



GEMTEC

www.gemtec.ca

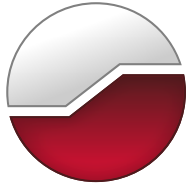
**Geotechnical Investigation Report
Proposed Development
5872, 5880, and 5884 Hazeldean
Road and 7 Savage Drive
Ottawa, Ontario**

GEMTEC Project: 104054.001

experience • knowledge • integrity



expérience • connaissance • intégrité



GEMTEC

www.gemtec.ca

Submitted to:

Hazeldean Heights Inc.
5872, 5880, and 5884 Hazeldean Road and 7 Savage Drive
Stittsville, Ontario
K2S1Z2

**Geotechnical Investigation Report
Proposed Development
5872, 5880, and 5884 Hazeldean Road
and 7 Savage Drive
Ottawa, Ontario**

July 17, 2026

GEMTEC Project: 104054.001 – Rev.01

TABLE OF CONTENTS

1.0	INTRODUCTION.....	1
2.0	BACKGROUND.....	1
2.1	Project Description.....	1
3.0	EXISTING INFORMATION ON SUBSURFACE CONDITIONS	2
3.1	Site Geology	2
3.2	Previous Investigations by Others	2
4.0	METHODOLOGY	2
4.1	Geotechnical Investigation	2
4.2	Hydrogeological Investigation	3
4.2.1	Monitoring Well Installation	3
4.2.2	Water Levels.....	3
4.2.3	Hydraulic Conductivity Testing	3
4.2.4	Groundwater Quality Sampling	4
5.0	SUBSURFACE CONDITIONS.....	4
5.1	Asphaltic Concrete.....	4
5.2	Fill material	4
5.3	Limestone Bedrock	5
5.4	Groundwater Level.....	6
5.5	Chemistry Relating to Corrosion	7
5.6	Hydraulic Conductivity	7
5.7	Groundwater Quality	8
6.0	GEOTECHNICAL GUIDELINES AND RECOMMENDATIONS.....	9
6.1	Grade Raise Restrictions	9
6.2	Excavation	9
6.2.1	Overburden Excavation	9
6.2.2	Bedrock Excavation	9
6.3	Groundwater Pumping and Management.....	11
6.4	Foundation Design.....	11
6.5	Frost Protection of Foundations	12
6.6	Seismic Site Class and Liquefaction Potential.....	12
6.7	Foundation Wall Backfill and Drainage.....	12
6.8	Lateral Earth Pressure	14
6.8.1	Static Geotechnical Design Parameters.....	14
6.8.2	Dynamic Geotechnical Design Parameters	14

6.9	Floor Slabs	16
6.9.1	General.....	16
6.9.2	Slab Support.....	16
6.10	Corrosion of Buried Concrete and Steel.....	17
6.11	Proposed Services.....	17
6.11.1	Excavation for the Site Services.....	17
6.11.2	Pipe Bedding	17
6.11.3	Trench Backfill	18
6.12	Exterior Pavement Design	18
6.12.1	Subgrade Preparation.....	19
6.12.2	Pavement Structure	19
6.12.3	Granular Material Compaction	20
6.12.4	Asphaltic Cement.....	20
6.12.5	Transition Treatments	20
6.12.6	Pavement Drainage	20
6.13	Interior Pavement Design.....	20
7.0	ADDITIONAL CONSIDERATIONS	21
7.1	Rock Anchors	21
7.2	Winter Construction	21
7.3	Effects of Construction Induced Vibration	21
7.4	Monitoring Well Abandonment	21
7.5	Disposal of Excess Soil and Re-Use of Existing Fill	21
7.6	Design Review and Construction Observation	22
8.0	CLOSURE.....	22

LIST OF TABLES

Table 4.1 – Summary of Grain Size Distribution Testing, Fill Material	5
Table 4.2 – Results of Unconfined Compressive Testing of Rock Core.....	6
Table 4.3 – Groundwater Level Depths and Elevations.....	6
Table 4.4 – Chemistry Relating to Corrosion.....	7
Table 4.5 – Summary of Hydraulic Testing Results.....	8
Table 4.6 – Calculated Hydraulic Conductivities.....	8
Table 5.1 – Peak Vibration Limits.....	10
Table 5.2 – Summary of Design Parameters, Drained Building Foundation Walls.....	15

LIST OF FIGURES

Figure 1 – Site Plan

LIST OF APPENDICES

Appendix A	Record of Borehole Logs
Appendix B	Laboratory Testing Results
Appendix C	Bedrock Core Photographs
Appendix D	Borehole Logs – Previous Investigation
Appendix E	Hydraulic Conductivity Testing
Appendix F	Chemical Analysis of Water Samples
Appendix G	Water Quality Testing Results

NOTE: This document and any attachments are confidential and intended solely for the use of the individual or entity to whom they are addressed. If you have received this document in error, please notify the sender immediately and delete the document from your system. Any unauthorized disclosure, copying, distribution, or reliance on the contents of this document is prohibited. Thank you for your cooperation.

1.0 INTRODUCTION

This report presents the results of the geotechnical investigation carried out for the proposed multi-storey residential development to be located at the corner of Hazeldean Road and Savage Street, at municipal addresses 5872, 5880, and 5884 Hazeldean Road, and 7 Savage Drive in Ottawa, Ontario.

The purpose of the investigation was to identify the general subsurface conditions at the site by means of a limited number of boreholes and, based on the information obtained, to provide engineering guidelines and recommendations on the geotechnical design aspects of the project, including construction considerations that could influence design decisions.

GEMTEC has carried out a Phase One Environmental Site Assessment (ESA) and a Phase II ESA, which are reported under separate covers.

This report is subject to the Conditions and Limitations of This Report, which follows the text of this report, and which are considered an integral part of this report.

2.0 BACKGROUND

2.1 Project Description

The site of the proposed development is located at the southeast corner of Hazeldean Road and Savage Drive, at the municipal addresses provided above. The site is currently a used car dealership, consisting of a slab on grade building and asphalt paved parking, as well as a residential dwelling with a basement.

Based on plans provided by Fotenn (Project No. 2428 – Hazeldean Road Rezone, dated August 19, 2024, Revision No. 1), the following is known about the proposed development:

- The development will consist of three buildings on site, as follows:
 - o Building A will be 7 to 15 storeys in height, with a footprint area of about 1,004 square metres;
 - o Building B will be 7 to 27 storeys in height, with a footprint area of about 1,010 square metres; and,
 - o Building C will be 4 storeys in height, with a footprint area of about 584 square metres.
- Buildings A and B are adjacent to each other with an approximate “U” shape with a courtyard in the middle;
- There will be two levels of underground parking, that will be located below Buildings A and B and courtyard footprint;
- Building C will be of slab on grade construction (i.e., no basement level); and,
- Surficial access roadway and parking areas are proposed.

3.0 EXISTING INFORMATION ON SUBSURFACE CONDITIONS

3.1 Site Geology

Surficial geology maps indicate the presence of glacial till over shallow bedrock at the site. Bedrock geology maps indicate limestone of the Bobcaygeon Formation is present below the soil cover. Drift thickness mapping indicates that the bedrock surface is expected at depths ranging from about 1 to 3 metres, being deeper to the north.

The site is in an area of ‘potential’ karst on the Ontario Geological Survey Southern Ontario Karst Map, and as such, it is understood that karst formations (i.e. underground caves and/or voids occurring as a result of dissolution of bedrock due to water) are possibly present at and in the vicinity of the site.

3.2 Previous Investigations by Others

A Phase II ESA was carried out at the site by Pinchin Limited in June 2024. The results were provided in the report titled “Phase II Environmental Site Assessment, 5872, 5880 and 5884 Hazeldean Road, Ottawa, Ontario” dated June 25, 2024 (Project No. 341092.001). This investigation and report are referred to further herein as Pinchin (2024).

As part of Pinchin (2024) two boreholes named MW1 and MW2 were advanced to depths of about 7.0 and 9.7 metres, respectively. The subsurface conditions encountered in these boreholes consisted of topsoil over fill material in borehole MW1, and concrete and fill material over glacial till and silty sand in borehole MW2. Limestone bedrock was encountered at a depth of about 1.2 and 2.1 in boreholes MW1 and MW2, respectively. A single monitoring well was installed in each borehole.

The conditions encountered during Pinchin (2024) are reasonably similar to the mapped geological conditions, except for the uncontrolled fill material which is typically not identified on the geological maps.

4.0 METHODOLOGY

4.1 Geotechnical Investigation

The fieldwork for this investigation was carried out on April 30 and May 1, 2025. On those days, four boreholes, identified as 25-01 to 25-04, inclusive, were advanced at the approximate locations shown on the Site Plan, Figure 1. The borehole locations were selected and positioned at the site relative to existing site features by GEMTEC personnel, and were surveyed using high precision GPS survey instrumentation.

The boreholes were advanced using a track mounted drill rig supplied and operated by Strata Drilling Group of Ottawa, Ontario. Standard penetration tests were carried out in the boreholes within the overburden and samples of the soils encountered were recovered using split spoon

sampling equipment. The boreholes were advanced to practical auger refusal at depths ranging from about 0.2 to 0.9 metres. Upon reaching auger refusal in boreholes 25-01, 25-02, and 25-03 the boreholes were then advanced using rotary diamond drilling techniques while retrieving HQ sized core. Coring was carried out to a final depth ranging from about 5.2 to 9.8 metres.

The fieldwork was supervised throughout by a member of our engineering staff who directed drilling operations, observed the in-situ testing, and logged the sample recovery.

Following the fieldwork, the soil and bedrock samples were returned to our laboratory for examination by a geotechnical engineer. Selected samples of the soil were tested for grain size distribution and water content testing. Select samples of the bedrock cores were submitted for unconfined compressive strength testing. Two samples of water, one recovered from each of the monitoring wells in boreholes 25-01 and 25-02, were sent to AGAT laboratories and Paracel laboratories for basic chemical testing related to corrosion of buried concrete and steel.

4.2 Hydrogeological Investigation

4.2.1 Monitoring Well Installation

A single standpipe piezometer (monitoring well) was installed in each of boreholes 25-01, 25-02, and 25-03. Each monitoring well consisted of a 50-millimetre diameter screened PVC pipe installed within a surround of filter sand. Above the surround of filter sand, bentonite was used to seal the well screen from overlying materials and the wells were finished with flush mounted caps. Well depths and screen lengths were chosen based on the material types and inferred groundwater levels encountered during drilling.

4.2.2 Water Levels

Groundwater levels were measured on May 9 and June 4, 2025 in the in the three monitoring wells installed during GEMTEC's investigation, and in the two existing monitoring wells in boreholes MW1 and MW2 from Pinchin (2024).

Preceding groundwater level measurements, monitoring wells were developed using a foot valve and tubing to purge the water column volume three times or until the well was purged dry.

4.2.3 Hydraulic Conductivity Testing

Hydraulic conductivity testing consisting of falling and rising head tests (i.e., slug tests) was carried out in in the monitoring wells installed in boreholes 25-01, 25-02 and 25-03.

Falling head testing involved introducing an instantaneous pressure increase to the water column within the well screen (equal to the volume o 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.

Rising head testing involved introducing an instantaneous pressure decrease to the water column within the well screen (equal to the volume of the slug) and monitoring the recover of the water level over time using a groundwater data logging pressure transducer together with an electric water level tape. Manual measurements were also taken for 5 minutes following the introduction and removal of the slug.

4.2.4 Groundwater Quality Sampling

A groundwater quality sample was collected from the monitoring well in borehole 25-02 on June 4, 2025. The sample was collected following well purging using dedicated downhole tubing and foot valve and stored in laboratory supplied bottles. The sample was submitted to a CALA-accredited laboratory for the analysis of “Baseline Monitoring” parameters as outlined in the City of Ottawa’s *Request To Discharge Wastewater From Construction or Remediation Projects*.

5.0 SUBSURFACE CONDITIONS

Descriptions of the subsurface conditions logged in the boreholes are provided on the Record of Borehole Sheets in Appendix A. Details of the monitoring wells are also provided on the borehole logs. The results of the soil classification testing are provided in Appendix B and on the Record of Borehole Sheets. Photographs of the bedrock core and the results of bedrock compressive strength testing are provided in Appendix C. Borehole logs from the Pinchin (2024) investigation are provided in Appendix D. Hydraulic conductivity testing results are provided in Appendix E. The results of the chemical analysis are provided in Appendix F. The results of the water quality testing are provided in Appendix G.

The following presents an overview of the subsurface conditions encountered in the boreholes advanced during the fieldwork investigation.

5.1 Asphaltic Concrete

Boreholes 25-02 and 25-04 were advanced through the asphaltic concrete parking lot surfacing, which has a thickness of about 100 and 110 millimetres, respectively.

5.2 Fill material

Fill material was encountered at ground surface at boreholes 25-01 and 25-03 and underlying the asphaltic concrete in boreholes 25-02 and 25-04. The fill material consists of sandy gravel, with trace to some non-plastic fines.

At boreholes 25-01, 25-02, and 25-03, the fill material extends to depths ranging from about 0.9 to 1.1 metres. It is uncertain if the shallow auger refusal in 25-04 at 200 millimetres reflects the base of the fill material at this location.

Standard penetration tests carried out in the fill material gave N values ranging from 13 to greater than 50 blows per 0.3 metres of penetration, which reflect a compact to very dense relative density. The higher blow counts likely reflect the presence of the cobbles, boulders and other hard material within the fill material, noting that rotary coring was required to fully penetrate the layer at the locations of boreholes 25-01, 25-02 and 25-03.

The results of the grain size distribution testing on one sample of the fill are summarized in Table 4.1. The water content of one sample of one sample of the fill material was measured to be about 6 percent.

Table 4.1 – Summary of Grain Size Distribution Testing, Fill Material

Borehole ID	Sample Number	Gravel (%)	Sand (%)	Silt and Clay (%)
25-03	GS1	69	23	8

5.3 Limestone Bedrock

Grey limestone bedrock was proven below the level of auger refusal in boreholes 25-01, 25-02, and 25-03, at depths ranging from about 910 millimetres to 1.1 metres. The limestone bedrock was cored to depths ranging from about 5.2 to 9.8 metres below the existing ground surface. As comparison, bedrock was reported in Pinchin (2024) at depths of 1.2 to 2.1 metres.

The upper about 0.3 and 0.2 metres of the bedrock in the boreholes 25-02 and 25-03, respectively, is moderately to highly fractured, with solid core recovery values of about 0 to 50 percent and rock quality designation values of 0 percent.

Below the fractured zone, total core recover (TCR) values ranging from about 83 to 100 percent, solid core recovery (SCR) values ranging from about 25 to 100 percent, and rock quality designation (RQD) values ranging from about 18 to 100 percent were obtained. Based on these values, in accordance with the classification system set out in the Canadian Foundation Engineering Manual (5th Edition) the bedrock can be classified as Very Poor to Excellent Quality, possibly increasing with depth.

The result of unconfined compressive strength testing carried out on six samples of recovered bedrock core from boreholes 25-01, 25-02, and 25-03 and the results are presented in Table 4.2. The rock strength classification in the Canadian Foundation Engineering Manual (5th Edition) has been applied.

Table 4.2 – Results of Unconfined Compressive Testing of Rock Core

Borehole ID	Depth (metres)	Rock Compressive Strength (MPa)	Rock Strength Classification
25-01	3.2 to 3.4	109	Very Strong
25-01	5.0 to 5.3	110	Very Strong
25-02	2.0 to 2.2	86	Strong
25-03	2.7 to 3.0	152	Very Strong
25-03	5.9 to 6.2	124	Very Strong
25-03	8.8 to 9.0	129	Very Strong

5.4 Groundwater Level

The groundwater levels in the monitoring wells are provided in Table 4.3. The groundwater levels may be higher during wet periods of the year such as the early spring or following periods of precipitation.

Table 4.3 – Groundwater Level Depths and Elevations

Borehole ID	Ground Surface Elevation (metres)	Groundwater Depth (metres)	Groundwater Elevation (metres)	Date of Reading
25-01	109.5	2.5	107.0	May 9, 2025
		2.5	107.0	June 4, 2025
25-02	108.9	0.8	108.1	May 9, 2025
		0.8	108.1	June 4, 2025
25-03	110.0	1.4	108.6	May 9, 2025
		1.5	108.4	June 4, 2025
MW1	109.1 ¹	1.9	107.2	May 9, 2025
		1.8	107.3	June 4, 2025
MW2	109.7 ¹	1.2	108.5	May 9, 2025
		5.8	103.9	June 13, 2024
		1.4	108.3	June 4, 2025

Note: 1. The ground surface elevation of the Pinchin boreholes (MW1 and MW2) were surveyed by GEMTEC

5.5 Chemistry Relating to Corrosion

The results of the for basic chemical testing relating to corrosion of buried concrete and steel are summarized in Table 4.4.

Table 4.4 – Chemistry Relating to Corrosion

Parameter	Borehole 25-01 Groundwater	Borehole 25-02 Groundwater
pH	7.2	7.7
Electrical Conductivity ($\mu\text{S}/\text{cm}$)	1,440	1,880
Sulphate (mg/L)	341	117
Chloride (mg/L)	202	416

5.6 Hydraulic Conductivity

A summary of the hydraulic testing results is provided in Table 4.5. Water level displacement is based on slug size of about 0.6 metres. The recovery curves are provided in Appendix E. Estimates of hydraulic conductivity were calculated from the results of the recovery test using the Bouwer-Rice method of analysis and are presented in Table 4.6 below.

The calculated hydraulic conductivities are within the literature value range for limestone bedrock, which ranges from about 10^{-9} to 10^{-5} metres per second (Freeze and Cherry, 1979). Given the rapid response observed in boreholes 25-02 and MW2, the hydraulic conductivity is expected to be much higher at these locations, likely associated with highly fractured bedrock at those locations.

The results of the hydraulic testing represent the conditions in the vicinity of the well screen and as distance increases from the well screen the conditions may vary from those reported, particularly in a fractured bedrock setting. Conditions between wells have not been established, therefore variability in hydraulic conductivity within the site should be anticipated.

Table 4.5 – Summary of Hydraulic Testing Results

Borehole ID	Falling Head Test		Rising Head Test	
	Recovery Time (minutes)	Recovery (percent)	Recovery Time (minutes)	Recovery (percent)
25-01	10	100	10	100
25-02	0 ²	100	0 ¹	100
25-03	14	100	18	100
MW1	3	95	3	95
MW2	0 ²	95	0 ¹	95

Notes:

1. Near instantaneous recovery

Table 4.6 – Calculated Hydraulic Conductivities

Borehole ID	Screened Geological Unit	Calculated Hydraulic Conductivity (m/s)	
		Falling Head	Rising Head
25-01	Limestone Bedrock	4×10^{-6}	4×10^{-6}
25-02	Limestone Bedrock	- ¹	- ¹
25-03	Limestone Bedrock	2×10^{-6}	2×10^{-6}
MW1	Limestone Bedrock	8×10^{-6}	9×10^{-6}
MW2	Limestone Bedrock	- ¹	- ¹

Notes:

1. Insufficient observed displacement (i.e., rapid response) for analysis of aquifer properties.

5.7 Groundwater Quality

The groundwater quality analytical results were compared against the Ottawa Sewer Use By-law (No. 2003-514), exceedances of which are summarised as follows:

Ottawa Sewer Use By-law – Storm Sewers:

- Total suspended solids of 90 milligrams per litre exceeded the limit of 15 milligrams per litre;
- Total manganese of 0.066 milligrams per litre exceeded the limit of 0.05 milligrams per litre.

Ottawa Sewer Use By-law – Sanitary and Combined Sewers:

- No exceedances were identified when compared to Sanitary and Combined Sewers.

Based on groundwater quality results, discharge to storm sewer and sanitary/combined sewer may be possible following proper treatment including sediment removal.

6.0 GEOTECHNICAL GUIDELINES AND RECOMMENDATIONS

6.1 Grade Raise Restrictions

We do not anticipate any grade raise restrictions at this site, from a geotechnical perspective. Notwithstanding, any filling above 3 metres of the original ground level should be assessed by GEMTEC.

6.2 Excavation

6.2.1 Overburden Excavation

The fill material outside the existing structures is anticipated to be readily excavatable using conventional hydraulic excavation equipment, in general, noting that fill material can contain boulders and other hard materials. Excavation of any debris associated with clearing the site of existing structures will be slower and require increased effort, if for example removal of large fragments of reinforced concrete, former slabs or building foundation be necessary.

The sides of the excavations should be sloped in accordance with the requirements in Ontario Regulation 213/91 under the Occupational Health and Safety Act. For excavations in Type 3 soils allowance should be made for excavation side slopes of one horizontal to one vertical extending upwards from the base of the excavation above the groundwater level. Below the groundwater level flatter side slopes of 3 horizontal to 1 vertical may be required. Re-evaluation of the applicable Soil Type should be carried out by a geotechnical practitioner once site clearing has been performed.

6.2.2 Bedrock Excavation

Bedrock removal at this site could be carried out using drill and blasting, hoe ramming techniques in conjunction with line drilling on close centres, or a combination of both. Provided that good

bedrock excavation techniques are used, the bedrock could be excavated using near vertical side walls. Any loose bedrock should be scaled from the sides of the excavation for worker safety.

As a guideline for blasting, the peak vibration limits suggested at the nearest structure or service are provided in Table 5.1, below. It is pointed out that the limits provided, although conservative, were established to prevent damage to existing buildings and services in good condition. More stringent criteria may be required to prevent damage to freshly placed (uncured) concrete or vibration sensitive equipment or utilities.

Table 5.1 – Peak Vibration Limits

Frequency of Vibration (Hz)	Vibration Limits (millimetres/second)
<10	5
10 to 40	5 to 50 (interpolated)
>40	50

Any blasting should be carried out under the supervision of a blasting specialist engineer and monitoring of the blasting should be carried out to ensure that the blasting meets the limiting vibration criteria. Pre-construction condition surveys of the nearby structures and existing buried services are considered essential. The effects due to vibration from blasting can be controlled by limiting the size and amount of charge, using delayed detonation techniques, and the like. A blasting specialist should be consulted on the effects of vibration on nearby services and separation distance between any blasting and existing underground services.

As an alternative to blasting, bedrock removal could be carried out using hoe ramming techniques in conjunction with line drilling on close centres. However, excavation rates will likely be slower by this method. For the bedrock at this site, it is suggested that allowance be made for line drilling 75 to 100 millimetre diameter holes on 200 to 300 millimetre centres. The vibration effects of hoe ramming are usually minor and localized. Monitoring of the hoe ramming could be carried out, at least initially, to measure the vibrations to ensure that they are below the acceptable threshold value.

The bedrock below founding level will likely break at a horizontal bedding plane below the design depth of the footings, which may necessitate thickening of the footings and/or lowering of the footings. As such, significant overbreak and underbreak should be expected in any bedrock removal.

6.3 Groundwater Pumping and Management

The amount of water entering the excavation for the construction of the underground parking and services at this site will depend on the size of the excavation, the material through which the excavation will be advanced, as well as the groundwater elevation at the time of construction. Open bedrock joints and discontinuities, or a high density of bedrock fractures and/or discontinuities may result in significantly higher groundwater inflow from the rock mass. Bedrock blasting may increase the density of bedrock fracturing and cause discontinuities to open. Significant groundwater inflows should be anticipated where these conditions are encountered in the excavation.

For temporary dewatering during construction over 50,000 litres per day an Environmental Activity and Sector Registry (EASR) is required, to be supported by a Water Taking and Discharge Plan report prepared by a Qualified Professional. As of July 1, 2025, no maximum limits apply to dewatering.

As part of the upcoming changes to *Ontario Regulation 387/04* under the *Ontario Water Resources Act* (effective July 1, 2025) low-risk foundation drainage systems, used primarily for residential purposes, that take less than 379,000 litres of groundwater per day are exempt from environmental permissions (EASR or PTTW registration). If long-term groundwater takings are over 379,000 litres per day, a Category 3 PTTW will be required, to be supported by a hydrogeological investigation.

Given the rapid hydraulic response observed in two monitoring wells, it is expected that any groundwater taking below the water table will require EASR registration (short-term) and may also require a Category 3 PTTW for long-term foundation drainage. A groundwater monitoring and dewatering plan may be required.

6.4 Foundation Design

The factored net geotechnical resistance at Ultimate Limit States (ULS) for spread footing foundations founded on or within the bedrock may be taken as 1,000 kilopascals. The factored geotechnical resistances at ULS includes a geotechnical resistance factor of 0.5.

Provided the bedrock surface is acceptably cleaned of soil or loose and fractured bedrock (i.e., any bedrock that can easily be removed with a hydraulic excavator), the settlement of footings at the corresponding service (unfactored) load levels will be less than 25 millimetres and therefore Serviceability Limit States (SLS) need not be considered in the foundation design. Accordingly, the post construction settlement of structural elements which derive their support from footings bearing on bedrock should be negligible.

6.5 Frost Protection of Foundations

All exterior footings should be provided with at least 1.5 metres of earth cover for frost protection purposes. Isolated, unheated exterior footings adjacent to surfaces which are cleaned of snow cover during the winter months should be provided with a minimum of 1.8 metres of earth cover. It is assumed that the underground parking level will be heated and as such, it is likely that additional protection of the foundations from freezing conditions will not be required.

6.6 Seismic Site Class and Liquefaction Potential

Based on the results of the investigation, and the provided structural drawings for the proposed structures, the proposed foundations will be supported on or within the bedrock.

If direct measurement of the average shear wave velocity in the bedrock be carried out it is possible that Site Class A or B (Site Designation X_A or X_B) would apply. In the absence of such testing, the building should be designed for seismic Site Class C (Site Designation X_C). GEMTEC can carry out such testing as the design progresses, upon request.

There is no potential for liquefaction of the overburden deposits at this site.

6.7 Foundation Wall Backfill and Drainage

It is assumed that the base of the foundation walls will be up to about 6.0 metres below the existing ground surface which will extend below the bedrock. The following alternatives could be considered for the foundation walls that are below the bedrock surface:

1. Foundation walls formed on both sides, damp proofed and backfilled with free draining, non-frost susceptible granular materials; OR
2. Foundation walls formed on one side, with a proprietary drainage system placed directly against the bedrock.

Alternative 2 could be considered where space constraints dictate and/or to limit the amount of bedrock excavation.

In areas where the walls are formed on both sides, the exterior of the wall should be damp proofed and a perforated plastic foundation drain with a surround of clear crushed stone should be installed on the exterior of the walls. The drain should outlet by gravity to a sump from which the water is pumped.

In areas where the walls will be cast directly on the bedrock, drainage could be achieved by means of a prefabricated drainage system, such as Miradrain 5000, fastened to the bedrock. In this case, the drainage system could be connected to a perforated drain below the slab, as discussed in Section 6.10.

Above the bedrock surface, the walls could be formed on both sides. In this case, the walls should be damp proofed and drainage could be achieved by means of a prefabricated drainage system, such as Miradrain 5000, fastened to the exterior of the wall and hydraulically linked (spliced) to the drainage system fastened to the bedrock or by means of a free draining granular backfill material.

To avoid frost adhesion and possible heaving, the walls should be backfilled with imported, free-draining, non-frost susceptible granular material such as that meeting the requirements of Ontario Provincial Standard Specifications (OPSS) Granular A, or Granular B Type I or II. Alternatively, the existing granular fill material at this site may be used as backfill against the foundation walls, provided it is reviewed on site by a geotechnical engineer prior to placement.

Where the backfill will ultimately support areas of hard surfacing (pavement, sidewalks or other similar surfaces), the backfill should be placed in maximum 200 millimetre thick lifts and should be compacted to at least 95 percent of the material's standard Proctor maximum dry density value using suitable vibratory compaction equipment. Light walk behind compaction equipment should be used next to the foundation walls to avoid excessive compaction induced stress on the walls. A gradual transition should be provided between those areas of hard surfacing underlain by non-frost susceptible granular wall backfill and those areas underlain by existing frost susceptible fill material to reduce the effects of differential frost heaving. It is suggested that granular frost tapers be constructed from 1.5 metres below finished grade to the underside of the granular subbase material for the hard surfaced areas. The frost tapers should be sloped at 1 horizontal to 1 vertical, or flatter.

Where future landscaped areas will exist next to the proposed structure and if some settlement of the backfill is acceptable, the backfill could be compacted to at least 90 percent of the material's standard Proctor maximum dry density value using suitable vibratory compaction equipment.

The frost susceptible native soils could be considered for foundation wall backfill purposes in landscaped areas provided that a suitable bond break is applied to the surface of the foundations to prevent frost jacking. A suitable bond break could consist of at least 2 layers of 6 MIL polyethylene sheeting or a proprietary plastic drainage medium. It is also pointed out that the native soils at this site can be impacted by changes in moisture content and this could affect the ability to compact this material to the required density.

In areas where the walls will be cast directly on the bedrock and will extend above the bedrock surface, a perforated plastic drain with a surround of clear crushed stone wrapped in a nonwoven geotextile should be installed on the exterior of the walls at the bedrock surface. The drain should outlet by gravity to a storm sewer or a sump from which the water is pumped.

6.8 Lateral Earth Pressure

The selection of the appropriate value of lateral earth pressure coefficient (i.e., active, or at rest) for design depends on the permissible movement in the retaining structures and the design approach adopted. For instance, relatively large wall movements are typically required to generate “Active” earth pressure conditions, and as such the use of “At Rest” earth pressure coefficients are recommended for preliminary design purposes unless the structures are specifically designed for such movements to occur. Further details can be provided as required.

In addition to the earth pressures, an appropriate value of uniform surcharge at ground surface should be considered to account for construction traffic and other applicable loads as appropriate. We suggest a minimum value of 15 kilopascals be considered.

Please note that the following sections assume that the foundation walls will be provided with drainage measures and will be installed with granular backfill against the walls (i.e., not formed against the bedrock). Further details on lateral earth pressures for foundation walls against the bedrock can be provided as the design progresses. Should a water-tight basement be considered, the foundation walls should be designed to resist the additional pressures from groundwater.

Heavy construction traffic should not be allowed to operate adjacent to foundation walls for the proposed buildings (within about 2 metres horizontal) during construction, without the approval of the designers.

6.8.1 Static Geotechnical Design Parameters

Foundation walls that are backfilled with granular material such as that meeting OPSS Granular B Type I or II requirements should be designed to resist “at rest” earth pressures (unless larger movements can be accommodated) calculated using the following formula:

$$\sigma_h = K_o (\gamma d + q)$$

where;

- σ_h : lateral earth pressure at depth, d (kilopascals)
- γ : Moist material unit weight (kilonewtons per cubic metre);
- K_o : “At-rest” earth pressure coefficient;
- q: Surcharge at the top of the wall (kilopascals)

6.8.2 Dynamic Geotechnical Design Parameters

Seismic shaking can increase the forces on the foundation walls. The selection of the appropriate value of dynamic earth pressure coefficient (i.e., considering full or 50 percent PGA values) for design depends on the permissible movement in the retaining structures and the design approach

adopted. For instance, for non-yielding structures the use of full PGA is recommended, while for yielding structures the reduced PGA value may be applied.

The total pressure due to combined static and seismic loads acting at a specified depth, d , below the top of the wall may be calculated using the following equation:

$$\sigma_h = K_o \gamma d + (K_{ae} - K_a) \gamma (H - d)$$

where;

- σ_h : lateral earth pressure at depth d (kilopascals);
- γ : Moist backfill material unit weight (21 kilonewtons per cubic metre);
- K_{ae} : Dynamic “Active” earth pressure coefficient;
- H : Wall height (metres);
- K_a : “Active” Earth Pressure Coefficient

The static thrust component (P_o) acts at a point located $H/3$ above the base of the wall. During seismic shaking, the dynamic at rest thrust component (P_o) acts at a point located about $0.6H$ above the base of the wall.

According to the 2020 National Building Code of Canada Seismic Hazard Tool, the peak ground acceleration (PGA) for this site is about 0.32 g for Site Class C (Site Designation X_C). The dynamic at rest earth pressure coefficient was calculated using the method suggested by Mononobe and Okabe, assuming a horizontal seismic coefficient, k_h , of 0.248 and assuming that the vertical seismic coefficient, k_v , is zero (i.e. non-yielding walls). For design purposes, the parameters provided in Table 5.2 can be used to calculate the thrust acting on the walls during static and seismic loading conditions.

Table 5.2 – Summary of Design Parameters, Drained Building Foundation Walls

Parameter	OPSS Granular B Type I	OPSS Granular B Type II
Material Unit Weight, γ (kilonewtons per cubic metre)	22	22
Estimated Friction Angle (degrees)	34	38
“At Rest” Earth Pressure Coefficient, K_o , assuming horizontal backfill behind the structure	0.44	0.38

Parameter	OPSS Granular B Type I	OPSS Granular B Type II
“Active” Earth Pressure Coefficient, K_a , assuming horizontal backfill behind the structure	0.28	0.24
Dynamic Earth Pressure Coefficient, K_{ae} , assuming horizontal backfill behind the structure	0.51	0.44

It should be noted that the above table assumes that the ground above the wall will be flat (i.e., not sloping). If a sloping ground surface behind the wall is proposed the thrust acting on the wall will be increased. It should also be noted that the values in the table above assumes a Site Class C (Site Designation X_C), and if direct measurement of the shear wave velocity is carried out (and a high Site Class/Site Designation is provided) the values will be updated.

