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Geotechnical Investigation Munroe Avenue East and Harry Street Reconstruction

Town of Renfrew, Ontario

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Submitted to:

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Geotechnical Investigation Munroe Avenue East and Harry Street Reconstruction

Town of Renfrew, Ontario

May 5, 2023
Project: 100040.017

experience • knowledge • integrity

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May 5, 2023 File: 100040.017

Morrison Hershfield
200-2392 Baseline Road
Ottawa, Ontario
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Re: Geotechnical Investigation
Munroe Avenue East and Harry Street Reconstruction
Town of Renfrew, Ontario

Enclosed is our report for the above noted project based on the scope of work presented in our proposal dated August 29, 2022. This report was prepared by Pat Baxter, Senior Technologist, and reviewed by Alex Meacoe, P.Eng.

Pat W. Alex Meacoe

Pat Baxter Alex Meacoe, P.Eng.

PB/JPG/WAM

Enclosures
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1.0 INTRODUCTION

This report presents the results of a subsurface investigation carried out for rehabilitation of the underground infrastructure along Munroe Avenue East and Harry Street in the Town of Renfrew, Ontario. The purpose of the investigation was to identify the general subsurface and groundwater conditions at the site by means of a limited number of boreholes and, based on the factual information obtained, to provide engineering guidelines on the geotechnical design aspects of the project, including construction considerations that could influence design decisions.

GEMTEC Consulting Engineers and Scientists Limited (GEMTEC) was also engaged to carry out an environmental screening program concurrently with the geotechnical and hydrogeological investigation. The results of the environmental screening program are provided in a separate report.

2.0 BACKGROUND

2.1 Project Description

Plans are being prepared to rehabilitate the road, sidewalk, curbs, and underground infrastructure along Munroe Avenue East and Harry Street. The project limits are as follows:

- Munroe Avenue East from about 70 metres west of Harry Street to 90 metres east of the cul-de-sac, with a length of about 400 metres; and,
- Harry Street from Munroe Avenue East to about 200 metres South of Munroe Avenue East.

Based on the information provided to us, the following is known about the project:

- A new storm sewer is to be constructed throughout Harry Street and Munro Avenue East including an outfall into the ravine east of the Munro Avenue East cul-de-sac with an excavation depth of between about 2.5 and 3.5 metres below ground surface;
- A full replacement of the watermain is to be carried out along Harry Street and Munroe Avenue East with an excavation depth of about 3 metres below ground surface;
- Localized repairs and replacement of sanitary sewers and services are to be carried out with an excavation depth of between about 3 and 4 metres below ground surface; and,
- Drainage improvements will be undertaken.

2.2 Site Geology

Based on our previous experience, and a review of published geological maps, the subsurface conditions within the project limits are anticipated to consist of the existing pavement structure overlying weathered silty clay crust and glacial till. The bedrock surface is expected at depths between 5 to 10 metres below the ground surface. Fill material associated with the past development of the area should be anticipated.

Based on Ontario Geological Survey Maps of the Renfrew area, the bedrock is mapped as Precambrian Rock.

3.0 METHODOLOGY

3.1 Geotechnical Investigation

The field work for the geotechnical investigation was carried out between November 4 and 8, 2022. During that time, a total of seven boreholes, numbered 22-01 to 22-07, inclusive, were advanced to depths ranging from about 6.4 to 6.7 metres below the existing ground surface using a truck mounted hollow stem auger drill rig supplied and operated by CCC Group of Ottawa, Ontario.

Standard penetration tests were carried out in the boreholes and samples of the soils encountered were recovered using a 50 millimetre diameter split barrel sampler. In situ vane shear testing was carried out, where possible, in the boreholes to measure the undrained shear strength of the silty clay.

Monitoring wells were installed in boreholes 22-02, 22-05, and 22-07 to measure the groundwater levels and facilitate hydraulic conductivity testing and groundwater sampling, where required.

The fieldwork was observed by a member of our engineering staff who directed the drilling operations, carried out the in situ testing and logged the samples and boreholes. Following the fieldwork, the soil samples were returned to our laboratory for examination by a geotechnical engineer. Selected samples of the soil were tested for water content, Atterberg limits, shrinkage limits, and grain size distribution testing.

Two samples of the soil recovered, one each from borehole 22-02 and 22-06, were sent to Paracel Laboratories Ltd. for basic chemical testing relating to corrosion of buried concrete and steel.

The borehole locations were selected by GEMTEC and positioned on site relative to existing features and utilities. The ground surface elevations at the location of the boreholes were determined using a Trimble R10 global positioning system. The coordinates and elevations of the boreholes are considered to be accurate within the tolerance of the instrument.

The approximate locations of the boreholes are shown on the Site Plan, Figure 1. Descriptions of the subsurface conditions logged in the boreholes are provided on the Record of Borehole sheets in Appendix A. The results of the laboratory testing are provided in Appendix B and on the Record of Borehole sheets. The results of the chemical testing on the soil samples are provided in Appendix C.

3.2 Rehabilitation Design Methods

The existing and required pavement structural capacity was determined according to the Ontario Ministry of Transportation (MTO) report MI-183, Adaptation and Verification of AASHTO Pavement Design Guide for Ontario Conditions.

Structural layer coefficients utilized in the report have been selected based on engineering judgement and the results of laboratory grain size testing, as appropriate.

Assessment of material suitability was made based on the MTO Pavement Design and Rehabilitation Manual, 2nd Edition dated March 2013 and engineering experience, as appropriate.

3.3 Hydraulic Testing

Hydraulic testing was carried out on December 15, 2022, in the monitoring wells installed as part of this investigation. The monitoring well screens were installed within a surround of filter sand. Above the filter sand pack, bentonite pellets were used to seal the monitoring well from the soil above. The hydraulic testing was performed to estimate the hydraulic conductivity of the soil within the anticipated depth of possible excavations and to provide an estimate of the potential quantity of water entering future excavations.

The hydraulic tests performed involved falling and/or rising head testing by introducing or removing a slug. Under circumstances where well recovery was slow, the well was purged to a known depth and the water level recovery was monitored to estimate the hydraulic properties of the soils. A summary of the hydraulic testing carried out in this investigation is provided in Table 3.1. Boreholes 22-05 and 22-07 had an inadequate water column height to perform testing (less than 35 centimetres). Hydraulic tests were performed in borehole 22-02; however, observed displacement within the well was inadequate for analysis purposes, potentially as the result of filter pack effects. Ultimately, only the purge and recovery data from borehole 22-02 was analysed to estimate the hydraulic conductivity of the weathered silty clay crust.

Details of the well screens are provided on the Record of Borehole sheets in Appendix A. The results of the hydraulic testing are provided in Appendix D.

Table 3.1 – Summary of Hydraulic Testing

Borehole	Geological Material	Test Methodology		
		Falling Head Test[1]	Rising Head Test[2]	Purge and Recovery[3]
22-02	Weathered Silty Clay	✓	✓	✓
22-05	Weathered Silty Clay	×	×	×
22-07	Weathered Silty Clay to Sandy Silt	×	×	×

Notes:

1. Falling head testing by introducing a slug involved introducing an instantaneous pressure increase to the water column within the well screen (equal to the volume of the slug) and monitoring the dissipation of the water level over time using a groundwater data logging pressure transducer together with an electric water level tape.
2. Rising head testing by removing a slug involved introducing an instantaneous pressure decrease to the water column within the well screen (equal to the volume of the slug) and monitoring the recovery of the water level over time using a groundwater data logging pressure transducer together with an electric water level tape.
3. Purge and recovery testing involved extracting water from the well until it is gurgle dry and monitoring the recovery of the well using a data logging pressure transducer. Purging during this method was assumed as an instantaneous displacement due to the low hydraulic conductivity materials supplying the well and it was analysed comparably to a rising head slug test.

3.4 Slope Stability Assessment

A site reconnaissance was carried out by a member of our engineering staff on October 26, 2022.

At the time of the site visit, the geometry of the slope at the location of the outfall within the ravine at the end of Munroe Avenue East was measured using hand surveying equipment. The cross section was positioned at the site by GEMTEC personnel. The location of the cross section considered is provided on Figure 1. A profile of the cross section of the slope is provided in Appendix E.

The geometries of the cross sections considered are summarized below in Table 3.2:

Table 3.2 – Slope Cross Section Height and Slope Inclination

Cross Section	Slope Height (metres)	Overall inclination from horizontal (degrees)
A-A	17.9	40

In general, the slope was vegetated with small to large trees, no grass was observed along the slope. Several fallen trees were observed along the toe of the slope. Signs of overall slope instability (i.e., previous rotational failures) were observed at the site.

4.0 SUBSURFACE CONDITIONS

4.1 General

As previously indicated, the soil and groundwater conditions identified in the boreholes are given on the Record of Borehole sheets in Appendix A. The borehole logs indicate the subsurface conditions at the specific test locations only. Boundaries between zones on the logs are often not distinct, but rather are transitional and have been interpreted. The precision with which subsurface conditions are indicated depends on the method of drilling, the frequency and recovery of samples and the uniformity of the subsurface conditions. Subsurface conditions at areas other than the borehole locations may vary from the conditions encountered in the boreholes. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties.

The groundwater conditions described in this report refer only to those observed at the place and time of observation noted in the report. These conditions may vary seasonally or as a consequence of construction activities in the area.

The soil descriptions in this report are based on commonly accepted methods of classification and identification employed in geotechnical practice. Classification and identification of soil involves judgement and GEMTEC does not guarantee descriptions as exact but infers accuracy to the extent that is common in current geotechnical practice. The following presents an overview of the subsurface conditions encountered in the boreholes advanced during this investigation.

4.2 Munroe Avenue East

Boreholes 22-01 to 22-05 were advanced along Monroe Avenue East.

4.2.1 Existing Pavement Structure

Asphaltic concrete was encountered at the surface at borehole locations 22-01 to 22-05 with a thickness ranging from 150 to 230 millimetres. Roadway base material was encountered below the asphaltic concrete at boreholes 22-01 to 22-05. The roadway base material consists of gravelly sand with some silt with a thickness ranging from about 230 to 660 millimetres.

Grain size distribution testing carried out on one sample of the roadway base material along with the grain size distribution envelope for Ontario Provincial Standard Specification (OPSS) Granular B Type I is provided in Appendix B and summarized in Table 4.1.

Table 4.1 – Summary of Grain Size Distribution Testing (Roadway Base Material)

Location	Sample Number	Sample Depth (metres)	Gravel (%)	Sand (%)	Silt & Clay (%)
22-03	1	0.2 to 0.8	25	61	14

The results indicate that the sample of roadway base material tested generally meets the gradation requirements for OPSS Granular B Type I, although the material exceeds the fines content (14 percent compared to the limit of 8 percent). This exceedance of the specification is not expected to negatively impact the performance of the existing pavement structure.

Moisture content testing on a sample of the roadway base material indicates a moisture content of about 4 percent.

A summary of the existing pavement structure encountered along Munroe Street is provided in Table 4.2.

Recommended structural layer coefficients are provided in Table 8-7 of MTO report MI-183, Adaptation and Verification of AASHTO Pavement Design Guide for Ontario Conditions. Using coefficients of 0.22 for the existing asphaltic concrete and 0.09 for the existing granular material, respectively, the existing Structural Number (SN) ranges from 60 to 92 millimetres.

The 15th percentile SN is 61 millimetres, meaning that the pavement structure should statistically have an SN in excess of this value over 85 percent of the area.

Table 4.2 – Summary of Existing Pavement Structure – Munroe Avenue East

Borehole	Asphaltic Concrete Thickness (millimetres)	Granular Thickness (millimetres)	Existing Structural Number (millimetres)
BH 22-01	180	230	60
BH 22-02	150	460	74
BH 22-03	150	660	92
BH 22-04	150	310	61
BH 22-05	230	280	76

4.2.2 Fill Material

Fill material was encountered below the pavement structure at borehole 22-05 with a thickness of about 0.4 metres and extending to a depth of about 0.9 metres below the existing ground surface. The fill material generally consists of silty clay with trace sand.

4.2.3 Silty Clay to Clayey Silt

Native deposits of silty clay to clayey silt were encountered in the boreholes at depths ranging from about 0.4 to 0.9 metres below the existing ground surface. The full depth of the silty clay to clayey silt deposit has been weathered to a grey brown crust. The silty clay deposits were not fully penetrated in the boreholes, but were proven to depths ranging from about 6.4 to 6.7 metres below the existing ground surface.

Standard penetration tests carried out in the weathered crust gave N values ranging from 1 to 17 blows per 0.3 metres of penetration. In situ shear strength testing carried out in the weathered crust gave undrained shear strengths ranging from about 67 to greater than 96 kilopascals. The results of the in-situ testing reflects a stiff to very stiff consistency.

