	

TETRA TECH	**Slug Test Analysis Report**
	Project: Ferry Road Sewer Line Upgrade
	Number: 705-1000120300
	Client: City of Winnipeg

Location: Ferry Road, Winnipeg	Slug Test: TH19-240 Falling	Test Well: TH19-240
Test Conducted by:		Test Date: 2020-06-11
Analysis Performed by:	TH19-240 Falling Head	Analysis Date: 2020-06-11
Aquifer Thickness: 10.00 m		

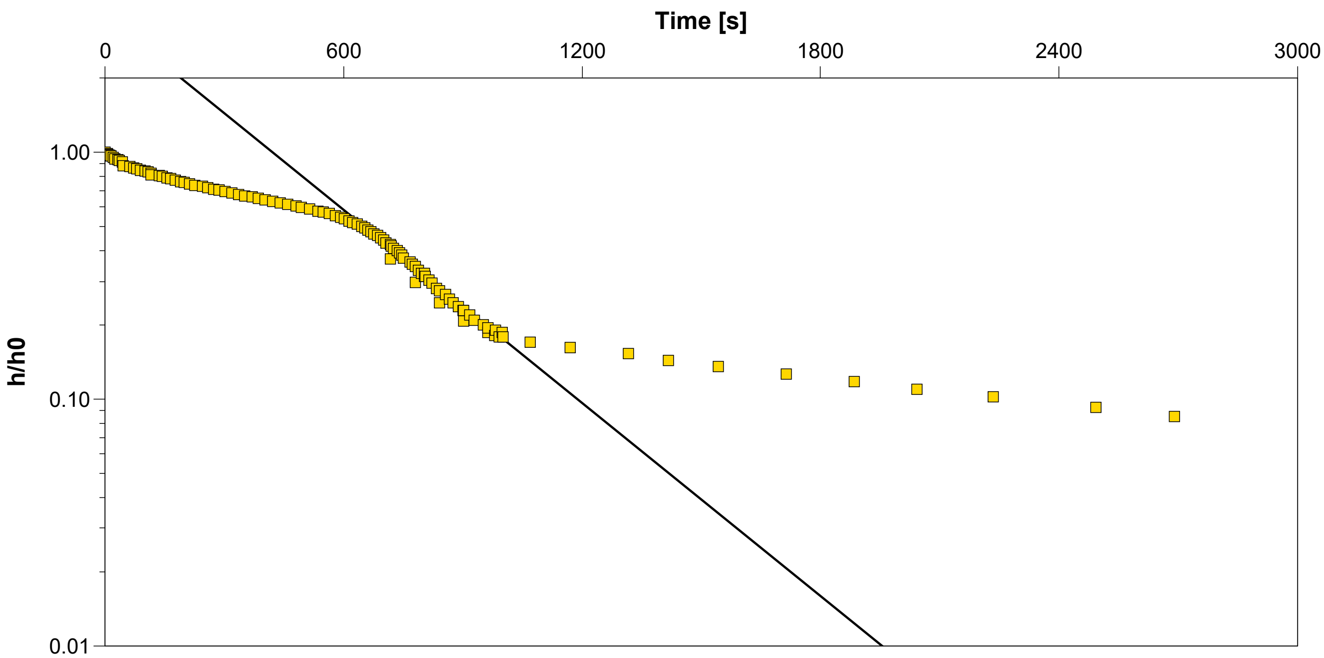


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
TH19-240	8.00×10^{-7}	

TETRA TECH	**Slug Test Analysis Report**
	Project: Ferry Road Sewer Line Upgrade
	Number: 705-1000120300
	Client: City of Winnipeg

Location: Ferry Road, Winnipeg	Slug Test: TH19-240 Falling	Test Well: TH19-240
Test Conducted by:		Test Date: 2020-06-11
Analysis Performed by:	TH19-240 Falling Head - Secondary	Analysis Date: 2020-07-21
Aquifer Thickness: 10.00 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
TH19-240	2.50×10^{-6}	

GEOTECHNICAL
ENGINEERS

DYREGROV ROBINSON INC.
1692 Dublin Ave #1, Winnipeg, MB, Canada R3H 1A8
204.632.7252
DRIGEOTECHNICAL.CA