6.9 Floor Slabs

6.9.1 General

The floor slab should be wet cured to minimize shrinkage cracking and slab curling. The slab should be saw cut to about 1/3 the thickness of the slab as soon as curing of the concrete permits, in order to minimize shrinkage cracks.

Proper moisture protection with a vapour retarder should be used for any floor slab where the floor will be covered by moisture sensitive flooring material or where moisture sensitive equipment, products or environments will exist. The “Guide for Concrete Floor and Slab Construction”, ACI 302.1R-04 should be considered for the design and construction of vapour retarders below the floor slab.

If the floor slab is waterproofed, the floor slab should be designed to resist hydrostatic pressures.

6.9.2 Slab Support

To provide predictable settlement performance of the basement slab loose bedrock, that is easily removed by a hydraulic excavator, should be removed from below the proposed slab.

The base of the basement floor slab should consist of at least 200 millimetres of granular A or 19-millimetre clear crushed stone. Any necessary grade raise fill should consist of either OPSS Granular B Type II or 19 millimetre clear crushed stone. The use of clear stone is preferable for a drained basement condition. It is suggested that drainage be provided below the slab by means of plastic perforated pipes spaced at about 5 metres on centre or as required to link any hydraulically isolated areas. The drains should outlet to the sump from which the water is pumped.

The Granular A and B Type II should be compacted in maximum 150 millimetre thick lifts to at least 95 percent of the material’s standard Proctor maximum dry density value using suitable

vibratory compaction equipment. The clear crushed stone should be nominally compacted with at least 2 passes of a diesel plate compactor.

OPSS documents allow recycled asphaltic concrete and concrete to be used in Granular B Type II material. Since the source of recycled material cannot be determined or controlled, it is suggested that any imported Granular B Type II materials be composed of 100 percent crushed rock only.

6.10 Corrosion of Buried Concrete and Steel

The measured sulphate concentration in the water samples recovered from monitoring wells in boreholes 25-01 and 25-02 were about 202 and 406 milligrams per litre, respectively. According to Canadian Standards Association (CSA) “Concrete Materials and Methods of Concrete Construction”, the concentration of sulphate can be classified as low. Therefore, any concrete in contact with the groundwater could be batched with general use (GU) cement. The effects of freeze thaw in the presence of de-icing chemical (sodium chloride) use on the roadway should be considered in selecting the air entrainment and the concrete mix proportions for any concrete.

Based on the resistivity and pH of the sample, the water in this area can be classified as slightly aggressive to aggressive towards unprotected steel. It should be noted that the corrosivity of the soil/groundwater could vary throughout the year due to the application sodium chloride for de-icing.

6.11 Proposed Services

Information on the proposed services/underground utilities were not available at the time of preparing this report. As such, relatively generic guidelines are provided. More tailored guidelines can be provided as further information becomes available.

6.11.1 Excavation for the Site Services

It is anticipated that the proposed services will be installed at a depth of up to about 3.0 metres. Excavations will be carried out through the fill material and into the bedrock.

Excavations for the services should be carried out as per Section 6.3. As an alternative to sloped excavations in the overburden, the service installations could be carried out within a tightly fitting, braced steel trench box, which is specifically designed for this purpose, in combination with suitable groundwater management measures. The possible presence of boulders and other hard material within the fill material should be considered. In order to advance the trench box, even boulders and hard material that partially intrude into the sides of the excavation must be removed, which may result in a wider excavation than anticipated.

6.11.2 Pipe Bedding

The bedding for service pipes should consist of at least 150 millimetres of crushed stone meeting OPSS requirements for Granular A. In areas where the subsoil is disturbed or where unsuitable

material exists below the pipe subgrade level, the disturbed/unsuitable material should be removed, the base of the trench should be compacted, and a subbedding layer of compacted granular material such as that meeting Granular B Type II. A 300 millimetre (minimum) thick layer of Granular B Type II subbedding material should be placed. The granular bedding and subbedding materials should be compacted in maximum 200 millimetre thick lifts to at least 95 percent of the material's standard Proctor dry density value using suitably sized vibratory compaction equipment.

Cover material, from spring line to at least 300 millimetres above the tops of the pipes, should consist of granular material, such as that meeting OPSS Granular A.

The use of clear crushed stone as a bedding, subbedding or cover material should not be permitted on this project.

6.11.3 Trench Backfill

In areas where the service trenches will be located below or in close proximity to existing or future areas of hard surfacing (pavement, sidewalk, etc.), acceptable excavated fill materials should be used as backfill between the roadway subgrade level and the depth of seasonal frost penetration in order to reduce the potential for differential frost heaving between the area over the trench and the adjacent hard surfaced area. The depth of frost penetration in exposed areas can normally be taken as 1.8 metres below finished grade. Where previously excavated fill material is used, it should match the native materials exposed on the trench walls. Backfill below the zone of seasonal frost penetration could consist of either acceptable excavated material or imported granular material conforming to OPSS Granular B Type I.

To minimize future settlement of the backfill and achieve an acceptable subgrade for the roadways, sidewalks, etc., the trench backfill should be compacted in maximum 300 millimetre thick lifts to at least 95 percent of the material's standard Proctor maximum dry density value using suitable vibratory compaction equipment. The specified density may be reduced to 90 percent of the standard Proctor maximum dry density value in areas where the trench backfill is not located below or in close proximity to existing or future roadways, parking areas, sidewalks, etc., and provided that some settlement above the trench is acceptable.

6.12 Exterior Pavement Design

Information on the pavement layout, zone of bulk excavation, and traffic loading levels are not available at the time of preparing this report. As such relatively generic guidelines are provided. More tailored guidelines can be provided as further information on parking lot/access roadways are available.

6.12.1 Subgrade Preparation

In preparation for the construction of roadways at this site, all surficial topsoil, and any loose/soft, wet, organic or deleterious materials should be removed from the proposed subgrade surface. This need not include removal of the existing fill material provided that some post construction settlement of the roadways can be tolerated.

Any subexcavated areas could be filled with compacted earth borrow. Similarly, should it be necessary to raise the roadway grades at this site, material which meets OPSS specifications for Select Subgrade Material or Earth Borrow may be used. The select subgrade material or earth borrow 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 suitable vibratory compaction equipment. Prior to placing granular material for the roadways, the exposed subgrade should be heavily proof rolled under suitable (dry) conditions, and inspected and approved by geotechnical personnel. Any soft areas evident from the proof rolling should be subexcavated and replaced with suitable earth borrow approved by the geotechnical engineer.

The subgrade should be shaped and crowned to promote drainage of the roadway granular materials.

6.12.2 Pavement Structure

The following minimum pavement structure is suggested for exterior roadways and parking areas that will be for light traffic only (i.e., no heavy truck traffic):

- 90 millimetre thick layer of asphaltic concrete (40 millimetres of Superpave 12.5 Traffic Level B over 50 millimetres of Superpave 12.5 Traffic Level B); over
- 150 millimetre thick layer of OPSS Granular A; over
- 300 millimetre thick layer of OPSS Granular B Type II;

The following minimum pavement structure is suggested for exterior roadways for heavy traffic (i.e., fire truck, garbage trucks etc. routes):

- 120 millimetre thick layer of asphaltic concrete (50 millimetres of Superpave 12.5 FC1 Traffic Level D over 70 millimetres of Superpave 19.0 Traffic Level D); over
- 150 millimetre thick layer OPSS Granular A; over
- 450 millimetre thick layer of OPSS Granular B Type II;

The above pavement structures assumes that the roadway subgrade surface is prepared as described in this report. If the roadway subgrade surface is disturbed or wetted due to construction operations or precipitation, the granular thickness given above may not be adequate and it may be necessary to increase the thickness of the Granular B Type II 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. In our experience, a geotextile will likely be required in most cases where the subgrade consists of overburden, if the roadway construction is planned during the wet period of the year (such as the spring or fall).

Similarly, if the granular pavement materials are to be used by construction traffic, it may be necessary to increase the thickness of the Granular B Type II, install a woven geotextile separator between the roadway subgrade surface and the granular subbase material, or a combination of both, to prevent pumping and disturbance to the subbase material. The contractor should be made responsible for their construction access.

6.12.3 Granular Material Compaction

The pavement granular materials should be compacted in maximum 300 millimetre thick lifts to at least 99 percent of material's standard Proctor maximum dry density using suitable vibratory compaction equipment.

6.12.4 Asphaltic Cement

Performance graded PG 58-34 asphaltic cement is recommended for light duty roadways and parking areas while performance graded PG 64-34 asphalt is recommended for heavy duty roadways.

6.12.5 Transition Treatments

In areas where the new pavement structure will abut existing pavements, the depths of the granular materials should taper up or down at 5 horizontal to 1 vertical, or flatter, to match the depths of the granular material(s) exposed in the existing pavement.

6.12.6 Pavement Drainage

Adequate drainage of the pavement granular materials and subgrade is important for the long-term performance of the pavement at this site. It is suggested that storm sewer catch basins be equipped with 3 metre stub drains extending in at least 2 directions. The stub drains should be installed at the subgrade level.

Further details on pavement drainage can be provided as the design progresses.

6.13 Interior Pavement Design

It is unknown at this time if the underground parking garage slab will be trafficked on the concrete slab, or if an asphaltic concrete surface will be constructed. Further guidelines on the interior pavement structure can be provided as the design progresses.

7.0 ADDITIONAL CONSIDERATIONS

7.1 Rock Anchors

Rock anchors may be required for the proposed structure to resist overturning and lateral loads, etc. Recommendations on the design on rock anchors can be provided as the design progresses.

7.2 Winter Construction

If construction is required during freezing temperatures, the soil below the proposed structures should be protected immediately from freezing using straw, propane heaters and insulated tarpaulins, or other suitable means.

Any open excavations should be opened for as short a time as practicable. The materials on the sides of the excavation 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.

Provision must be made to prevent freezing of any soil below the level of any existing structures or services. Freezing of the soil could result in heaving related damage to structures or services.

7.3 Effects of Construction Induced Vibration

Some of the construction operations (such as granular material compaction, bedrock 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. The magnitude of the vibrations will be much less than that required to cause damage to the nearby structures or services in good condition. Consideration should be given to vibration and settlement monitoring for surrounding structures and critical infrastructure.

7.4 Monitoring Well Abandonment

All monitoring wells installed as part of this investigation should be decommissioned by a licensed well technician. The well abandonment could be carried out in advance of or during construction.

7.5 Disposal of Excess Soil and Re-Use of Existing Fill

It is noted that the professional services retained for this project include only the geotechnical aspects of the subsurface conditions at this site. 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. This report does not constitute a Phase II Environmental Site Assessment (ESA) nor does it constitute a contaminated material management plan.

As indicated above, the existing granular base and subbase could be used for grade raise fill below the new parking areas, or depending on the quality of the material, possibly within the new pavement structure or as grade raise material below the floor slabs (other than in areas where

the use of clear stone has been specified). The material should be carefully separated and stockpiled for evaluation by GEMTEC at the time of construction. Existing, non-deleterious earth fill could likely be used as grade raise material in soft landscaped areas, subject to approval by GEMTEC at the time of construction.

7.6 Design Review and Construction Observation

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 buildings, services, and access roadway/parking areas 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.



Alex Meacoe, P.Eng.
Senior Geotechnical Engineer



Daire Cummins, M.Sc.

Enclosures

N:\Projects\104000\104054.001\05_Technical Work\Reports\03 - Geotechnical Investigation Report\104054.001_RPT_GEOT_Hazeldean and Savage_Rev.1_2026-07-17.docx

GEOTECHNICAL REPORT CONDITIONS & LIMITATIONS

STANDARD OF CARE: GEMTEC has prepared this report in a manner consistent with generally accepted engineering or environmental consulting practice in the jurisdiction in which the services are provided at the time of the report. No other warranty, expressed or implied is made.

COPYRIGHT: The contents of this report are subject to copyright owned by GEMTEC, save to the extent that copyright has been legally assigned by us to another party or is used by GEMTEC under license. To the extent that GEMTEC owns the copyright in this report, it may not be copied without our prior written agreement for any purpose other than the purpose indicated in this report. The methodology (if any) contained in this report is provided to the Client in confidence and must not be disclosed or copied to third parties without the prior written agreement of GEMTEC. Disclosure of that information may constitute an actionable breach of confidence or may otherwise prejudice our commercial interests.

COMPLETE REPORT: This report is of a summary nature and is not intended to stand alone without reference to the instructions given to GEMTEC by the Client, communications between GEMTEC and the Client and to any other reports prepared by GEMTEC for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. GEMTEC can not be responsible for use of portions of the report without reference to the entire report.

BASIS OF REPORT: This Report has been prepared for the specific site, development, design objectives and purposes that were described to GEMTEC by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the document, subject to the limitations provided herein, are only valid to the extent that this report expressly addresses the proposed development, design objectives and purposes. Any change of site conditions, purpose or development plans may alter the validity of the report and GEMTEC cannot be responsible for use of this report, or portions thereof, unless GEMTEC is requested to review any changes and, if necessary, revise the report.

TIME DEPENDENCE: If the proposed project is not undertaken by the Client within 18 months following the issuance of this report, or within the timeframe understood by GEMTEC to be contemplated by the Client, the guidance and recommendations within the report should not be considered valid unless reviewed and amended or validated by GEMTEC in writing.

USE OF THIS REPORT: The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without GEMTEC's express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the client, GEMTEC may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

NO LEGAL REPRESENTATIONS: GEMTEC makes no representations whatsoever concerning the legal significance of its findings, or as to other legal matters touched on in this report, including but not limited to, ownership of any property, or the application of any law to the facts set forth herein. With respect to regulatory compliance issues, regulatory statutes are subject to interpretation and change. Such interpretations and regulatory changes should be reviewed with legal counsel.

DECREASE IN PROPERTY VALUE: GEMTEC shall not be responsible for any decrease, real or perceived, of the property or site's value or failure to complete a transaction, as a consequence of the information contained in this report.

RELIANCE ON PROVIDED INFORMATION: The evaluation and conclusions contained in this report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to us. We have relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, we cannot accept responsibility for any deficiency, misstatement or inaccuracy contained in this report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by us. We are entitled to rely on such representations, information and instructions and are not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

INVESTIGATION LIMITATIONS: Site investigation programs are a professional estimate of the scope of investigation required to provide a general profile of subsurface conditions but even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions.

The data derived from the site investigation program and subsequent laboratory testing are interpreted by trained personnel and extrapolated across the site to form an inferred geological representation and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour with regard to the proposed development. Conditions between and beyond the borehole/test hole locations may differ from those encountered at the borehole/test hole locations and the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies. Accordingly, GEMTEC does not warrant or guarantee the exactness of the subsurface descriptions.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

In addition, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report. The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

SAMPLE DISPOSAL: GEMTEC will dispose of all uncontaminated soil and/or rock samples 60 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

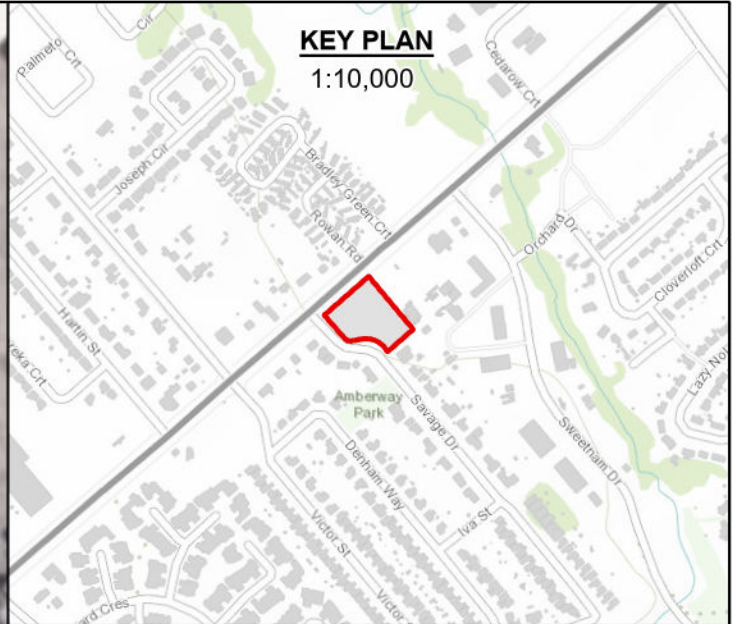
FOLLOW-UP AND CONSTRUCTION SERVICES: All details of the design were not known at the time of submission of GEMTEC's report. GEMTEC should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of GEMTEC's report.

During construction, GEMTEC should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of GEMTEC's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in GEMTEC's report. Adequate field review, observation and testing during construction are necessary for GEMTEC to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, GEMTEC's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

CHANGED CONDITIONS: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that GEMTEC be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that GEMTEC be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

DRAINAGE: Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. GEMTEC takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

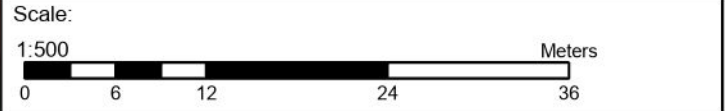
N:\Projects\1040001\104054.001\106_Civil Drafting\GSP R0\104054.001_GSP_R0_2025_06.aprx



LEGEND

- BH# — BOREHOLE ID
- XXXX — GROUND SURFACE ELEVATIONS, IN METRES GEODETIC DATUM
- ⊕ — BOREHOLE LOCATION (GEMTEC 2025)
- ⊕ — MONITORING WELL LOCATION (ELEVATIONS RECORDED BY GEMTEC, PINCHIN 2024)
- APPROXIMATE SITE BOUNDARY
- - - PROPOSED BUILDING
- == PROPOSED ROADWAY

GENERAL NOTES:
1. Coordinate system: NAD83 UTM zone 18N.
2. Geographic dataset source: Ontario GeoHub.
3. Contains information licensed under the Open Government Licence – Ontario.
4. Service Layer Credits: Ottawa 2022 Imagery, World Topographic Map City of Ottawa, Province of Ontario, Esri, Canada, Esri, HERE, Garmin, INCREMENT P, Intermap, USGS, METI/NASA, EPA, USDA, AAFC, NRCan



Drawing **SITE PLAN**

Client: **E-LANDSCAPING**

Project **GEOTECHNICAL INVESTIGATION
PROPOSED DEVELOPMENT
5872, 5880, AND 5884 HAZELDEAN ROAD, AND 7 SAVAGE DRIVE
OTTAWA, ONTARIO**

Drwn By: **SL** Chkd By: **WAM**

Project No. **104054.001** Revision No. **0**

Date **JULY 2026** **FIGURE 1**



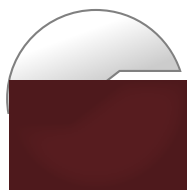
GEMTEC
CONSULTING ENGINEERS
AND SCIENTISTS

32 Steacie Drive
Ottawa, ON, K2K 2A9
Tel: (613) 836-1422
www.gemtec.ca
ottawa@gemtec.ca



APPENDIX A

Record of Borehole Logs
List of Abbreviations and Symbols
Boreholes 25-01 to 25-04



GEMTEC

www.gemtec.ca

Ottawa Office Soil Classification and Soil and Rock Logging Manual

Rev 0, January 2025

TABLE OF CONTENTS

1.0	INTRODUCTION.....	1
2.0	SOIL CLASSIFICATION.....	2
2.1	Overview.....	2
2.2	Cohesionless Soils.....	3
2.3	Cohesive Soils.....	4
2.4	Organic Soils.....	6
2.5	Water Content/Moisture Condition.....	6
2.6	Soil Structure.....	7
2.7	Soil Descriptions.....	8
3.0	REPORT ABBREVIATIONS AND DESCRIPTION SHEETS.....	9
4.0	FIELD LOGGING.....	9
4.1	Soil.....	9
4.2	Rock.....	10

NOTE: This document and any attachments are confidential and intended solely for the use of GEMTEC staff. If you have received this document in error, please notify the sender immediately and delete the document from your system. Any unauthorized disclosure, copying, distribution, or reliance on the contents of this document is prohibited. Thank you for your cooperation.

LIST OF TABLES

Table 1: Particle Sizes	3
Table 2: Gradation of Cohesionless Soils.....	4
Table 3: Particle Angularity and Shape	4
Table 4: Water Content (Cohesive Soils)	6
Table 5: Field moisture condition (Cohesionless Soil)	6

LIST OF FIGURES

Figure 1: Soil Classification Flow Chart.....	2
Figure 2: Guideline for visually estimating particle distribution percentages	3
Figure 3: Atterberg Limit Graph for Soil Classification	5

LIST OF APPENDICES

Appendix A	MTC Soil Classification Manual
Appendix B	Report Description Sheets
Appendix C	Soil Logging Template
Appendix D	Testpit Field Log Templates
Appendix E	Rock Field Logging Template
Appendix F	Field Shear Vane Memo

1.0 INTRODUCTION

This manual outlines the soil classification system and basic soil and rock logging practices to be used for Ottawa area projects.

The soil classification system is based on the Ontario Ministry of Transportation and Communications (MTC, now MTO – Ministry of Transportation of Ontario) Soil Classification manual which is in turn a modification of the Unified Soil Classification System (USCS). The MTC soil classification manual is provided in Appendix A and the following sections of this manual provide an overview of the soil classification system, notes on the application of the system and general guidance for field logging of soil and rock.

2.0 SOIL CLASSIFICATION

2.1 Overview

Soil should be classified using the MTC system based on the *bulk* engineering behaviour of the soil strata. The flow chart shown in Figure 1 provides an overview of the classification system. As indicated in that flow chart, coarse-grained soils are classified based on particle gradation but fine-grained soils are classified based on plasticity.

The initial determination is an assessment of the organic content and then a determination if the majority of the soil constituents (i.e., more than 50%) are fine (cohesive) or coarse grained (cohesionless) soils.

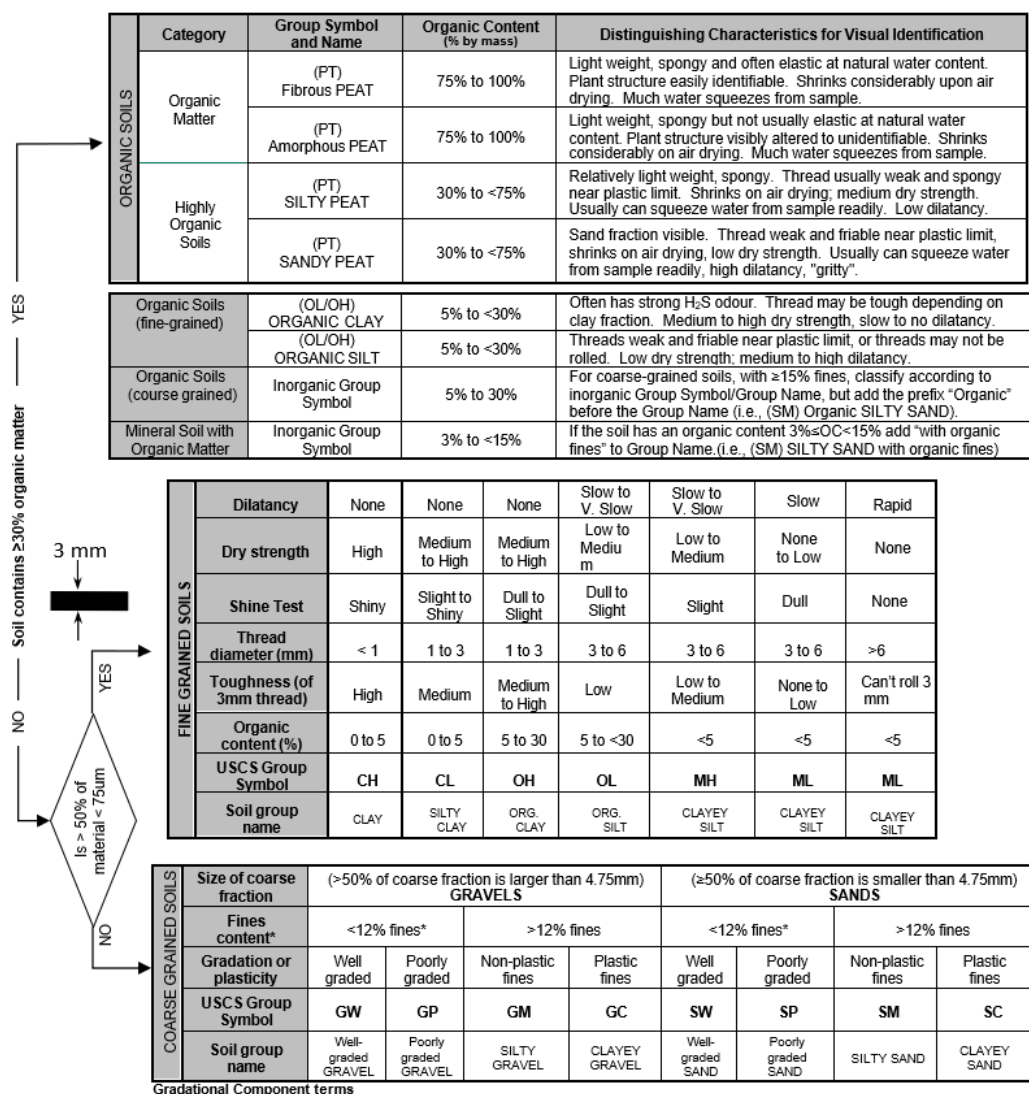


Figure 1: Soil Classification Flow Chart

2.2 Cohesionless Soils

Cohesionless soils are further classified based on the percentage (by mass) sands and gravels, the percentage of fines (i.e., particles less than 0.075 mm in diameter), the plasticity of the fines and the gradation (whether well or poorly graded).

The particle sizes are indicated in the following table:

Table 1: Particle Sizes

Soil constituent	Particle size description	Particle Size	
		Millimetres	Inches or (US std. sieve size)
BOULDERS	Not applicable	>300	>12
COBBLES	Not applicable	75 to 300	3 to 12
GRAVEL	Coarse	19 to 75	0.75 to 3
	Fine	4.75 to 19	(4) to 0.75
SAND	Coarse	2.00 to 4.75	(10) to (4)
	Medium	0.425 to 2.00	(40) to (10)
	Fine	0.075 to 0.425	(200) to (40)
SILT/CLAY	Not applicable	<0.075 mm	< (200)

A visual representation of the particle size distributions is shown in the following:

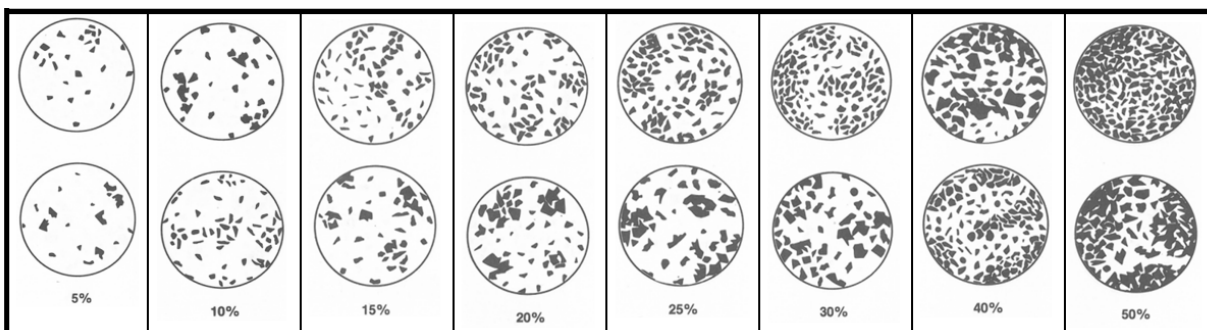


Figure 2: Guideline for visually estimating particle distribution percentages

Sands and gravels with less than 5% fines are described as having no or trace fines as applicable. Sands or gravels with between 5 to 12% fines should be described as having some fines and using a dual symbol, e.g., GW-GM for gravel with fines content between 5 and 12%.

Sands or gravels with greater than 12% by mass of fines are described as “silty” or “clayey”, depending if the fines are non-plastic or plastic.

The sands or gravels are then further classified by gradation in accordance with the following:

Table 2: Gradation of Cohesionless Soils

Particle size distribution

Particle Size Distribution	Sub category	Description	Visual Example
Well Graded	-	Even distribution of particle sizes	
Poorly Graded	-	Uneven distribution of particle sizes	
	Gap Graded	Intermediate particle sizes absent	
	Uniformly Graded	Primarily one particle size	

Sands and gravels may be further described with respect to the particle angularity and shape in accordance with the following:

Table 3: Particle Angularity and Shape

Shape and Angularity	Term	Description	Visual Example
Angularity	Rounded	Smoothly curved sides No edges Smooth or polished surfaces	
	Sub-rounded	Plane sides Well-rounded edges Partially polished surfaces	
	Sub-angular	Plane Sides Partially rounded edges Unpolished surfaces	
	Angular	Plane sides Sharp edges Unpolished surfaces	
Shape (Typically gravel)	Flat	Width (W) to Thickness (T) ratio >3	
	Elongated	Length (L) to Width (W) ratio >3	

Angularity should be described at a minimum.

2.3 Cohesive Soils

Cohesive soils are classified on the basis of plasticity which should in turn be based on laboratory (i.e., Atterberg Limit) testing as indicated in Figure 2 (below) field indicators for plasticity and classification include the following:

- Dilatancy;
- Dry strength;
- Shine Test;
- Thread Diameter;
- Toughness;

The dry strength test is not a practical field test and is not discussed further here, although it is described on page 10 of the MTC manual.

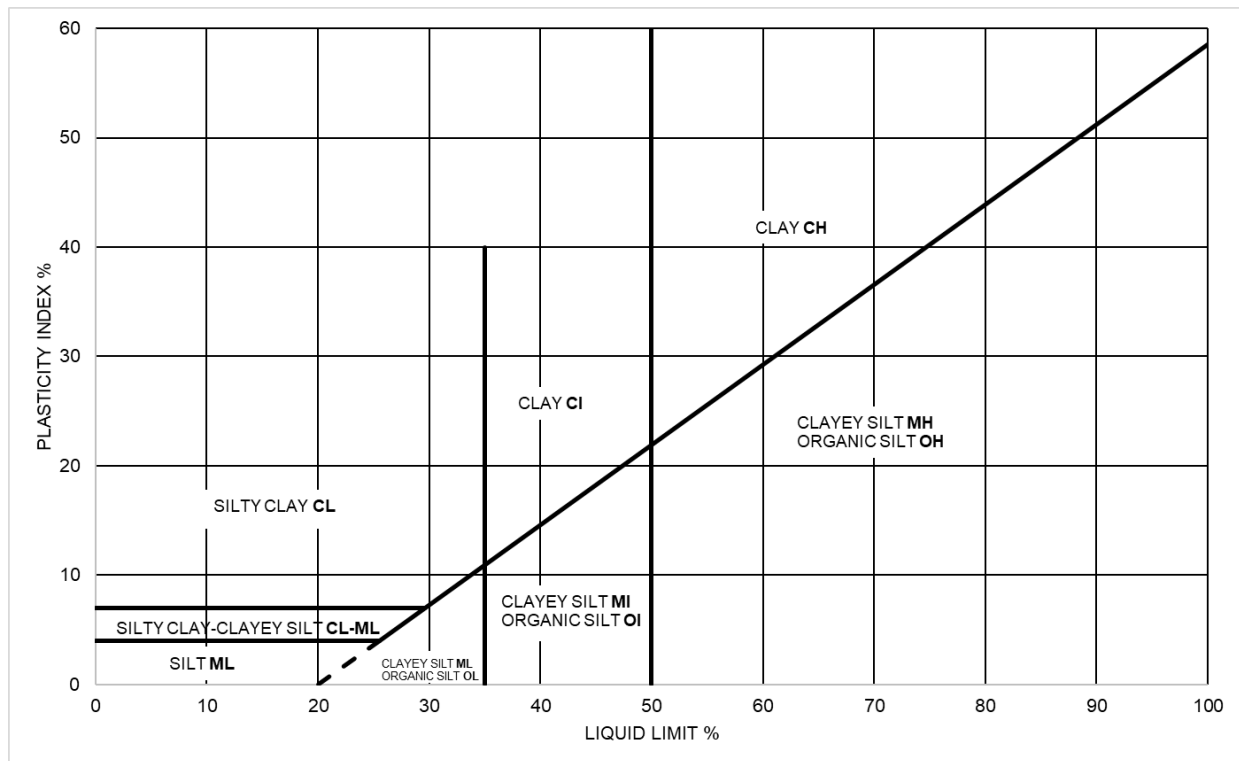


Figure 3: Atterberg Limit Graph for Soil Classification

Dilatancy and toughness are also described on page 10 of the MTC manual and the shine test is described on page 12 of that manual.

A useful test is the thread diameter test (which is not described in the MTC manual). In brief for that test, a representative portion of the sample is mixed with water until it can be molded or shaped without sticking to your fingers. This moisture content is referred to as being just below the 'sticky limit'. In practice with natural clays, the water content may be higher than the 'sticky limit' but the test can be carried out as long as the material is not too wet to roll. The smallest diameter of thread that may be rolled without breaking or crumbling provides an indication of the soil plasticity and classification.

2.4 Organic Soils

Organic soils fall into four categories (as indicated in Figure 1):

- Fine or coarse-grained soils with organic contents between 5 and 30%;
- Highly organic soils with organic contents between 30 and 75%; and,
- Organic Matter, i.e., Peat.