The results of Atterberg limit testing on three samples of the weathered crust are provided in Appendix B and summarized in Table 4.3.

Table 4.3 – Summary of Atterberg Limit Testing (Weathered Crust)

Borehole	Sample Number	Sample Depth (metres)	Water Content (%)	LL (%)	PL (%)	PI (%)
22-01	4	2.3 to 2.9	30	49	22	27
22-03	7	4.6 to 5.2	41	25	17	7
22-05	8	5.3 to 5.9	29	23	19	4

Moisture content testing carried out on samples of the weathered crust indicate moisture contents ranging from about 23 to 41 percent.

As per Table 8-6 of MTO report MI-183, a representative subgrade resilient modulus value of 30 megapascals is considered appropriate for a good quality medium to high plasticity clay.

4.2.4 Groundwater Levels

Standpipe piezometers were installed in boreholes 22-02 and 22-05. Table 4.4 summarizes the observed groundwater levels.

Table 4.4 – Summary of Groundwater Levels

Borehole	Ground Surface Elevation (metres)	Groundwater Depth (metres)	Groundwater Elevation (metres)	Date of Reading
22-02	122.0	4.2	117.8	December 8, 2022
22-05	123.4	5.8	117.7	December 8, 2022

The groundwater levels may be higher during wet periods of the year such as the early spring or following periods of precipitation.

4.3 Harry Street

Boreholes 22-06 and 22-07 were advanced along Harry Street.

4.3.1 Existing Pavement Structure

Asphaltic concrete was encountered at the surface at borehole locations 22-06 and 22-07 with a thickness of 130 and 100 millimetres, respectively. Roadway base material was encountered below the asphaltic concrete at boreholes 22-06 and 22-07. The roadway base material consists of gravelly sand with some silt with a thickness of about 330 and 460 millimetres, respectively.

Grain size distribution testing carried out on a sample of the roadway base material along with the grain size distribution envelope for Ontario Provincial Standard Specification (OPSS) Granular B Type I is provided in Appendix B and summarized in Table 4.5 below.

Table 4.5 – Summary of Grain Size Distribution Testing (Roadway Base Material)

Location	Sample Number	Sample Depth (metres)	Gravel (%)	Sand (%)	Silt & Clay (%)
22-06	1	0.2-0.8	24	60	16

The results indicate that the sample of roadway base material tested generally meets the gradation requirements for OPSS Granular B Type I, although the material exceeds the fines content (16 percent compared to the limit of 8 percent). This exceedance of the specification is not expected to negatively impact the performance of the existing pavement structure.

Moisture content testing on one sample of the roadway base material indicates a moisture content of about 6 percent.

A summary of the existing pavement structure encountered on Harry Street is provided in Table 4.6.

Recommended structural layer coefficients are provided in Table 8-7 of MTO report MI-183, Adaptation and Verification of AASHTO Pavement Design Guide for Ontario Conditions. Using coefficients of 0.22 for the existing asphaltic concrete and 0.09 for the existing granular material, respectively, the existing Structural Number (SN) ranges from 58 to 63 millimetres.

The 15th percentile SN is 59 millimetres, meaning that the pavement structure should statistically have a SN in excess of this value over 85 percent of the area.

Table 4.6 – Summary of Existing Pavement Structure – Harry Street

Borehole	Asphaltic Concrete Thickness (millimetres)	Granular Thickness (millimetres)	Existing Structural Number (millimetres)
BH 22-06	100	460	63
BH 22-07	130	330	58

4.3.2 Silty Clay

Native deposits of silty clay were encountered in the boreholes at depths ranging from about 0.4 to 0.6 metres below the existing ground surface. The full depth of the silty clay deposit has been weathered to a grey brown crust. The silty clay deposits were not fully penetrated in the boreholes, but were proven to depths of about 6.7 metres below the existing ground surface.

Standard penetration tests carried out in the weathered crust gave N values ranging from 4 to 9 blows per 0.3 metres of penetration. Based on our experience with native clays in the Ottawa Valley region, N values of 2 or greater generally reflect a stiff to very stiff consistency.

Moisture content testing carried out on samples of the weathered silty clay crust indicate moisture contents ranging from about 31 to 45 percent.

As per Table 8-6 of MTO report MI-183, a representative subgrade resilient modulus value of 30 megapascals is considered appropriate for a good quality medium to high plasticity clay.

4.3.3 Groundwater Levels

A standpipe piezometer was installed in borehole 22-07. Table 4.7 summarizes the observed groundwater levels.

Table 4.7 – Summary of Groundwater Levels

Borehole	Ground Surface Elevation (metres)	Groundwater Depth (metres)	Groundwater Elevation (metres)	Date of Reading
22-07	125.1	5.6	119.5	December 8, 2022

The groundwater levels may be higher during wet periods of the year such as the early spring or following periods of precipitation.

4.4 Soil Chemistry Relating to Corrosion

The results of chemical testing of a sample of the soil recovered from boreholes 22-02 and 22-06 are provided in Appendix C and summarized in Table 4.8, below.

Table 4.8 – Summary of Chemical Testing Relating to Corrosion

Parameter	Borehole 22-02 Sample 3	Borehole 22-06 Sample 3
Chloride Content (µg/g)	404	1000
Resistivity (Ohm.m)	11.5	6.01
Conductivity (µs/cm)	868	1660
pH	7.35	7.28
Sulphate Content (µg/g)	38	84

4.5 Hydraulic Testing Results

The results of the hydraulic testing carried out in the well screens are provided in Appendix D. As previously outlined, one purge and recovery test were successfully analysed within the monitoring well installed in borehole 22-02. The test was performed within the weathered silty clay crust deposit. The initial static water level within the well was about 4.2 metres below the existing ground surface, and the water level was purged down to about 5.2 metres below the existing ground surface (i.e., a displacement of about 1.0 metres). Following cessation of purging, the well recovered about 70 percent over 40 minutes. The hydraulic conductivity calculated using the Hvorslev analysis method from the purge and recovery test within borehole 22-02 was approximately 7 × 10^{-7} metres per second. This is aligned with literature values for silt (10^{-9} to 10^{-5} metres per second; Freeze & Cherry, 1997), which is reasonable due to weathering of the clay and the significant silt content in the overburden at the site.

5.0 GEOTECHNICAL DESIGN RECOMMENDATIONS AND GUIDELINES

5.1 General

The information in the following sections is provided for the guidance of the design engineers and is intended for the design of this project only. Contractors bidding on or undertaking the works should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for construction, and make their own interpretation of the factual data as it affects their construction techniques, schedule, safety and equipment capabilities.

The professional services retained for this project include only the geotechnical aspects of the subsurface conditions. The implications of possible surface and/or subsurface contamination resulting from previous uses or activities of this site or adjacent properties, and/or resulting from the introduction onto the site from materials from offsite sources are outside the terms of reference for this report and have not been addressed.

5.2 Proposed Services

5.2.1 Excavation

As previously indicated, the proposed plans include replacement of the existing watermain, storm sewer, and portions of the sanitary sewer.

The excavation for the proposed services will be carried out through the existing pavement structure, fill material, where encountered and into the native deposits of weathered silty clay crust. The excavation for flexible service pipes should be in accordance with Ontario Provincial Standard Drawing (OPSD) 802.010 for Type 3 soil. The excavation for rigid service pipes should be in accordance with OPSD 802.031 for Type 3 soil.

The sides of the excavations within overburden soils should be sloped in accordance with the requirements in Ontario Regulation 213/91 under the Occupational Health and Safety Act. According to the Act, the soils at this site above the groundwater level can be classified as Type 3 soils. Therefore, for design purposes, allowance should be made for 1 horizontal to 1 vertical, or flatter, excavation slopes. The soils below the groundwater level can be classified as Type 4 soils, and as such, allowance should be made for 3 horizontal to 1 vertical, or flatter, excavation slopes. As an alternative or where space constraints dictate, the service installation could be carried out within a tightly fitting, braced steel trench box, which is specifically designed for this purpose.

5.2.2 Pipe Bedding

The bedding for sewers and watermains should be in accordance with OPSD 802.010 and 802.031 for flexible and rigid pipes in Type 3 soils, respectively.

The bedding for service pipes should consist of at least 150 millimetres of crushed stone meeting OPSS requirements for Granular A. Cover material, from spring line to at least 300 millimetres above the top of the pipe, should consist of granular material, such as that meeting OPSS Granular A. The pipe bedding should be compacted in maximum 300 millimetre thick lifts to at least 95 percent of the standard Proctor maximum dry density value.

In areas where the subgrade soil is disturbed, or where unsuitable material exists below the pipe subgrade level, the disturbed and unsuitable material should be removed and replaced with a subbedding layer of compacted granular material, such as that meeting the requirements of OPSS Granular B Type II or III (50 or 100 millimetre minus crushed stone).

To provide adequate support for the pipe in the long term, in areas where subexcavation of material is required below design subgrade level, the excavations should be sized to allow a 1 horizontal to 2 vertical spread of granular material down and out from the bottom of the pipe.

The use of clear crushed stone as bedding or subbedding material should not be permitted.

5.2.3 Trench Backfill

The backfill materials within the design frost penetration depth (i.e., 1.8 metres below finished grade) should match the materials exposed on the trench walls. This will reduce the potential for differential frost heaving between the area over the trench and the adjacent roadway. Backfill below the design frost penetration depth could consist of either acceptable native material, consisting of weathered silty clay crust, or imported granular material conforming to OPSS Granular B Type I, II or III.

To minimize future settlement of the backfill and achieve an acceptable subgrade for any roadways, curbs, etc., the trench backfill should be compacted in maximum 300 millimetre thick lifts to at least 95 percent of the standard Proctor maximum dry density value.

The overburden deposits within the anticipated depth of excavation are sensitive to changes in moisture content due to precipitation. As such, depending on the weather conditions at the time of construction, the specified densities may not be possible to achieve, and, as a consequence, some settlement of these backfill materials could occur. Consideration could be given to implementing one or a combination of the following measures to reduce post construction settlement above the trenches, depending on the weather conditions encountered during the construction:

- Allow the overburden materials to dry prior to compaction;
- Reuse any wet materials in the lower part of the trenches and make provision to defer hard surfacing (i.e., paving, concrete, etc.) for 3 months, or longer, to allow the trench backfill settlement to occur and thereby improve the final appearance of the hard surfacing; or,

- Avoid reusing any wet material within the trench. If additional material is required for trench backfill, consideration could be given to using imported relatively dry earth fill material, or imported OPSS Select Subgrade Material below the zone of frost penetration.

5.2.4 Groundwater Pumping and Management

With respect to groundwater management, a preliminary assessment was performed utilizing the results of this investigation. This investigation located groundwater at depths ranging between about 4.0 and 5.7 below the existing ground surface. The groundwater levels may be higher during wet periods of the year, such as the early spring or following periods of precipitation. Considering the proposed maximum excavation depth of up to about 4 metres below the existing ground surface, it is assumed that approximately up to about 1.0 metres of groundwater level lowering may be required to dewater the excavation. Water may be transmitted to the excavation through introduced fill materials and natural overburden materials that vary in thickness and hydraulic properties along the proposed excavation. The hydraulic conductivity of the native silty clay was estimated at about 7×10^{-7} metres per second using a purge and recovery test.

It is anticipated that groundwater volumes will be manageable by pumping from filtered sumps within the excavation. Further, water takings for this project will likley be less than about 50,000 litres per day under conservative assumptions, indicating that an Environmental Activity and Sector Registry (EASR) may not be required, in accordance with Environmental Protection Act Part II.2 Section 20.21, but may be advisable to avoid logistical delays during construction.

Should this precautionary approach be taken, an EASR report should be prepared to support construction dewatering methods and confirm dewatering estimates. It should be noted that if dewatering is required and groundwater must be discharged to a storm or sanitary sewer, ditch, or the environment, the groundwater quality will need to be assessed and the required permits, for example a sewer use agreement with the Town of Renfrew, will need to be obtained prior to discharging the water to a storm or sanitary sewer.

It is not expected that short term pumping during excavation will have a significant effect on nearby structures and services.

5.2.5 Thrust Restraint for Watermains

Based on the results of the boreholes, the subsurface at the depth of the proposed watermains will likely consist of weathered silty clay crust. In areas where the subgrade below the thrust bock is disturbed or where unsuitable material (such as existing fill, trench backfill material) exists below the pipe subgrade level, the disturbed and unsuitable material should be removed and replaced with a layer of compacted granular material, such as that meeting OPSS Granular B Type II. Any compacted Granular B Type II should extend at least 1.5 metres horizontally beyond the thrust block and should be compacted in maximum 200 millimetre thick lifts to at least 95 percent of the material's standard Proctor maximum dry density value. Where removal of the existing fill material is not feasible, thrust restraint for the proposed watermains could be provided by friction (since we cannot provide a reliable bearing pressure for thrust blocks founded on fill material).