Soils with organic inclusions (i.e., discrete organic portions within a more homogenous soil mass), such as fill with lumps of topsoil or peat, should not be described as organic but as containing “organic matter”. Topsoil is simply described as TOPSOIL, with the main constituents but without a USCS group symbol.

2.5 Water Content/Moisture Condition

The water content or field moisture conditions should be described, based on field estimates of water content testing. For fine-grained soils, the water content should be indicated in relation to the plastic limit of the material:

Table 4: Water Content (Cohesive Soils)

Term	Field Identification
w < PL	Material is estimated to be drier than the Plastic Limit (cannot be rolled to a thread diameter of 4 mm).
w ~ PL	Material is estimated to be close to the Plastic Limit (can be rolled a thread diameter of between 2 mm and 4 mm).
w > PL	Material is estimated to be wetter than the Plastic Limit (can be rolled to a thread diameter of less than 2 mm).

For coarse-grained soils, the field moisture condition should be described in relation to the materials' optimum water content for compaction:

Term	Field Identification
Dry	Moisture content well below optimum. Soil flows freely through fingers.
Moist	Soil has a moisture content at or near optimum. Soils are darker than in the dry condition and may feel cool.
Wet	Moisture content well above optimum. Free water forms on hands when soils are handled.

Table 5: Field moisture condition (Cohesionless Soil)

2.6 Soil Structure

Further descriptions of the soils should be provided as applicable in accordance with Table 6 below:

Table 6: Soil Structure

Term	Description
Heterogeneous	Soil mass is of non-uniform, variable composition or structure.
Homogeneous	Soil mass is of uniform composition or structure.
Repetitive Structures	
Laminated	Closely spaced, alternating layers of differing soils and/or differing colours or shades of soils of similar gradation, usually arranged in a regular pattern. The following terms may be used: - Thinly laminated – mean spacing under 6 mm - Thickly laminated – 6 mm to 20 mm
Stratified or Layered	Differing soils or visible variations in soil constituents or colour arranged in layers, generally but not necessarily parallel to one another. The following terms may be used: - Very thinly bedded – 20 mm to 60 mm - Thinly bedded – 60 mm to 200 mm - Medium bedded – 200 mm to 600 mm - Thickly bedded – 600 mm to 2 m - Very thickly bedded – over 2 m
Discrete layers or features	
Varved	A laminated soil consisting of two distinct soils (usually clay and silt) occurring in a regularly repeating pattern resulting from seasonal variations in sediment load in a lacustrine environment.
Lens	An inclusion of a different soil type within surrounding soils, which thins out laterally (horizontally) and may not be continuous over any significant distance. Typically identified by test pits or correlation between boreholes.
Parting	Paper thin separation of one soil type by another. Usually applied to fine grained soils.
Pocket	A different soil type of very limited thickness or lateral extent (a small lens).
Seam	A soil layer of considerable extent but with a thickness of less than about 10 mm.
Term	Field identification

Fissured	Generally applied to dried or overconsolidated fine grained soils (silts and clays) containing cracks or physical discontinuities which can be vertical, horizontal or inclined. Described as highly, moderately and slightly fissured.
Friable, blocky, platy	Otherwise cohesive soil breaks into small (friable), larger (blocky) or thin, plate like (platy) fragments with little effort.
Slickensided	Polished or striated surfaces. Often an indication of an existing failure or slip surface. If continuous slickensided shear zones are found an estimate should be made of their angle in relation to the horizontal plane.

2.7 Soil Descriptions

Soil descriptions should follow the order indicated in the following table:

Table 7: Soil Description Order of Precedence

Order/Item/Parameter
1) FILL, BASE, SUBBASE, REFUSE/WASTE, ROCK FILL, TAILINGS, TOPSOIL (if applicable)
2A) USCS Group Symbol – in (BLOCK LETTERS) e.g., (ML)
2B) Soil Group Name - in BLOCK LETTERS for Primary Constituents, e.g., SILTY SAND (except for fill)
2C) Secondary Constituents (i.e., gravelly, sandy, SILTY, CLAYEY; or trace to some gravel, sand, silt, clay) added in accordance with flow-chart rules, in lower case (except SILTY and CLAYEY)
3) Gradational Components including modifiers (i.e., some, trace,) based on an estimate of their percentage(s), and including their particle angularity and shape (optional) for coarse-grained soils, or plasticity (low, medium or high) for fine-grained soils (required).
4) Colour.
5) Weathering (if applicable).
6) Structure. e.g., zoning, fissuring, cementation, stratification, discrete layers or features (if applicable).
7) Sensitivity (if applicable).
8) Contamination, staining and odour (if applicable).
9) Additional observations: origin or geological notes (e.g. TILL, ALLUVIUM, LOESS) or presence of cobbles/boulders, deleterious materials (e.g. with pieces of brick, asphalt and concrete) or mineralogy (e.g. calcareous, micaceous) (if applicable).
10) Behaviour (non-cohesive or cohesive).
11) Field Moisture Condition (non-cohesive soils) or Water Content (cohesive soils).
12) Compactness (non-cohesive soils) or Consistency (cohesive soils).

Example Soil Descriptions:

FILL - (SC) CLAYEY SAND; some gravel, trace low plasticity fines; grey- brown; cohesive, w~PL, firm.

(GP) Poorly graded GRAVEL; fine angular gravel, some coarse sand, trace non-plastic fines; light brown; non-cohesive, dry, dense.

(CL) Sandy SILTY CLAY; some sand, trace gravel; grey-brown, cohesive, $w < PL$, stiff.

(ML) Sandy SILT; trace gravel; brown, hydrocarbon odour; non-cohesive, moist, dense.

(SW-SM) Well-graded SAND; trace gravel; trace non-plastic fines, brown, non-cohesive, wet, compact.

3.0 REPORT ABBREVIATIONS AND DESCRIPTION SHEETS

Report abbreviations and descriptions sheets are provided in Appendix B and consist of the following:

- Method of Soil Classification Sheet;
- Abbreviations and Terminology Used on Records of Boreholes and Test Pits; and,
- Lithological and Geotechnical Rock Description Terminology.

4.0 FIELD LOGGING

This section is not intended to provide a comprehensive manual for field logging of soil and rock but provides an introduction to the field logging templates and notes on key items.

The field logging template for soil is provided in Appendix C, samples of test pit field logs are provided in Appendix D and the logging template for rock is provided in Appendix E.

The soil logging information provided in the templates is consistent with the classification methodology provided herein. Every effort should be made in the field to collect complete information and staff going to the field should be intimately familiar with this manual and the information provided on the templates.

4.1 Soil

The information on the templates and this manual will not be repeated here but some key points to emphasize are:

- Notes on the log indicating the drill rig reaction, such as augers grinding, snapping or jerking, is invaluable. That information needs to indicate the depth of the augers at that point.
- If water or polymers are introduced for hole stability, that has to be noted and at what depth that was started.
- Open hole water levels are to be measured at the completion of augering in the overburden (before starting rock coring) and at the end of the day and next morning if the

hole is left open overnight. Open hole water levels are to be taken even if a monitoring well is to be installed since those measurements provide good indicators for the groundwater inflows that might be encountered during construction.

- Boreholes should not be terminated in fill, clays where the measured shear strength is still decreasing or is remaining constant (i.e., not increasing) or with sampler refusal, without checking with the project manager or the responsible engineer.

In the Ottawa area, field vane shear testing of the Champlain Sea clays is often critical for design. The memorandum provided in Appendix F provides the basis used in the GEMTEC Ottawa office for obtaining the field vane coefficients, their application to field reading and general guidance for field vane shear testing. GEMTEC's field coordinator tracks our field shear vanes and provides the coefficient for use with each individual vane but all staff carrying out field testing should be familiar with the contents of that memo.

4.2 Rock

The rock logging template provided in Appendix E is for basic rock logging applicable to most projects in the Ottawa area. Structural logging of rock for complex rock mechanics projects is a complex field specialty not covered in this manual.

Key points to consider for rock coring investigations:

- Triple tube coring should be considered the standard equipment for all rock investigations. Use of double or single tube coring equipment will result in degraded RQD values (particularly in the sedimentary shale and limestone rock common in the Ottawa area) and can result in overly conservative foundation or excavation designs. Double tube coring can be used but only with the explicit approval of the PM or technical lead.
- RQD, TCR and SCR is not recorded for coring advanced through soil or boulders within the soil; the depth of the soil/rock interface needs to be clearly noted on the log.
- The quality of retrieved rock core is also highly dependent on the availability of flush water and the skill of the driller:
 - o Trying to use limited amounts of water for rock coring will result in premature bit wear and broken core. In addition, HQ sized equipment will require larger volumes of water than NQ sized equipment. Planning for the investigation should recognize that a sufficient supply of water will be needed and must be provided.
 - o Rock coring requires considerable experience to carry out successfully. Provided sufficient flush water is available, consistent 1.5 or 3 m runs should be achievable. A key sign of driller inexperience is short runs and the PM should be informed if there are consistent difficulties.
- Rock type can be difficult to assess in the field and must be reviewed in the office with the aid of geological mapping and publications. Precise identification in the field is not necessary.



APPENDIX A

MTC Soil Classification Manual

M T C

SOIL CLASSIFICATION

MANUAL



Ministry of
Transportation and
Communications

MTC SOIL CLASSIFICATION MANUAL

ENGINEERING MATERIALS OFFICE
DOWNSVIEW
JANUARY 1980

NOTES:

The M.T.C. Soil Classification Manual supersedes the draft of the "M.T.C. Soil Classification System, published by the Engineering Materials Office in January, 1979.

Additional copies of the Manual may be obtained by request, addressed to the M.T.C. Record Services Office, 1201 Wilson Ave., Downsview, Ontario. M3M 1J8.

Orders by External Individuals or Agencies should be accompanied by a cheque or money order of \$5.00 for each copy requested, payable to the Treasurer of Ontario.

FOREWORD

Upon the recommendation of the Regional Geotechnical Heads it was decided that the Unified Soil Classification System, with some modifications, should be adopted by this Ministry. This new policy was announced in Ministry Directive B-13, Provincial Roads, dated 1978 11 06.

Accordingly, the Manager of the Engineering Materials Office appointed a Task Force to prepare a manual for the uniform usage of this modified system which is now known as "The MTC Soil Classification System".

This publication, prepared by the Task Force, contains a detailed description of the MTC Soil Classification System and explains the procedures for classifying soils, both visually in the field and by laboratory methods.

This classification system shall be used by Ministry staff for the identification and description of soils in the field, based on visual examination and simple manual tests. This system shall also be used in delineating particle size characteristics, liquid limit, and plasticity index, when precise classification is required.

The description of soil layers in borelogs, Soils Design Reports, Foundation Investigation and Design Reports, etc., shall be carried out using the soil terminology and group symbols of the new system.

Suggestions and queries pertaining to the MTC Soil Classification System should be addressed to any member of the Task Force. The Task Force members are:

A.K. Barsvary	Engineering Materials Office (Chairman)
M. Devata	Engineering Materials Office
A.J. Hanks	Engineering Materials Office
S. Chen	Eastern Region
S.G. Wilson	Northern Region

TABLE OF CONTENTS

	Page
FOREWORD	I
TABLE OF CONTENTS	II
GLOSSARY	III
INTRODUCTION	1
Chapter 1 – THE CLASSIFICATION SYSTEM	
1.1 Boulders and Cobbles	2
1.2 Soil Categories	2
1.3 Coarse-grained Soils	3
1.4 Fine-grained Soils	6
1.5 Organic Soils	7
Chapter 2 – FIELD IDENTIFICATION AND DESCRIPTION OF SOILS	
2.1 General	7
2.2 Visual Method	7
2.3 Visual Procedure for Coarse-grained Soils	8
2.4 Visual Procedure for Fine-grained Soils	10
2.4.1 Manual Tests	10
2.4.2 Silts and Clays of Low Plasticity	12
2.4.3 Silts and Clays of Intermediate Plasticity	14
2.4.4 Elastic Silts and Fat Clays	14
2.5 Visual Procedure for Highly Organic Soils	14
2.6 Guide for Field Description Procedure	14
2.7 Description of Foundation Soils	16
Chapter 3 – LABORATORY CLASSIFICATION OF SOILS	
3.1 Test Apparatus	17
3.2 Test Samples	17
3.3 Procedure for Classification of Coarse-grained Soils	18
3.4 Procedure for Classification of Fine-grained Soils	18
REFERENCES	20
APPENDIX	
Abbreviations for Boring & Test Data	22
MTC Soil Classification Chart	23
Chart for Engineering Properties of Soils	24

GLOSSARY

<i>Aggregate</i>	– Particles of natural rock or artificial solid materials which satisfy the gradation and quality requirements of the type of material specified.
<i>Clay</i>	– Fine grained soil having particles smaller than 75 μm that can be made to exhibit plasticity (putty like property) within a range of water contents, and which exhibits considerable strength when dry.
<i>Coarse-Grained Soils</i>	– Soils with more than half of the particles between 75 mm and 75 μm .
<i>Cobbles</i>	– Rock fragments, usually rounded or subrounded, with an average dimension between 75 mm and 200 mm.
<i>Cohesionless Soil</i>	– A soil that, when unconfined and air-dried, has little or no strength, and that has little or no cohesion when submerged.
<i>Cohesive Soil</i>	– A soil that, when unconfined and air-dried, has considerable strength, and that has significant cohesion when submerged.
<i>Dilatancy</i>	– The expansion of cohesionless soils when subjected to shearing deformation.
<i>Earth</i>	– Earth and soil are synonymous, but the term “earth” is also used as a pay item in contract documents to distinguish any excavation or fill material from rock or granular as specified in MTC Specification Form 200.
<i>Effective Diameter – (D_{10})</i>	– Particle diameter corresponding to 10% finer on the grain-size curve.
<i>Fine-Grained Soils</i>	– Soils in which more than half of the particles finer than 75 mm are in the silt and clay range.
<i>Fines</i>	– Portion of a soil finer than 75 μm .
<i>Glacial Till</i>	– Material deposited by glaciation, usually composed of a wide range of particle sizes, which has not been subjected to the sorting action of water.
<i>Gradation</i>	– (Grain Size Distribution). Proportion of material of each grain-size present in a given soil.
<i>Grain Size Analysis</i>	– (Mechanical Analysis). The process of determining gradation.
<i>Granular (Soil, Material)</i>	– (a) Synonymous to cohesionless soil or material. – (b) Coarse-grained soils from which base and sub-base aggregates can be produced.

<i>Granular 'A' and 16 mm Crushed 'A' & 'B'</i>	– Mixtures of sand and crushed rock, gravel, or slag with specified gradation bands complying with the requirements of MTC Specification Form 1010, usually used for base courses or shoulders.
<i>Granular 'B' & 'C'</i>	– Sands and/or gravels of various proportions (may contain traces of cobbles), having specified gradation bands and complying with the requirements of MTC Specification Form 1010, usually used for sub-base course aggregates.
<i>Granular 'D'</i>	– Crushed rock screenings with a gradation band specified in MTC Specification Form 1010, used as an alternate subbase material.
<i>Gravel</i>	– Rounded, subrounded or angular particles of rock that will pass a 75 mm sieve and be retained on a 4.75 mm sieve.
<i>Ground Water</i>	– Water that is free to move through a soil mass under the influence of gravity.
<i>Ground Water Level</i>	– Elevation at which the pressure in the water is zero with respect to the atmospheric pressure.
<i>Liquid Limit – (w_L)</i>	– (a) The water content corresponding to the arbitrary boundary between the liquid and plastic states of consistency of a soil. (b) The water content at which a pat of soil, parted by a groove of standard dimensions, will flow together for a distance of 13 mm under the impact of 25 blows in a standard liquid limit apparatus.
<i>Muck</i>	– An organic soil of soft to very soft consistency.
<i>Optimum Moisture Content (w_{opt})</i>	– The water content at which a soil can be compacted to a maximum dry density by a given compactive effort.
<i>Organic Soil</i>	– Soil with a high organic content, may contain shells and/or fibres. In general, organic soils are very compressible and have poor load-sustaining properties.
<i>Overburden</i>	– (a) Earth overlying granular deposits which must be removed prior to extraction of the granular deposit. (b) Earth or other unconsolidated materials, either transported or formed in place, overlying bedrock.
<i>Parent Material</i>	– (a) Material from which a soil has been derived. (b) The unconsolidated material, unaltered by weathering, from which the overlying 'A' and 'B' horizons developed.
<i>Peat</i>	– A mass of organic matter usually fibrous in texture in various stages of decomposition, generally dark brown to black in colour and of spongy consistency.
<i>Plasticity</i>	– The property of a soil which allows it to be deformed beyond the point of recovery without cracking or appreciable volume change.

<i>Plasticity Index</i> – (I_p)	– Numerical difference between the liquid limit and the plastic limit.
<i>Plastic Limit</i> – (w_p)	– (a) The water content corresponding to an arbitrary boundary between the plastic and the semi-solid states of consistency of a soil. – (b) Water content at which a soil will just begin to crumble when rolled into a thread approximately 3 mm in diameter.
<i>Rock</i>	– Natural solid mineral matter occurring in large masses or fragments.
<i>Sand</i>	– Particles that will pass a 4.75 mm sieve and be retained on a 75 μ m sieve.
<i>Silt</i>	– Particles passing a 75 μ m sieve that are non-plastic or very slightly plastic and that exhibit little or no strength when air-dried.
<i>Soil</i>	– (Earth). Sediments or other unconsolidated accumulations of solid particles produced by the physical and chemical disintegration of rocks, and which may or may not contain organic matter.
<i>Soil Profile</i>	– Vertical section of a soil showing the nature and sequence of the various layers, as developed by deposition or weathering, or both.
<i>Specific Gravity</i>	– The old term ‘specific gravity’ is replaced by the term ‘relative density’.
<i>Stone</i>	– Crushed or naturally angular particles of rock that will pass a 75 mm sieve and be retained on the 4.75 mm sieve.
<i>Water Content</i> – (w) (Moisture Content)	– The ratio expressed as a percentage of the mass of water to the mass of solid particles in a given soil mass.

INTRODUCTION

The term soil or earth, in engineering practice, is defined as sediments or other unconsolidated accumulations of solid particles produced by the physical and chemical disintegration of rocks, and which may or may not contain organic matter. Only hard rock, which remains firm after exposure, is excluded from the definition.

To the engineer or technician engaged in the design and construction of roads, foundations and earthwork, the physical properties of soil, such as density, permeability, strength, compressibility and interaction with water, are of primary importance. It is apparent that a standard system of describing the soil and placing it into a category or group which has distinct engineering properties is most desirable in order to provide a common language for the transmission of information and experience. **The description of soil** usually gives detailed information on the gradation, plasticity, colour, particle characteristics, moisture content, strength and the like. Few if any soils will have identical descriptions. **Soil classification** on the other hand, places a soil in one of a limited number of groups, on the basis of a few key characteristics. These characteristics must be easy to measure and must be significant in indicating the engineering properties and performance of the particular soil.

Such a classification system was originally proposed by Professor A. Casagrande in 1942 for the U.S. Corps of Engineers to be used in airfield construction. In 1952, after some modification, this system was adopted by the U.S. Bureau of Reclamation and was named the "Unified Soil Classification System". The advantages of the Unified System in identifying soils on the basis of their engineering properties was soon recognized and as a result it gained wide acceptance all over the world. Casagrande later suggested an extension to his classification and some of the users also made slight modifications to suit their needs. The principles of the original system however, remain the same. The MTC Soil Classification System introduced in this publication is basically the Unified System modified by Casagrande with some further slight changes implemented by the Task Force including particles larger than 75 mm and metric conversion.

Chapter 1

THE CLASSIFICATION SYSTEM

(1.1) Boulders and Cobbles

Particles larger than 75 mm are excluded from the Unified Soil Classification System. However, the amount of such material is of great importance in Ministry practice, hence any description of soils should always contain information on these particles. They are classified into boulders with an average dimension larger than 200 mm and cobbles with particles between 200 mm and 75 mm.

Because of the large particle sizes, the percentage and dimensions of these materials can only be adequately described by visual observations of excavations or exposures.

If more than half of a mixed coarse grained stratum is larger than 75 mm the deposit shall be called boulders and/or cobbles. The portion of the material smaller than 75 mm shall be described by the constituent soils according to the rules of the MTC Classification System. (See Section 1.3 and 1.4.)

Example: A material consisting of 60% cobbles, 32% gravel and 8% sand may be described thus: *Gravelly cobbles, trace of coarse sand.*

If the material contains less than 50% boulders and/or cobbles, the “oversize” particles should be removed and the classification should be carried out on the portion of the material smaller than 75 mm, according to the rules of the MTC Classification System. The description of the soil should contain information on constituent particles larger than 75 mm.

Example: Soil in a test hole, consisting of approximately 45% gravel, 50% sand and 5% silt and having a few randomly distributed cobbles may be described thus: *Well graded gravelly sand, trace of silt, a few random rounded cobbles of 100 mm to 200 mm size throughout the deposit.*

(1.2) Soil Categories

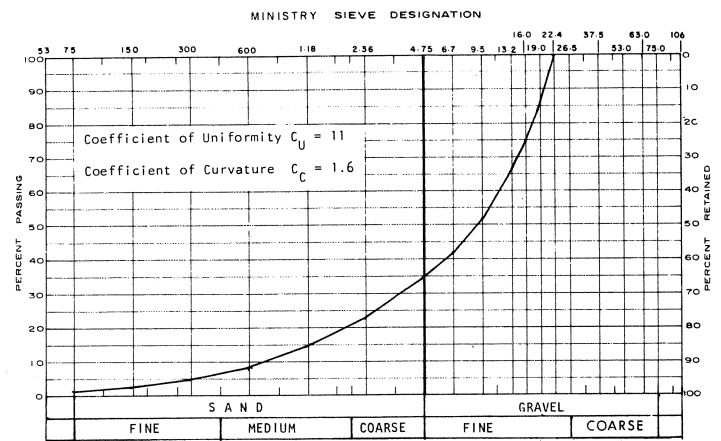
The system is based upon the sizes of the particles smaller than 75 mm, the distribution of the particle sizes, and the properties of the fine-grained portion. First, the soils are divided into three major categories: (1) coarse-grained soils, (2) fine-grained soils, and (3) highly organic soils. Second, the soil is subdivided by either gradation or plasticity characteristics.

Coarse-grained soil (sand and gravel) is that material which has particle sizes between 75 mm and 75 μ m. The smallest size in this category is about the smallest particle size which can be distinguished with the naked eye.

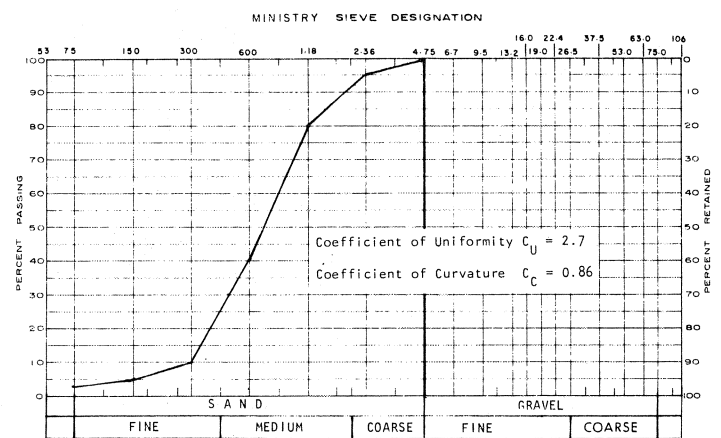
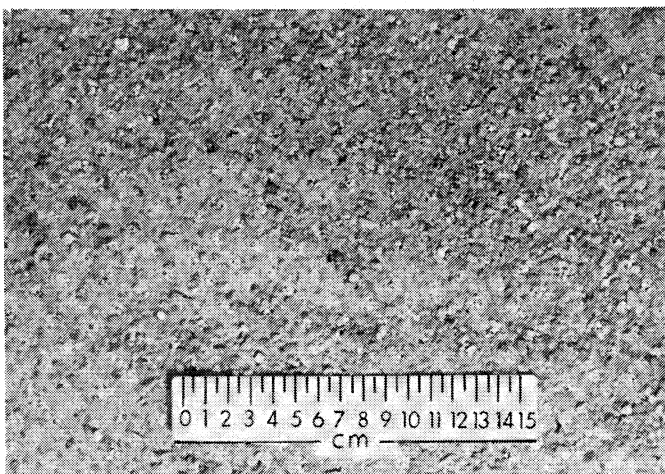
Photographs of typical coarse-grained soils and the corresponding grain size curves are shown in Figure 1.

Fine-grained soil (silt and clay) is that material having particle sizes smaller than 75 μ m.

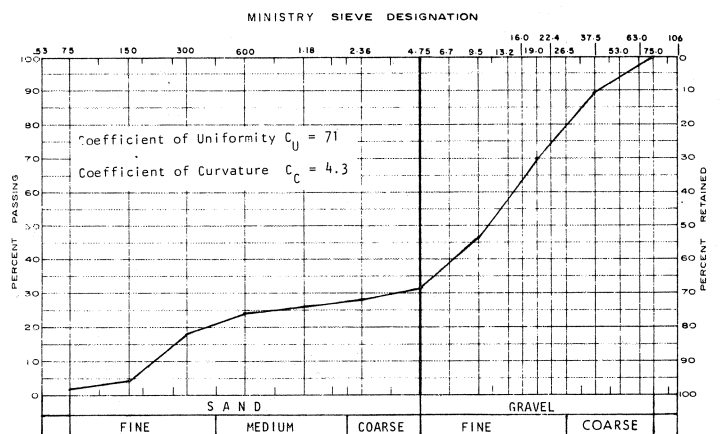
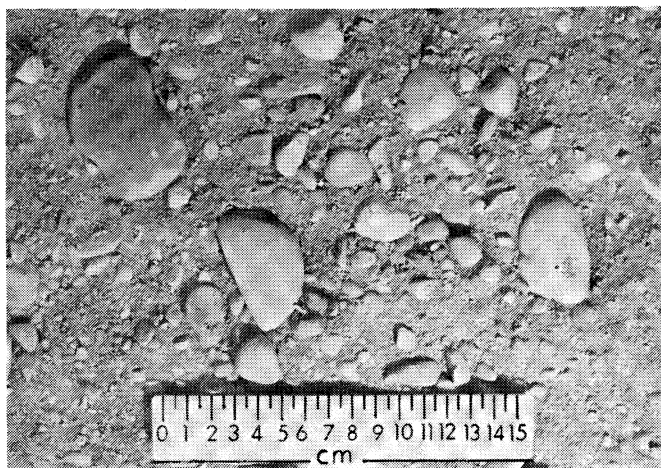
Highly organic soils are peat or other soils which contain substantial amounts of organic matter.



(a) Well-graded sandy gravel (GW)



(b) Poorly-graded coarse to fine (uniform) sand (SP)



(c) Poorly-graded (gap-graded) sandy gravel (GP)

Figure 1. Typical Soil Gradations

In the MTC System, soils having 50% or more material larger than 75 μm are classified as coarse-grained while those having less than 50% are classified as fine-grained. No laboratory criteria are used for the highly organic soils, but generally they can be identified in the field by their distinctive colour and odour and by their spongy feel and fibrous texture.

(1.3) Coarse-Grained Soils

The two major divisions of coarse-grained soils are gravel and sand. A coarse-grained soil having more than 50% of the coarse-grained fraction (larger than 75 μm) retained on a 4.75 mm sieve is classified as gravel, denoted by the symbol G. A coarse-grained soil having more than 50% of the coarse-grained fraction passing a 4.75 mm sieve is classified as sand, denoted by the symbol S. Coarse-grained soils are further sub-divided either by their gradation (distribution of grain sizes) or by the properties of the fine-grained fraction of the soil.

The classification and criteria for each group are given in the MTC Classification Chart in the Appendix, together with a Plasticity Chart which is instrumental in classification by this System.

(a) Less Than 5% Pass the 75 μm Sieve

Those coarse-grained soils having less than 5% passing the 75 μm sieve are subdivided by their gradation and are given the classification of GW, SW, GP and SP meaning, respectively, Gravel – Well-graded, Sand – Well-graded, Gravel – Poorly-graded, and Sand – Poorly-graded. These groups include those soils in which the fine-grained portion is so small that it should not affect engineering characteristics.

GW Group: Well-graded gravels and sandy gravels which contain little or no fines are classified as GW. In these soils, the presence of fines must have no effect on strength characteristics and on free draining characteristics. In addition to the criteria stated previously, this group must have a uniformity coefficient (C_U) greater than 4, and the coefficient of curvature (C_C) of the soil must be between 1 and 3.

*The coefficient of uniformity C_U
and coefficient of curvature C_C
are expressed as follows:*

$$C_U = \frac{D_{60}}{D_{10}} \qquad C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

where

*D_{10} , D_{30} and D_{60} are the grain-size diameters
corresponding respectively to 10, 30, and 60%
passing on the cumulative grain-size curve.*

SW Group: This group of soils is similar to the GW group except that the predominant grain size is sand rather than gravel. It includes well-graded sands and gravelly sands. The uniformity coefficient of soil in this classification must be greater than 6 and the coefficient of curvature must be between 1 and 3.

GP Group: Soils which classify as gravels and which will not meet the grading requirements of the GW group are placed in the GP group. These soils include poorly graded gravels and sandy gravels having little or no fines.

SP Group: Soils which classify as sands and which will not meet the grading requirements of the SW group are placed in the SP group. These soils include uniformly graded and gap-graded sands and gravelly sands.

(b) More Than 12% Pass the 75 μm Sieve

Those coarse-grained soils having more than 12% passing the 75 μm sieve are subdivided by the plasticity characteristics of the fine-grained portion and are given the classification of GM*, GC, SM*, and SC meaning, respectively, Gravel – With Silt Fines, Gravel – With Clay Fines, Sand – With Silt Fines, and Sand – With Clay Fines. The amount of fines in these groups is enough to affect engineering characteristics. Gradation is not a factor in classification.

GM Group: Soils comprising this group are those in which the predominant fine-grained fraction is silt. This group of soils includes silty gravels and mixtures of gravel, sand and silt. Soils which classify as gravels and having a fine-grained portion for which the Atterberg limits (liquid limit and plasticity index) will plot below the A-Line or the plasticity index (I_p) is less than 4 are placed in the GM group. The A-Line is shown and defined on the Plasticity Chart located with the MTC Soil Classification Chart in the Appendix. It is also discussed under Fine-Grained Soils in Section (1.4).

GC Group: Soils which classify as gravels and having a fine-grained portion for which the Atterberg limits will plot above the A-Line and for which the plasticity index is more than 7 are placed in the GC group. This group includes clayey gravels and poorly graded gravel-sand-clay mixtures.

SM Group: This group is the same as the GM group except that the predominant coarse-grained fraction is sand. The group includes poorly graded sand-silt mixtures and silty sands.

SC Group: This group is the same as the GC group except that the predominant coarse-grained fraction is sand. The group includes clayey sands and sands with clays.

(c) Borderline (Between 5% and 12% Pass the 75 μm Sieve)

Those coarse-grained soils containing between 5% and 12% material passing the 75 μm sieve are termed borderline and are given a dual classification such as SW-SM. Also, those coarse-grained soils containing more than 12% material passing the 75 μm sieve and for which the Atterberg limits plot in the hatched zone of the Plasticity Chart receive a dual classification such as SM-SC. These double symbols are appropriate to the grading and plasticity characteristics.

(1.4) Fine-Grained Soils

These soils are not subdivided by grain size but by the properties of plasticity and compressibility. Fine-grained soils are classified as silt and clay of low, intermediate or high plasticity. Criteria for classification are based upon the relationship between the liquid limit (w_L) and the plasticity index (I_p) and are given in the form of a Plasticity Chart. On this chart, for classification, the plasticity index is plotted against the liquid limit.**

*Symbol M for the Swedish word 'Mo', meaning silt.

** Soils of low plasticity generally exhibit low compressibility and those of high plasticity are usually highly compressible.

The A-Line shown on the Plasticity Chart divides inorganic clays from silts and organic soils. Those soils for which the Atterberg limits plot above this line are clays and are designated by the symbol C, while those which plot below it are either silts with the designation M or organic soils with the designation O.

Soils (both silt and clay) which have a liquid limit of less than 35 and low plasticity and compressibility are designated by the symbol L. Soils having a w_L between 35 and 50 are called silts or clays of intermediate plasticity and compressibility designated by the symbol I. Those soils having a w_L greater than 50 are termed highly plastic and compressible and are designated by the symbol H. Hence, a soil determined to be a highly plastic and compressible clay is designated as CH, etc.

ML Group: Contains silts having bulky shaped grains, rock flour and sandy silt.

MI Group: Silts of medium compressibility and plasticity are classified in this group, including silty fine sands with some clay, below the A-Line.

MH Group: Silts having flaky shaped grains, including micaceous silts, diatomaceous silts, and elastic silts.

CL Group: Most Kaolinite-type clays are classified in this group, which usually includes gravelly clays, sandy clays, and lean or low plasticity clays.

CI Group: Clays of medium compressibility and plasticity and inorganic silty clays are placed in this category.

CH Group: Montmorillonite-type clays are classified in this group, which includes fat or highly plastic clays, volcanic clays, and bentonites.

Borderline: Those fine-grained soils for which the Atterberg limits plot in the hatched zone on the Plasticity Chart are given the dual classification of CL-ML.

(1.5) Organic Soils

The placement of soils into this group is based upon visual inspection. However, they are subdivided within the group in accordance with their plasticity characteristics. All of these soils should plot below the A-Line on the Plasticity Chart and they are termed organic silts or clays of low (L), intermediate (I), or high plasticity and compressibility (H).

Organic matter tends to decay and thus create more voids in the soil mass. It can be instrumental in chemical alterations which change the physical properties of the soil.

OL Group: This group consists of organic soils having a liquid limit of less than 35. Organic silts and organic silts with sand are usually included in this group.

OI Group: Organic soils having a liquid limit between 35 and 50 belong in this category. Soils in this group are classified as organic clays of medium plasticity or organic silty clays.

OH Group: This group consists of organic soils having a liquid limit of more than 50. Organic clays, and some organic silty clays, will be included in this group.

PT Group: Materials composed mainly of fibrous organic matter are classified separately in this group. Peat and other highly organic soils in various stages of decomposition shall be placed in this category.

Chapter 2

FIELD IDENTIFICATION AND DESCRIPTION OF SOILS

(2.1) General

As implied earlier, soils in nature seldom exist separately as boulders, cobbles, gravel, sand, silt, clay or organic matter but are usually found as mixtures with varying proportions of these components. The MTG Soil Classification System is based on recognition of the type and predominance of the constituents, considering grain size, gradation, plasticity and compressibility. It separates soils into three major divisions – coarse-grained soils, fine-grained soils, and highly organic (peaty) soils and within these divisions it establishes eighteen (18) soil groups.

Two methods for classifying soils have been adopted:

- (a) The *visual method* which employs simple manual tests and visual observations to estimate the size and distribution of the coarse-grained soil fractions and to indicate the plasticity characteristics of the fine-grained fractions. The visual method is used predominantly for field classification purposes.
- (b) The *laboratory method* which, in addition to visual observations, employs laboratory determinations of the particle-size distribution and plasticity of the fines to assist in assigning soil group names. The laboratory method is used only when confirmation or precise description is required. It is also useful as a training aid for beginners. (See Chapter 3.)

(2.2) Visual Method

No special apparatus or equipment is required for the visual identification and/or description of soils. However, the following items will facilitate the procedure:

- (a) A rubber syringe or a small oil can.
- (b) A supply of clean water.
- (c) Small bottle of dilute hydrochloric acid (HCl).
- (d) Classification chart (Appendix).

The classification of a soil by this method is based on visual observations and estimates of its engineering behaviour in a remoulded state. If the soil is to be utilized in a foundation, the condition of the soil in the undisturbed state must also be described, as discussed in section 2.7. The procedure for visual classification of a soil is, in effect, a process of simple elimination, beginning on the left side of the classification chart and working to the right until the proper group name is obtained. It is emphasized that the group name must be supplemented by a detailed description which points out peculiarities of a particular soil and differentiates it from others in the same group.

Many natural soils will have properties not clearly associated with any one soil group, but which are common to two or more groups. Or they may be near the borderline between two groups, either in percentages of the various sizes or in plasticity characteristics. For this substantial number of soils, boundary classifications are assigned and boundary group symbols are used. The two group symbols most nearly indicating the proper soil description are recorded. These are connected by a hyphen as, for example, GW-GC, SC-CL, ML-CL, and others.

Preparation of Sample

The following procedure should be used:

- (a) Select a representative sample of the soil.
- (b) Estimate the maximum particle size in the sample.
- (c) Estimate the percentage by mass of particles larger than 75 mm.
- (d) If more than half of the particles are larger than 75 mm, classify the soil as boulders and/or cobbles as explained under section (1.1).
- (e) If less than half of the particles are larger than 75 mm, remove all these particles from the sample. Only that fraction of the sample smaller than 75 mm is classified.

Division between Coarse and Fine-Grained Particles

Classify the sample as coarse-grained or fine-grained by estimating the percent by mass, of individual particles which can be seen by the naked eye. Soils containing more than 50% visible particles are coarse-grained soils. Soils containing less than 50% visible particles are fine-grained soils.

(2.3) Visual Procedure for Coarse-Grained Soils

If it has been determined that the soil is predominantly coarse-grained, it is further identified by estimating the percentages of grains in the size range (a) 75 mm to 4.75 mm, and (b) 4.75 mm to 75 μ m. If percentage (a) is greater than (b), the soil will finally be placed in one of the GRAVEL groups (Symbol G), and if percentage (b) is greater than (a), it will be placed in one of the SAND groups (Symbol S), as described below.

Gravel – Gravels are further identified as being CLEAN (containing little or no fines) or DIRTY (containing appreciable fines) by estimating the percentage of grains not visible to the naked eye. If the soil is obviously clean and pervious, the final classification will be either:

WELL-GRADED GRAVEL (GW) if there is a good representation of all particle sizes, or

POORLY-GRADED GRAVEL (GP) if there is an absence of intermediate particle sizes or an excess of one size.

If the soil is obviously dirty and relatively impervious, the final classification will be either SILTY GRAVEL (GM) if the fines have no or low plasticity, or

CLAYEY GRAVEL (GC) if the fines are of low to medium plasticity.

Sand – If it was determined that the soil would finally be placed in one of the SAND groups, the same procedure would be applied as for gravels except that the word SAND replaces GRAVEL in the groups and the Symbol S replaces G. Thus, the obviously clean sands will be classified as either:

WELL-GRADED SAND (SW) or

POORLY-GRADED SAND (SP)

and the obviously dirty sands will be classified as SILTY SAND (SM) if the fines have no or low plasticity, or

CLAYEY SAND (SC) if the fines are of low to medium plasticity.

Coarse-Grained Soils – Descriptive information for coarse-grained soils may include:

- (a) Typical name.
- (b) Maximum size of particles, percentage of cobbles and boulders which are not included in the classification.
- (c) Approximate percentage of gravel, sand and fines.
- (d) Description of average size of sand or gravel; whether coarse, medium or fine according to the groups as follows:

Coarse gravel	– 75 mm to 26.5 mm
Fine gravel	– 26.5 mm to 4.75 mm
Coarse sand	– 4.75 mm to 2.00 mm
Medium sand	– 2.00 mm to 425 μ m
Fine Sand	– 425 μ m to 75 μ m
- (e) Description of the shape of the grains; rounded, subrounded, angular, subangular. (See Figure 2.)
- (f) The surface coatings, cementation, and hardness of the grains and possible breakdown when compacted.
- (g) The colour and organic content.
- (h) Plasticity of fines.
- (i) Geologic origin or formation, if known.
- (j) Group symbol.

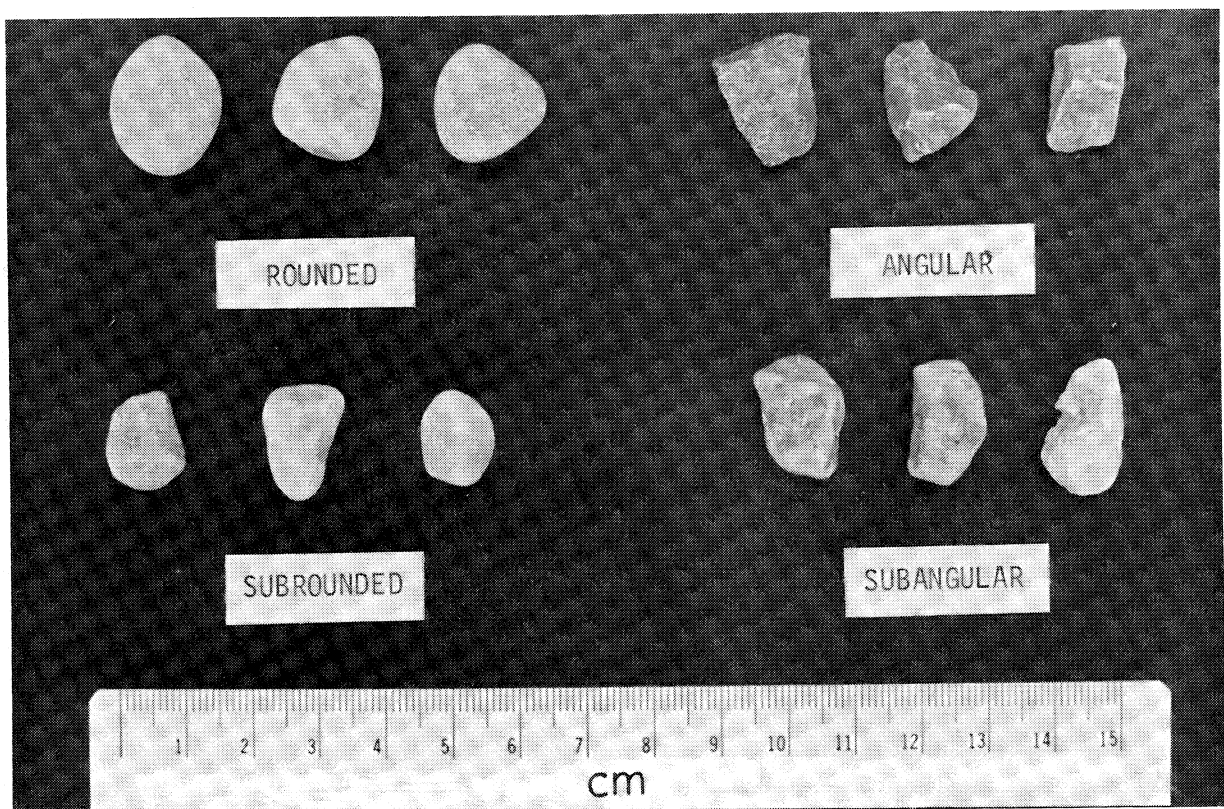


Figure 2. Typical Shapes of Gravels

(2.4) Visual Procedure for Fine-Grained Soils

If it has been determined that the soil is predominantly fine-grained (smaller than 75 μm), it is further identified according to its plasticity characteristics. The manual tests for dry strength, dilatancy, and toughness are performed as described below, and the results of these tests will determine which of the nine (9) standard group terminologies will apply. The same procedures are used to identify the fine-grained fraction of coarse-grained soils to determine whether they are silty or clayey.

(2.4.1) Manual Tests

The tests for identifying fine-grained soils in the laboratory are performed on that fraction of the soil finer than 425 μm . Therefore, the first step in classifying these soils in the field is to select a representative sample and remove by hand as much of the large particle size material as is practical. Then prepare three small specimens by moistening until they can easily be rolled into a ball. Perform the tests listed below, carefully noting the behaviour of each soil pat during each test. Operators with considerable experience find that it is not necessary in all cases to prepare all three pats. For example, if the soil contains dry lumps, the dry strength can be readily determined without preparing a pat for this particular purpose.

(a) Dry Strength (crushing resistance)

Air dry one of the prepared specimens. Then determine its resistance to crumbling and powdering between the fingers. This resistance, called “dry strength”, is a measure of the plasticity of the soil and is influenced largely by the colloidal fraction contained. The dry strength is designated as “slight” if the dried pat can be easily powdered, “medium” if considerable finger pressure is required, and “high” if it cannot be powdered at all.

High dry strength is characteristic of clays. Silts possess “none to slight” dry strength.

Note: The presence of high-strength water-soluble cementing materials, such as calcium carbonates or iron oxides, may cause high dry strengths. Non-plastic soils, such as caliche, coral, crushed limestone, or soils containing carbonaceous cementing agents, may have high dry strengths, but this can be detected by the effervescence caused by the application of dilute hydrochloric acid (see acid test below).

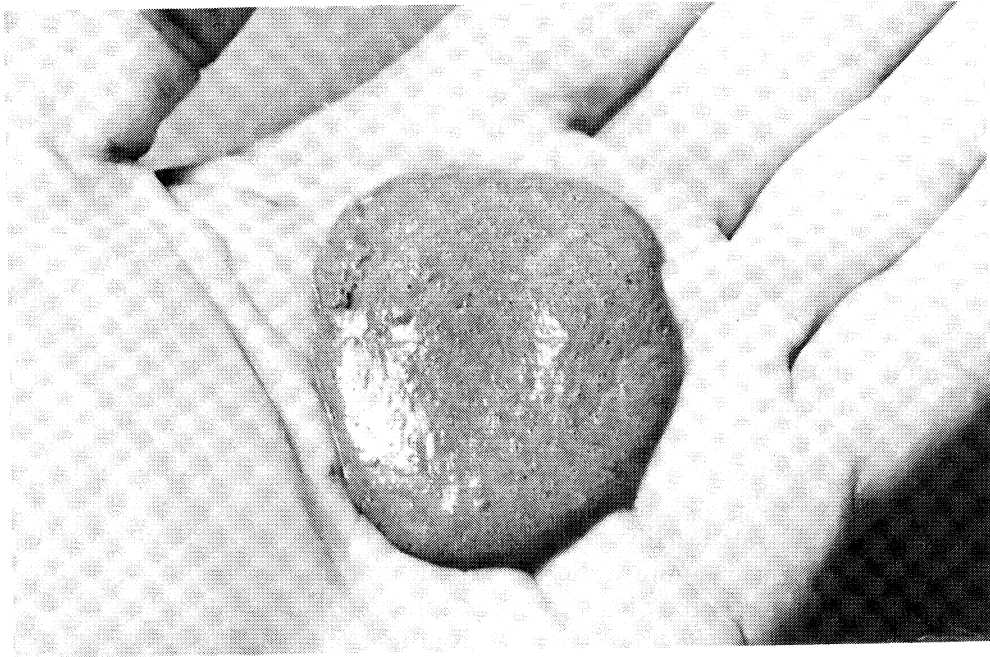
(b) Dilatancy (reaction to shaking)

Add enough water to nearly saturate one of the soil pats. Place the pat in the open palm of one hand and shake horizontally striking vigorously against the other hand several times. Squeeze the pat between the fingers. The appearance and disappearance of the water with shaking and squeezing is referred to as “reaction” (Figure 3). This reaction is called “quick” if water appears and disappears rapidly, “slow” if water appears and disappears slowly, and “no reaction” if the water condition does not appear to change.

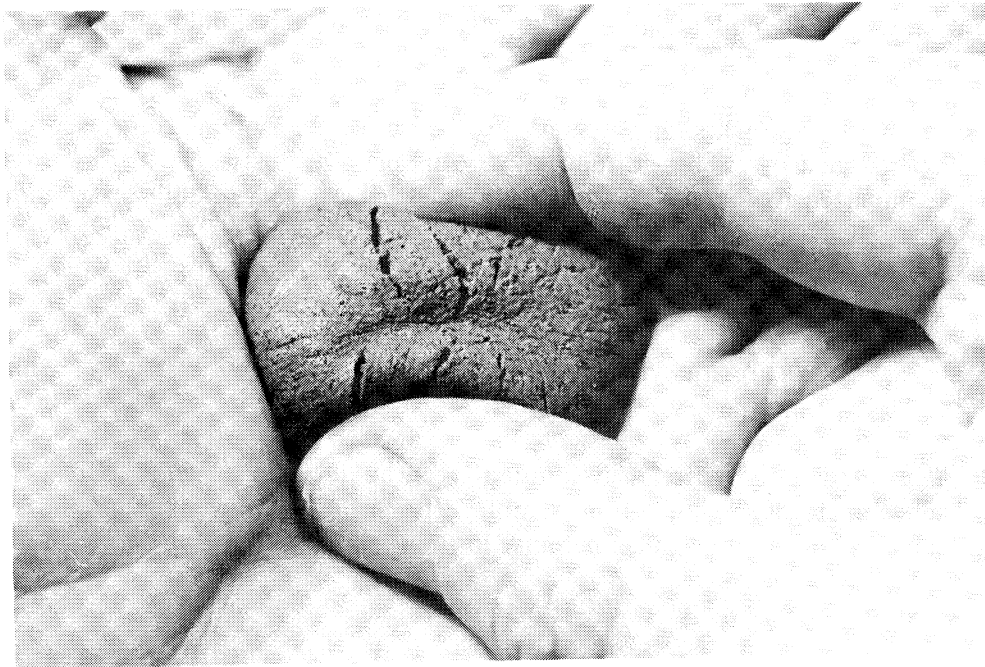
Fine clean sands give the quickest reaction, while plastic clays have no reaction. Silts usually show “slow to quick” reaction.

(c) Toughness (consistency near plastic limit)

Mould one of the prepared specimens into a pat having the consistency of putty. If too dry, water must be added and if too sticky the specimen should be allowed to partially dry. Roll the pat on a smooth surface or between the palms into a thread about 3 mm in diameter. Fold and reroll the thread repeatedly to 3 mm diameter so that its moisture content is



(a) Reaction to shaking



(b) Reaction to squeezing

Figure 3. Test for Dilatancy

gradually reduced until the 3 mm thread just crumbles (Figure 4). The moisture content at this time is called “the plastic limit”, and the resistance to moulding at the plastic limit is called the “toughness”. After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles. If the lump can still be remoulded slightly drier than the plastic limit and if high finger pressure is required to roll the thread between the palms of the hands, the soil is described as possessing “high toughness”.

“Medium toughness” is indicated by a medium tough thread, and a lump formed of the threads slightly below the plastic limit will crumble; while “slight toughness” is indicated by a weak thread that breaks easily and cannot be lumped together when drier than the plastic limit. The thread will be soft and spongy. Nonplastic soils cannot be rolled into a thread of 3 mm diameter at any moisture content.

(d) Organic Content and Colour

Fresh, wet organic soils usually have a distinctive odour of decomposed organic matter. This odour can be made more noticeable by heating the wet sample. Another indication of the organic material is the distinctive dark colour. Dry, inorganic clays develop an earthy odour upon moistening, which is distinctive from that of decomposed organic matter.

(e) Additional Identification Tests

Acid Test – This test, using dilute hydrochloric acid (HCl), is primarily a test for the presence of calcium carbonate. Two or three drops of the acid solution on soil or rock will cause effervescence if the material contains calcium carbonate. For soils with high dry strength, a strong reaction indicates that the strength may be due to calcium carbonate as a cementing agent, rather than colloidal clay. The results of this test should be included in the soil description, if pertinent.

Shine – This is a quick supplementary procedure for determining the presence of clay. The test is performed by rubbing a lump of dry or slightly moist soil with the thumb. A shiny surface imparted to the soil indicates highly plastic clay, while a dull surface indicates silt or clay of low plasticity.

Grit – Silts feel gritty to the teeth, clays do not.

Stickiness – Clays are sticky. Silts are not. Silts can be readily dusted from the hands after drying. Clays cannot be readily dusted off.

Miscellaneous – Other criteria undoubtedly can be developed by the individual as he gains experience in classifying soils. For example, differentiation between some of the fine-grained soils depends largely upon the experience in the “feel” of the soils.

(2.4.2) Silts and Clays of Low Plasticity (Symbol L)

The following three groups in this category are commonly thought of as soils possessing low plasticity. Various combinations of results of the manual identification tests indicate which grouping is proper for the soil in question.

- (a) INORGANIC SILT (ML) normally possesses no dry strength, quick dilatancy, and no toughness.

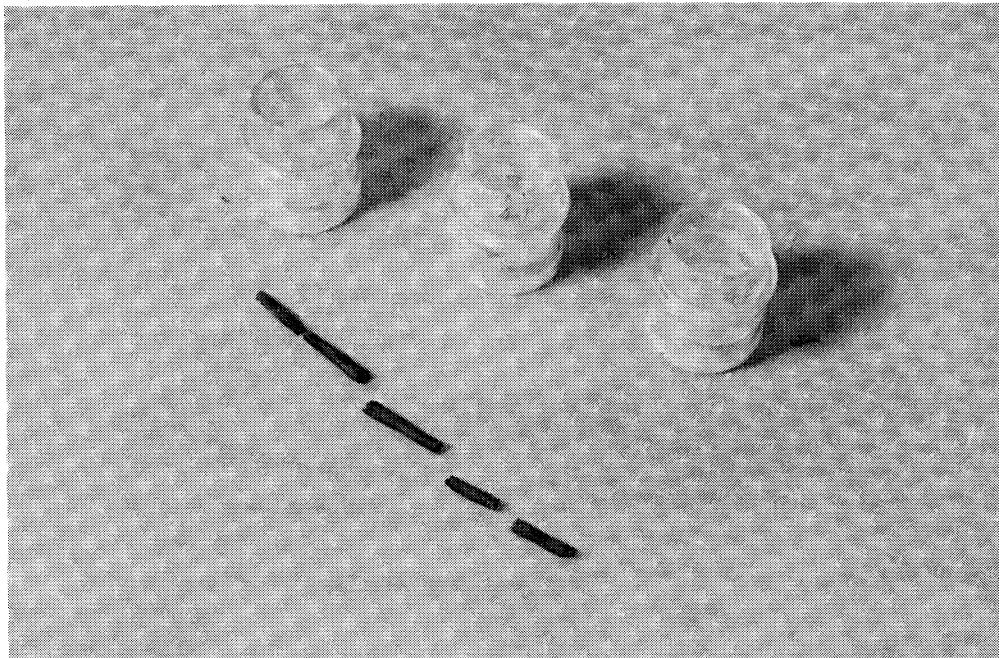
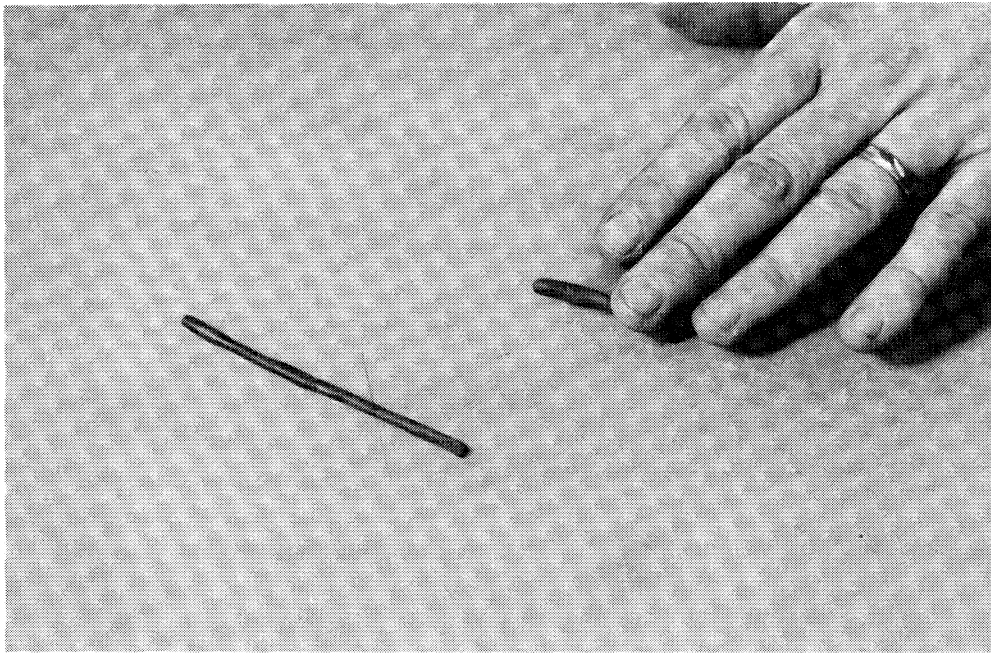


Figure 4. Test for Plastic Limit

- (b) INORGANIC CLAY (CL) usually has medium to high dry strength, none to very slow dilatancy, and medium toughness.
- (c) ORGANIC SILT OR CLAY (OL) generally has slight to medium dry strength, slow dilatancy and slight toughness. Organic matter must be present in sufficient amounts to influence the soil properties in order for a soil to be placed in this group.

(2.4.3) Silts and Clays of Intermediate Plasticity (Symbol I)

- (a) INORGANIC SILT (MI) has “none to slight” dry strength, slow to quick dilatancy, and slight toughness.
- (b) INORGANIC CLAY (CI) usually has high dry strength, no dilatancy, and medium to high toughness.
- (c) ORGANIC SILT OR CLAY (OI) generally has slight to medium dry strength, very slow dilatancy and slight toughness. Organic matter must be present in sufficient amounts to influence soil properties in order for a soil to be placed in this group.

(2.4.4) Elastic Silts and Fat Clays (Symbol H)

- (a) INORGANIC SILT (MH) is generally very absorptive, has slight to medium dry strength, “none to slow” dilatancy, and medium toughness. Some inorganic soils (such as kaoline which may be a clay from a mineralogical standpoint) possessing medium dry strength and toughness will fall in this group.
- (b) INORGANIC CLAY (CH) always possesses high to very high dry strength, no dilatancy, and usually high toughness.
- (c) ORGANIC SILT OR CLAY (OH) normally has medium to high dry strength, none to very slow dilatancy, and slight to medium toughness. Organic matter must be present in sufficient amounts to influence soil properties in order for a soil to be placed in this group.

2.5 Visual Procedure for Highly Organic Soils (Symbol Pt)

Highly organic material is readily identified by colour, odour, spongy feel and it may be fibrous or amorphous. These materials are not broken down further.

Partly organic soils tend to have the properties of their inorganic component but will exhibit high compressibility in relation to their organic content. These soils are further identified based on their inorganic components using the procedures described above.

Fine-Grained and Organic Soils – Descriptive information for remoulded fine-grained soils may include:

- (a) Typical name.
- (b) Amount and maximum size of coarse grains.
- (c) Colour and organic content.
- (d) Natural moisture content, drainage conditions.
- (e) Plasticity characteristics.
- (f) Geologic origin or local name, if known, (e.g. Glacial Till, Leda Clay).
- (g) Group Symbol.

2.6 Guide for Field Description Procedure

In the field the soil may be described using the following steps. Abbreviations (see Table 1 in the Appendix) are used for pavement structure investigations owing to the numerous bore-hole logs required for this type of work.

1st Step: Decide whether the sample is predominantly coarse-grained, fine-grained or organic. In borderline cases dual descriptions may be used.

2nd Step: Identify the principal component based on grain size if coarse-grained, or on behaviour if fine-grained, and use as a noun in the soil description.

Example: *Medium sand (Med Sa)*
Clay (Cl)

3rd Step: Identify the second component. Does it have a substantial effect on the total sample (in the range of 10% - 15% of the total mass of a coarse-grained material).

If yes, use it as an adjective preceding the noun in the soil description.

Example: *Silty fine sand (Si F Sa)*
Silty fine sand to fine sandy silt (Si F SA-Sa F Si)
Silty clay (Si Cl)

If no, treat as in step 4.

4th Step: Are there minor components which still have a significant effect on the sample?

If yes, identify by using the word “with--”.

Example: *Silty fine sand with gravel (Si F Sa with Gr)*
Sand with silt (Sa with Si)

5th Step: Are there components which have only a minor effect on the sample?

If yes, identify by using the word “trace--”.

Example: *Silty fine sand trace of clay (Si F Sa Tr Cl)*
Silty fine to medium sand with gravel trace of clay (Si F-Med Sa with Gr Tr Cl)
Coarse sand trace of silt (Co Sa Tr Si)

6th Step: Describe the colour of the soil.

Example: *Grey silty sand (Gry Si Sa)*

7th Step: Describe the moisture content. The field moisture content may be defined as; dry, moist or wet.

Dry: a dry soil has a moisture content well below optimum ($w < w_{opt}$)

Moist: a soil with a moisture content at or near optimum ($w \approx w_{opt}$)

Wet: a soil with a moisture content well above optimum ($w > w_{opt}$)

Saturated: denotes the moisture condition of a soil below the water table. It may be below, at or above the optimum moisture content.

Example: *Grey silty sand, moist (Gry Si Sa, moist)*

2.7 Description of Foundation Soils

The in-place condition of soils which are to be utilized as foundations for structures assumes primary importance in soil classification. Borehole logs of foundation explorations and descriptions of undisturbed samples, therefore, must emphasize such in-situ conditions of the soil. It is necessary for the classifier to present a complete word picture describing the soil as it exists in-situ, in addition to placing it in the proper group. The following properties should be described for foundation soils in addition to those properties listed earlier.

- (1) Permeability or drainage properties in the natural condition.
- (2) Structure (stratified, flocculent, honeycomb, etc.).
- (3) Type and degree of cementation.
- (4) Degree of compactness or denseness.

For fine-grained soils the consistency in undisturbed and remoulded states should also be described.

The consistency of a cohesive, and the denseness of a non-cohesive soil in the field, are usually determined by Field Vane Tests or Standard Penetration Tests respectively.

Consistency – Is described on the basis of undrained shear strength (c_u)* as follows:

Consistency	c_u (kPa)
Very soft	0 – 12
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very stiff	100 – 200
Hard	> 200

Denseness – is described as indicated by Standard Penetration Test 'N' values as follows:

Denseness	'N' (Blows/0.3 m)
Very loose	0 – 5
Loose	0 – 10
Compact	10 – 30
Dense	30 – 50
Very dense	> 50

The principal engineering properties of the various soil groups are tabulated in the Appendix.

* c_u is the symbol for apparent cohesion, which, in an undrained condition with saturated cohesive soils, is also called "undrained shear strength". Shear strength at failure $\tau_f = c_u + \sigma \tan \phi_u$; but in the undrained case $\phi_u = 0$, thus $\tau_f = c_u$

Chapter 3

LABORATORY CLASSIFICATION OF SOILS

Laboratory classification will, in general, be applied to those materials taken from natural deposits. All processed materials, and some materials from natural deposits will be tested and classified under the provisions of MTC Specification Division 10 for aggregates (e.g., HL1 and 3, Granular 'B', etc.).

Precise delineation of the soil groups may be obtained in the laboratory by means of grain-size analysis and Atterberg limits. For foundation or slope stability investigations, these tests are carried out as a matter of course together with other extensive testing, such as the measurement of strength and compressibility.

Laboratory tests may also be used as training for field personnel to improve their ability in estimating grain size percentage and degree of plasticity.

3.1 Test Apparatus

Descriptions of the apparatus required may be found in the following test methods described in the MTC Laboratory Testing Manual:

- LS-700 Method of Dry Preparation of Soil ...
- LS-600 Method of Preparation of Aggregates ...
- LS-703 Method of Test for Liquid Limit of Soils ...
- LS-704 Method of Test for Plastic Limit ...
- LS-602 Method of Test for Sieve Analysis ...
- LS-702 Method of Test for Particle Size Analysis ...

3.2 Test Samples

Test samples shall be prepared as follows:

- (a) The sample as received from the field shall be thoroughly dried in air or a drying oven not exceeding 60°C if it is predominantly fine-grained. Predominantly coarse-grained material may be dried in an oven at $110 \pm 5^\circ\text{C}$.
- (b) The dried sample is separated into fractions on a 4.75 mm sieve if it is predominantly sand, silt or clay and on a 26.5 mm sieve if it has a substantial portion larger than 26.5 mm. The coarse portions are sieved in each case and the masses retained on each sieve recorded.
- (c) Samples passing the 4.75 mm sieve are split and one portion is ground in a mortar with a rubber pestle and passed through a 2.00 mm sieve. The mass of material passing the 2.00 mm sieve may be split further to produce one sample for particle size analysis and one sample to be ground further to produce sufficient material passing the 425 μm sieve for Atterberg limit or organic tests.
- (d) Samples passing the 26.5 mm sieve are placed in the Gilson sieving apparatus to obtain the grain-size distribution for particles from 19.00 mm to 4.75 mm. The material passing the 4.75 mm sieve is split to obtain a representative sample for the sieve analysis of the medium to fine sand.

- (e) When all the tests have been completed, the grain-size distribution curve is plotted and the classification procedure may be carried out.

3.3 Procedure for Classification of Coarse-Grained Soils

- (a) Classify the material as gravel (G) if 50% or more of the fraction retained on the 75 μm sieve is larger than 4.75 mm.
- (b) Classify the material as sand (S) if more than 50% of the fraction retained on the 75 μm sieve is smaller than 4.75 mm.
- (c) If less than 5% of the sample passes the 75 μm sieve, compute the coefficient of uniformity (C_U) and the coefficient of curvature (C_C) as explained under Section (1.3).
- (d) Classify the sample as well-graded gravel (GW) or well-graded sand (SW), if C_U is greater than 4 for gravel and greater than 6 for sand, and C_C is between 1 and 3. Classify the sample as poorly-graded gravel (GP) or poorly-graded sand (SP) if either the C_U or C_C criteria are not satisfied.
- (e) If more than 12% of the sample passes the 75 μm sieve, the liquid limit and plasticity index of the pass 425 μm portion should be determined.
- (f) Classify the sample as silty gravel (GM) or silty sand (SM) if the results of the limit tests show the fines to be silty i.e., below the A-line or with plasticity index (I_p) less than 4. Classify the sample as clayey gravel (GC) or clayey sand (SC) if the results of the limit tests plot above the A-line and the plasticity index (I_p) is greater than 7.
- (g) If the fines are intermediate between silt and clay, i.e., plot on or close to the A-line and with plasticity index (I_p) in the range of 4-7 (the hatched area in the plasticity chart), the sample should be given a borderline classification, such as GM-GC or SM-SC.
- (h) If 5 to 12% of the sample passes the 75 μm sieve, the material should be given a borderline classification based on gradation and plasticity characteristics, such as GW-GC or SP-SM. In doubtful cases, the rule is to favour the less plastic classification.