For thrust block design purposes the coefficient of friction between granular backfill and smooth plastic pipe should be 0.25. The bearing pressure for blocks bearing on native soil or on a pad of compacted granular material on native soil is 100 kilopascals.

The above allowable bearing pressures for the thrust blocks assume that they are vertical and bear on native, undisturbed soil.

5.2.6 Seepage Barriers

We recommend that seepage barriers be constructed along the service trenches that are below the groundwater level to reduce the potential for groundwater lowering due to groundwater flow along the granular bedding and surround for the services. The seepage barriers should begin at subgrade level and extend vertically through the granular pipe bedding and granular surround to within the native backfill materials, and horizontally across the full width of the service trench excavation. The seepage barriers could consist of 1.5 metre wide dykes of compacted weathered crust. The weathered crust should be compacted in maximum 300 millimetre thick lifts to at least 95 percent of the material's standard Proctor maximum dry density value.

The seepage barriers should be spaced at about 150 metres along the trench.

5.3 Corrosion of Buried Concrete and Steel

The measured sulphate concentration in the sample of the soil recovered from boreholes 22-02 and 22-06 is about 38 and 84 micrograms per gram, respectively. According to the Canadian Standards Association "Concrete Materials and Methods of Concrete Construction" (CSA A23.1-14 Table 3), the concentration of sulphate in the soil, is less than the minimum concentration for 'Moderate' sulfate exposure. As such, the CSA A23.1 Class of Exposure is not a sulfate class. Other factors (structurally reinforced or non-structurally reinforced, freeze-thaw environment, chloride exposure, agricultural environment) should be considered in selecting the Class of Exposure and associated air entrainment and concrete mix proportions for any concrete.

Based on the pH and resistivity of the soil and groundwater samples, the soil and groundwater can be classified as slightly aggressive to aggressive towards unprotected steel. The manufacturer of any buried steel elements that will be in contact with the soil and groundwater should be consulted to ensure that the durability of the intended product is appropriate. It is noted that the corrosivity of the groundwater could vary throughout the year due to the application of de-icing chemicals.

5.4 Roadway Reconstruction

5.4.1 Subgrade Preparation

In preparation for construction of the roadways any soft, wet, deleterious material should be removed from the subgrade surface. If needed, the grade below the roadway could then be raised with compacted granular material such as that meeting OPSS specifications for Select Subgrade Material, Granular B Type I, Granular B Type II or III and/or reuse of existing fill material which meets OPSS Granular B Type I. Prior to placing granular material, the subgrade surface should be proof rolled with a large steel drum roller (i.e., 10 tonne or larger) under dry conditions.

In areas where abrupt changes in the frost susceptibility of the subgrade materials are encountered, frost tapers and/or some subexcavation of materials may be required to prevent future localized differential frost heaving of the pavement structure. The frost taper and subexcavation requirements should be assessed at the time of construction by geotechnical personnel.

The roadway subgrade surface should be made smooth and crowned or sloped prior to placing the granular materials to promote drainage of the roadway base and subbase materials.

Grade raise fill material placed below the roadway should be placed in maximum 300-millimetre-thick lifts and compacted to at least 95 percent of the material's standard Proctor maximum dry density value using suitably sized vibratory compaction equipment.

5.4.2 Traffic Data

Based on information provided in the request for proposal documents, an annual average daily traffic (AADT) of approximately 2,000 to 3,000 vehicles per day can be expected. No information concerning heavy vehicle volumes was provided, however, the area is residential and heavy vehicle traffic is expected to be minimal.

Using 3,000 vehicles per day with 2 percent heavy vehicles (up to 30 per day in each direction), as well as an average Truck Factor of 2.5 for heavy vehicles, the roadways may be expected to experience a 20-year Equivalent Single Axle Load (ESAL) count of approximately 820,000 (includes 2 percent annual growth). This level of heavy traffic falls within Traffic Level B under OPSS 1151 (Material Specification for Superpave).

5.4.3 Pavement Structural Capacity Required

The following AASHTO 93 design inputs were used to determine the required pavement structural capacity:

- Initial Serviceability, PSI = 4.4;
- Terminal Serviceability, PSI = 2.2;

- Overall Standard Deviation = 0.49;
- Design Reliability = 90 percent;
- Design Subgrade Modulus = 30 megapacals; and
- 20-year ESAL count = 820,000

The required Structural Number (SN_{req}) to resist the anticipated vehicle loading was calculated to be 100 millimetres. As the average existing SN values are about 61 millimetres for each roadway, some structural strengthening is recommended.

5.4.4 Trench Reinstatement or Full Depth Reconstruction

The pavement structure for trench reinstatement where services are to be installed/rehabilitated or full depth reconstruction should incorporate the following minimum asphaltic concrete and granular thicknesses following compaction of the earth backfill material in the service trenches:

- 40 millimetres of Superpave 12.5 Traffic Level B; placed over
- 60 millimetres of Superpave 19 Traffic Level C (placed in a single layer); over,
- 150 millimetres of Granular A, over
- 300 millimetres of Granular B Type II (or 400 millimetres of Granular B Type I).

Using structural coefficients of 0.42 for new Hot Mix Asphalt (HMA), 0.14 for crushed granular materials such as Granular A and Granular B Type II, or 0.09 for Granular B Type I, the recommended pavement reconstruction alternative will provide a SN of 105 millimetres.

It is our experience that a woven geotextile separator is usually required between the roadway subgrade surface and the granular subbase material to prevent pumping and disturbance of the granular material, particularly if the service installation and roadway construction is carried out during wet periods of the year (such as the Fall).

5.4.5 Asphaltic Concrete Type

Performance graded PG 58-34 asphaltic concrete meeting the requirements of OPSS.MUNI 1101 should be specified. The use of polish-resistant aggregates (i.e., Friction Course) is not warranted in the surface HMA. The asphaltic concrete should meet the requirements of OPSS.MUNI 1151 and be constructed to the requirements of OPSS 310 as modified by the Town of Renfrew.

5.4.6 Granular Material Compaction

All imported granular materials should be placed in maximum 200-millimetre-thick lifts and should be compacted to at least 98 percent of the material’s standard Proctor maximum dry density value using suitable sized vibratory compaction equipment.

5.4.7 Pavement Drainage

Adequate drainage of the pavement granular materials and subgrade is important for the long term performance of the pavement at this site. The catch basins should be provided with minimum 3-metre-long perforated stub drains which extend in at least two directions from each catch basin at the pavement subgrade level.

5.4.8 Pavement Transitions

As part of the roadway reconstruction, the new pavement will abut the existing pavement at various locations. The following is suggested to improve the performance of the joint between the new and the existing pavements:

- Neatly saw cut the existing asphaltic concrete;
- Remove the asphaltic concrete and slope the bottom of the excavation within the existing granular base and subbase at 1 horizontal to 1 vertical, or flatter, to avoid undermining the existing asphaltic concrete.
- To avoid cracking of the asphaltic concrete due to an abrupt change in the thickness of the roadway granular materials where new pavement areas join with the existing pavements, the granular depths should taper up or down at 5 horizontal to 1 vertical, or flatter, to match the existing pavement structure.
- Remove (mill off) about 40 to 50 millimetres of the existing asphaltic concrete to a distance of about 300 millimetres at the joint and tack coat the asphaltic concrete at the joint in accordance with the requirements in OPSS 310.

6.0 SLOPE STABILITY ANALYSIS

6.1 General

The purpose of this preliminary stability assessment is to asses the factor of safety against global instability for the slope at the location of the proposed outfall.

The slope stability analysis was carried out using Slope/W, a two-dimensional limit equilibrium slope stability program. The results of the slope stability analysis are provided in Appendix E.

6.2 Soil Strength Parameters

The soil conditions used in the stability analyses were based, in part, on the results of the boreholes advanced across the site. The slope stability analysis was carried out using weathered crust and silty clay strength parameters based on our experience with the soils in the area of the site. To determine the existing factor of safety against overall rotational failure, the slope stability analysis was carried out using drained soil parameters, which reflect long term conditions.

The following table summarizes the soil parameters used in the analyses:

Table 6.1 – Slope Stability Soil Strength Parameters

Soil Type	Effective Angle of Internal Friction, φ (degrees)	Effective Cohesion, c′ (kilopascals)	Unit Weight, γ (kN/m^3)	Undrained Shear Strength (kilopascals)
Weathered Crust	35	5	17.5	80
Silty Clay	34.7	7.7	16.5	50

The results of the stability analysis are highly dependent on the assumed groundwater conditions. The groundwater level measured during this investigation was at an elevation of about 118 metres.

The slope stability analyses were carried out using soil parameters, groundwater conditions and a slope profile that attempt to model the slope but do not exactly represent the actual conditions.

For the purposes of this study, a computed factor of safety of less than 1.0 to 1.3 is considered to represent a slope bordering on failure to marginally stable, respectively; a factor of safety of 1.3 to 1.5 is considered to indicate a slope that is less likely to fail in the long term and provides a degree of confidence against failure ranging from marginal (1.3) to adequate (1.4 and greater) should conditions vary from the assumed conditions. A factor of safety of 1.5, or greater, is considered to indicate adequate long-term stability.

6.3 Existing Conditions

Based on the results of the analysis, the slope has a factor of safety against global instability of about 0.4 and 0.8 under static and pseudo seismic conditions, respectively. As such, the slope at the storm sewer outfall is not considered to be stable in its current configuration. This is consistent with GEMTEC's observations at the time of our site visit, which included several fallen trees and signs of previous rotational failure.

The location of the outfall may be moved to an alternate location and the assessment of the slope at the proposed outfall locations is ongoing at the time of the submission of this report.

7.0 ADDITIONAL CONSIDERATIONS

7.1 Effects of Soil Disturbance and Construction Traffic

The guidelines above for the roadway reconstruction assume that the trench backfill is adequately compacted and prepared as described in this report. If the subgrade surface above the trenches becomes disturbed or wetted due to construction operations or precipitation, the subbase thickness given above may not be adequate and it may be necessary to increase the thickness of the subbase and/or to incorporate a woven geotextile separator between the roadway subgrade surface and the granular subbase material. The adequacy of the design pavement thickness should be assessed by geotechnical personnel at the time of construction.

If the granular pavement materials above the trench are to be used by construction traffic, it may be necessary to increase the thickness of the subbase, install a woven geotextile separator between the subgrade surface and the granular material, or a combination, to prevent pumping and disturbance to the subbase material. The contractor should be made responsible for their construction access.

The required thickness of the subbase materials will depend on a number of factors, including schedule, contractor methodology, soil types and weather conditions, and should be assessed by geotechnical personnel at the time of construction. In our opinion, the preferred approach from a geotechnical point of view is to:

- Proof roll the subgrade conditions at the time of construction under the supervision of experienced geotechnical personnel.
- Adjust the thickness of the subbase material and include a woven geotextile separator, as required. Unit rate allowances should be made in the contract for a geotextile and subexcavation and replacement with OPSS Granular B Type II.

7.2 Effects of Existing Service Trenches

Differential frost heaving could occur in areas where abrupt changes in the frost susceptibility of the subgrade materials exist. The locations of any service trenches that cause differential frost heaving issues during the winter period should be identified at the design stage. To mitigate future differential frost heaving at these locations, granular frost tapers (sloped at 5 horizontal to 1 vertical, or flatter) and/or some subexcavation of materials could be carried out as part of the rehabilitation. The frost heave treatment could be assessed at the time of the construction by geotechnical personnel.

7.3 Effects of Construction Induced Vibration

Some of the construction operations (such as granular material compaction, excavation, etc.) will cause ground vibration on and off of the site. The vibrations will attenuate with distance from the source but may be felt at nearby structures. Provided that construction procedures are used, the magnitude of vibrations should be less than that required to cause damage to the nearby structures or services that are in good condition.

We recommend that preconstruction surveys be carried out on the adjacent structures and that vibration monitoring be carried out, at least initially, so that any damage claims can be addressed in a fair manner.

7.4 Winter Construction

Most of the soils that exist at this site are highly frost susceptible and are prone to significant ice lensing. In order to carry out the work during freezing temperatures and maintain adequate performance of the trench backfill as a roadway subgrade, the service trenches should be opened for as short a time as practicable and the excavations should be carried out only in lengths which allow all of the construction operations, including backfilling, to be fully completed in one working day. The sides of the trenches should not be allowed to freeze. In addition, the backfill should be excavated, stored and replaced without being disturbed by frost or contaminated by snow or ice.

7.5 Excess Soil Management

The presence or implications of possible surface and/or subsurface contamination, including naturally occurring source of contamination, are outside the terms of reference for this report. Information regarding excess soil is provided in a separate report prepared by GEMTEC.