Example: *a gravel with 10% fines, a C_U of 20, a C_C of 2 and a plasticity index of 6 would be classified as GW-GM rather than GS-GC.*

3.4 Procedure for Classification of Fine-Grained Soils

- (a) If results of Atterberg limit tests plot above the A-line and the plasticity index is greater than 7, classify the sample as clay of high plasticity (CH) if the liquid limit is above 50; intermediate plasticity (CI) if the liquid limit is between 35 and 50 and low plasticity (CL) if the liquid limit is below.
- (b) If results of Atterberg limit tests plot below the A-line or the plasticity index is less than 4, classify the sample as silt of high plasticity (MH) if the liquid limit is above 50; intermediate plasticity (MI) if the liquid limit is between 35 and 50 and low plasticity (ML) if the liquid limit is below 35.

- (c) If the sample has a dark colour and an organic odour when moist and warm, the results of Atterberg limit tests plot below the A-line or the plasticity index is less than 4, classify the sample as organic clay or silty-clay of high plasticity (OH) if the liquid limit is above 50 and intermediate plasticity (OI) if the liquid limit is between 35 and 50. If the liquid limit is less than 35, classify the material as organic silt or organic silt with sand (OL).
- (d) If the organic content is in doubt, a determination should be made by oxidation or reduction. If this cannot be carried out, Atterberg limit tests should be performed on natural, air-dried or oven-dried soil. Marked differences in the liquid limit or plasticity index would indicate a high organic content.
- (e) If the results of Atterberg limit tests fall close to or on the A-line or in the hatched area of the plasticity chart ($w_L < 30\%$; $I_P = 4-7\%$) the sample should be classified as borderline such as CL-ML or CI-MI.
- (f) If the plot of the liquid limit versus plasticity index falls close to or on the vertical line of 35 or 50% liquid limit, the sample should be given a borderline classification such as CI-CH, MI-MH, CL-CI or ML-MI. In doubtful cases, the rule is to favour the more plastic classification.

Example: *a fine-grained soil with a liquid limit of 50 and a plasticity index of 22 would be classified as CH-MH rather than CI-MI.*

REFERENCES

1. AASHTO. Washington, D.C. (1978), *Manual on Foundation Investigations* (pp B-26 to B-36).
2. ASTM. (1978), *Annual Book of ASTM Standards. Part 19*. D 653 (Reapproved 1973); D-2487 (Reapproved 1975); D 2488 (Reapproved 1975).
3. Ministry of Transportation and Communications, Ontario (1977), *Geotechnical Metric Guide* (Revised edition).
4. Ministry of Transportation and Communications, Ontario (1979), *Laboratory Testing Manual*.
5. National Research Council of Canada (1955), *Guide to the Field Description of Soils for Engineering Purposes*.
6. Road Research Laboratory. Great Britain (1954), *Soil Mechanics for Road Engineers*. Chapter 4.
7. Soil Mechanics Bureau. N.Y. State DOT. (1978), *Soil Description Procedure*.
8. U.S. Department of the Interior. Bureau of Reclamation. Denver, Colorado, (1963), *Unified Soil Classification System*.

APPENDIX

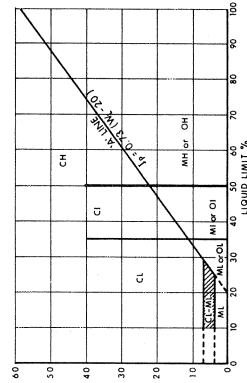
ABBREVIATIONS FOR BORING AND TEST DATA

Amor	— Amorphous	Grn	— Green	Ip	— Plasticity Index
Asph	— Asphalt	Grey	— Grey	PSty	— Polystyrene
BR	— Bedrock	Hi	— Highly	Poss	— Possible
Blk	— Black	HM	— Hot Mix	PST	— Prime & Surface Treated
Bl	— Blue	Lt	— Light	Quant	— Quantity
Bld(y)	— Boulder (y)	Liq	— Liquid	Reinf	— Reinforced
Blds	— Boulders	w _L	— Liquid Limit	RF	— Rock Fill
BU	— Break Up	Matl	— Material	Sa	— Sand
Br	— Brown	Max	— Maximum	Sat	— Saturated
Cl	— Clay	MDD	— Maximum Dry Density	Sh Rk	— Shot Rock
Co	— Coarse	MWD	— Maximum Wet Density	Si	— Silt(y)
Cob	— Cobbles	Med	— Medium	Sl(y)	— Slight(l y)
Comp	— Compact	Mod	— Moderate	D _R	— Relative Density
Conc	— Concrete	Mott	— Mottled	Stks	— Streaks
Contam	— Contaminated	Mul	— Mulch	Surf	— Surface
Cord	— Corduroy	NFP	— No Further Progress	Temp	— Temperature
Cr	— Crushed	NFP (Blds)	— No Further Progress (Boulders)	Tps	— Topsoil
Dk	— Dark	Num	— Numerous	Tr	— Trace
Decomp	— Decomposed	Occ	— Occasional	Unreinf	— Unreinforced
E	— Earth	w _{opt}	— Optimum Moisture Content	Varv	— Varved
Fib	— Fibrous	Ora	— Orange	VF	— Very Fine
w	— Field Moisture Content	Org	— Organic	WT	— Water Table
F	— Fine	Org M	— Organic Matter	Weath	— Weathered
Fr Wat	— Free Water	Ob	— Overburden	Wd(y)	— Wood(y)
FB	— Frost Boil	Pavt	— Pavement	Yel	— Yellow
FH	— Frost Heave	Pedo	— Pedological		
Gran	— Granular	Pen Mac	— Penetration Macadam		
Gr	— Gravel(l y)	w _p	— Plastic Limit		

SUSCEPTIBILITY TO FROST HEAVING

HSFH — High
BSFH — Borderline
LSFH — Low

M. T. C. SOIL CLASSIFICATION									
FIELD IDENTIFICATION PROCEDURES				TYPICAL NAMES		INFORMATION REQUIRED FOR DESCRIBING SOILS		LABORATORY CLASSIFICATION CRITERIA	
(EXCLUDING PARTICLES LARGER THAN 75 mm AND BASING FRACTIONS ON ESTIMATED MASS)				GRP SYMB					
GRAVELS MORE THAN HALF OF COARSE FRACTION IS LARGER THAN 4.75 mm	CLEAN GRAVELS (LITTLE OR NO FINES)	WIDE RANGE IN GRAIN SIZE & SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZE		GM	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES; LITTLE OR NO FINES		DETERMINE PERCENTAGES OF GRAVEL & SAND FROM GRAIN SIZE CURVE. DEPENDING ON PERCENTAGE OF FINES (FRACTION SMALLER THAN 75 μm) COARSE GRAINED SOILS ARE CLASSIFIED AS FOLLOWS: LESS THAN 5% GM, GP, SM, SP MORE THAN 12% GM, GC, SH, SC 5% TO 12% BORDERLINE CASES REQ. USE OF DUAL SYMBOLS		
	GRAVEL WITH FINES (APPRECIABLE AMOUNT OF FINES)	PREDOMINANTLY ONE SIZE OF A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING		GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES; LITTLE OR NO FINES		NOT MEETING ALL GRADATION REQUIREMENTS FOR GM		
		NON-PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)		GM	SILTY GRAVELS, POORLY GRADED GRAVEL-SAND-SILT MIXTURES		ABOVE A-LINE WITH t_p BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS		
SANDS MORE THAN HALF OF FRACTION IS SMALLER THAN 4.75 mm	CLEAN SANDS (LITTLE OR NO FINES)	WIDE RANGE IN GRAIN SIZES & SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZES		SM	WELL GRADED SANDS, GRAVELLY SANDS; LITTLE OR NO FINES		C _u = $\frac{D_{60}}{D_{10}}$ GREATER THAN 6 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ BETWEEN ONE AND 3		
	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	PREDOMINANTLY ONE SIZE OR A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING		SP	POORLY GRADED SANDS, GRAVELLY SANDS; LITTLE OR NO FINES		NOT MEETING ALL GRADATION REQUIREMENTS FOR SH		
		NON-PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)		SM	SILTY SANDS, POORLY GRADED SAND-SILT MIXTURES		ABOVE A-LINE WITH t_p BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS		
		PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)		SC	CLAYEY SANDS, POORLY GRADED SAND-CLAY MIXTURES		ATTEBERG LIMITS ABOVE A-LINE WITH t_p GREATER THAN 7		
IDENTIFICATION PROCEDURES ON FRACTION SMALLER THAN 425 μm						USE GRAIN SIZE CURVE IN IDENTIFYING THE FRACTIONS AS GIVEN UNDER FIELD IDENTIFICATION			
SILTS AND CLAYS	LIQUID LIMIT LESS THAN 35%	DRY STRENGTH (CRUSHING CHARACTERISTICS)	DILATANCY (REACTION TO SHAKING)	TOUGHNESS (CONSISTENCY NEAR PLASTIC LIMIT)	ML	INORGANIC SILTS & SANDY SILTS OF SLIGHT PLASTICITY, ROCK FLOUR			
		NONE	QUICK	NONE	CL	SILTY CLAYS (INORGANIC), GRAVELLY CLAYS, SANDY CLAYS, LEAN CLAYS			
		MEDIUM TO HIGH	NONE TO VERY SLOW	MEDIUM	OL	ORGANIC SILT OF LOW PLASTICITY, ORGANIC SANDY SILTS			
	LIQUID LIMIT BETWEEN 35% AND 50%	NONE TO SLIGHT	SLOW TO QUICK	SLIGHT	MI	INORGANIC COMPRESSIBLE FINE SANDY SILT WITH CLAY OF MEDIUM PLASTICITY, CLAYEY SILTS		FOR UNDISTURBED SOILS AND INFORMATION ON STRUCTURE, STRATIFICATION, CONSISTENCY IN UNDISTURBED & REPOULDED STATES, MOISTURE & DRAINAGE CONDITIONS.	
		HIGH	NONE	MEDIUM TO HIGH	CI	SILTY CLAYS (INORGANIC) OF MEDIUM PLASTICITY			
	SLIGHT TO MEDIUM	VERY SLOW	SLIGHT	OI	ORGANIC SILTY CLAYS OF MEDIUM PLASTICITY				
LIQUID LIMIT GREATER THAN 50%	SLIGHT TO MEDIUM	SLOW TO NONE	MEDIUM	MH	INORGANIC SILTS, HIGHLY COMPRESSIBLE MICACEOUS OR DIATOMACEOUS FINE SANDY SILTS, ELASTIC SILTS		PEAT & OTHER HIGHLY ORGANIC SOILS		
	HIGH TO VERY HIGH	NONE	HIGH	CH	CLAYS (INORGANIC) OF HIGH PLASTICITY, FAT CLAYS				
	MEDIUM TO HIGH	NONE TO VERY SLOW	SLIGHT TO MEDIUM	OH	ORGANIC CLAYS OF HIGH PLASTICITY				
READILY IDENTIFIED BY COLOUR, ODOUR, SPONGY FEEL & FREQUENTLY BY FIBROUS TEXTURE				PL	PEAT & OTHER HIGHLY ORGANIC SOILS				



PLASTICITY CHART
FOR LABORATORY CLASSIFICATION OF FINE GRAINED SOILS

TYPICAL NAMES OF SOIL GROUPS	GROUP SYMBOLS	PERMEABILITY WHEN COMPACTED	STRENGTH WHEN COMPACTED	COMPRESSIBILITY WHEN COMPACTED	WORKABILITY AS A CONSTRUCTION MATERIAL	SCOUR RESISTANCE	SUSCEPTIBILITY TO SURFICIAL EROSION	SUSCEPTIBILITY TO FROST ACTION	DRAINAGE CHARACTERISTICS
WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	GW	PERVIOUS	EXCELLENT	NEGLECTIBLE	EXCELLENT	MEDIUM	NEGLECTIBLE	NEGLECTIBLE	EXCELLENT
POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	GP	VERY PERVIOUS	GOOD	NEGLECTIBLE	GOOD	MEDIUM	NEGLECTIBLE	NEGLECTIBLE	EXCELLENT
SILTY GRAVELS, POORLY GRADED GRAVEL-SAND-SILT MIXTURES	GM	SEMI-PERVIOUS TO IMPERVIOUS	GOOD	NEGLECTIBLE	GOOD	LOW TO MEDIUM	SLIGHT	SLIGHT	FAIR TO SEMI IMPERVIOUS
CLAYEY GRAVELS, POORLY GRADED GRAVEL-SAND-CLAY MIXTURES	GC	IMPERVIOUS	GOOD TO FAIR	VERY LOW	GOOD	MEDIUM	SLIGHT	NEGLECTIBLE TO SLIGHT	PRACTICALLY IMPERVIOUS
WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	SW	PERVIOUS	EXCELLENT	NEGLECTIBLE	EXCELLENT	LOW TO MEDIUM	SLIGHT	NEGLECTIBLE	EXCELLENT
POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	SP	PERVIOUS	GOOD	VERY LOW	FAIR TO GOOD	LOW TO MEDIUM	MODERATE	NEGLECTIBLE TO SLIGHT	EXCELLENT
SILTY SANDS, POORLY GRADED SAND-SILT MIXTURES	SM	SEMI-PERVIOUS TO IMPERVIOUS	GOOD	LOW	FAIR	LOW	MODERATE	SLIGHT TO MODERATE	FAIR TO SEMI IMPERVIOUS
CLAYEY SANDS, POORLY GRADED SAND WITH SOME CLAY MIXTURES	SC	IMPERVIOUS	GOOD TO FAIR	LOW	GOOD	VERY LOW TO LOW	MODERATE TO SLIGHT	NEGLECTIBLE	PRACTICALLY IMPERVIOUS
INORGANIC SILTS AND SANDY SILTS OF SLIGHT PLASTICITY, ROCK FLOUR	ML	SEMI-PERVIOUS TO IMPERVIOUS	FAIR	MEDIUM	FAIR	VERY LOW	SEVERE	SEVERE	FAIR TO POOR
INORGANIC CLAYEY SILTS OF LOW PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, LEAN CLAYS	CL	IMPERVIOUS	FAIR	MEDIUM	GOOD TO FAIR	LOW TO MEDIUM	SLIGHT TO MODERATE	MODERATE TO SEVERE	PRACTICALLY IMPERVIOUS
ORGANIC SILTS OF LOW PLASTICITY	OL	SEMI-PERVIOUS TO IMPERVIOUS	POOR	MEDIUM	FAIR TO POOR	VERY LOW TO LOW	SEVERE	SEVERE	POOR
INORGANIC COMPRESSIBLE SILTS OF MEDIUM PLASTICITY	MI	SEMI-PERVIOUS TO IMPERVIOUS	FAIR	MEDIUM TO HIGH	FAIR TO POOR	LOW	MODERATE	MODERATE TO SEVERE	FAIR TO POOR
INORGANIC SILTY CLAYS OF MEDIUM PLASTICITY	CI	IMPERVIOUS	FAIR TO POOR	HIGH	FAIR	LOW TO MEDIUM	SLIGHT	MODERATE TO SEVERE	SEMI IMPERVIOUS TO PRACTICALLY IMPERVIOUS
ORGANIC SILTY CLAY OF MEDIUM PLASTICITY	OI	SEMI-PERVIOUS TO IMPERVIOUS	POOR	HIGH	POOR	VERY LOW TO LOW	SEVERE	MODERATE TO SEVERE	POOR TO PRACTICALLY IMPERVIOUS
INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS	HI	SEMI-PERVIOUS TO IMPERVIOUS	FAIR TO POOR	HIGH	POOR	VERY LOW	MEDIUM	SEVERE	POOR
INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	CH	IMPERVIOUS	POOR	HIGH	FAIR TO POOR	LOW TO MEDIUM	SLIGHT TO NEGLECTIBLE	NEGLECTIBLE	PRACTICALLY IMPERVIOUS
ORGANIC CLAYS OF HIGH PLASTICITY	OH	IMPERVIOUS	POOR	HIGH	POOR	LOW	MODERATE	NEGLECTIBLE TO SLIGHT	PRACTICALLY IMPERVIOUS
PEAT AND OTHER HIGHLY ORGANIC SOILS	PL	—	—	—	—	LOW	SEVERE	—	FAIR TO POOR

ENGINEERING PROPERTIES OF SOILS



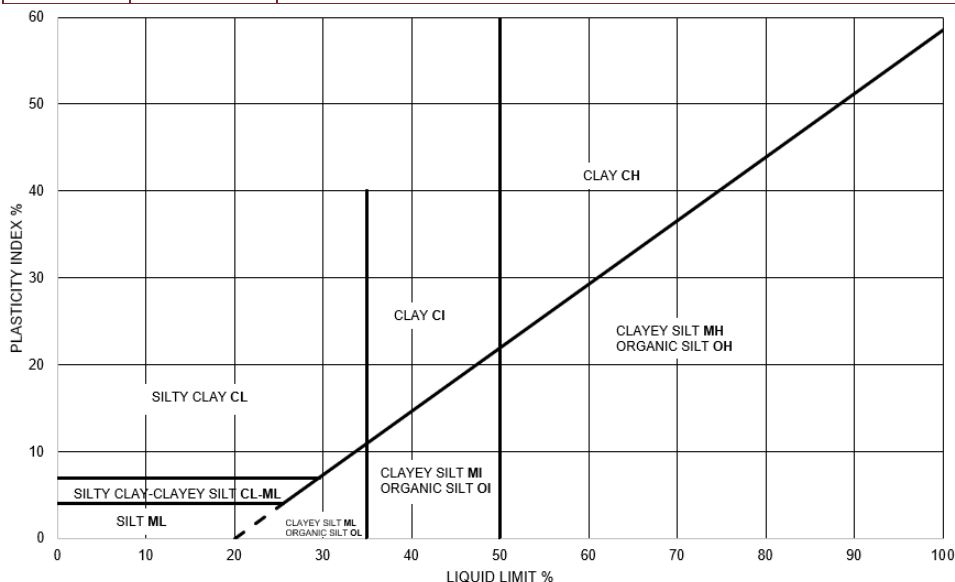
APPENDIX B

Report Description Sheets

Method of Soil Classification

GEMTEC's Soil Classification is based on the MTC Soil Classification Manual (January 1980)

Organic or Inorganic	Soil Group	Type of Soil		Gradation or Plasticity	$C_u = \frac{D_{60}}{D_{10}}$	$C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$	USCS Group Symbol	Group Name	
Inorganic (Organic Content less than 30%)	Coarse Grained Soils (>50% is larger than 0.075 mm)	Gravel (>50% of coarse fraction is > 4.75 mm)	Gravel with ≤12% fines	Poorly Graded	<4	≤1 or ≥3		GP	Gravel
				Well Graded	≥4	1 to 3		GW	Gravel
			Gravel with >12% fines	Below A Line	N/A			GM	Silty Gravel
				Above A Line	N/A			GC	Clayey Gravel
		Sand (≥50% coarse fraction is > 4.75 mm)	Sand with ≤12% fines	Poorly Graded	<6	≤1 or ≥3		SP	Sand
				Well Graded	≥6	1 to 3		SW	Sand
			Sand with >12% fines	Below A Line	N/A			SM	Silty Sand
				Above A Line	N/A			SC	Clayey Sand
	Soil Group	Type of Soil	Liquid Limit	Field Tests			USCS Group Symbol	Group Name	
				Dilatancy	Thread Diameter	Toughness			
	Fine Grained Soils (≥50% is smaller than 0.075 mm)	Silt (Non-Plastic or PI and LL plot below A-Line)	<50	Rapid	>6 mm	N/A	ML	Silt	
				Slow	3 to 6 mm	None to low	ML	Clayey Silt	
				Slow to V. Slow	3 to 6 mm	Low	OL	Organic Silt	
			≥50	Slow to V. Slow	3 to 6 mm	Low to Medium	MH	Clayey Silt	
				None	1 to 3 mm	Medium to High	OH	Organic Silt	
		Clays (PI and LL plot above A-Line)	Liquid Limit <35	None	~3 mm	Low to Medium	CL	Silty Clay	
			Liquid Limit 35 to 50	None	1 to 3 mm	Medium	CI	Silty Clay	
			Liquid Limit >50	None	<1 mm	High	CH	Clay	
	Highly Organic (> 30%)	Peat (Amorphous or Fibrous)						PT	Peat



Dual Symbol – Is used to indicate when soils are transitional. For coarse grained soils, it is used when the soil has between 5 and 12% fines (e.g., SP-SC, Sand to Silty Sand). For fine-grained soils it is used when the plasticity index and liquid limit values plot in the area shown in the plasticity chart on this page.

Borderline Symbol – Is used to indicate soils that are not clearly in one soil type but have similar behaviour and properties as similar materials (e.g., CL/CI or GM/SM).

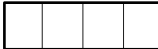
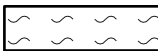
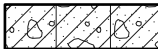
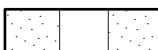
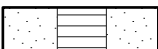
ABBREVIATIONS AND TERMINOLOGY USED ON RECORDS OF BOREHOLES AND TEST PITS

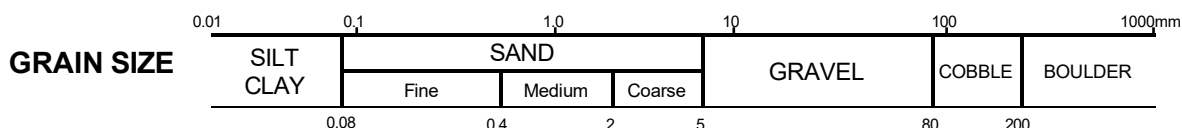
SAMPLE TYPES	
AS	Auger sample
CA	Casing sample
CS	Chunk sample
BS	Borros piston sample
GS	Grab sample
MS	Manual sample
RC	Rock core
SS	Split spoon sampler
ST	Slotted tube
TO	Thin-walled open shelby tube
TP	Thin-walled piston shelby tube
WS	Wash sample

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

		
GRAVEL	SAND	SILT
		
CLAY	FILL	ORGANICS
		
BOULDER	BEDROCK	TILL
		
PIPE WITH BENTONITE	PIPE WITH BACKFILL	PIPE WITH SAND
		
SCREEN WITH SAND	GROUNDWATER LEVEL	



DESCRIPTIVE TERMINOLOGY

TRACE	SOME	ADJECTIVE	noun > 30% and main fraction
trace clay, etc	some gravel, etc.	silty, etc.	sand and gravel, etc.

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING STATE	
Fresh	No visible sign of rock material weathering
Faintly weathered	Weathering limited to the surface of major discontinuities
Slightly weathered	Penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material
Moderately weathered	Weathering extends throughout the rock mass but the rock material is not friable
Completely weathered	Rock is wholly decomposed and in a friable condition but the rock and structure are preserved

CORE CONDITION
Total Core Recovery (TCR) The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run
Solid Core Recovery (SCR) The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.
Rock Quality Designation (RQD) The percentage of solid drill core, greater than 100 mm length, as measured along the centerline axis of the core, relative to the length of the total core run. RQD varies from 0% for completed broken core to 100% for core in solid segments.

BEDDING THICKNESS	
Description	Thickness
Thinly laminated	< 6 mm
Laminated	6 - 20 mm
Very thinly bedded	20 - 60 mm
Thinly bedded	60 - 200 mm
Medium bedded	200 - 600 mm
Thickly bedded	600 - 2000 mm
Very thickly bedded	2000 - 6000 mm

DISCONTINUITY SPACING	
Description	Spacing
Very close	20 - 60 mm
Close	60 - 200 mm
Moderate	200 - 600 mm
Wide	600 - 2000 mm
Very wide	2000 - 6000 mm

ROCK QUALITY	
RQD	Overall Quality
0 - 25	Very poor
25 - 50	Poor
50 - 75	Fair
75 - 90	Good
90 - 100	Excellent

ROCK COMPRESSIVE STRENGTH	
Comp. Strength, MPa	Description
1 - 5	Very weak
5 - 25	Weak
25 - 50	Moderate
50 - 100	Strong
100 - 250	Very strong



APPENDIX C

Soil Logging Template

FIELD BOREHOLE LOG

JOB No. 123456.001Job Name CLIENT/OVERPASS 416/OTTAWADate MARCH 14, 2025BH No. 25-01

BH Location HUNT CLUB/HWY 416 SE RAMP (SEE REVERSE)Elevation SEE SURVEY DATADatum

Coordinates: Lat. Long. Drill Rig (circle): Truck ☒ Skid Other Make & Model CME 750

Contractor DOWNINGDriller BOBHelper DOUG

Weather / Temp SUNNY/WARMHammer (circle): Automatic ☒ Safety ManualWt. 140lbsDrop 30inches

ABBREVIATIONS				FIELD ABBREVIATIONS			
AS - AUGER SAMPLE	SA - SAMPLE	V - VANE SHEAR	BC - BROKEN CORE				
GS - GRAB SAMPLE	SC - SOIL CORE	WH - WT. OF HAMMER	LC - LOST CORE				
PH - PRESSURE, HYDRAULIC	SS - SPLIT SPOON	WL - WATER LEVEL	RC - ROCK CORE				
PM - PRESSURE, MANUAL	TO - THIN-WALLED, OPEN	WR - WT. OF RODS	RQD - ROCK QUALITY DESIG.				
	TP - THIN-WALLED, PISTON	WS - WASH SAMPLE	SCR - SOLID CORE RECOVERY				
			TCR - TOTAL CORE RECOVERY				

METHOD	CASING	SOIL STRATIGRAPHY		DCPT / Fractures: per	DEPTH	*Group Symbol	SAMPLES					SAMPLE DESCRIPTIONS AND BORING NOTES		
		DESCRIPTION	DEPTH				MOIST.	TYPE	No.	RECOV.	FORCE	Start of Shift	Time: 07:30 AM	Depth of Hole:
														Depth of Casing:
8" POWER AUGER	4 1/4" I.D. HOLLOW STEM AUGER	GROUND SURFACE	0.05		0									
		TOPSOIL - silty sand; black	0.2"											
		FILL - (ML) sandy silt Some gravel; dark brown; non-cohesive, moist, loose	1.22		2	ML	moist	GS	1	-	-			AUGERED TO 2'6" 0.76
		(SW-SM) SAND, some non-plastic fines; brown non-cohesive, moist, loose	4.0"		4	SW-SM	moist	SS	2	29/24	2 1/2			SA No. 2 2" SS 2'6" to 4'6" 0.76-1.37
		(CI/CH) SILTY CLAY; grey; brown (WEATHERED CRUST); cohesive, w>pl, stiff to very stiff	2.06		6	SW-SM	moist	SS	3	18/24	3 1/2			2A 2'6"-4'6" FILL - (ML) Sa Si, so Grav; Dk Br; moist
		(CI/CH) SILTY CLAY; grey; cohesive, w>pl, stiff to firm	3.05		8	CI/CH	w>pl	SS	4	24/24	2 3/4			2B 4'0"-4'6" (SW-SM) Sa, so Si; Lt Br; moist
		(SM) SILTY SAND, some gravel; grey, with cobbles and boulders (TILL); non-cohesive, wet, compact to very dense	5.69		10	CI/CH	w>pl	SS	5	24/24	2 1/4			AUGERED TO 5'0" 1.52
			18'8"		12									SA No. 3 2" SS 5'0" to 7'0" 1.52-2.13
					14									(SW-SM) Sa, so Si, Lt Br, moist * (CI/CH) Si Cl IN TIP OF SPOON
					16	CI/CH	w>pl	TP	6	18/24	PH			PULLED AUGERS AND SCRAPE HOLE
WASH BORE	HW CASING		7.98		18									2" TOPSOIL - Si Sa; Bk
			26'2"		20	SM	wet	SS	7	8/9	3 1/2			SA No. 1 GS 1'0" to 2'0" 0.30-0.61
					22									FILL - (ML) Sa Si, So Grav; Dk Br; moist
					24	SM	wet	SS	8	15/14	8 15/12 17			AUGERED TO 7'6" 2.29
ROTARY DAILL	HQ CORE	BEDROCK			26	SM	wet	SS	9	12/14	2 3/4			SA No. 4 2" SS 7'6" to 9'6" 2.29-2.90
		SEE ROCK LOGGING TEMPLATE			28									(CI/CH) Si Cl; Gr Br (wc); w>PL
			9.50		30									AUGERED TO 10'0" 3.05
		END OF BOREHOLE	31'2"		32									SA No. 5 2" SS 10'0" to 12'0" 3.05-3.66
					34									(CI/CH) Si Cl; Gr; w>PL
					36									
					38									

SPECIAL NOTES: (groundwater conditions etc.)

• MTD N VANE USED

TIME 07:30 - 14:30

STANDBY DELAY TIME 1.25

STANDBY, DELAY COMMENTS CALL TO PM (LOCATES)

DEPTH OF HOLE 31'2" DEPTH OF CASING 22'6" DEPTH TO W.L. 17'4" DEPTH TO CAVE 19'6"

LOGGED BY MACKENZIE

MANDATORY - Final Check-Offs

BH Details	Sketch & Method	Sample Details	W.L. & Cave	Well Details
☒	☒	☒	☒	☒

Job No. 123456.001

Borehole No. 25-01

DEPTH 0'0" TO 31'2"

Page 1 of 1

ADVANCE HW CASING TO 25'0" 7.62

SA No. 9 2" SS 25'0" to 26'2" 7.62-7.98

(SM) Si Sa, so Grav; Gr (TILL); wet * B/R IN TP

ADVANCE HW CASING TO 26'5" 8.05

SA No. 10 HQ RC 26'2" to 31'2" 7.98-9.50

SEE ROCK LOGGING TEMPLATE

Backfill / Well Install >

GEMTEC OTTAWA OFFICE GEOTECHNICAL BOREHOLE LOG TEMPLATE

SCOPE — This template reflects Ottawa office practice only. It is intended for use when logging geotechnical boreholes only; other practices may apply for environmental boreholes. This template also applies mainly to boreholes in soil. Other practices are required for bedrock boreholes.

SOIL DESCRIPTIONS — Soil descriptions should follow the sequence of:, FILL Identification, USCS Group Symbol, MAIN CONSTITUENTS, Minor Constituents, SEMICOLON, Colour, Weathering, Structure, Sensitivity, Contamination, Descriptor (e.g.: FILL MATERIAL, GLACIAL TILL), SEMICOLON, Behaviour, Field Moisture Condition, Relative Density/Consistency. The main constituents should be capitalized and underlined on the log (left side of sheet). Deposits of consistent composition but varying properties (colour, density index, or consistency) are separated by dashed lines on the log.

USCS GROUP SYMBOLS — Soils should be grouped and classified according to the modified Unified Soil Classification System:

Major Divisions		Group Symbol	Typical Description
Coarse -grained soils (>50% of particles larger than .075 mm)	Gravel and Gravelly Soils	GW	Well-graded gravels or gravel-sand mixtures, trace or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, trace or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	Sand and Sandy Soils	SW	Well-graded sands or gravelly sands, trace or no fines.
		SP	Poorly-graded sands or gravelly sands, trace or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
Fine -grained soils (>50% of particles smaller than .075 mm)	Silt and Clay Soils LL < 35%	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		OL	Organic silts and organic silty clays of low plasticity
	Silt and Clay Soils 35% < LL < 50%	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts
		CI	Inorganic clays of medium plasticity, silty clays
		OI	Organic clays of medium plasticity
	Silt and Clay Soils LL > 50%	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
OH		Organic clays of high plasticity, organic silts.	
Highly Organic Soils (>30% Organic mass)		PT	Peat and other organic soils.

RELATIVE DENSITY/CONSISTENCY

Cohesionless Soils	
N Value (blows/ft)	Density Index
0 – 4	Very loose
4 – 10	Loose
10 – 30	Compact
30 – 50	Dense
over 50	Very Dense

Cohesive Soils	
Undrained Shear Strength (kPa)	Consistency
0 – 12 kPa	Very soft
12 – 25 kPa	Soft
25 – 50 kPa	Firm
50 – 100 kPa	Stiff
100 – 200 kPa	Very Stiff
Over 200 kPa	Hard

Notes: Cohesive soils include clay, silty clay, and clayey silt. Amorphous peat may also sometimes be described as cohesive. All other soils are treated as cohesionless. Where the relative density/consistency of a deposit varies randomly, the log should read from least to most (i.e., loose to dense). If the density index/consistency increase or decrease somewhat consistently with depth, the log should read from shallow to deep (i.e., “Dense to loose” if the sand gets gradually loose with depth).

Colour

The colour description should be kept brief and should generally be confined to one or two words only, without the use of suffixes. For the Ottawa area, the more common colour descriptions for soil would be: **Brown, Light brown, Dark brown, Grey brown, Red brown, Grey, Dark grey, and Black**. “Grey brown” is the preferred descriptions for weathered silty clay crust. The transition from grey brown crust to grey silty clay is important for noting a change in the engineering behaviour of clay. If the colour changes part way through a deposit (e.g. from brown to grey with depth), the deposit should be divided into two separate units on the log by a dashed line.

Constituents

The constituents description should be kept brief but complete. The natural soil constituents should generally be limited to the following words: clay, silt, sand, gravel, cobbles, and boulders. The Main Constituents should be a one or two word description, capitalised for native soils. For Ottawa, we use the following classification:

Percentage	Classification	Category	Example
0 – 5	Trace	Minor Constituents	trace silt
5 – 12	Some		some gravel
12 – 30	adjective (“y” ending)	Major Constituents	SILTY SAND; gravelly SAND
> 30	And		SAND and GRAVEL

Notes:

- Local glacial till is commonly described as: (SM) SILTY SAND, some gravel, with cobbles and boulders; grey (GLACIAL TILL); non-cohesive. sandy SILT is also common but the actual composition should be used in the description (i.e., there are clayey silt tills for example). The full term “GLACIAL TILL” should be used on the log. The short form “TILL” is acceptable for sample descriptions only
- The term “with” is used for cobbles and boulders because their presence is inferred from auger resistance but the actual proportion is unknown.
- The upper desiccated stiff portion of the silty clay is generally described as: (CI/CH) SILTY CLAY; grey brown (WEATHERED CRUST).
- The composition of topsoil should be noted. i.e., TOPSOIL silty sand; black.
- Where organic matter is present in a deposit, it should be noted as “organic matter” and not as “organics”. Describe the type of organic matter (roots, wood fragments, etc.)
- In a fill deposit, the constituents of the fill are not capitalised, only the term “FILL”. Crushed stone fill should generally be described as “crushed” with the soil described as above (i.e., sandy gravel) with the identifier “BASE” or “SUBBASE” if appropriate. The maximum particle size can be noted.
- Peat should be described as “fibrous” or “amorphous”
- “SILTY fine SAND” should be used in preference to “fine SILTY SAND”
- Sandy soil should generally be described in the singular as “SAND” and not in the plural form as “SANDS”
- For the “adjective” for a major constituent, SILTY and CLAYEY are always capitalized, whereas sandy and gravelly are written in lower case.

SAMPLE TYPES

The common sample types are: AS – Auger sample, SS – Split Spoon, RC – Rock core (note the size, NQ etc.), CA – Casing sample (i.e., wash boring)
TO – Thin walled open (conventional Shelby tube), and TP – Thin walled piston (Shelby taken with piston sampler)

VANES

- The conventional sequence is to **take a split spoon sample followed by two vanes without advancing the augers**. However, vanes can be substituted for the spoon if doing otherwise would miss the critical vane measurement.
- Vanes are typically taken with the tip 1 foot and then 2 feet past the spoon. After pushing to each depth, waiting 1 minute before turning the undisturbed strength. Then turn the vane 10 full rotations and immediately take the remoulded vane.
- The N vane is most common and preferred. The undisturbed vane is generally taken with the 12 inch position. Remoulds are generally taken with the 6 inch position
- Two “fish” scales are commonly used **and the field coordinator should provide the conversion factor for each individual vane (which should be numbered)**. The vane strength may be obtained as follows: 12 inch handle spacing: Su (kPa) = 2 x spring scale reading x vane coefficient; 6 inch handle spacing: Su (kPa) = spring scale reading x vane coefficient; or, 3 inch handle spacing: Su (kPa) = 0.5 x spring scale reading x vane coefficient.
- In general, the lowest and most critical vane measurement is directly below the weathered crust. N values less than 2 indicate that it may be possible to turn a vane.

ABBREVIATIONS

- Abbreviations may be used for logging the samples on the right side (sample side) of the log. Abbreviations should be avoided on the left side (log side) unless space is restricted. Abbreviations used by the Ottawa office are:
- Colour: Br – Brown, Gr – Grey, Blk – Black, Dk – Dark, Lt – Light
- Composition: Cl – Clay, Si – Silt, Sa – Sand, Grav – Gravel, Cobb – Cobbles, Bldrs – Boulders, B/R – Bedrock, Tps – Topsoil
F – Fine, M – Medium, C - Coarse
- Sampler resistance: PH – Pressure hydraulic (sampler advanced with drill head), PM – Pressure manual (sampler advanced manually), WH – Weight of hammer (sampler advanced by weight of hammer), WR – Weight of rods (sampler advanced by weight of rods)

ADDITIONAL NOTES

- The log should be terminated with “End of Borehole.” “Auger Refusal” should be added if that has occurred.
- When augering through a deposit without sampling, its composition must be inferred from drilling resistance (i.e. grinding on cobbles and boulders) and from cuttings on the augers. The deposit must then be described as “Possibly” and the main constituents should not be capitalized.
- Observations of the groundwater level during drilling or in the open hole prior to backfilling must be noted on the log.
- Except for unusual circumstances of short boreholes with complex stratigraphy, the depth scale should be maintained at 1 foot per division.
- Spoon refusal at the end of a log should be referred to as “Sampler Refusal”. However, sampler refusal is NOT an acceptable substitute for auger refusal if that is the borehole termination criteria. Sampler refusal should generally be avoided to end the borehole, unless target depth is achieved.
- A good sampling procedure on many boreholes is to drive the 2.5 to 4.5 foot spoon, then auger to 5 feet, pull the augers and scrape the hole (to obtain topsoil thickness and shallow stratigraphy), followed by the 5 to 7 foot spoon. Delaying scraping of the hole until completion of the borehole can make identification of the topsoil layer difficult, particularly for boreholes in clay. If fill is suspected on a site, consider taking a spoon from 0.5 to 2.5 feet to assist in defining its thickness, composition, and state of packing.
- Where the transition from one soil type to another occurs within a split spoon sample, both soils can be saved into separate sample bags marked A and B and labelled with the appropriate depth range. (i.e., in the 5'0" – 7'0" spoon, Sa A with depths of 5'0" – 6'3" and Sa B with depths of 6'3" – 7'0". Not top 3" or bottom 7"). Remember that the sample recovered in the split spoon must start from the top of the spoon without gaps.
- The sample moisture condition should be described as either **dry, moist, or wet for cohesionless soils or in relation to the plastic limit for cohesive soils**.
- Unusual odours or appearance of the soil samples should be noted.
- Borehole logs and samples should be returned to the office ideally **at the end of every day or at the end of the job** to avoid potential loss of information. On a long or out of town project, photos of the logs should be sent to the Project Manager at the end of each day. If the borehole is part of a geotechnical/environmental project, send a photo or a copy of the boreholes to the **Environmental Lead at the end of each day**.
- No garbage should be left on the site, either by GEMTEC staff or the drilling contractor. Our clients expect us to leave a clean site!
- The logs should be returned with the field file folder marked with job number and name and also containing the field plan and other paperwork. The logs should be converted to metric in RED PEN before being given to the project engineer. **Note: 1 foot = 0.3048 m 1 kPa = 20.9 PSF**

SUPPLIES CHECKLIST

Borehole Log Sheets, Clip Board, Sample Bags, Shelby Caps And Spacers, Straight Edge, Tape Measure, Long Tape, MTO N Vane, Fish Scales, Pen/Pencil
PPE Required: High Visibility Vest, Hard Hat, Hearing Protection, Safety Glasses, Nitril Gloves (Enviro Sampling).



APPENDIX D

Testpit Field Log Templates

Testpit Field Log Sample # 1

JOB

DATE May 26/05 PAGE 1 of 6

TP - 2

Depth (m) Description

Thin topping of crushed gravel & dust
0-0.2 OK brn sand so grav tr si (FILL)
0.2-0.5 Lt brn si sa so grav tr cl (FILL)
0.5-0.8 gr brn si cl tr grav tr org
cobbles (FILL)
0.8-2.70 gr br si cl tr grav cobbles
(FILL)

2.70 Refusal (Weathered bedrock)

Test Pit dry upon completion

Backfilled native.

SA1 0.0 - 0.2

SA2 0.2 - 0.5

SA3 0.5 - 0.8

SA4 2.0 - 2.2



Cansel

PARTY CHIEF

WEATHER

Testpit Field Log Sample # 2

JOB

DATE May 26/05 PAGE 2 of 6

TP - 1

Depth (mm) Description

0-50 Asphaltic concrete
50-230 Gr. crushed stone. (BASE)
230-310 Br sa and grav. (SUBBASE)
310-2200 Gr br si cl tr to so
grav si sa pockets
cobbles and boulders
(FILL)
2200 REFUSAL (prob. Weathered
BIR)

Water Seeping in at 2200 mm depth

Backfill Native.

SA1 50-230

SA2 230-310

PARTY CHIEF

WEATHER



Cansel

JOB Testpit Field Log Sample # 3

DATE July 28/04 PAGE 3 of 12

Test Pit #1

0-150 Topsoil

150-1450 Blast rock and masonry
discards

1400-2150 fi sa, so grav (FILL)
SA1 1750-2150 adjacent
to poured ftg.

2150-4200 gr br si cl (W. Crust)
SA 2 2150-2350
SA 3 2450-2650

Vane1 @ 2700mm > 130 kPa

SA#4 2700-2900

Vane 2 @ 2950mm > 130 kPa

SA 5 3100-3300

Vane 3 @ 3450 > 130 kPa

SA 6 3550-3750

Vane 4 @ 3800 52 kPa


Cansel

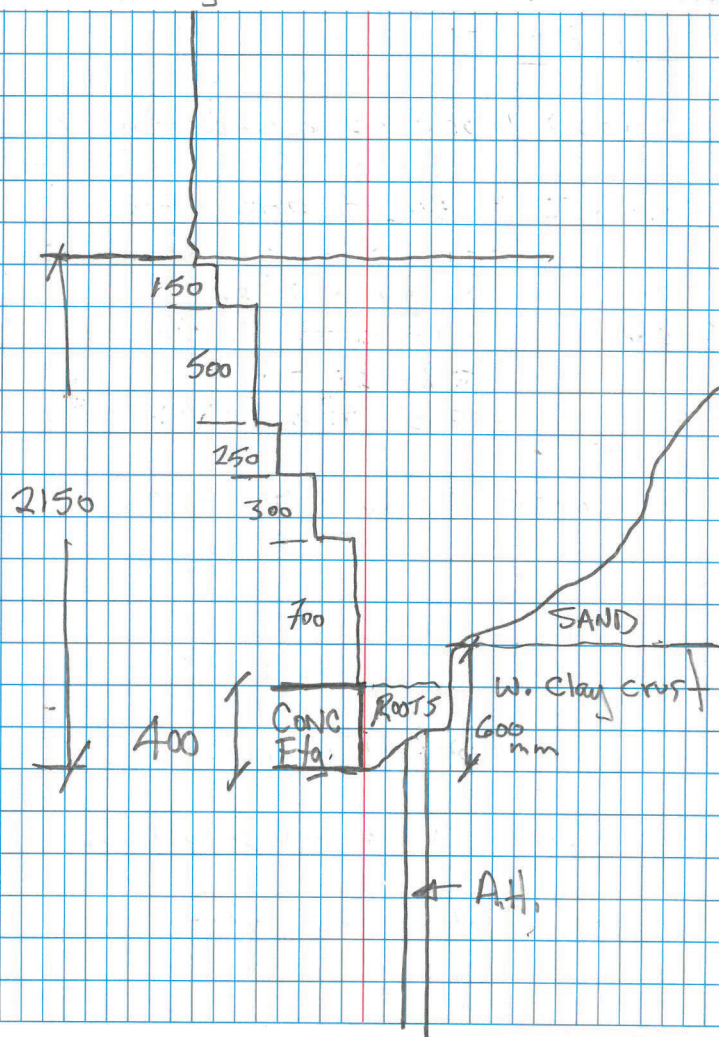
PARTY CHIEF

WEATHER

JOB

North side of face

DATE July 28/04 PAGE 4 of 12



PARTY CHIEF

WEATHER


Cansel

JOB

Testpit Field Log Sample # 3 (cont'd)

DATE

July 28/04 PAGE 5 of 12

Test Pit #1 cont'd

Vane 5 @ 3850 60 kPa

SA 7 3900 - 4050

Vane 6 @ 4100 50 kPa

Vane 7 @ 4150 70 kPa

4200 - 4650 gr si cl

SA 8 4200 - 4400

Vane 8 @ 4250 40 kPa

Vane 9 @ 4300 48 kPa

SA 9 4500 - 4650

Vane 10 @ 4700 44 kPa

Vane 11 @ 4750 60 kPa

4750 end of tp/auger hole

Upon completion no free water.



Cansel

PARTY CHIEF

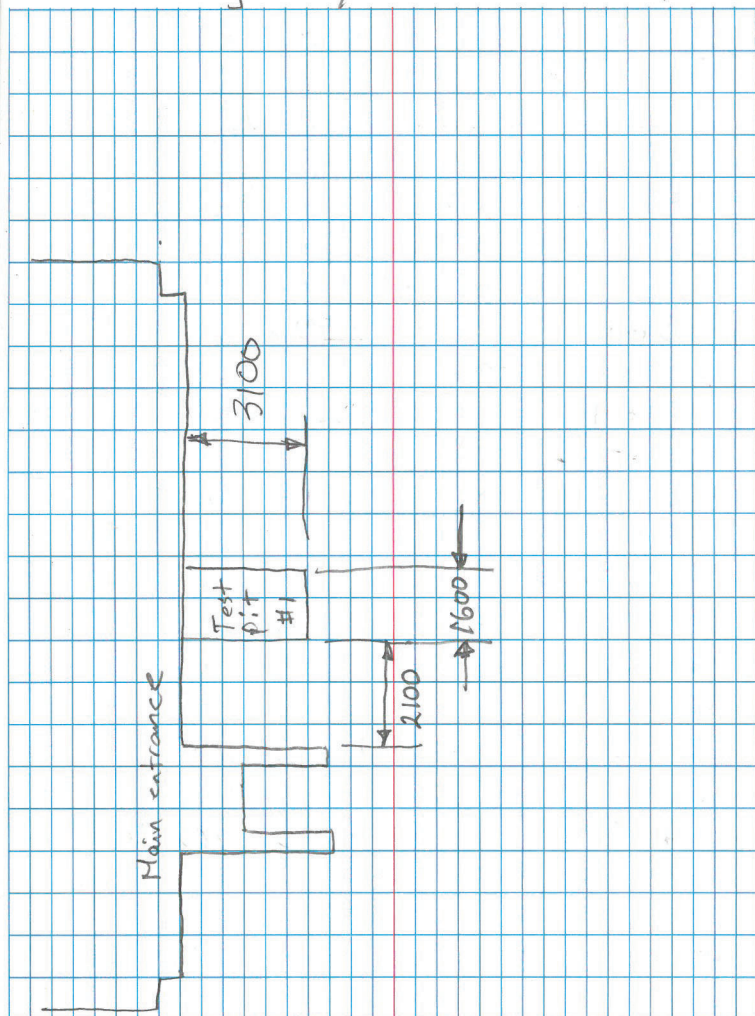
WEATHER

JOB

Testpit Field Log Sample # 3 (cont'd)

DATE

July 28/04 PAGE 6 of 12

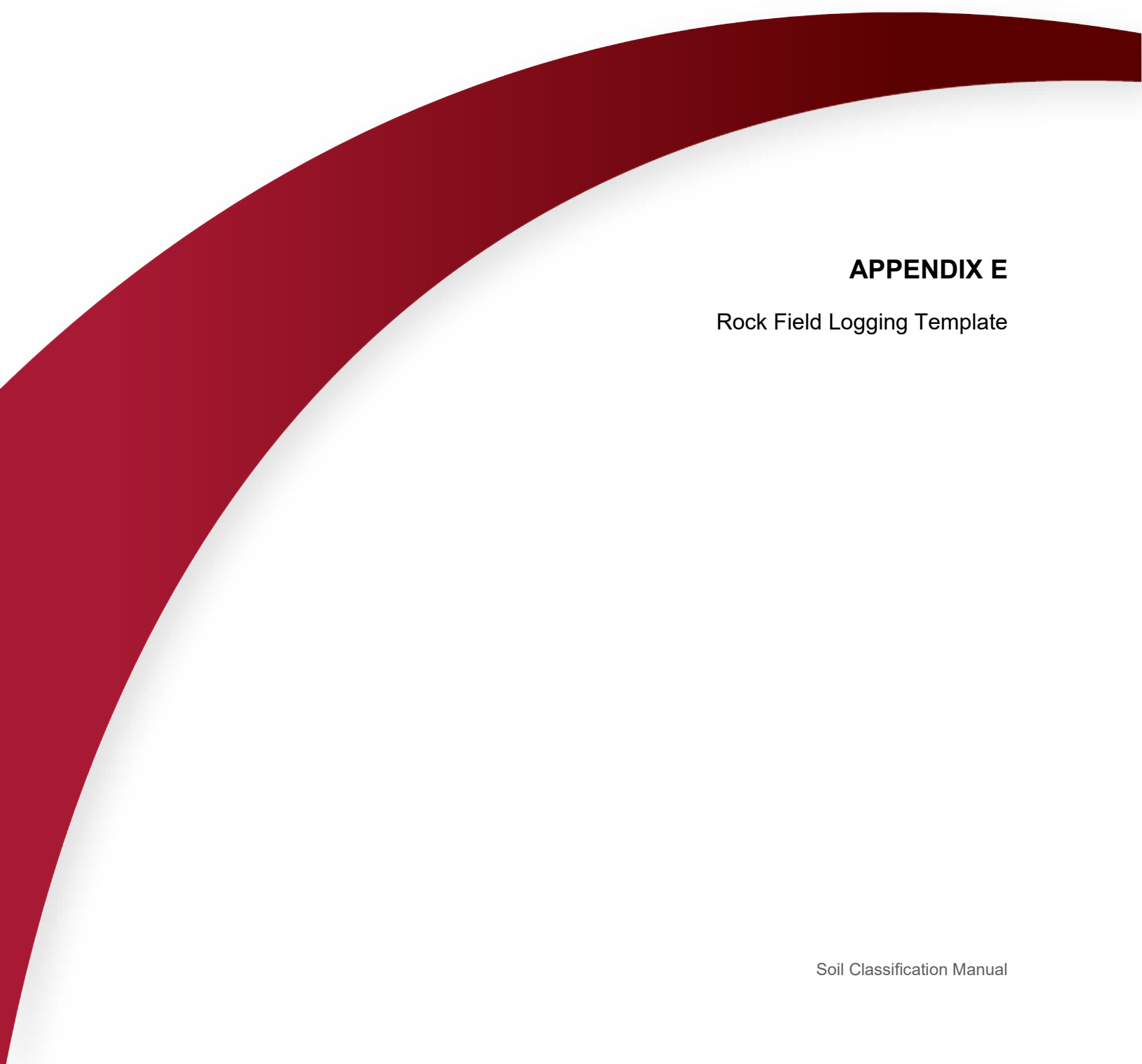


PARTY CHIEF

WEATHER



Cansel



APPENDIX E

Rock Field Logging Template

BASIC ROCK LOGGING TEMPLATE - GEMTEC Ottawa

FIELD BOREHOLE LOG

JOB No. 100100-XXX JOB NAME CLIENT/STRUCTURE/OTTAWA DATE DEC 13, 2022 BOREHOLE No. 22-01
BH. LOCATION NW CORNER OF LOT ELEVATION (obtained from) DATUM
TYPE OF RIG CME 55-TRACK CONTRACTOR DOWNING DRILLER JOE L-
CASING HAMMER WT. LB. DROP INCHES SAMPLER HAMMER WT. 140 LB. DROP 30 INCHES
TEMPERATURE 5 °C WEATHER SUNNY

	SAMPLE CONDITIONS	A.S. - AUGER SAMPLE	D.O. - DRIVE OPEN	SA. - SAMPLE	WH. - WEIGHT, HAMMER
	DISTURBED	C.S. - CHUNK SAMPLE	T.O. - THIN-WALLED, OPEN	CA. - CASING	PH. - PRESSURE, HYDRAULIC
	FAIR	W.S. - WASH SAMPLE	T.P. - THIN-WALLED, PISTON	WL. - WATER LEVEL	PM. - PRESSURE, MANUAL
	GOOD	D.S. - DENISON SAMPLE	S.T. - SLOTTED TUBE	V. - IN SITU VANE SHEAR TEST	PL. - PRESSURE, LEVER
	LOST	F.S. - FOIL SAMPLE	R.C. - ROCK CORE		

METHOD	CASING	SOIL STRATIGRAPHY		BLOWS/FT.	DEPTH	% WATER RETURN	SAMPLES					SAMPLE DESCRIPTIONS AND BORING NOTES	
		DESCRIPTION	DEPTH				COND.	TYPE	No.	RECOV.	FORCE	TIME	DEPTH OF HOLE
												DEPTH TO W.L.	DEPTH OF CASING
		GROUND SURFACE			0								

OVERBURDEN LOGGING

10.5	NW	Moderately weathered grey black SHALE, thinly lam. to laminated very weak rock	10.3	10						FI			RC 1 10'3" to 12'7"
										>10			TCR = 25/28 = 89%
										>10			SCR = 8/28 = 29%
		Slightly weathered grey, LIMESTONE	11.5	11	8%		RC 1			>10			RQD = 6/28 = 21%
		thinly bedded, weak to medium strong rock		12						>10			ROOTS DROPPED 2" @ 11'6"
				13	25%								SHALE TO 11'6"
			14.0	14					4				LIMSTN TO 12'7"
		Fresh, grey LIMESTONE		15					2				RC 2 12'7" to 17'7"
		thinly to medium bedded medium strong rock		16	100%		RC 2						12'7" to 14'0"
				17					1				TCR = 17/17 = 100%
			17.6	18					0				SCR = 9/17 = 53%
													RQD = 7/17 = 41%
													14'0" to 17'7"
													TCR = 43/43 = 100%
													SCR = 41/43 = 95%
													RQD = 43/43 = 100%
													SW to 14'0"
													FRESH TO 17'7"

SPECIAL NOTES: (Groundwater conditions etc.)

TIME _____ HOURS PRODUCTIVE _____
HOURS STANDBY _____ HOURS DELAYED _____
DEPTH OF HOLE 17'7" DEPTH OF CASING _____ DEPTH TO W.L. 6'
ENGINEER Bill Carr (PRIOR TO CORING)

General Notes

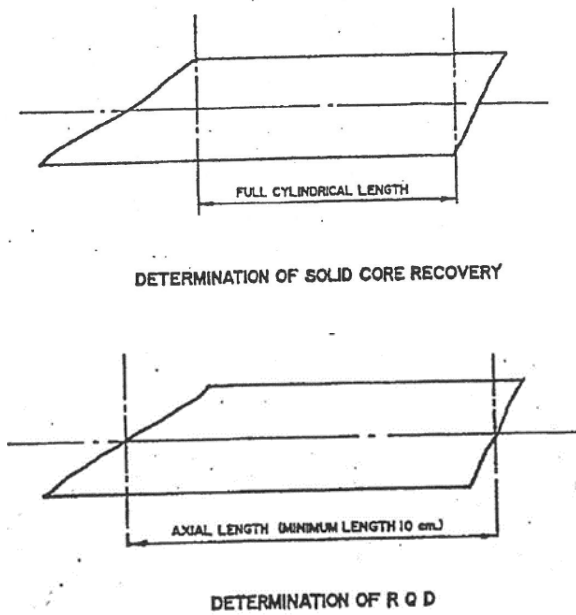
- Triple tube coring (i.e., NQ3 or HQ3) should always be used unless the PM or engineer indicates double tube coring equipment may be used.
- Core runs can be broken up by RQD to differentiate between highly fractured and better quality rock mass.

Total Core Recovery (TCR)

- TCR is total amount of core recovered over measured length drilled for each core run.
- Length of broken core should be included and estimated as its true length in ground (not as it looks in core box).
- Core Loss – important to identify, can be indicative of weak/highly fractured zones.
- Rubble/slough that has fallen into the drill hole and recovered at the top of a core lift should not be counted as recovered core.

Solid Core Recovery

- Percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the core run.



Rock Quality Designation (RQD)

- RQD is cumulative length of all pieces of core greater than 10cm in length from the mid-point of one natural fracture to the mid-point of the next natural fracture.
- Mechanical, drill-induced breaks should not count toward RQD. If uncertain count as a natural fracture.
 - Mechanical breaks / drill induced: clean, fresh, irregular surfaces, oriented close to 90°, rejoined with hairline separation, etc.
 - Natural fractures: stained surfaces, weathered, contain infilling/coatings, occur at some angle other than perpendicular, cannot be rejoined clearly, etc.
- Special Case: Single fracture sub-parallel to core axis (within about 10°): sound core with a single sub-parallel fracture is counted as intact rock and assigned RQD of 100%.

Fracture Index

- A count of the number of natural discontinuities in the rock core over a specified length (typically 30 cm).

Field Strength

Grade	Description	Field Identification	Approx Range of UCS Strength (MPa)
R6	Extremely strong	Specimen can only be chipped with geological hammer	>250
R5	Very strong	Specimen requires many blows of geological hammer to fracture it	100-250
R4	Strong	Specimen requires more than one blow of geological hammer to fracture it	50-100
R3	Medium strong	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer	25-50
R2	Weak	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer	5-25
R1	Very weak	Crumbles under firm blows with point of geological hammer	1-5
R0	Extremely weak	Indented by thumbnail	0.25-1

Weathering

- Qualitative measure of the degree of weathering (chemical alteration).
- Assess weathering on each interval

Term	Symbol	Description	Discoloration Extent	Fracture Condition	Surface Characteristics
Fresh	W1	No visible signs of rock material weathering	None	Closed or Discoloured	Unchanged
Slightly Weathered	W2	Discolouration indicates weathering of rock material on discontinuity surfaces. Less than 5% of rock mass altered	<20% of fracture spacing on both sides of fracture	Discoloured, may contain thin filling	Partial discolouration
Moderately Weathered	W3	Less than 50% of the rock material is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as corestones	>20% of fracture spacing on both sides of fracture	Discoloured, may contain thick filling	Partial to complete discolouration, not friable except poorly cemented rocks
Highly Weathered	W4	More than 50% of the rock material is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as corestones	Throughout	Filled with alteration minerals	Friable and possibly pitted
Completely Weathered	W5	100% of rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact	Throughout	Filled with alteration minerals	Resembles soil
Residual Soil	W6	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported	Throughout	N/A	Resembles soil

BEDDING THICKNESS

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



APPENDIX F

Field Shear Vane Memo

March 20, 2023

File: Office Admin – Geotechnical

To: Geotechnical Group

From: Bill Cavers, Senior Geotechnical Engineer

Lauren Ashe, Manager of Geotechnical Services

Re: Field Shear Vane Testing and Coefficients

This memorandum provides the basis for assessing the field shear vane coefficients and some practical guidance for carrying out the testing.

FIELD VANE COEFFICIENT

The standard vane in Ontario for carrying out field shear vane testing in clays is the Ministry of Transportation (MTO) N-vane (sometimes referred to as the 'Standard N-vane'). The dimensions of the N-vane are indicated in Figure 1.

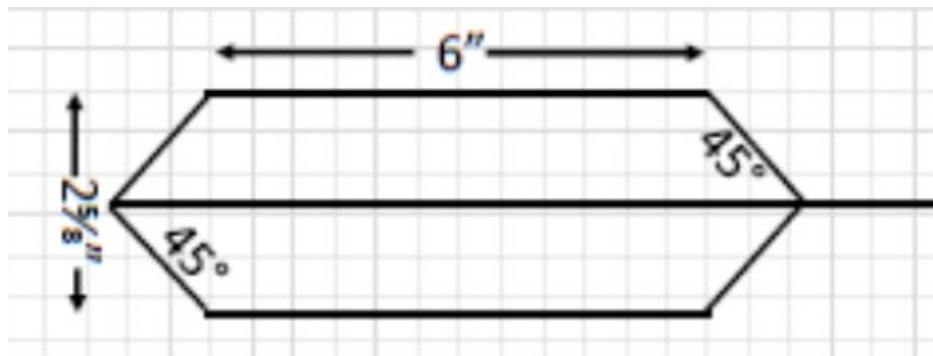


Figure 1: Standard N-Vane

The coefficients to be used to obtain the peak shear strength value (S_u), from the torque required to shear (fail) the soil during turning of the vane, can be obtained from ASTM 2573/2573M-18 using the following formula:

$$(s_u)_{fv} = \frac{12 \times T}{\pi D^2 \cdot \left(\frac{D}{\cos(i_T)} + \frac{D}{\cos(i_B)} + 6H \right)} \times K$$

where:

$(S_u)_{fv}$ = peak undrained shear strength from the vane (lbs/ft²)

T = measured maximum torque at failure (lbs·ft)

D = vane diameter in feet (2 5/8" or 0.219 feet for an N-vane)

i_T = angle at top of vane (45° for an N-vane)

i_B = angle at bottom of vane (45° for an N-vane)

H = Height of vane between angles in feet (6 inches or 0.5 feet for an N-vane)

K = unit constant; equal to one for values in feet and pounds

The resulting vane coefficient for an N-vane is 20.8 and the obtained $(S_u)_{fv}$ value in lbs/ft² is equal to 20.8T. Converting to kPa (20.885 lbs/ft² per kPa) the final result is:

$$(S_u)_{fv} = 0.997T, \text{ where } T \text{ is in lbs·ft and } (S_u)_{fv} \text{ is in kPa}$$

There is an argument to be made that the coefficient obtained above is unconservative since it does not account for the torque created by the vane shaft. The torque required to overcome shaft resistance is difficult to quantify since it is a function of clay shear strength and the adhesion factor (a) which varies with the shaft material as well as the clay. Various researchers have suggested adhesion values ranging from 0.25 to 0.5 for shear vane testing. Figure 2 provides a graph of the torque to overcome shaft resistance for various adhesion values and clay strengths:

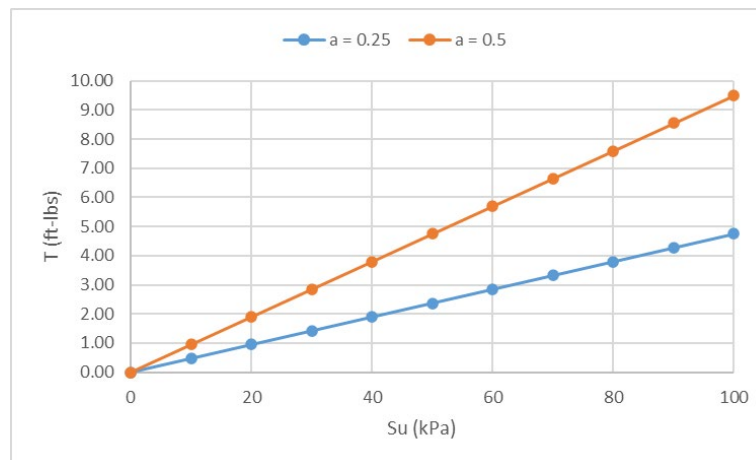


Figure 2: Torque to overcome shaft friction versus clay shear strength.

Based on Figure 2, the torque to overcome shaft friction may range from about 5 to 10% of the measured S_u value (depending on the assumed adhesion value). This also assumes that the vane is embedded to a depth of 18 inches below the lead end of the auger, which is not always the case. The first vane is often taken 12 inches below the auger and therefore the shaft length for the purpose of the above calculation will be 4 inches, not the full shaft length (10 inches). Or about 40% of 10%, assuming the upper bound of a 10% reduction, which would be a 4% reduction of the vane coefficient. The final, reasonably conservative, coefficient for an N-vane would therefore be:

$$(S_u)_{fv} = (0.96 \times 0.997)T$$

$$(S_u)_{fv} = 0.96T$$

again, where T is in lbs·ft and $(S_u)_{fv}$ is in kPa.

The above should not be assumed for any vane and all vanes should be measured and the vane coefficients calculated. A check of a recent shipment of N-vanes indicates the diameters are all consistently less than 2 5/8" and the resulting coefficient for estimating the shear strength for those vanes is 0.99 (versus the 0.96 indicated above).

The coefficient outlined above is applied to the full torque value, which if measured using a torque wrench, is the wrench reading. If using two spring scales and the T-handle, T is the torque which is the spring scale reading multiplied by 2 and then multiplied by the arm length in feet. This can be simplified to:

- 12 inch handle spacing: S_u (kPa) = 2 x spring scale reading x vane coefficient;
- 6 inch handle spacing: S_u (kPa) = spring scale reading x vane coefficient; or,
- 3 inch handle spacing: S_u (kPa) = 0.5 x spring scale reading x vane coefficient.

GENERAL NOTES FOR FIELD SHEAR VANE TESTING

The following should be considered for all field shear vane testing:

- Torque wrenches require at least annual calibration and should be maintained by the GEMTEC office (not the drillers).
- Spring scales should be calibrated monthly using known weights and discarded if out by more than 2 pounds.