7.6 Abandonment of Standpipe Piezometers

All monitoring wells installed as part of this investigation should be decommissioned by a licensed well technician in accordance with Ontario Regulation 903, as amended by Ontario Regulation 128/03. The well abandonment could be carried out in advance or during construction.

7.7 Design Review and Construction Observation

It is recommended that the final design drawings be reviewed by the geotechnical engineer to ensure that the guidelines provided in this report have been interpreted as intended.

The engagement of the services of the geotechnical consultant during construction is recommended to confirm that the subsurface conditions throughout the proposed excavations do not materially differ from those given in the report and that the construction activities do not adversely affect the intent of the design. The subgrade surfaces for the proposed services and roadways should be inspected by experienced geotechnical personnel to ensure that suitable materials have been reached and properly prepared. The placing and compaction of earth fill and imported granular materials should be inspected to ensure that the materials used conform to the grading and compaction specifications.

8.0 CLOSURE

We trust this report provides sufficient information for your present purposes. If you have any questions concerning this report, please do not hesitate to contact our office.

Pat

Pat Baxter
Senior Technologist

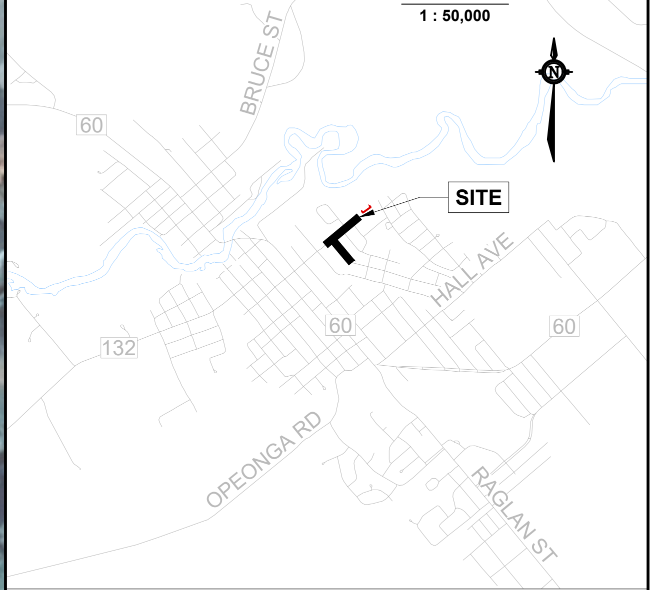
W. Alex Meacoe

Alex Meacoe, P.Eng.
Senior Geotechnical Engineer

LICENSED PROFESSIONAL ENGINEER
W. A. MEACOE
100162115
May 5, 2023
PROVINCE OF ONTARIO

KEY PLAN

1 : 50,000



LEGEND

BH # ◄— BOREHOLE ID

XX.XX ◄— GROUND SURFACE ELEVATION, IN METRES GEODETIC DATUM

⊕ **BOREHOLE LOCATION**
(current investigation by GEMTEC)

SLOPE CROSS SECTION

GENERAL NOTE(S)

1. Coordinate system: NAD83, UTM ZONE 18N.

SCALE

1:2000

0 40 80 120m

DRAWING

SITE PLAN

CLIENT

MORRISON HERSHFIELD

PROJECT

GEOTECHNICAL INVESTIGATION
MUNROE AVENUE EAST AND HARRY STREET RECONSTRUCTION
TOWN OF RENFREW, ONTARIO

DRAWN BY	CHECKED BY
S.L.	W.A.M.
PROJECT NO.	REVISION NO.
100040.017	0
DATE	FIGURE NO.
DECEMBER 2022	**FIGURE 1**

GEMTEC
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AND SCIENTISTS

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Tel: (613) 836-1422
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APPENDIX A

Record of Borehole Logs
List of Abbreviations and Symbols
Boreholes 22-01 to 22-07

Report to: Morrison Hershfield
Project: 100040.017 (May 5, 2023)

ABBREVIATIONS AND TERMINOLOGY USED ON RECORDS OF BOREHOLES AND TEST PITS

SAMPLE TYPES	
AS	Auger sample
CA	Casing sample
CS	Chunk sample
BS	Borros piston sample
GS	Grab sample
MS	Manual sample
RC	Rock core
SS	Split spoon sampler
ST	Slotted tube
TO	Thin-walled open shelby tube
TP	Thin-walled piston shelby tube
WS	Wash sample

SOIL TESTS	
w	Water content
PL, w_p	Plastic limit
LL, w_L	Liquid limit
C	Consolidation (oedometer) test
D_R	Relative density
DS	Direct shear test
G_S	Specific gravity
M	Sieve analysis for particle size
MH	Combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	Organic content test
UC	Unconfined compression test
γ	Unit weight

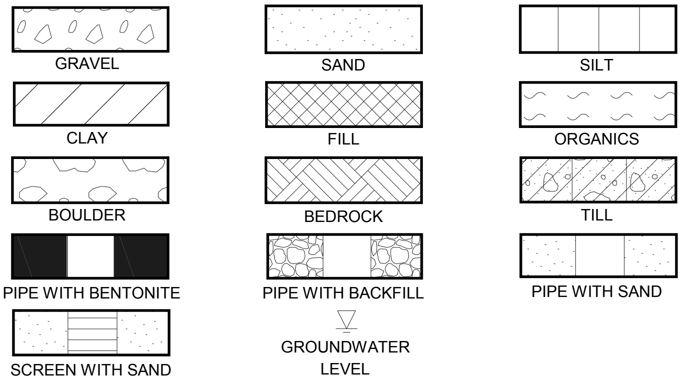
PENETRATION RESISTANCE

Standard Penetration Resistance, N
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 millimetres (30 in.) required to drive a 50 mm split spoon sampler for a distance of 300 mm (12 in.). For split spoon samples where less than 300 mm of penetration was achieved, the number of blows is reported over the sampler penetration in mm.

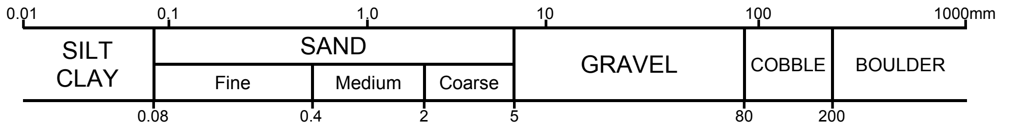
Dynamic Penetration Resistance
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive a 50 mm (2 in.) diameter 60° cone attached to 'A' size drill rods for a distance of 300 mm (12 in.).

WH	Sampler advanced by static weight of hammer and drill rods
WR	Sampler advanced by static weight of drill rods
PH	Sampler advanced by hydraulic pressure from drill rig
PM	Sampler advanced by manual pressure

COHESIONLESS SOIL Compactness		COHESIVE SOIL Consistency	
SPT N-Values	Description	Cu, kPa	Description
0-4	Very Loose	0-12	Very Soft
4-10	Loose	12-25	Soft
10-30	Compact	25-50	Firm
30-50	Dense	50-100	Stiff
>50	Very Dense	100-200	Very Stiff
		>200	Hard



GRAIN SIZE



DESCRIPTIVE TERMINOLOGY

(Based on the CANFEM 4th Edition)

0 10 20 35

TRACE	SOME	ADJECTIVE	noun > 35% and main fraction
trace clay, etc	some gravel, etc.	silty, etc.	sand and gravel, etc.

GEMTEC

descriptive terms.pub
Modified May 2018

RECORD OF BOREHOLE 22-01

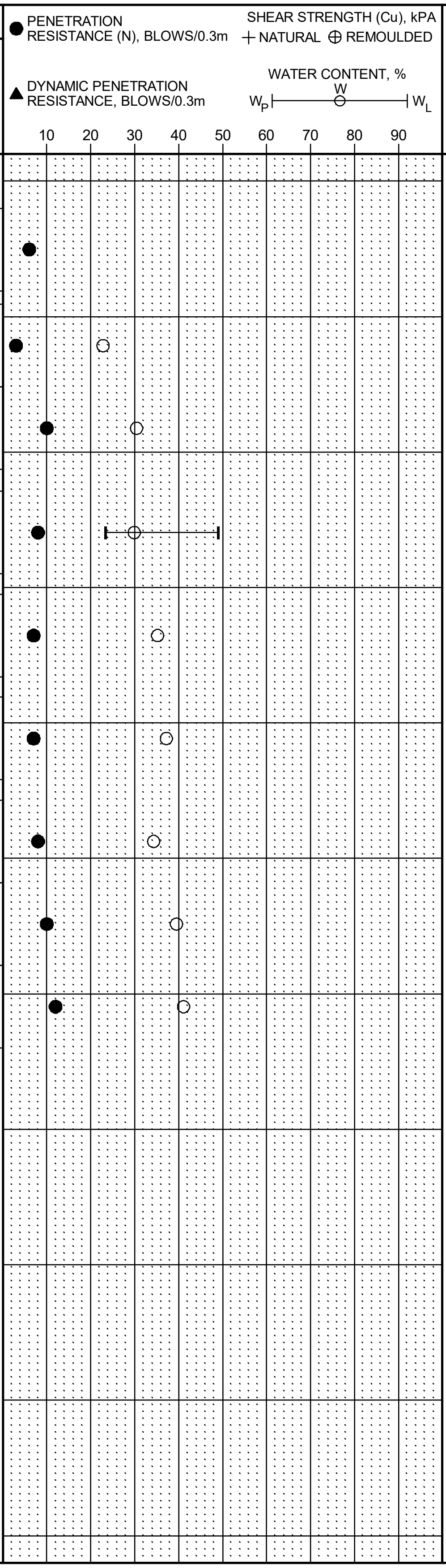
CLIENT: Morrison Hershfield
PROJECT: Geotechnical Investigation, Munroe Avenue East and Harry Street Reconstruction, Renfrew, Ontario
JOB#: 100040.017
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Nov 4 2022

BORING METHOD: Power Auger, Hollow Stem Auger (210mm OD)

SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)
Ground Surface	120.87
ASPHALTIC CONCRETE	120.69 0.18
Brown gravelly sand, some silt (BASE MATERIAL)	120.46 0.41
Stiff to very stiff, grey brown SILTY CLAY, trace sand (WEATHERED CRUST)	114.47 6.40
End of Borehole	

SAMPLES NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m
1	SS	130	6
2	SS	510	3
3	SS	560	10
4	SS	610	8
5	SS	610	7
6	SS	610	7
7	SS	610	8
8	SS	610	10
9	SS	610	12



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION: Auger Cuttings

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LOGGED: TM
CHECKED: WAM

RECORD OF BOREHOLE 22-02

CLIENT: Morrison Hershfield
PROJECT: Geotechnical Investigation, Munroe Avenue East and Harry Street Reconstruction, Renfrew, Ontario
JOB#: 100040.017
LOCATION: See Site Plan, Figure 1

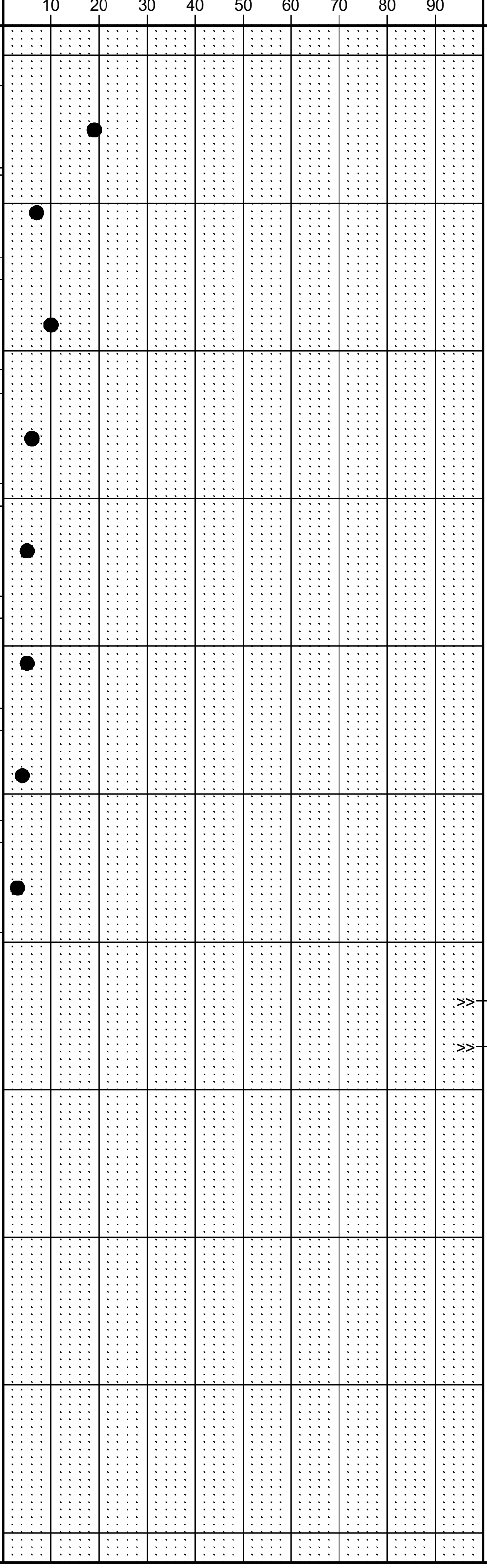
SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Nov 7 2022