- Spring scales should be checked in the field before use by hooking them together and pulling through the full range to check for agreement.
- All vanes should be measured, the vane coefficient calculated in accordance with the above procedure and numbered prior to use in the field. Mich Lalonde in the Ottawa office looks after the vanes (for that office) and will provide a numbered vane with a known coefficient for use.
- The vane number should be recorded on the log.
- If using a non-standard or driller supplied vane, measure and record all the vane dimensions.
- Check vanes before going to the field and do not use damaged (i.e., twisted or bent) vanes. Immediately return all damaged vanes to Mich for repair or replacement.
- Tighten all joints (including the T-handle or drive nut) with wrenches.
- The vane test depth is the depth to the tip of the vane.
- Maximum torque on the vane is 100 ft-lbs (50 pounds if using spring scales at the 12 inch arm position).
- Remould tests should be carried out by rotating the vane through 5 complete revolutions and then immediately testing. Ideally, start by using the 3 inch position on the handle for the remould test and only switch to the 6 inch position if needed.
- Vanes should always be carried out in sets of two (since the first vane may be in disturbed soil).
- Record the vane depth, handle position (i.e., 12, 6 or 3 inch position) and scale (or wrench) reading on the log.
- Complete the conversion to shear strength in kPa on the log (ideally in red pen).
- Clean the vane between tests and at the end of the days testing.

experience • knowledge • integrity



civil	civil
geotechnical	géotechnique
environmental	environnement
structural	structures
field services	surveillance de chantier
materials testing	service de laboratoire des matériaux

expérience • connaissance • intégrité



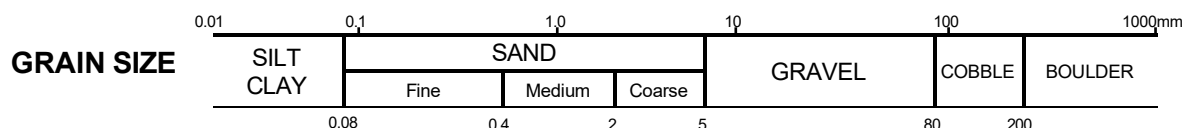
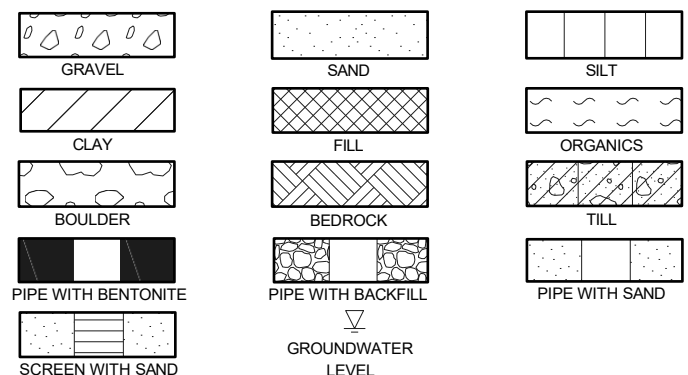
ABBREVIATIONS AND TERMINOLOGY USED ON RECORDS OF BOREHOLES AND TEST PITS

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



DESCRIPTIVE TERMINOLOGY

TRACE	SOME	ADJECTIVE	noun > 30% and main fraction
trace clay, etc	some gravel, etc.	silty, etc.	sand and gravel, etc.

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING STATE	
Fresh	No visible sign of rock material weathering
Faintly weathered	Weathering limited to the surface of major discontinuities
Slightly weathered	Penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material
Moderately weathered	Weathering extends throughout the rock mass but the rock material is not friable
Completely weathered	Rock is wholly decomposed and in a friable condition but the rock and structure are preserved

CORE CONDITION
Total Core Recovery (TCR) The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run
Solid Core Recovery (SCR) The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.
Rock Quality Designation (RQD) The percentage of solid drill core, greater than 100 mm length, as measured along the centerline axis of the core, relative to the length of the total core run. RQD varies from 0% for completed broken core to 100% for core in solid segments.

BEDDING THICKNESS	
Description	Thickness
Thinly laminated	< 6 mm
Laminated	6 - 20 mm
Very thinly bedded	20 - 60 mm
Thinly bedded	60 - 200 mm
Medium bedded	200 - 600 mm
Thickly bedded	600 - 2000 mm
Very thickly bedded	2000 - 6000 mm

DISCONTINUITY SPACING	
Description	Spacing
Very close	20 - 60 mm
Close	60 - 200 mm
Moderate	200 - 600 mm
Wide	600 - 2000 mm
Very wide	2000 - 6000 mm

ROCK QUALITY	
RQD	Overall Quality
0 - 25	Very poor
25 - 50	Poor
50 - 75	Fair
75 - 90	Good
90 - 100	Excellent

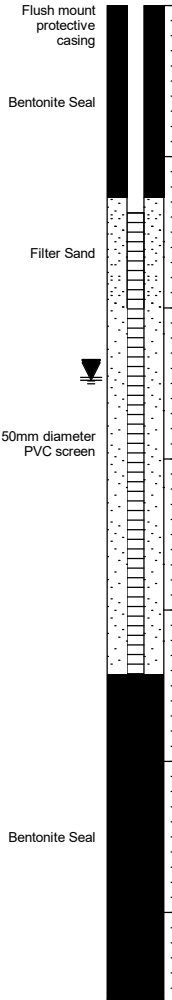
ROCK COMPRESSIVE STRENGTH	
Comp. Strength, MPa	Description
1 - 5	Very weak
5 - 25	Weak
25 - 50	Moderate
50 - 100	Strong
100 - 250	Very strong

RECORD OF BOREHOLE 25-01

CLIENT: E-Landscaping
 PROJECT: Geotechnical Investigation, Proposed Development, 5872, 5880, and 5884 Hazeldean Road and 7 Savage Drive, Ottawa, Ontario
 JOB#: 104054.001
 LOCATION: See Figure 1, Site Plan

SHEET: 1 OF 1
 DATUM: CGVD28
 BORING DATE: Apr 30 2025

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES				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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
0	Power Auger	Ground Surface		109.51	1	SS	100	13	●																							Flush mount protective casing																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
		FILL - (GP-GM) sandy gravel, some non-plastic fines; grey brown; non-cohesive, moist, compact			2	SS	0	>50																										Bentonite Seal																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
1	Hollow Stem Auger (210mm OD)	Moderately weathered to fresh, thinly bedded, very strong LIMESTONE BEDROCK		108.60	3	RC		TCR=	100%	SCR=	100%	RQD=	100%																							Filter Sand																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
				0.91	4	RC		TCR=																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						



GROUNDWATER OBSERVATIONS		
DATE	DEPTH (m)	ELEV. (m)
25/05/09	2.48	107.0
25/06/04	2.46	107.1

RECORD OF BOREHOLE 25-02

CLIENT: E-Landscaping
 PROJECT: Geotechnical Investigation, Proposed Development, 5872, 5880, and 5884 Hazeldean Road and 7 Savage Drive, Ottawa, Ontario
 JOB#: 104054.001
 LOCATION: See Figure 1, Site Plan

SHEET: 1 OF 1
 DATUM: CGVD28
 BORING DATE: Apr 30 2025

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES				PENETRATION RESISTANCE (N), BLOWS/0.3m		SHEAR STRENGTH (Cu), kPa		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	● PENETRATION RESISTANCE (N), BLOWS/0.3m	▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	+ NATURAL ⊕ REMOULDED			
											WATER CONTENT, %			
0	Power Auger Hollow Stem Auger (210mm OD)	Ground Surface		108.92									UCS	Flush mount protective casing Bentonite Seal Filter Sand 50mm diameter PVC screen Bentonite Seal
		ASPHALTIC CONCRETE		108.82										
		FILL - (GM-GM) sandy gravel, some non-plastic fines; grey; non-cohesive, moist, compact		0.10	1	SS	205	25						
					2	SS	0	>50						
1	Hollow Stem Auger (210mm OD)				3	RC								
		Highly fractured, grey, LIMESTONE BEDROCK		107.80	4	RC		TCR=	100%	SCR= 0%	RQD= 0%			
				1.12										
	Diamond Rotary Core HQ (89mm OD)				5	RC		TCR=	90%	SCR= 45%	RQD= 18%			
		Slightly weathered to fresh, grey, thinly bedded to medium, strong, LIMESTONE BEDROCK		107.28	6	RC		TCR=	100%	SCR= 100%	RQD= 62%			
2				1.64										
					7	RC		TCR=	96%	SCR= 25%	RQD= 25%			
3	Diamond Rotary Core HQ (89mm OD)													
						8	RC		TCR=	96%	SCR= 96%	RQD= 91%		
4														
5														
		End of Borehole		103.72										
				5.20										
6														
7														
8														
9														
10														

GROUNDWATER OBSERVATIONS		
DATE	DEPTH (m)	ELEV. (m)
25/05/09	0.78	108.1
25/06/04	0.77	108.2

GEO - BOREHOLE LOG 104054.001_BH LOGS_2025-05-14_REVA_PS.GPJ GEMTEC 2018.GDT 6/27/25

RECORD OF BOREHOLE 25-03

CLIENT: E-Landscaping
PROJECT: Geotechnical Investigation, Proposed Development, 5872, 5880, and 5884 Hazeldean Road and 7 Savage Drive, Ottawa, Ontario
JOB#: 104054.001
LOCATION: See Figure 1, Site Plan

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: May 1 2025

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES				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
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m					
0	Power Auger	Ground Surface		109.97								M	Flush mount protective casing
		FILL - (SP/GM) sandy gravel, some non-plastic fines; grey brown; non-cohesive, moist, compact			1	SS	150	19					
1	Hollow Stem Auger (210mm OD)			108.90	2	RC						UCS	Bentonite Seal
		Moderately fractured, grey LIMESTONE BEDROCK		1.07	3	RC		TCR=	83%; SCR= 50%; RQD= 0%				
		Moderately weathered to fresh, grey, thinly bedded to medium, very strong, LIMESTONE BEDROCK		108.62	4	RC		TCR=	100% SCR= 60%; RQD= 32%				
				1.35									
2					5	RC		TCR=	100% SCR= 47%; RQD= 47%				
3													
4					6	RC		TCR=	100% SCR= 100%; RQD= 100%				
5													
6	Diamond Rotary Core HQ (89mm OD)				7	RC		TCR=	100% SCR= 100%; RQD= 100%				
7					8	RC		TCR=	100% SCR= 100%; RQD= 100%				
8												UCS	Bentonite Seal
9					9	RC		TCR=	100% SCR= 93%; RQD= 87%				
10		End of Borehole		100.14									
				9.83									

GROUNDWATER OBSERVATIONS		
DATE	DEPTH (m)	ELEV. (m)
25/05/09	1.40	108.6
25/06/04	1.53	108.4

RECORD OF BOREHOLE 25-04

CLIENT: E-Landscaping
PROJECT: Geotechnical Investigation, Proposed Development, 5872, 5880, and 5884 Hazeldean Road and 7 Savage Drive, Ottawa, Ontario
JOB#: 104054.001
LOCATION: See Figure 1, Site Plan

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Apr 30 2025

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES				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
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m						
0	Power Auger Hollow Stem Auger (210mm OD)	Ground Surface		109.11										
		ASPHALTIC CONCRETE	XXXX	109.00	1	SS	0	>50						Auger Cuttings 
		FILL- (GP-GM) sandy gravel, trace non-plastic fines; grey; non-cohesive, moist, very dense		108.41										
		End of Borehole		0.20										
		Auger Refusal												
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														

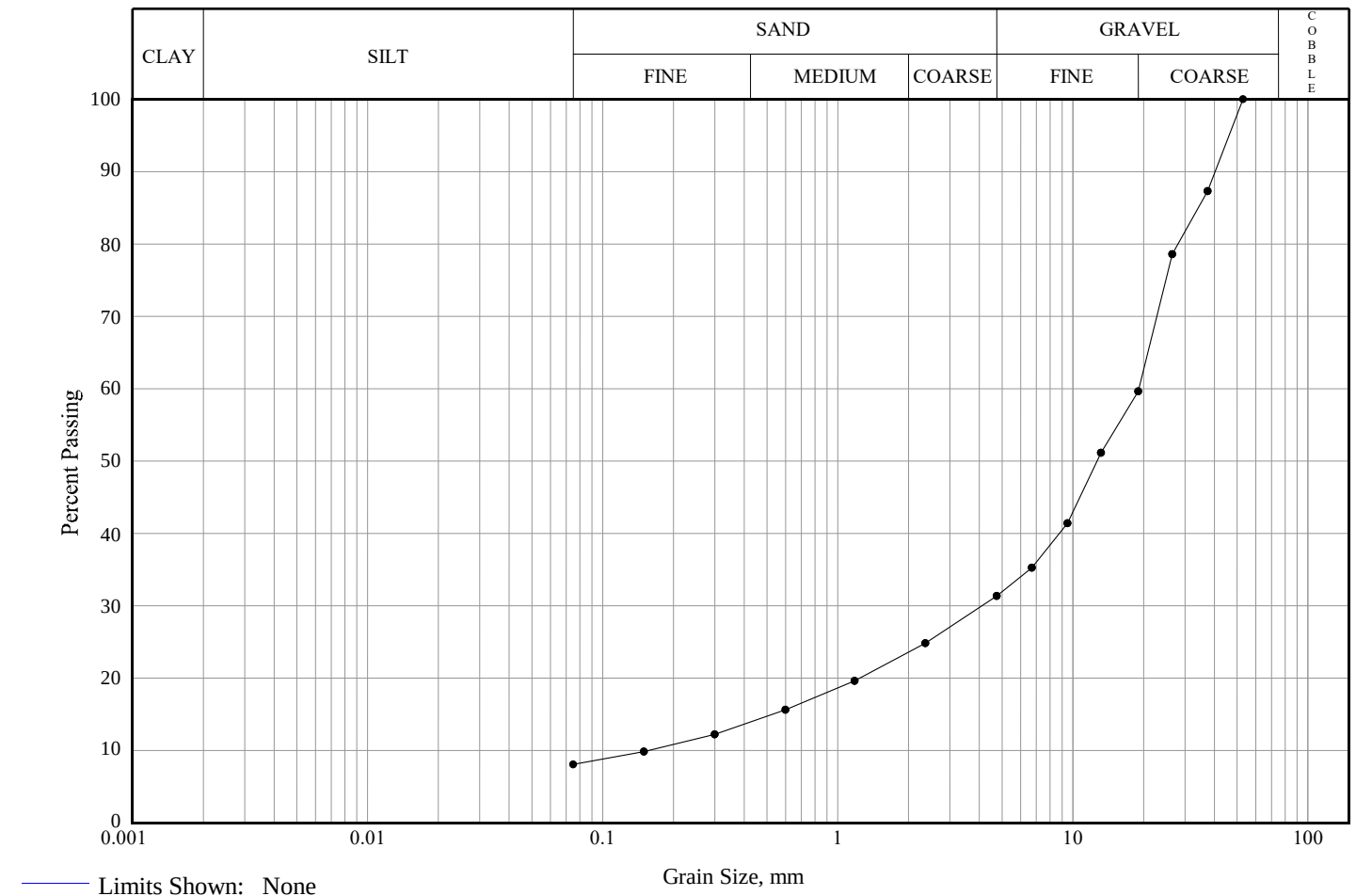
GEO - BOREHOLE LOG 104054.001 BH LOGS 2025-05-14 REVA_PS.GPJ GEMTEC 2018.GDT 6/27/25



APPENDIX B

Laboratory Testing Results Grain Size Distribution Chart

 GEMTEC CONSULTING ENGINEERS AND SCIENTISTS	Client: E-Landscaping	Soils Grading Chart
	Project: Hazeldean Heights Inc	
	Project #: 104054001	



Line Symbol	Sample	Borehole/ Test Pit	Sample Number	Depth	% Cob.+ Gravel	% Sand	% Silt	% Clay
—●—	FILL MATERIAL	25-03	GS1	0.0-0.61	68.7	23.3	8.1	

Line Symbol	CanFEM Classification	USCS Symbol	D ₁₀	D ₁₅	D ₃₀	D ₅₀	D ₆₀	D ₈₅	% 5-75µm
—●—		N/A	0.158	0.531	4.11	12.71	19.13	34.22	---

Note: More information available upon request



APPENDIX C

Bedrock Core Photographs
Figures C1 to C6

Unconfined Compressive Strength Test Results

BOREHOLE: 25-01
BORING DATE: APRIL 30, 2025
DEPTH: 0.81 TO 6.58 METRES BELOW GROUND SURFACE



NOTE: MATERIAL IN CORE BOX FROM 0.81 TO 0.91 METRES BELOW GROUND SURFACE IS GRAVEL WITHIN FILL MATERIAL



32 Steacie Drive, Ottawa, ON K2K 2A9
 T: (613) 836-1422 | www.gemtec.ca | ottawa@gemtec.ca

Project
 GEOTECHNICAL INVESTIGATION
 PROPOSED DEVELOPMENT
 5872, 5880, AND 5884 HAZELDEAN ROAD,
 AND 7 SAVAGE DRIVE
 OTTAWA, ONTARIO

Drawing
 ROCKCORE PHOTOGRAPH
 BOREHOLE 25-01 (DRY)

Project No. 104054.001	Drwn By SL	Chkd By CC	Rev No. 0	Date JUNE 2025
---------------------------	---------------	---------------	--------------	-------------------

FIGURE C1

BOREHOLE: 25-01
BORING DATE: APRIL 30, 2025
DEPTH: 0.81 TO 6.58 METRES BELOW GROUND SURFACE



NOTE: MATERIAL IN CORE BOX FROM 0.81 TO 0.91 METRES BELOW GROUND SURFACE IS GRAVEL WITHIN FILL MATERIAL



32 Steacie Drive, Ottawa, ON K2K 2A9
T: (613) 836-1422 | www.gemtec.ca | ottawa@gemtec.ca

Project
GEOTECHNICAL INVESTIGATION
PROPOSED DEVELOPMENT
5872, 5880, AND 5884 HAZELDEAN ROAD,
AND 7 SAVAGE DRIVE
OTTAWA, ONTARIO

Drawing
ROCKCORE PHOTOGRAPH
BOREHOLE 25-01 (WET)

Project No.
104054.001

Drwn By
SL

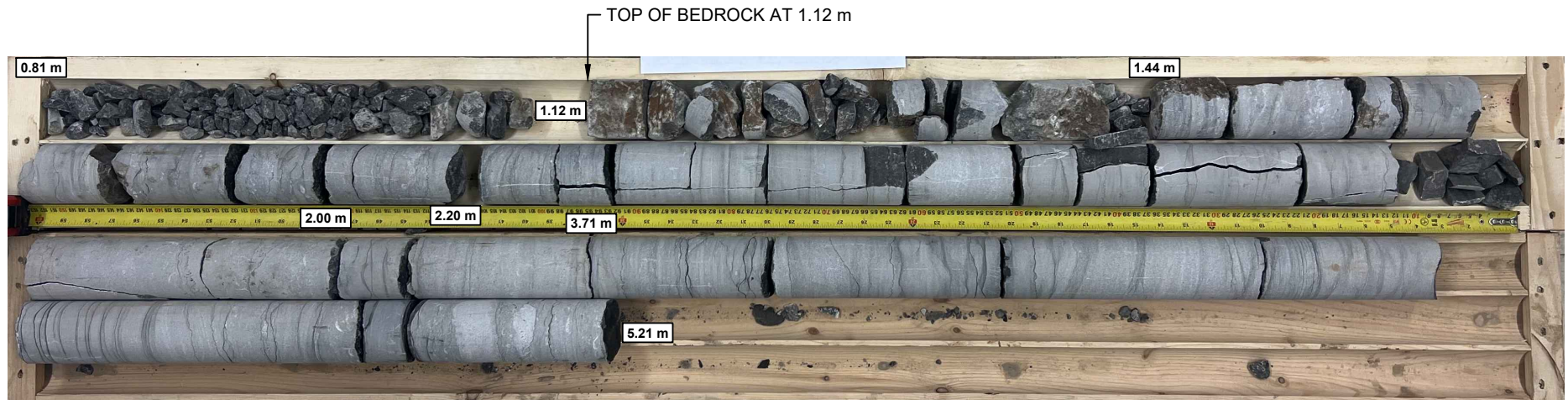
Chkd By
CC

Rev No.
0

Date
JUNE 2025

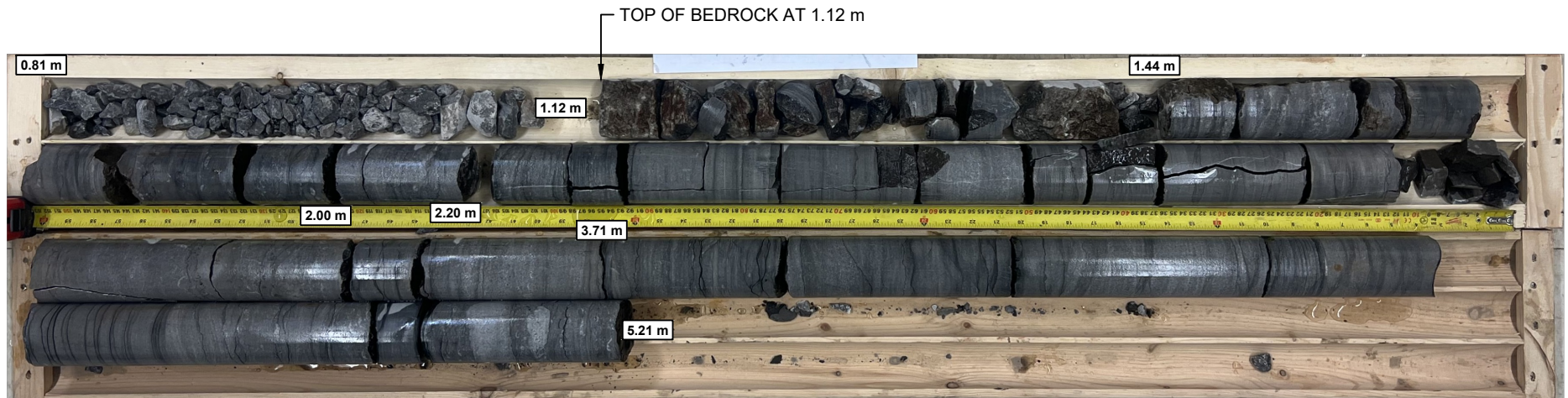
FIGURE C2

BOREHOLE: 25-02
BORING DATE: APRIL 30, 2025
DEPTH: 0.81 TO 5.21 METRES BELOW GROUND SURFACE



NOTE: MATERIAL IN CORE BOX FROM 0.81 TO 1.12 METRES BELOW GROUND SURFACE IS GRAVEL WITHIN FILL MATERIAL

BOREHOLE: 25-02
BORING DATE: APRIL 30, 2025
DEPTH: 0.81 TO 5.21 METRES BELOW GROUND SURFACE



NOTE: MATERIAL IN CORE BOX FROM 0.81 TO 1.12 METRES BELOW GROUND SURFACE IS GRAVEL WITHIN FILL MATERIAL



32 Steacie Drive, Ottawa, ON K2K 2A9
T: (613) 836-1422 | www.gemtec.ca | ottawa@gemtec.ca

Project
**GEOTECHNICAL INVESTIGATION
PROPOSED DEVELOPMENT**
5872, 5880, AND 5884 HAZELDEAN ROAD,
AND 7 SAVAGE DRIVE
OTTAWA, ONTARIO

Drawing			
ROCKCORE PHOTOGRAPH BOREHOLE 25-02 (WET)			
Project No.	Drwn By	Chkd By	Rev No.
104054.001	SL	CC	0

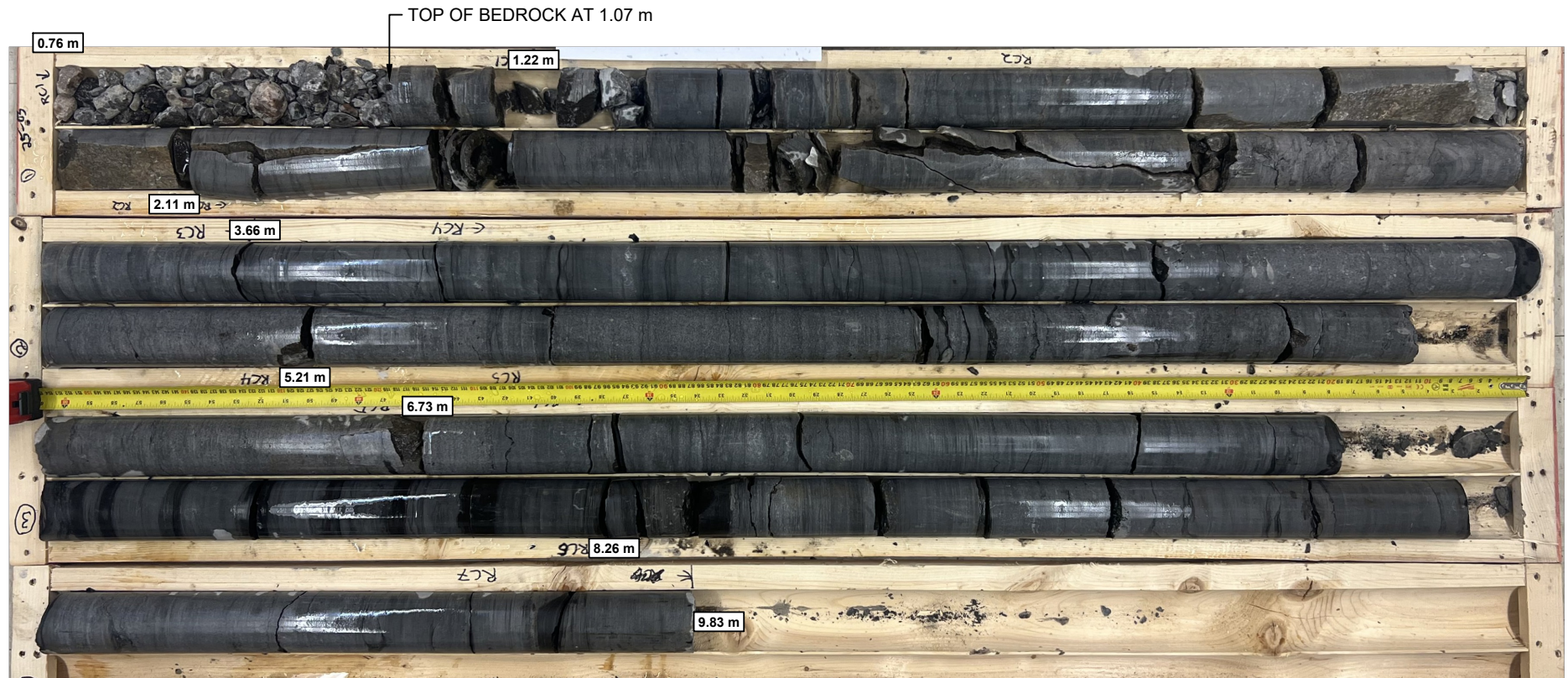
FIGURE C4
Date
JUNE 2025

BOREHOLE: 25-03
BORING DATE: MAY 1, 2025
DEPTH: 0.76 TO 9.83 METRES BELOW GROUND SURFACE



NOTE: MATERIAL IN CORE BOX FROM 0.76 TO 1.07 METRES BELOW GROUND SURFACE IS GRAVEL WITHIN FILL MATERIAL

BOREHOLE: 25-03
BORING DATE: MAY 1, 2025
DEPTH: 0.76 TO 9.83 METRES BELOW GROUND SURFACE



NOTE: MATERIAL IN CORE BOX FROM 0.76 TO 1.07 METRES BELOW GROUND SURFACE IS GRAVEL WITHIN FILL MATERIAL

	Client: E-Landscaping	Rock Core Compressive Strength
	Project: Hazeldean Heights Inc	
	Project #: 104054001	

Date/Time Sampled: 25/05/08 1:57:54 PM	Date/Time Tested: 25/05/08 1:57:54 PM
--	---------------------------------------

BH	Sample No	Depth	Description	Diameter, mm	Area, mm ²	Length After Capping, mm	L/D	Load, kN	Comp. Str., MPa
25-01	RC3	3.20-3.38		63.2	3136	122	1.93	343.700	108.9
25-01	RC5	5.03-5.31		63.1	3130	126	1.99	346.450	110.0
25-02	RC6	2.00-2.18		63.3	3144	126	1.99	271.910	85.9
25-03	RC4	2.74-2.97		63.3	3150	121	1.92	481.500	151.9
25-03	RC6	5.86-6.22		63.3	3148	123	1.95	393.200	124.1
25-03	RC8	8.81-9.01		63.2	3140	125	1.98	408.680	129.3



APPENDIX D

Borehole Logs – Previous Investigation
Previous Investigation by Pinchin (341092.001)
Boreholes MW1 and MW2



Log of Borehole: MW1

Project #: 341092.001

Logged By: MW

Project: Phase II Environmental Site Assessment

Client: 1727897 Ontario Inc.

Location: 5872, 5874 and 5880, Hazeldean Road, Ottawa, Ontario

Drill Date: June 3, 2024

SUBSURFACE PROFILE					SAMPLE			
Depth	Symbol	Description	Measured Depth (m)	Monitoring Well Details	Recovery (%)	Sample ID	Soil Vapour Concentration* (ppm) CGI/PID	Laboratory Analysis
0 ft 0 m		Ground Surface	0.00					
1		Topsoil	0.00		40	S1	40/0	pH
2		Fill: Gravelly Sand	-0.76					
3		Brown, trace silty clay	0.76		30	S2	35/0	PAHs, PHCs(F1-F4), VOCs
4		Fill: Sand						
5		Brown, some gravel and silty clay						
6								
7		Bedrock: Limestone						
8		Grey						
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								
32			-9.75					
33		End of Borehole	9.75					
34								

Contractor: Strata Drilling Group

Drilling Method: Split Spoon

Well Casing Size: 5.08 cm

Note:

* Soil vapour concentrations measured using a RKI Eagle 2 equipped with a combustible gas indicator (CGI) and a photoionization detector (PID).

Grade Elevation: NM

Top of Casing Elevation: NM

Sheet: 1 of 1



Log of Borehole: MW2

Project #: 341092.001

Logged By: MW

Project: Phase II Environmental Site Assessment

Client: 1727897 Ontario Inc.

Location: 5872, 5874 and 5880, Hazeldean Road, Ottawa, Ontario

Drill Date: June 3, 2024

SUBSURFACE PROFILE					SAMPLE			
Depth	Symbol	Description	Measured Depth (m)	Monitoring Well Details	Recovery (%)	Sample ID	Soil Vapour Concentration* (ppm) CGI/PID	Laboratory Analysis
0 ft 0 m		Ground Surface	0.00					
1		Concrete	0.00					
2		Fill: Sand and Gravel	-0.76		10	S1	25/0	
3		Glacia Till	0.76					
4		Trace organics, moist	-1.52		10	S2	10/0	PAHs, PHCs(F1-F4), VOCs
5		Silty Sand	1.52					
6		Brown, some gravel, wet	-2.13		40	S3	5/0	pH, Grain Size
7		Bedrock: Limestone	2.13					
8		Grey						
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23			-7.01					
24		End of Borehole	7.01	GW Level=5.8 mbgs				
25								

Contractor: Strata Drilling Group

Drilling Method: Split Spoon

Well Casing Size: 5.08 cm

Note:
* Soil vapour concentrations measured using a RKI Eagle 2 equipped with a combustible gas indicator (CGI) and a photoionization detector (PID).