BORING METHOD: Power Auger
Hollow Stem Auger (210mm OD)

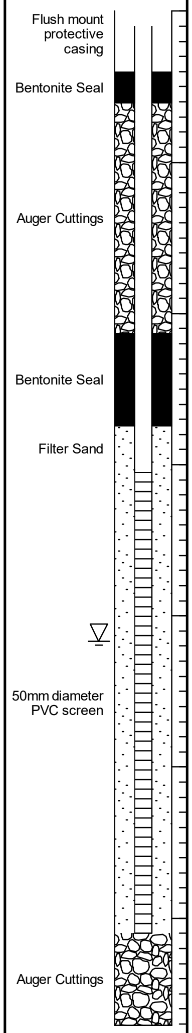
SOIL PROFILE		SAMPLES			
DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m
Ground Surface	121.98				
ASPHALTIC CONCRETE	121.83 0.15				
Compact, brown gravelly sand, some silt (BASE MATERIAL)	121.37 0.61	1	SS	330	19
Stiff to very stiff, grey brown SILTY CLAY (WEATHERED CRUST)		2	SS	355	7
		3	SS	610	10
		4	SS	610	6
		5	SS	610	5
		6	SS	610	5
		7	SS	610	4
		8	SS	610	3
	115.27 6.71				
End of Borehole					

● PENETRATION RESISTANCE (N), BLOWS/0.3m
▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m
SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED
WATER CONTENT, %: W_P — W — W_L

ADDITIONAL LAB. TESTING



PIEZOMETER OR STANDPIPE INSTALLATION



GROUNDWATER OBSERVATIONS		
DATE	DEPTH (m)	ELEV. (m)
22/12/08	4.2 ▽	117.8

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Consulting Engineers and Scientists

LOGGED: TM
CHECKED: WAM

RECORD OF BOREHOLE 22-03

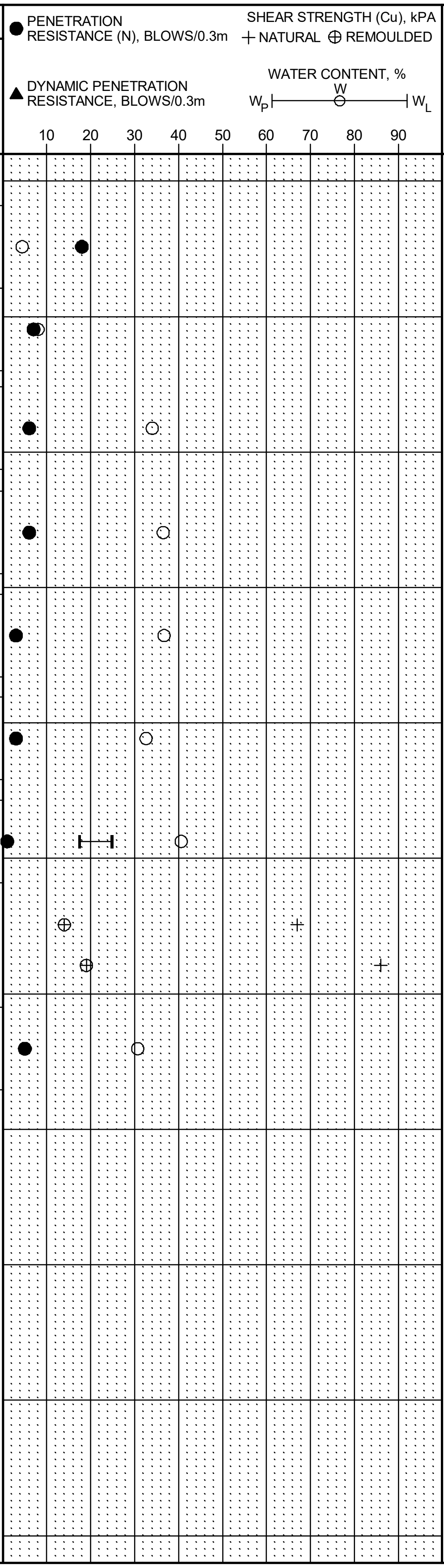
CLIENT: Morrison Hershfield
PROJECT: Geotechnical Investigation, Munroe Avenue East and Harry Street Reconstruction, Renfrew, Ontario
JOB#: 100040.017
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Nov 4 2022

BORING METHOD: Power Auger, Hollow Stem Auger (210mm OD)

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
Ground Surface	122.86
ASPHALTIC CONCRETE	
Compact, brown gravelly sand, some silt (BASE MATERIAL)	122.71 0.15
Stiff to very stiff, grey brown SILTY CLAY (WEATHERED CRUST)	122.05 0.81
Stiff to very stiff, grey brown SILTY CLAY, some sand to sandy (WEATHERED CRUST)	119.81 3.05
Stiff, brown CLAYEY SILT, some sand (WEATHERED CRUST)	118.29 4.57
End of Borehole	116.15 6.71

SAMPLES NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	ADDITIONAL LAB. TESTING
1	SS	150	18	M
2	SS	75	7	
3	SS	610	6	
4	SS	610	6	
5	SS	610	3	
6	SS	610	3	
7	SS	610	1	
8	SS	610	5	



PIEZOMETER OR STANDPIPE INSTALLATION: Auger Cuttings

DEPTH SCALE METRES: 0 – 10

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LOGGED: TM
CHECKED: WAM

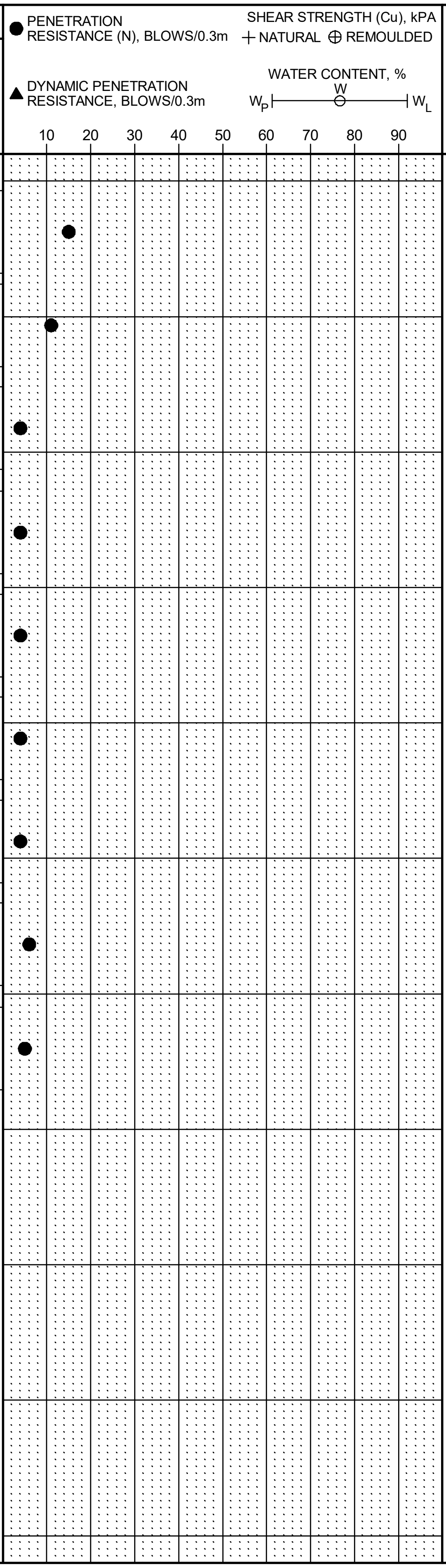
RECORD OF BOREHOLE 22-04

CLIENT: Morrison Hershfield
PROJECT: Geotechnical Investigation, Munroe Avenue East and Harry Street Reconstruction, Renfrew, Ontario
JOB#: 100040.017
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Nov 7 2022

BORING METHOD: Power Auger, Hollow Stem Auger (210mm OD)

DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m
Ground Surface	123.41				
ASPHALTIC CONCRETE	123.26 0.15				
Compact, brown gravelly sand, some silt (BASE MATERIAL)	122.95 0.46	1	SS	355	15
Stiff to very stiff, grey brown SILTY CLAY (WEATHERED CRUST)		2	SS	355	11
		3	SS	560	4
		4	SS	610	4
		5	SS	610	4
		6	SS	610	4
		7	SS	610	4
Stiff to very stiff, grey brown SILTY CLAY, some sand to sandy (WEATHERED CRUST)	118.08 5.33	8	SS	610	6
		9	SS	610	5
End of Borehole	116.70 6.71				



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION: Auger Cuttings (0 to 6.71 m)

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

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LOGGED: TM

CHECKED: WAM

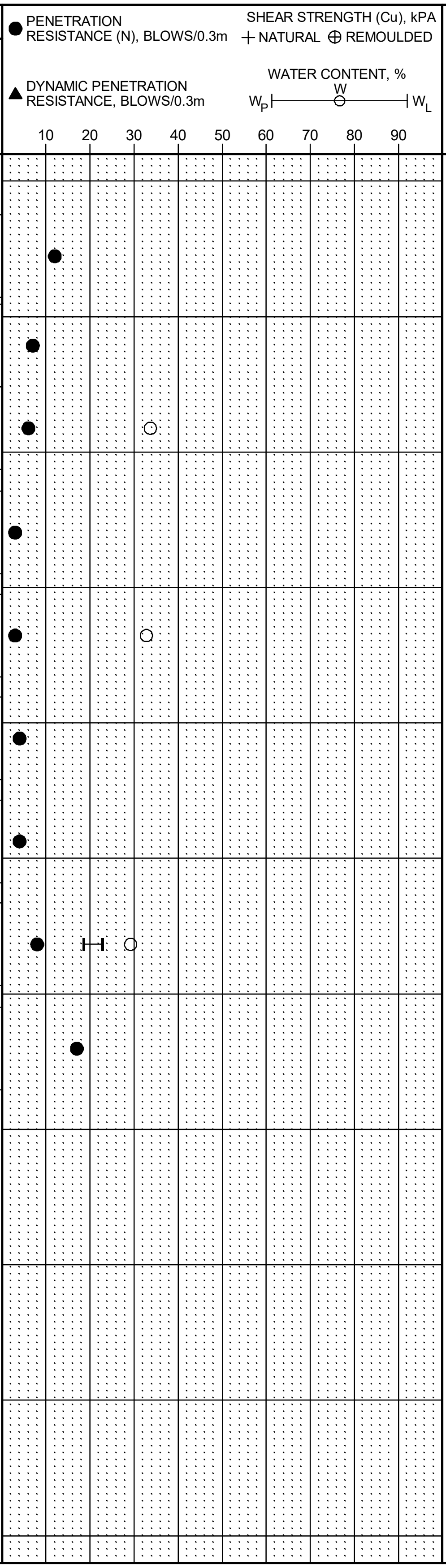
RECORD OF BOREHOLE 22-05

CLIENT: Morrison Hershfield
PROJECT: Geotechnical Investigation, Munroe Avenue East and Harry Street Reconstruction, Renfrew, Ontario
JOB#: 100040.017
LOCATION: See Site Plan, Figure 1

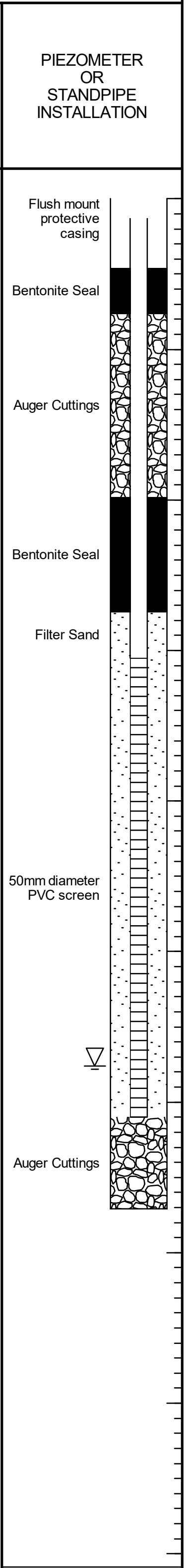
SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Nov 4 2022

BORING METHOD: Power Auger, Hollow Stem Auger (210mm OD)

SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m
Ground Surface	123.42				
ASPHALTIC CONCRETE	123.19 0.23				
Brown gravelly sand, trace silt (BASE MATERIAL)	122.91 0.51				
Grey brown silty clay, trace sand (FILL MATERIAL)	122.51 0.91	1	SS	405	12
Stiff to very stiff, grey brown SILTY CLAY, some sand to sandy (WEATHERED CRUST)	118.29 5.13	2	SS	560	7
		3	SS	610	6
		4	SS	610	3
		5	SS	610	3
		6	SS	610	4
		7	SS	610	4
Stiff to very stiff, brown CLAYEY SILT, some sand (WEATHERED CRUST)	116.71 6.71	8	SS	560	8
		9	SS	355	17
End of Borehole					



ADDITIONAL LAB. TESTING



GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/12/08	5.8 ▽	117.7

LOGGED: TM
CHECKED: WAM

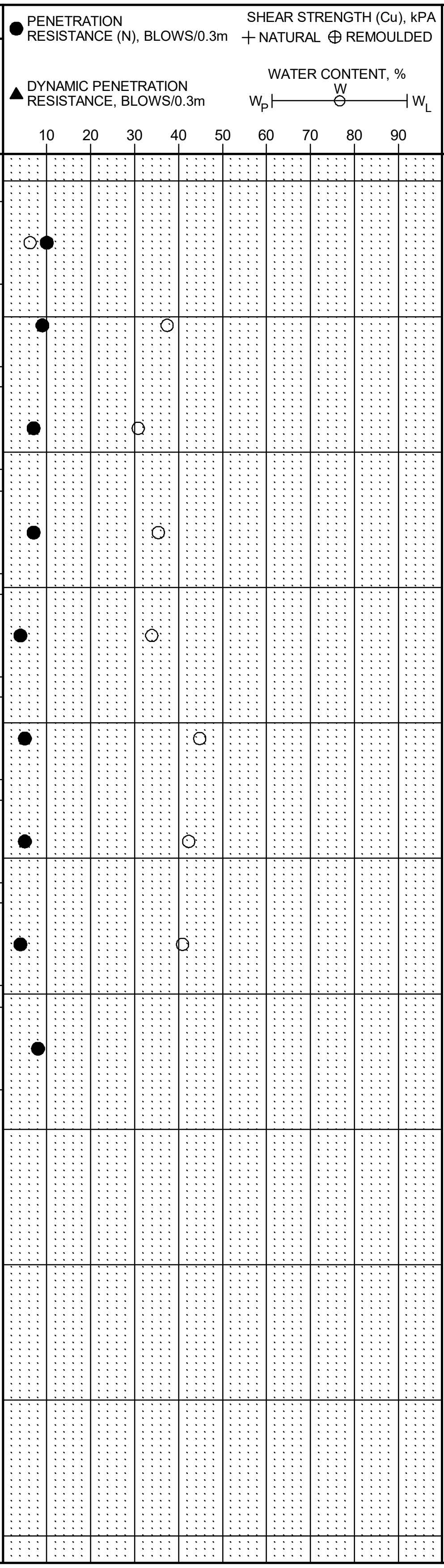
GEMTEC Consulting Engineers and Scientists

RECORD OF BOREHOLE 22-06

CLIENT: Morrison Hershfield
PROJECT: Geotechnical Investigation, Munroe Avenue East and Harry Street Reconstruction, Renfrew, Ontario
JOB#: 100040.017
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Nov 7 2022

BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
	Ground Surface	124.16						
Power Auger Hollow Stem Auger (210mm OD)	ASPHALTIC CONCRETE	124.06 0.10						
	Brown gravelly sand, some silt (BASE MATERIAL)	123.60 0.56	1	SS	130	10	M	
	Stiff to very stiff, grey brown SILTY CLAY, trace sand (WEATHERED CRUST)		2	SS	380	9		
			3	SS	610	7		
			4	SS	610	7		
			5	SS	610	4		Auger Cuttings
			6	SS	610	5		
			7	SS	610	5		
			8	SS	610	4		
		117.45 6.71	9	SS	535	8		
	End of Borehole							



DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

GEMTEC
CONSULTING ENGINEERS AND SCIENTISTS

LOGGED: TM
CHECKED: WAM

RECORD OF BOREHOLE 22-07

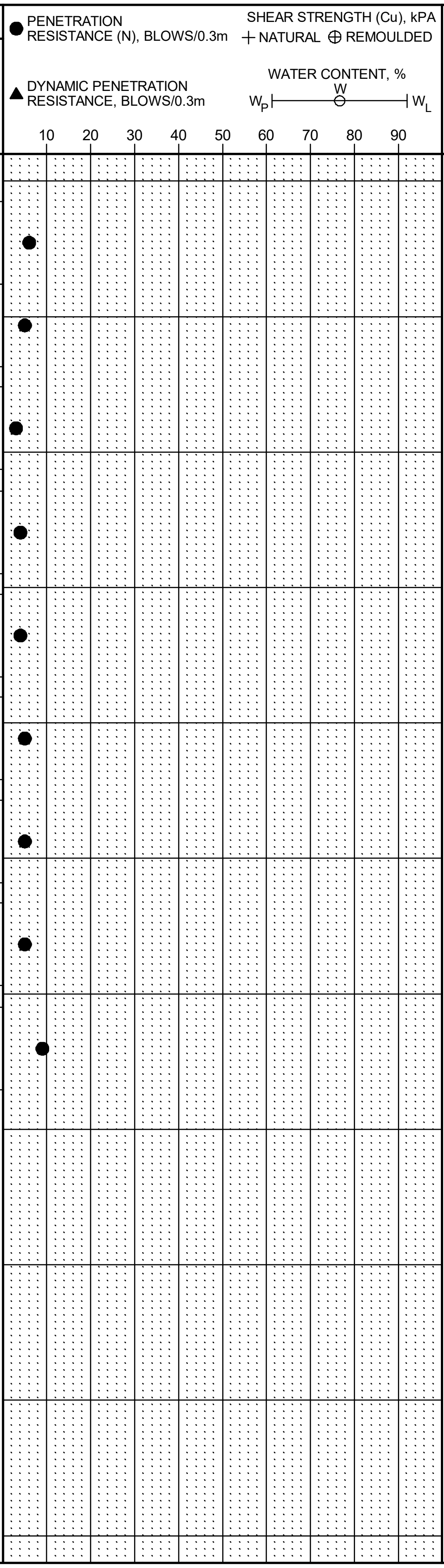
CLIENT: Morrison Hershfield
PROJECT: Geotechnical Investigation, Munroe Avenue East and Harry Street Reconstruction, Renfrew, Ontario
JOB#: 100040.017
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Nov 8 2022

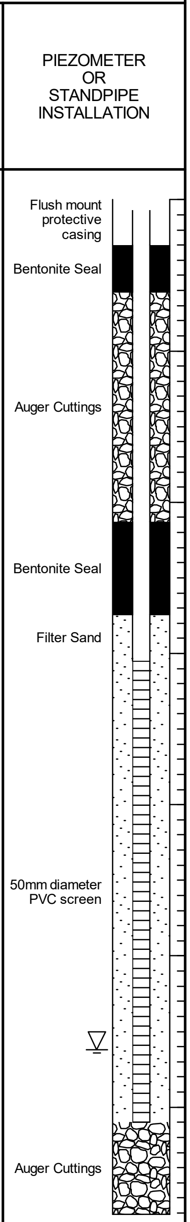
BORING METHOD: Power Auger, Hollow Stem Auger (210mm OD)

SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)
Ground Surface	125.14
ASPHALTIC CONCRETE	125.01 0.13
Brown gravelly sand, some silt (BASE MATERIAL)	124.68 0.46
Stiff to very stiff, grey brown SILTY CLAY (WEATHERED CRUST)	120.57 4.57
Stiff to very stiff, grey brown SILTY CLAY, some sand to sandy (WEATHERED CRUST)	118.43 6.71
End of Borehole	

NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m
1	SS	205	6
2	SS	405	5
3	SS	610	3
4	SS	610	4
5	SS	610	4
6	SS	610	5
7	SS	610	5
8	SS	610	5
9	SS	610	9



ADDITIONAL LAB. TESTING



GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/12/08	5.6 ▽	119.5

GEMTEC Consulting Engineers and Scientists

LOGGED: TM
CHECKED: WAM

APPENDIX B

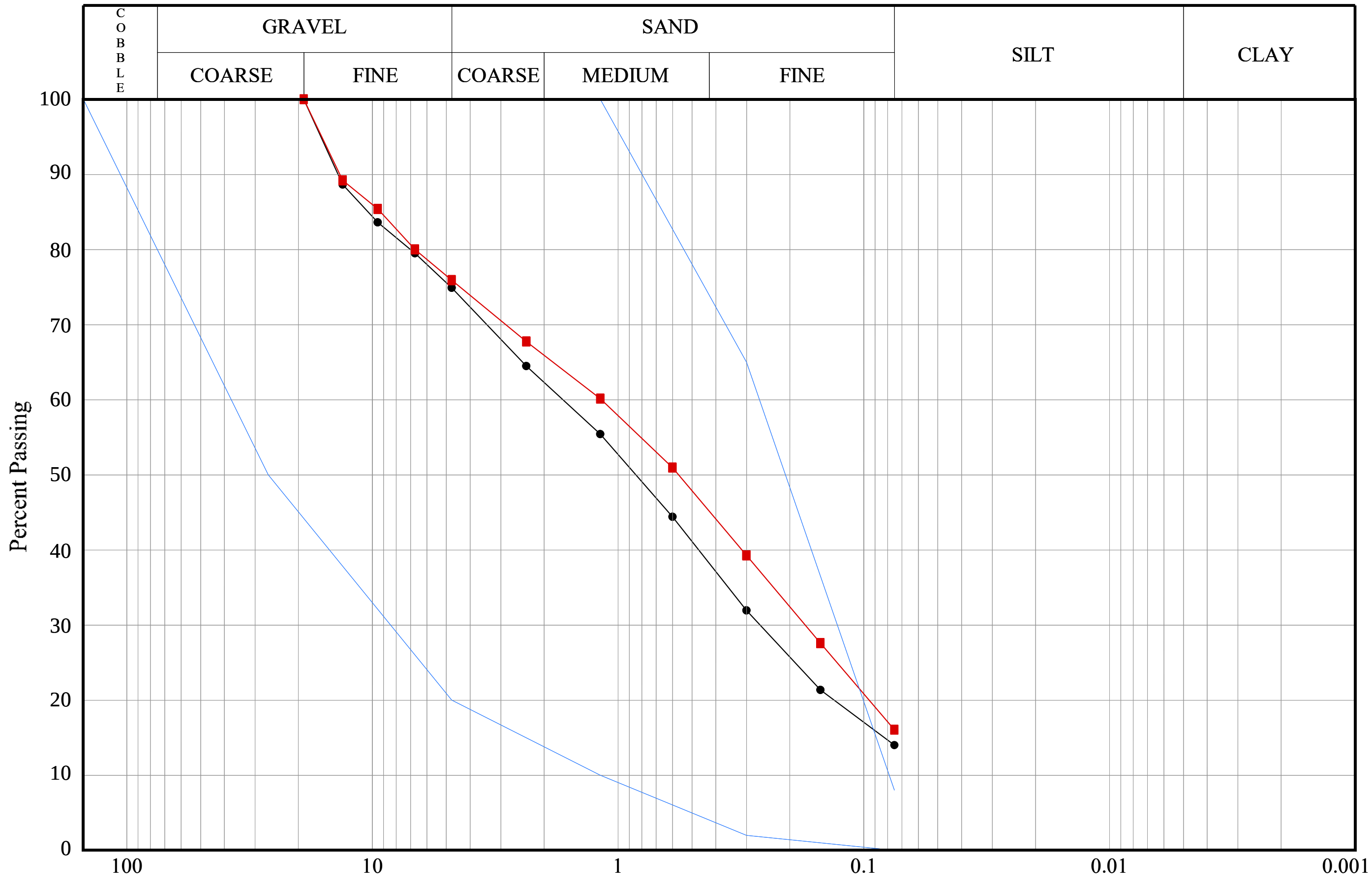
Laboratory Test Results
Grain Size Distribution Testing
Plasticity Chart

Report to: Morrison Hershfield
Project: 100040.017 (May 5, 2023)

GEMTEC
Consulting Engineers and Scientists

Client: Morrison Hershfield Limited
Project: Geotechnical and environmental Engineering Services:
Project #: 100040017

Soils Grading Chart



Limits Shown: OPSS 1010 Granular B Type I

Line Symbol	Sample	Borehole/ Test Pit	Sample Number	Depth	% Cob.+ Gravel	% Sand	% Silt	% Clay
—●—	BASE MATERIAL	22-03	1	0.18-0.78	25.1	60.9	14.0	
—■—	BASE MATERIAL	22-06	1	0.15-0.76	24.1	59.9	16.1	

Line Symbol	CanFEM Classification	USCS Symbol	D_{10}	D_{15}	D_{30}	D_{50}	D_{60}	D_{85}	% 5-75µm
—●—	Gravelly sand , some silt	N/A	---	0.08	0.26	0.85	1.68	10.41	---
—■—	Gravelly sand , some silt	N/A	---	---	0.17	0.57	1.17	9.26	---

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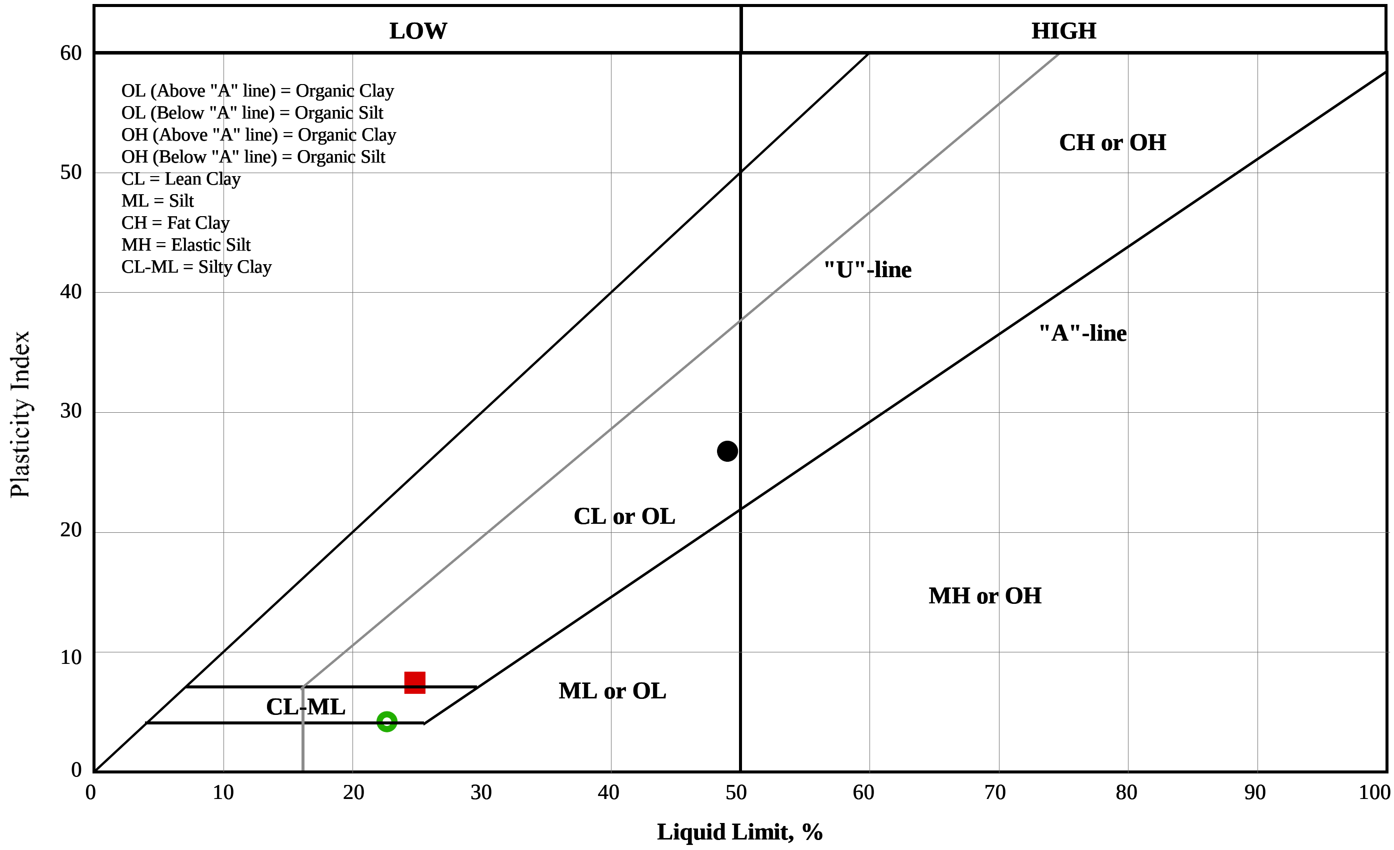
CONSULTING ENGINEERS AND SCIENTISTS

Client: Morrison Hershfield Limited
Project: Geotechnical and environmental Engineering Services:
Project #: 100040017

Plasticity Chart (D4318)



Symbol	Borehole /Test Pit	Sample Number	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Non-Plastic	Moisture Content, %
●	22-01	4	2.28-2.89	49.0	22.3	26.7	☐	29.85
🟥	22-03	7	4.57-5.18	24.8	17.4	7.4	☐	40.61
○	22-05	8	5.33-5.94	22.7	18.5	4.2	☐	29.23

Note: More information available upon request

APPENDIX C

Chemical Analysis of Soil Samples
Samples Relating to Corrosion
(Paracel Laboratories Ltd. Order No. 2247480)

Report to: Morrison Hershfield
Project: 100040.017 (May 5, 2023)

Certificate of Analysis

Report Date: 24-Nov-2022

Client: **GEMTEC Consulting Engineers and Scientists Limited**

Order Date: 17-Nov-2022

Client PO:

Project Description: 100040.017

Client ID:		BH22-02 SA3	BH22-06 SA3	-	-		
Sample Date:		17-Nov-22 14:25	17-Nov-22 14:29	-	-	-	-
Sample ID:		2247480-01	2247480-02	-	-		
Matrix:		Soil	Soil	-	-		
	MDL/Units						
Physical Characteristics							
% Solids	0.1 % by Wt.	75.4	72.2	-	-	-	-
General Inorganics							
Conductivity	5 uS/cm	868	1660	-	-	-	-
pH	0.05 pH Units	7.35	7.28	-	-	-	-
Resistivity	0.1 Ohm.m	11.5	6.01	-	-	-	-
Anions							
Chloride	5 ug/g	404	1000	-	-	-	-
Sulphate	5 ug/g	38	84	-	-	-	-

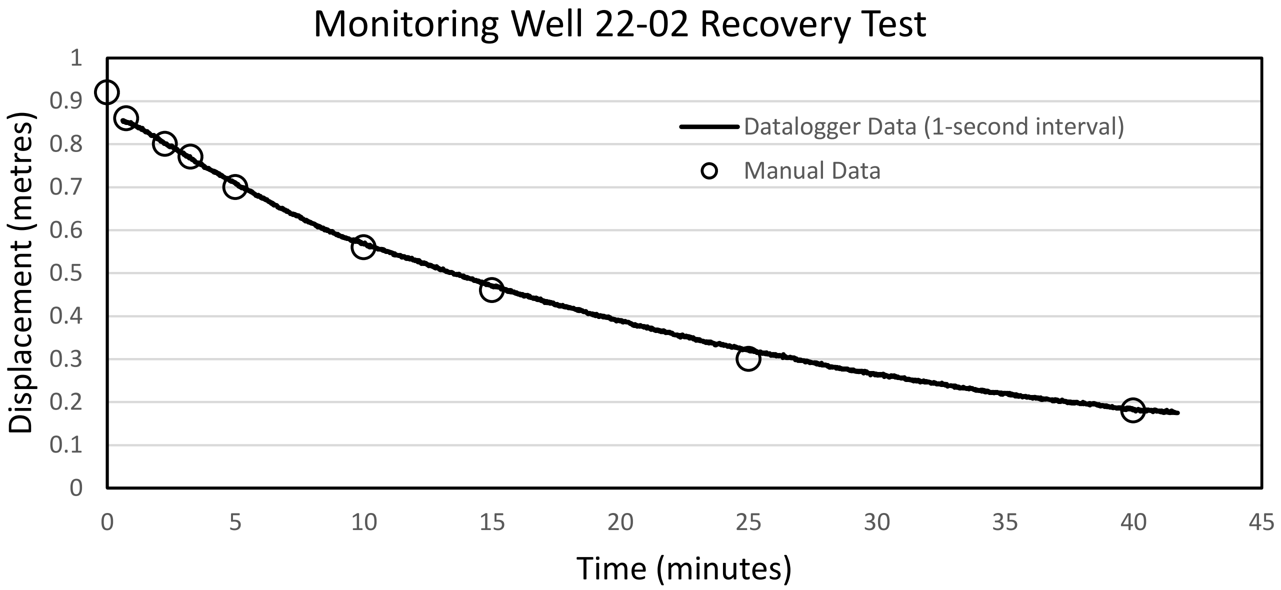
APPENDIX D

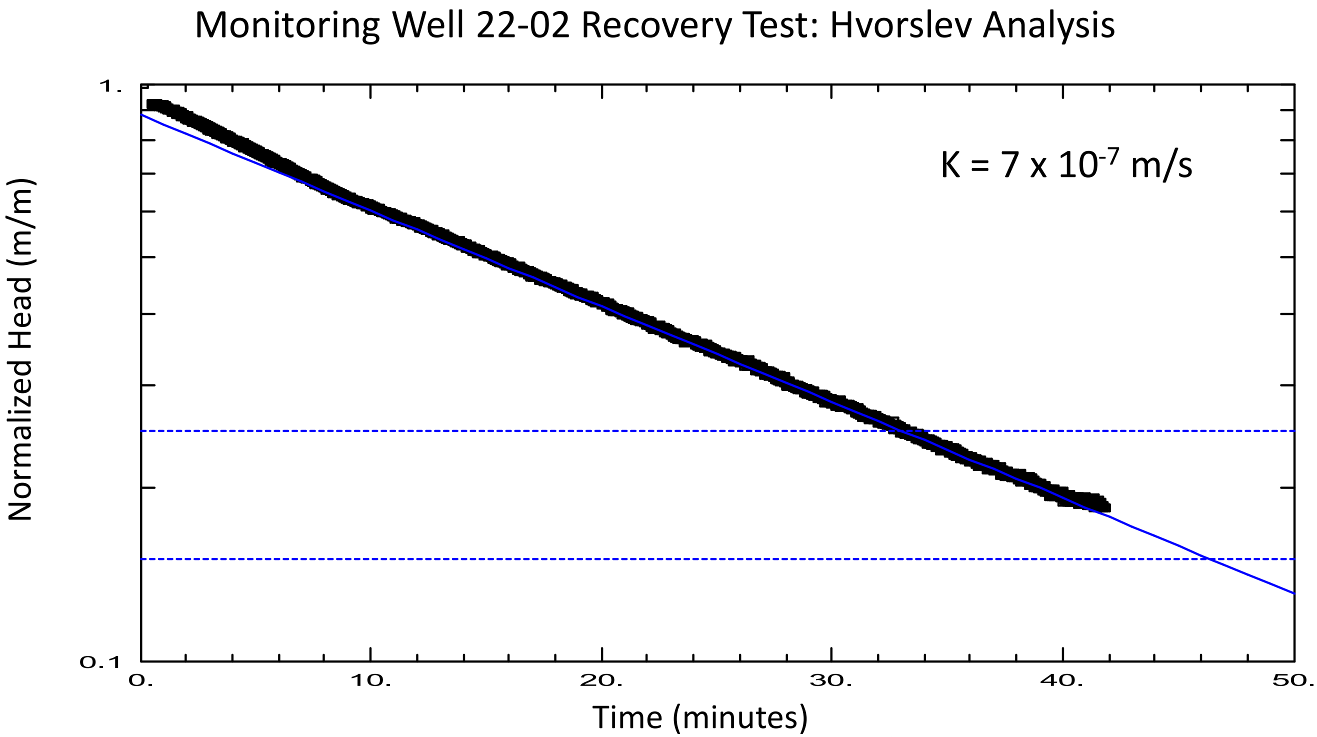
Hydraulic Conductivity Testing
Figure D1

Report to: Morrison Hershfield
Project: 100040.017 (May 5, 2023)

Recovery Test Data

FIGURE D1





Well Data:

Displacement observed: 0.92 metres
Well Depth: 6.71 metres
Screen Length: 3.05 metres
Well Radius: 0.0255 metres

Aquifer Data

Saturated Thickness: 1.66 metres
Anisotropy Ratio (Kz/Kr): 1.0
Aquifer Model: Unconfined, Hvorslev
Static Water Level: 1.66 metres toc

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AND SCIENTISTS

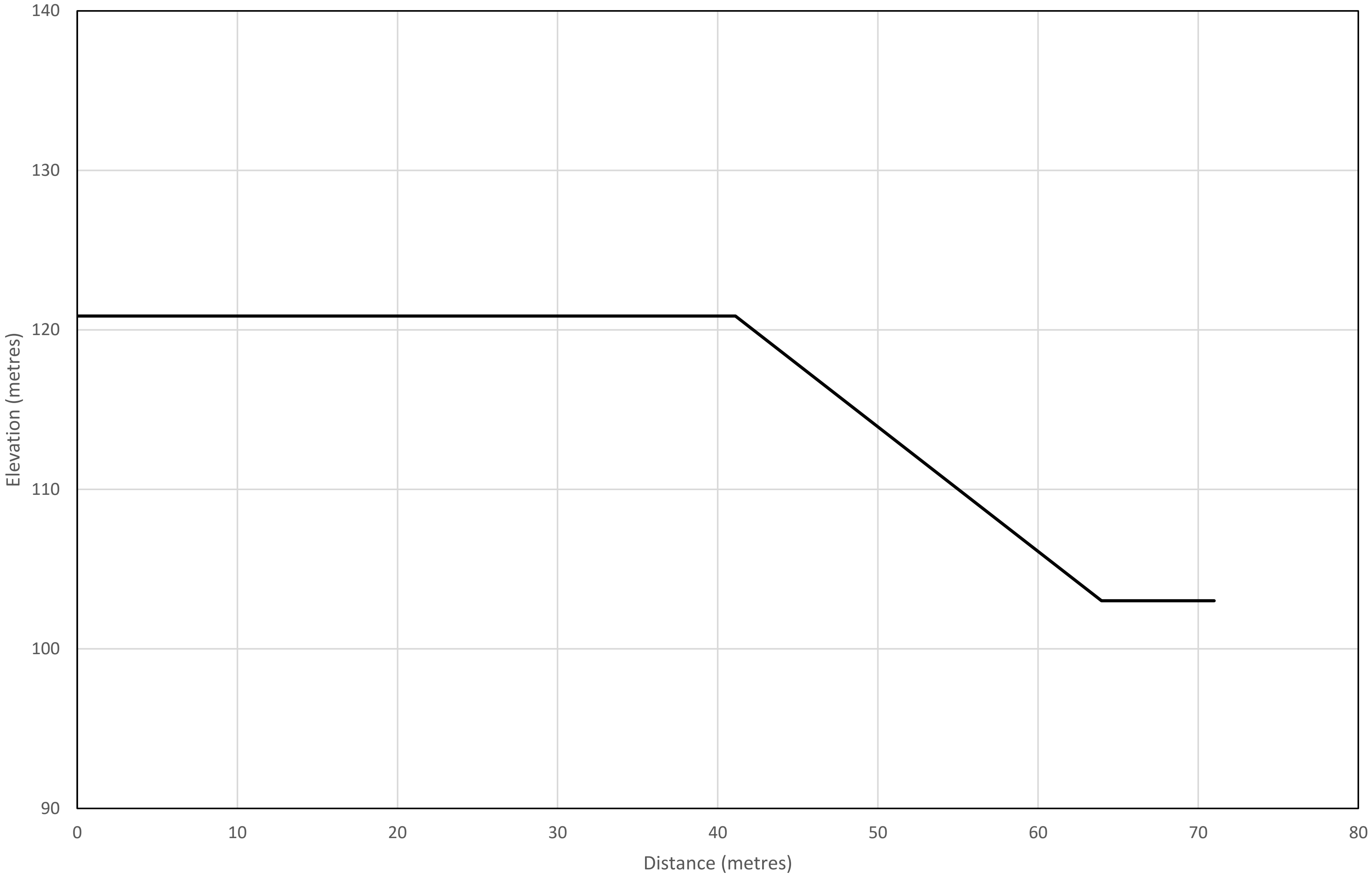
Date: December 2022

Project: 100040.017

APPENDIX E

Results of Slope Stability Analysis
Figures E1 to E3

Report to: Morrison Hershfield
Project: 100040.017 (May 5, 2023)



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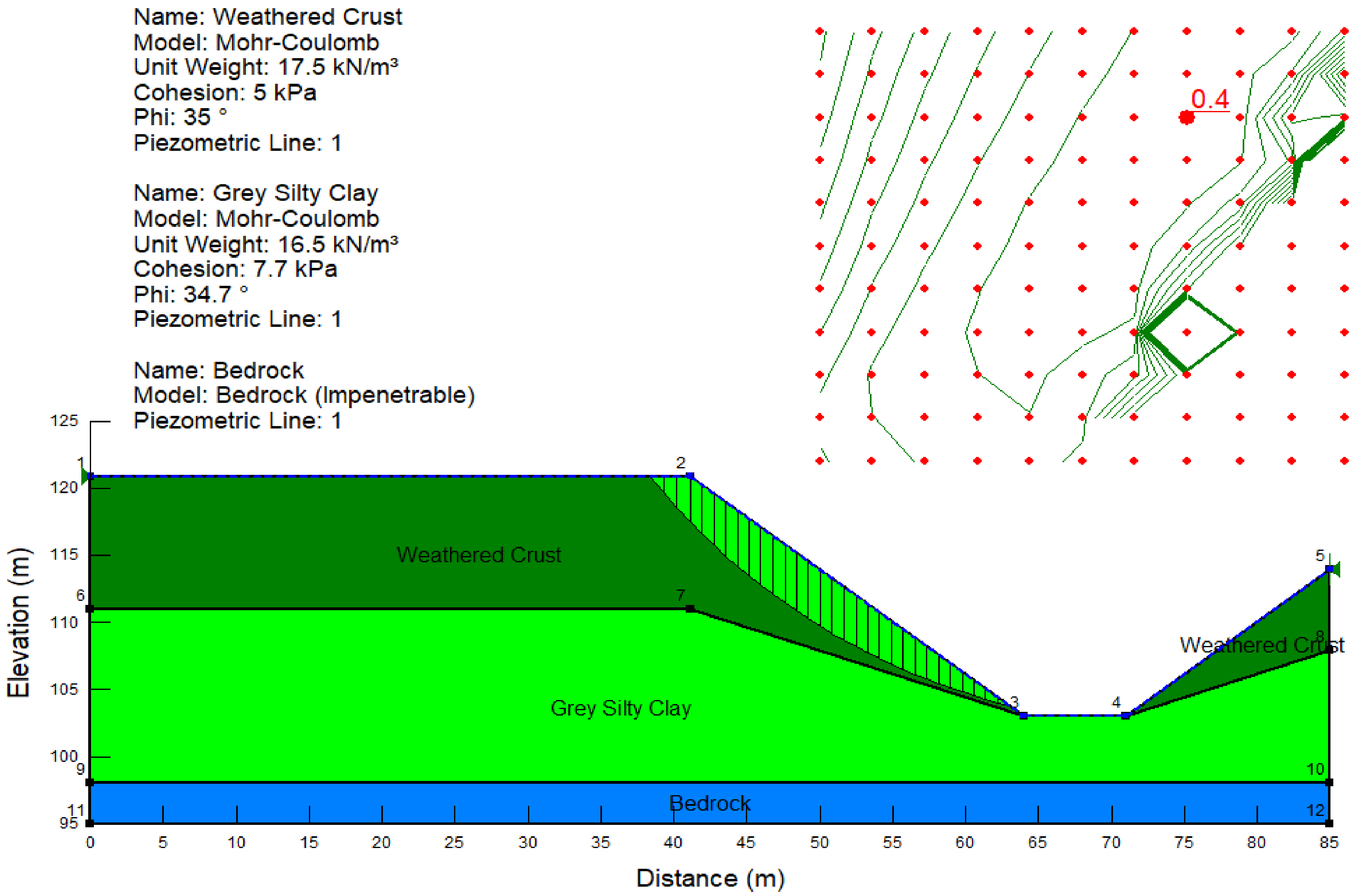
Slope Cross Section A-A

Munroe Street Outfall

Renfrew, Ontario

Project No.	100040.017
Drawn:	WAM
Date:	12/20/2022

Figure E1



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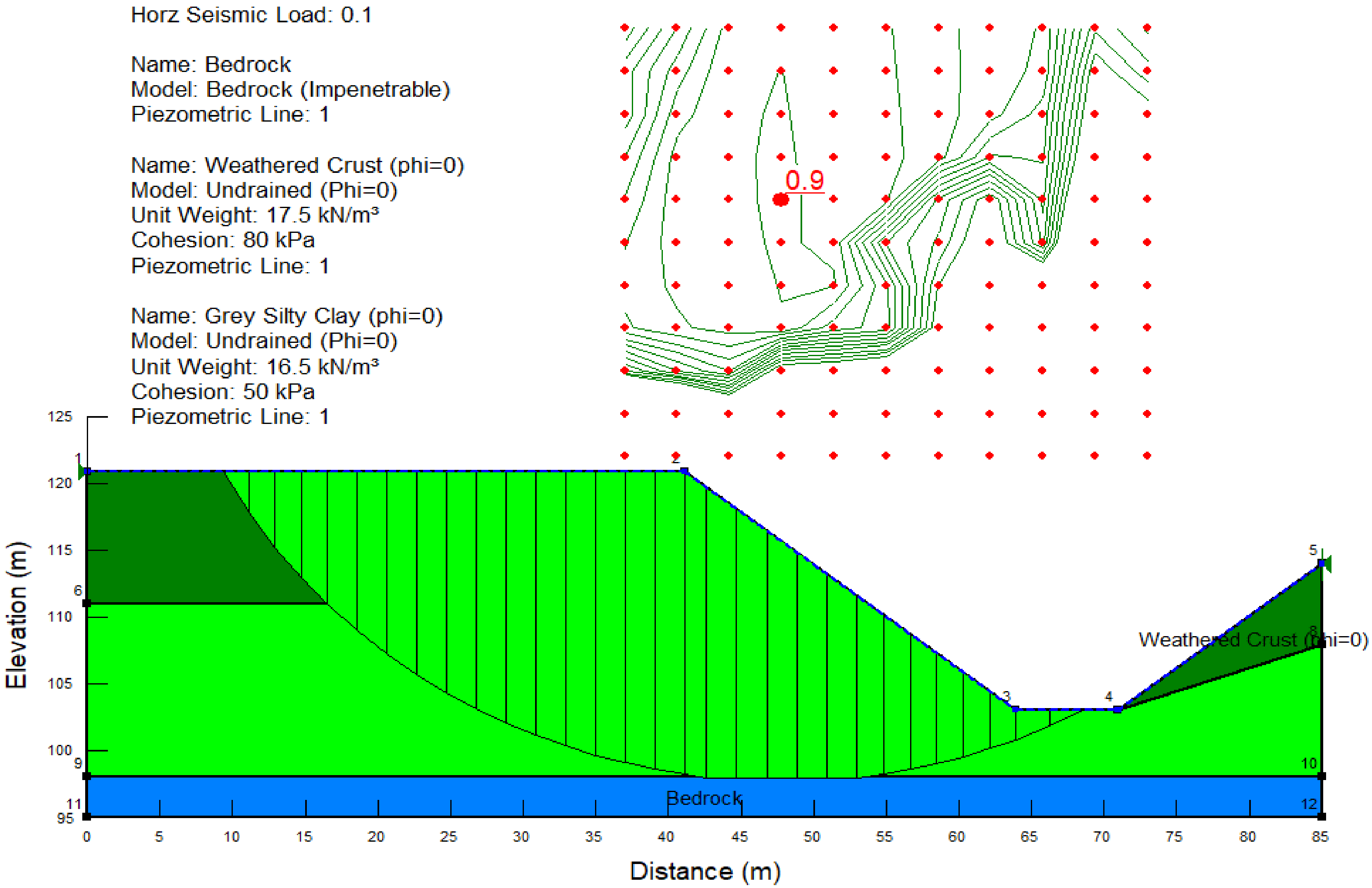
Slope Cross Section A-A - Static Analysis

Munroe Street Outfall

Renfrew, Ontario

Project No. 100040.017
Drawn: WAM
Date: 12/20/2022

Figure E2



Horz Seismic Load: 0.1

Name: Bedrock
Model: Bedrock (Impenetrable)
Piezometric Line: 1

Name: Weathered Crust (phi=0)
Model: Undrained (Phi=0)
Unit Weight: 17.5 kN/m³
Cohesion: 80 kPa
Piezometric Line: 1

Name: Grey Silty Clay (phi=0)
Model: Undrained (Phi=0)
Unit Weight: 16.5 kN/m³
Cohesion: 50 kPa
Piezometric Line: 1

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Slope Cross Section A-A - Seismic Analysis

Munroe Street Outfall

Renfrew, Ontario

Project No.	100040.017
Drawn:	WAM
Date:	12/20/2022

Figure E3

experience • knowledge • integrity

civil	civil
geotechnical	géotechnique
environmental	environnementale
field services	surveillance de chantier
materials testing	service de laboratoire des matériaux

expérience • connaissance • intégrité