Grade Elevation: NM

Top of Casing Elevation: NM

Sheet: 1 of 1



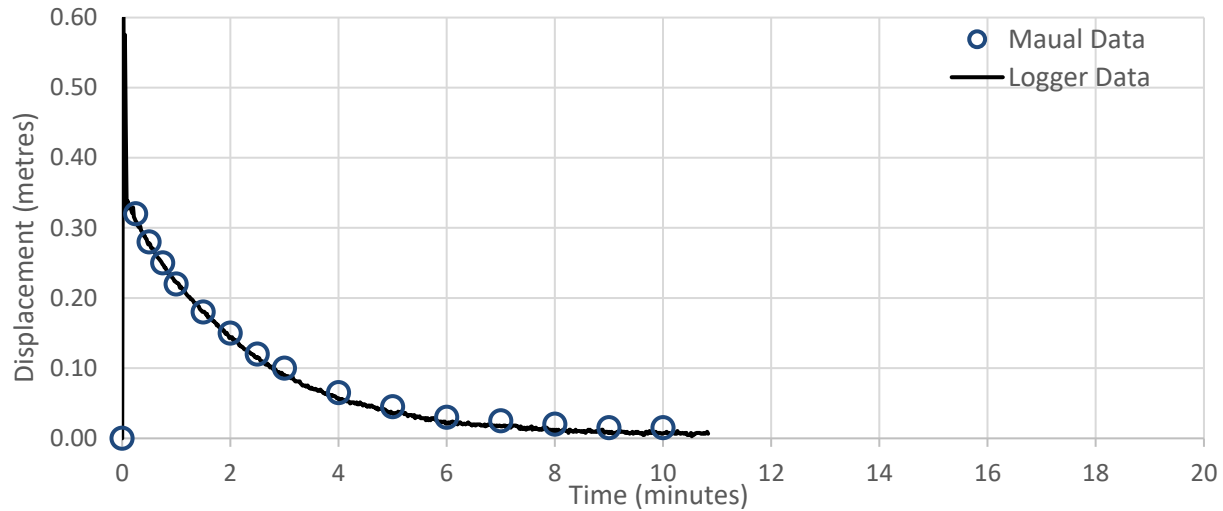
APPENDIX E

Hydraulic Conductivity Testing
Figures E1, E2, and E3

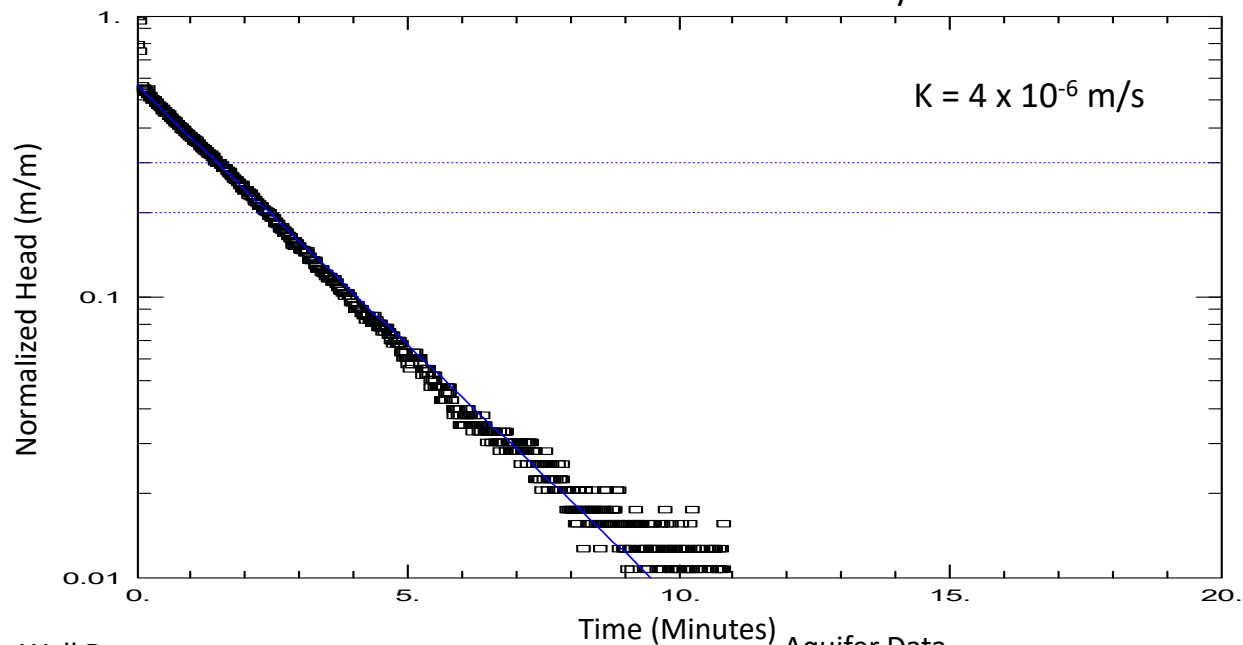
Slug Test Data

**MW25-01
FH**

Borehole 25-01 Falling Head (FH) Test



Borehole 25-01 FH: Bouwer-Rice Analysis



Well Data:

Displacement based on slug size: 0.60 metres
Well Depth: 4.45 metres
Screen Length: 3.05 metres
Well Radius: 0.0254 metres

Aquifer Data

Saturated Thickness: 2.01 metres
Anisotropy Ratio (K_z/K_r): 0.1
Aquifer Model: Unconfined, Bouwer-Rice
Static Water Level: 2.44 metres bgs



GEMTEC

CONSULTING ENGINEERS
AND SCIENTISTS

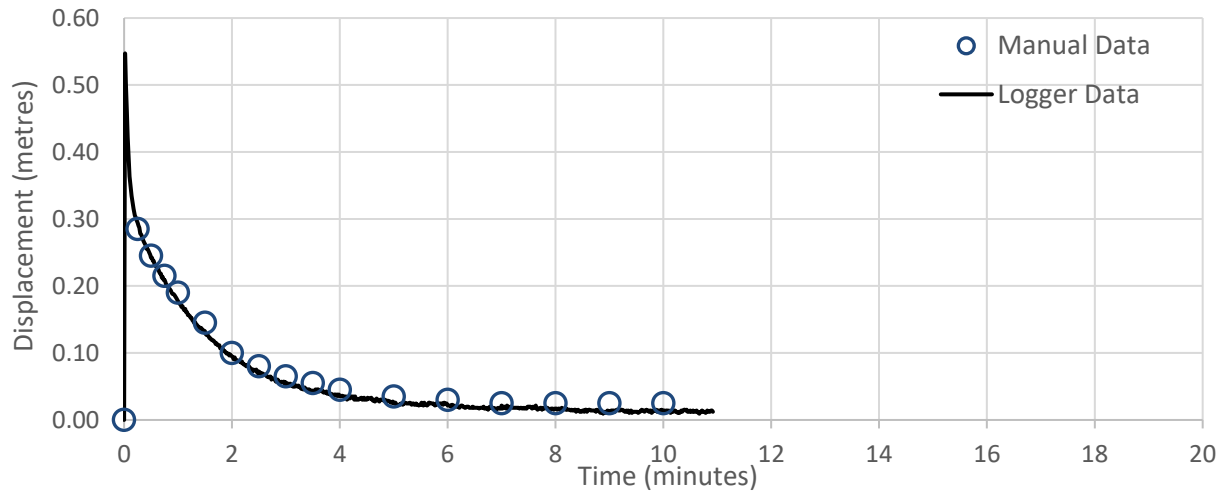
Date: June 2025

Project: 104054.001

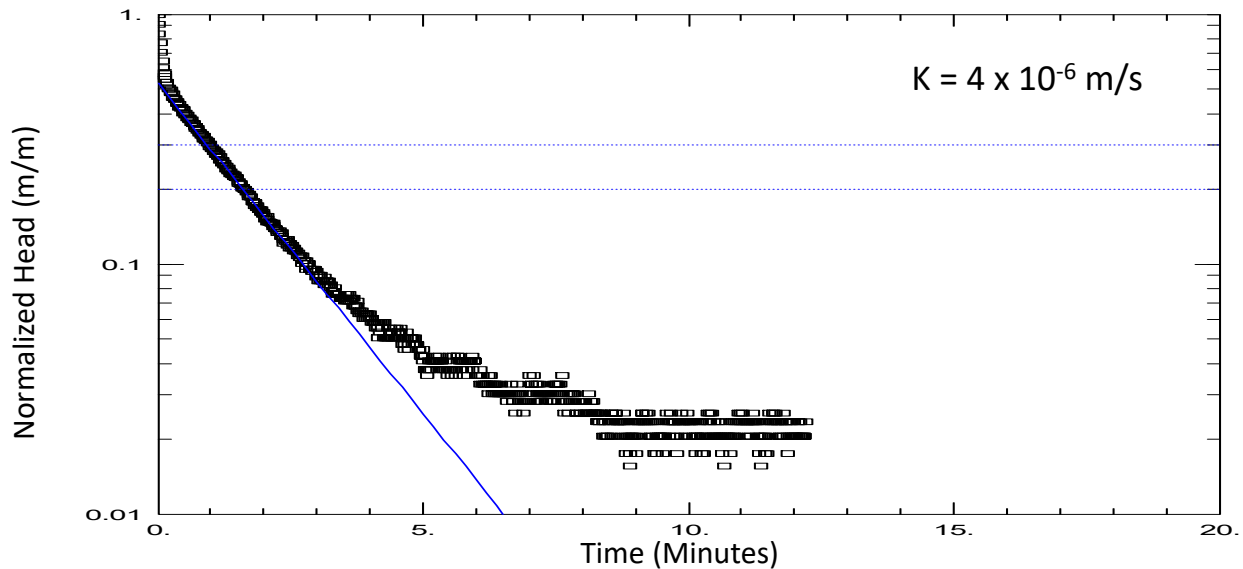
Slug Test Data

**MW25-01
RH**

Borehole 25-01 Rising Head (RH) Test



Borehole 25-01 RH: Bouwer-Rice Analysis



Well Data:

Displacement based on slug size: 0.60 metres
Well Depth: 4.45 metres
Screen Length: 3.05 metres
Well Radius: 0.0254 metres

Aquifer Data

Saturated Thickness: 2.01 metres
Anisotropy Ratio (K_z/K_r): 0.1
Aquifer Model: Unconfined, Bouwer-Rice
Static Water Level: 2.44 metres bgs



GEMTEC

CONSULTING ENGINEERS
AND SCIENTISTS

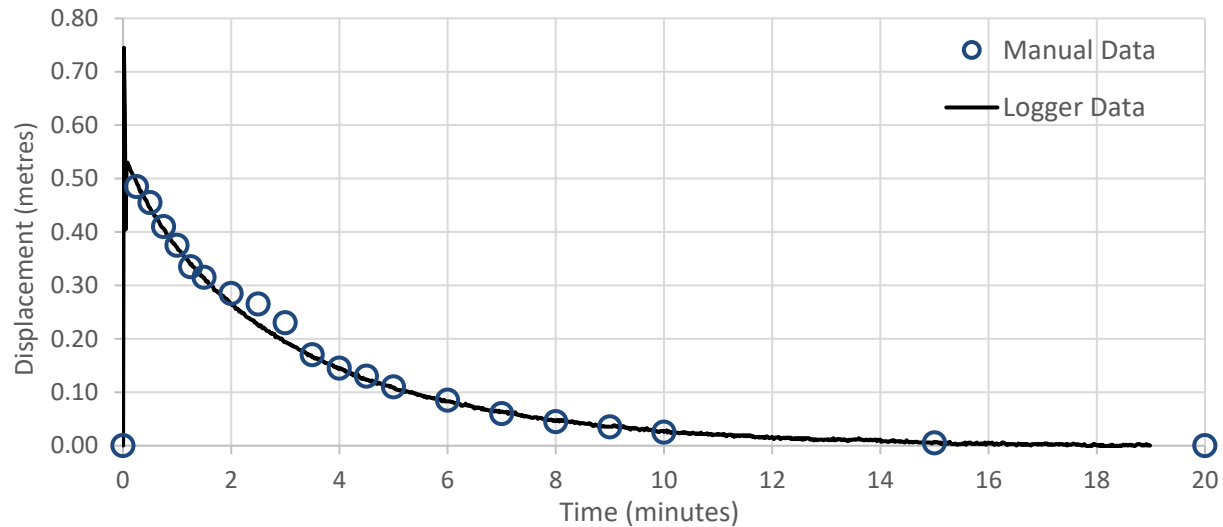
Date: June 2025

Project: 104054.001

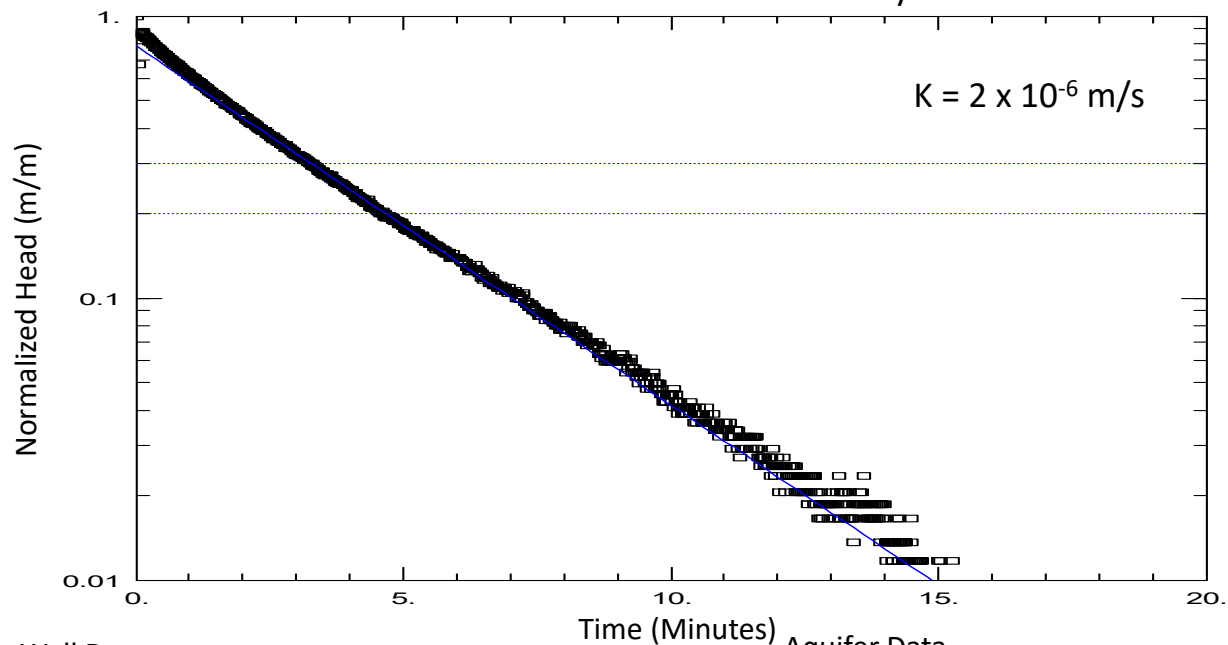
Slug Test Data

MW25-03 FH

Borehole 25-03 Falling Head (FH) Test



Borehole 25-03 FH: Bouwer-Rice Analysis



Well Data:

Displacement based on slug size: 0.60 metres
Well Depth: 5.21 metres
Screen Length: 3.05 metres
Well Radius: 0.0254 metres

Aquifer Data

Saturated Thickness: 3.82 metres
Anisotropy Ratio (K_z/K_r): 0.1
Aquifer Model: Unconfined, Bouwer-Rice
Static Water Level: 1.39 metres bgs



GEMTEC

CONSULTING ENGINEERS
AND SCIENTISTS

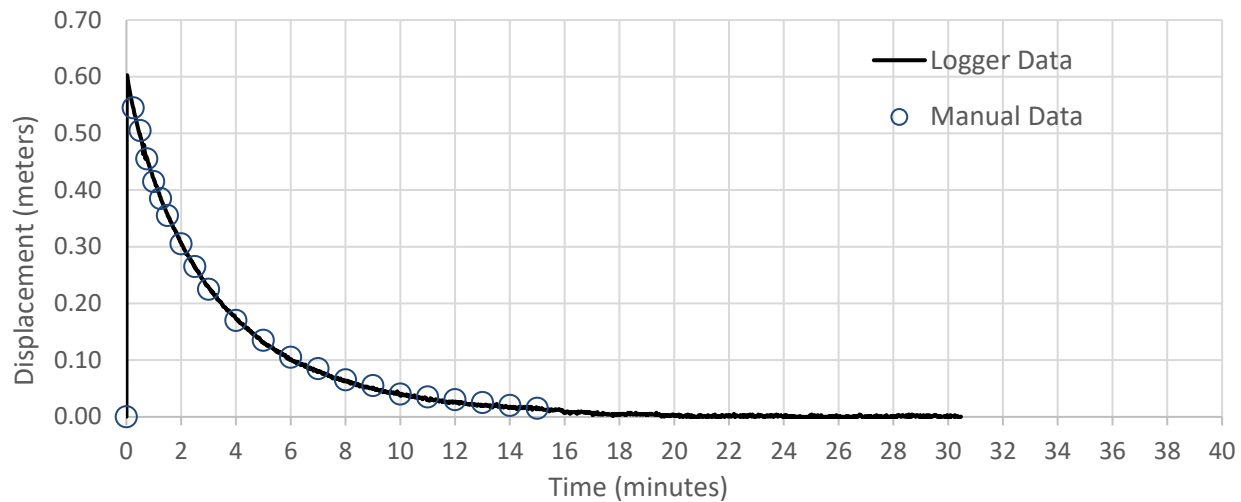
Date: June 2025

Project: 104054.001

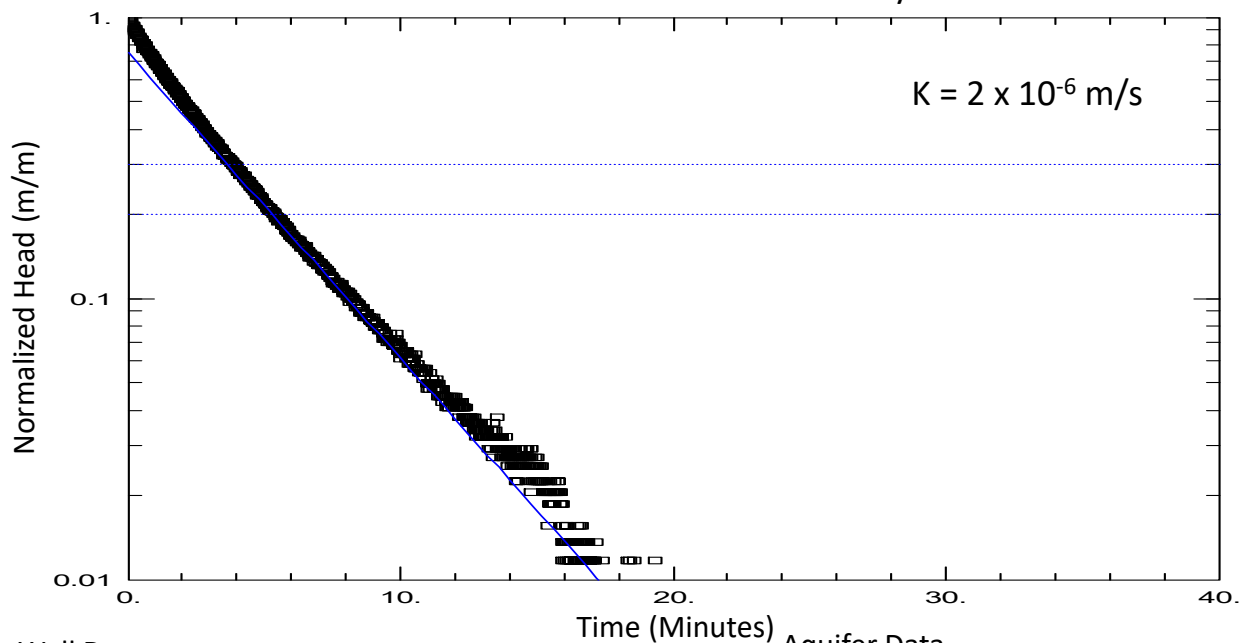
Slug Test Data

MW25-03 RH

Borehole 25-03 Rising Head (RH) Test



Borehole 25-03 RH: Bouwer-Rice Analysis



Well Data:

Displacement based on slug size: 0.60 metres
Well Depth: 5.21 metres
Screen Length: 3.05 metres
Well Radius: 0.0254 metres

Aquifer Data

Saturated Thickness: 3.82 metres
Anisotropy Ratio (K_z/K_r): 0.1
Aquifer Model: Unconfined, Bouwer-Rice
Static Water Level: 1.39 metres bgs



GEMTEC

CONSULTING ENGINEERS
AND SCIENTISTS

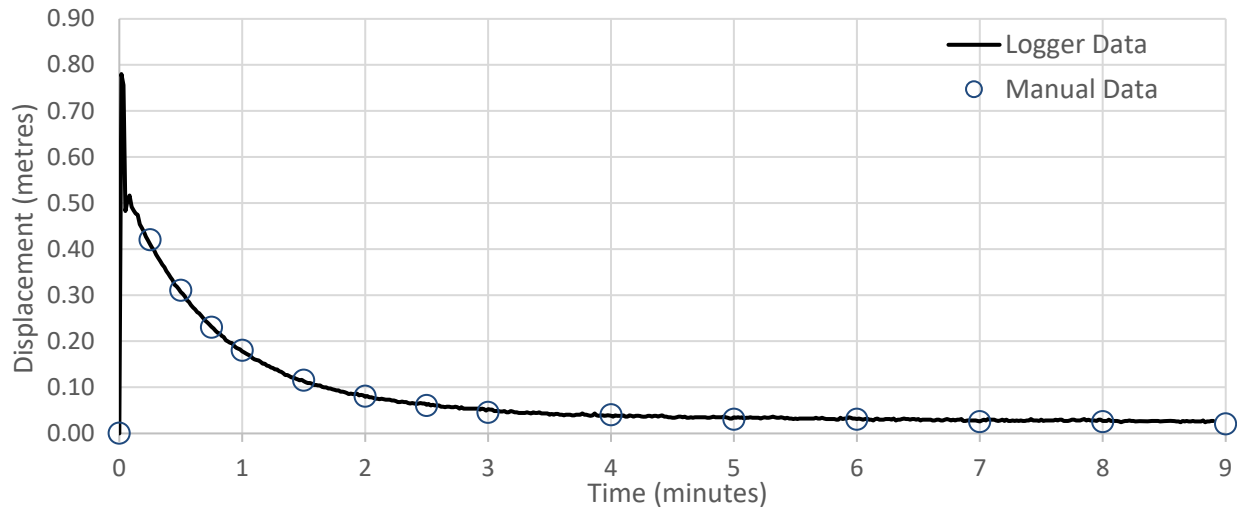
Date: June 2025

Project: 104054.001

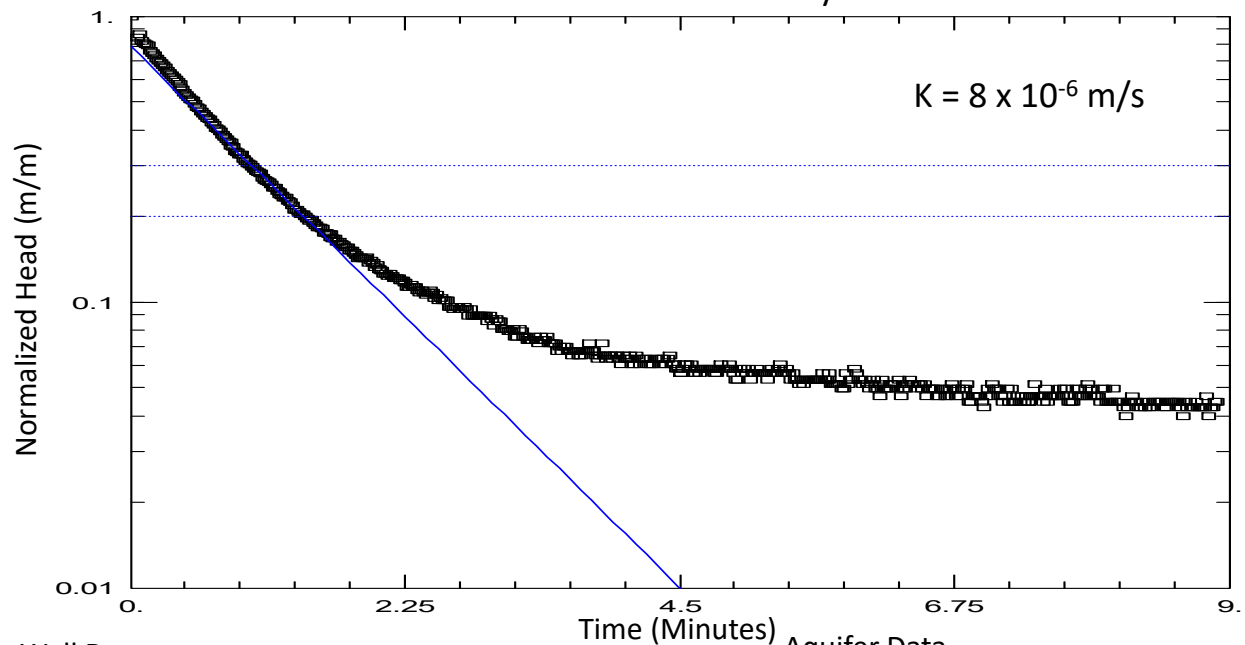
Slug Test Data

MW1 FH

MW1 Falling Head (FH) Test



MW1 FH: Bouwer-Rice Analysis



Well Data:

Displacement based on slug size: 0.60 metres
Well Depth: 8.95 metres
Screen Length: 3.05 metres
Well Radius: 0.0254 metres

Aquifer Data

Saturated Thickness: 7.14 metres
Anisotropy Ratio (K_z/K_r): 0.1
Aquifer Model: Unconfined, Bouwer-Rice
Static Water Level: 1.71 metres bgs



GEMTEC

CONSULTING ENGINEERS
AND SCIENTISTS

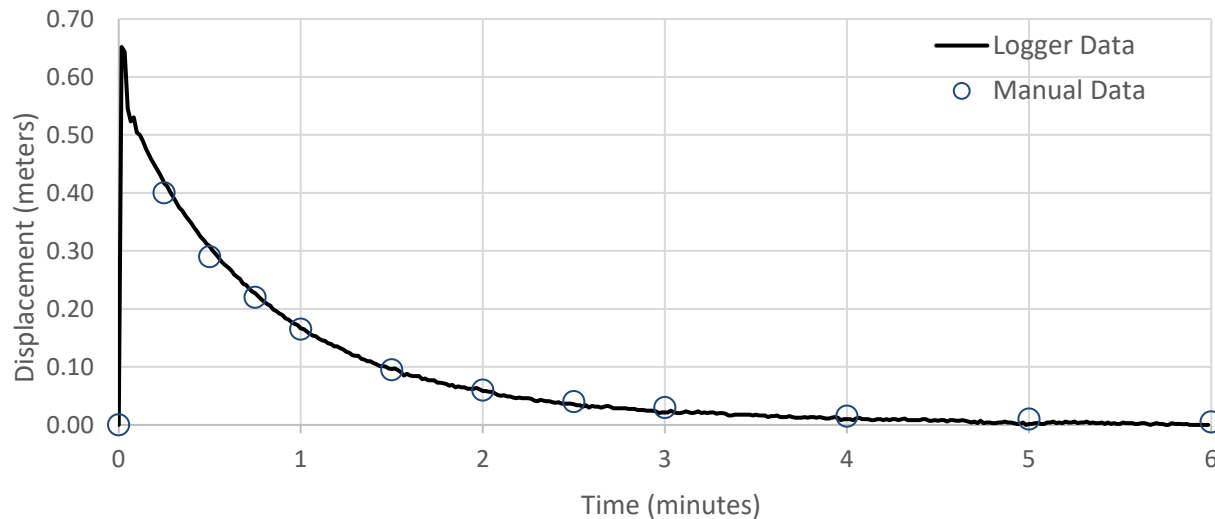
Date: June 2025

Project: 104054.001

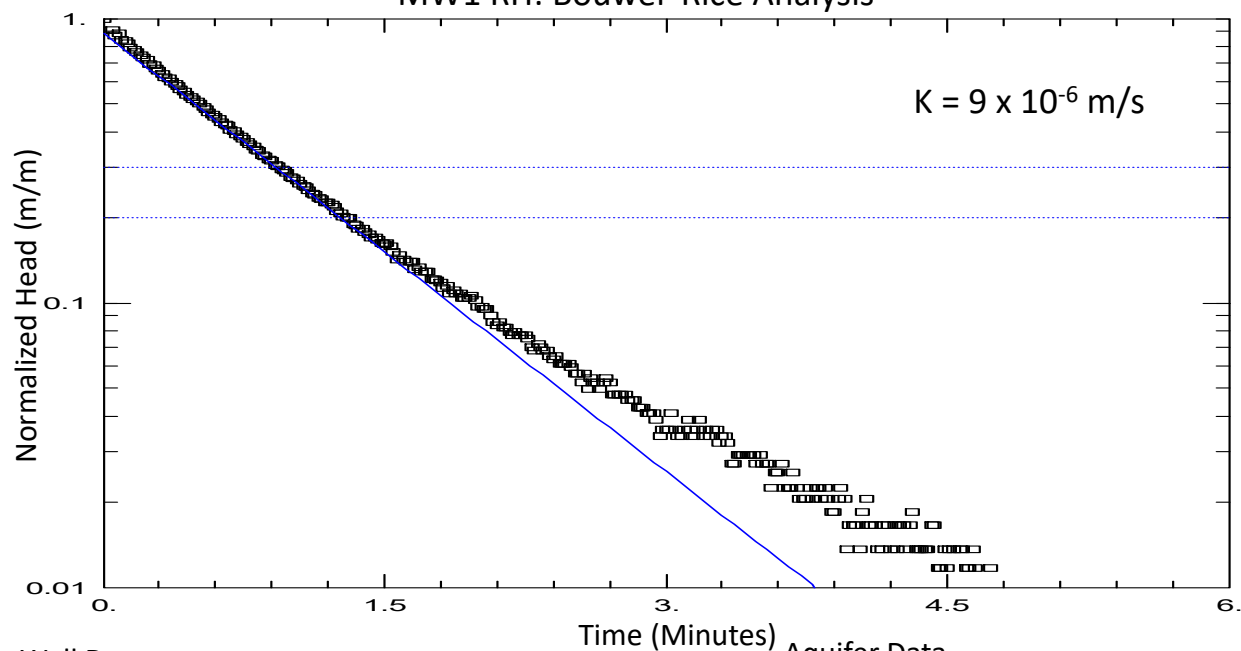
Slug Test Data

MW1 RH

MW1 Rising Head (RH) Test



MW1 RH: Bouwer-Rice Analysis



Well Data:

Displacement based on slug size: 0.60 metres
Well Depth: 8.95 metres
Screen Length: 3.05 metres
Well Radius: 0.0254 metres

Aquifer Data

Saturated Thickness: 7.14 metres
Anisotropy Ratio (K_z/K_r): 0.1
Aquifer Model: Unconfined, Bouwer-Rice
Static Water Level: 1.71 metres bgs

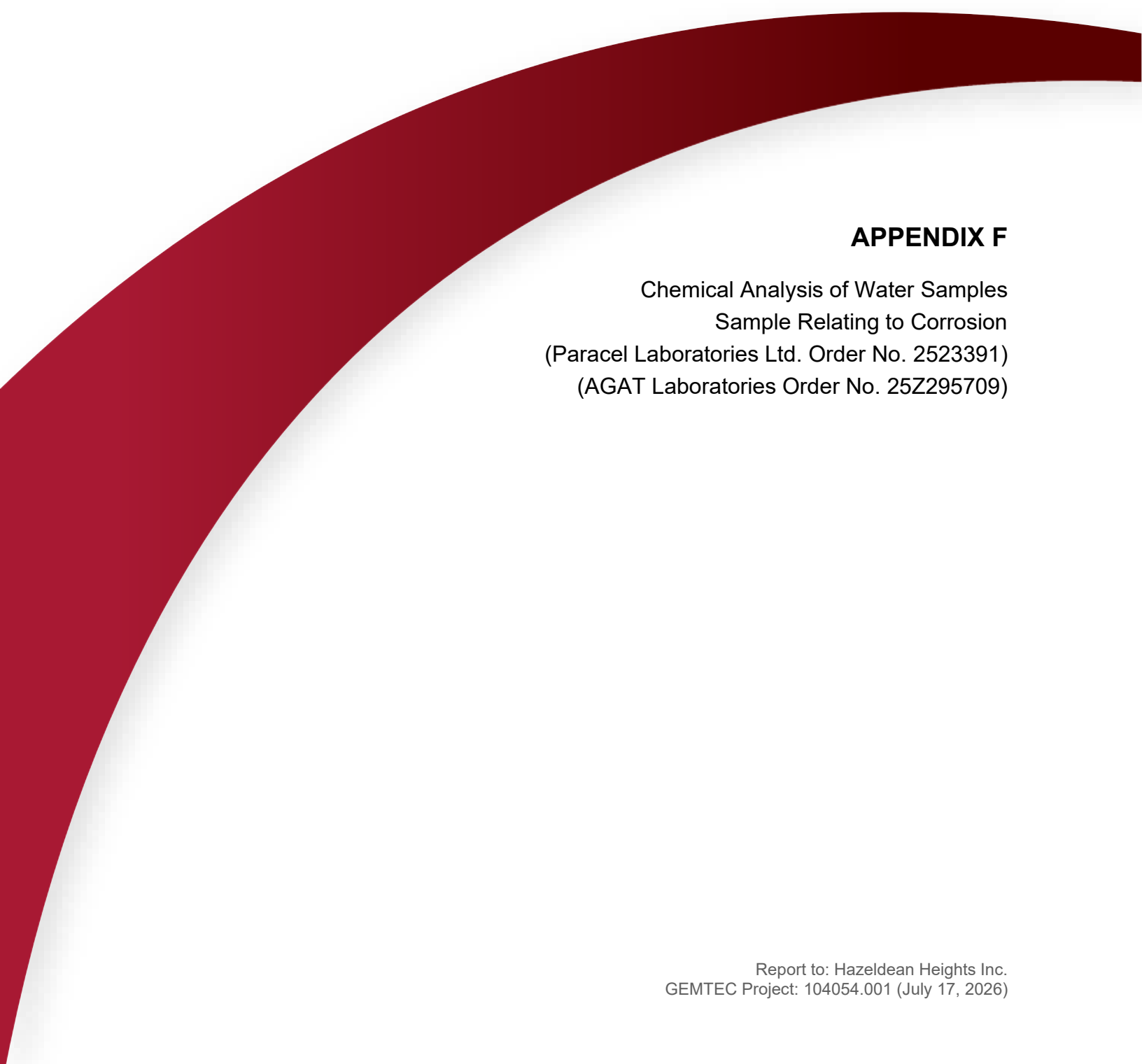


GEMTEC

CONSULTING ENGINEERS
AND SCIENTISTS

Date: June 2025

Project: 104054.001



APPENDIX F

Chemical Analysis of Water Samples
Sample Relating to Corrosion
(Paracel Laboratories Ltd. Order No. 2523391)
(AGAT Laboratories Order No. 25Z295709)

Certificate of Analysis

CLIENT NAME: GEMTEC CONSULTING ENGINEERS AND SCIENTISTS

PROJECT: 104054.001 - Corrosion

SAMPLING SITE:

AGAT WORK ORDER: 25Z295709

ATTENTION TO: Nicole Soucy

SAMPLED BY: CD

pH, Chloride, Sulphate and EC

SAMPLE TYPE: Water

SAMPLE ID: 6751567

DATE RECEIVED: May 20, 2025

DATE SAMPLED: 2025-05-16

DATE REPORTED: May 27, 2025

SAMPLE DESCRIPTION: MW25-01 Corrosion

PARAMETER	UNIT	RESULT	G / S	RDL	DATE ANALYZED	INITIAL	DATE PREPARED
pH	pH Units	7.20		NA	May 22, 2025	ND	May 22, 2025
Chloride	mg/L	341		0.12	May 23, 2025	LC	May 23, 2025
Sulphate	mg/L	202		0.10	May 23, 2025	LC	May 23, 2025
Electrical Conductivity	µS/cm	1440		2	May 22, 2025	ND	May 22, 2025

COMMENTS:

RDL - Reported Detection Limit; G / S - Guideline / Standard
Dilution required, RDL has been increased accordingly.

Certified By:




Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

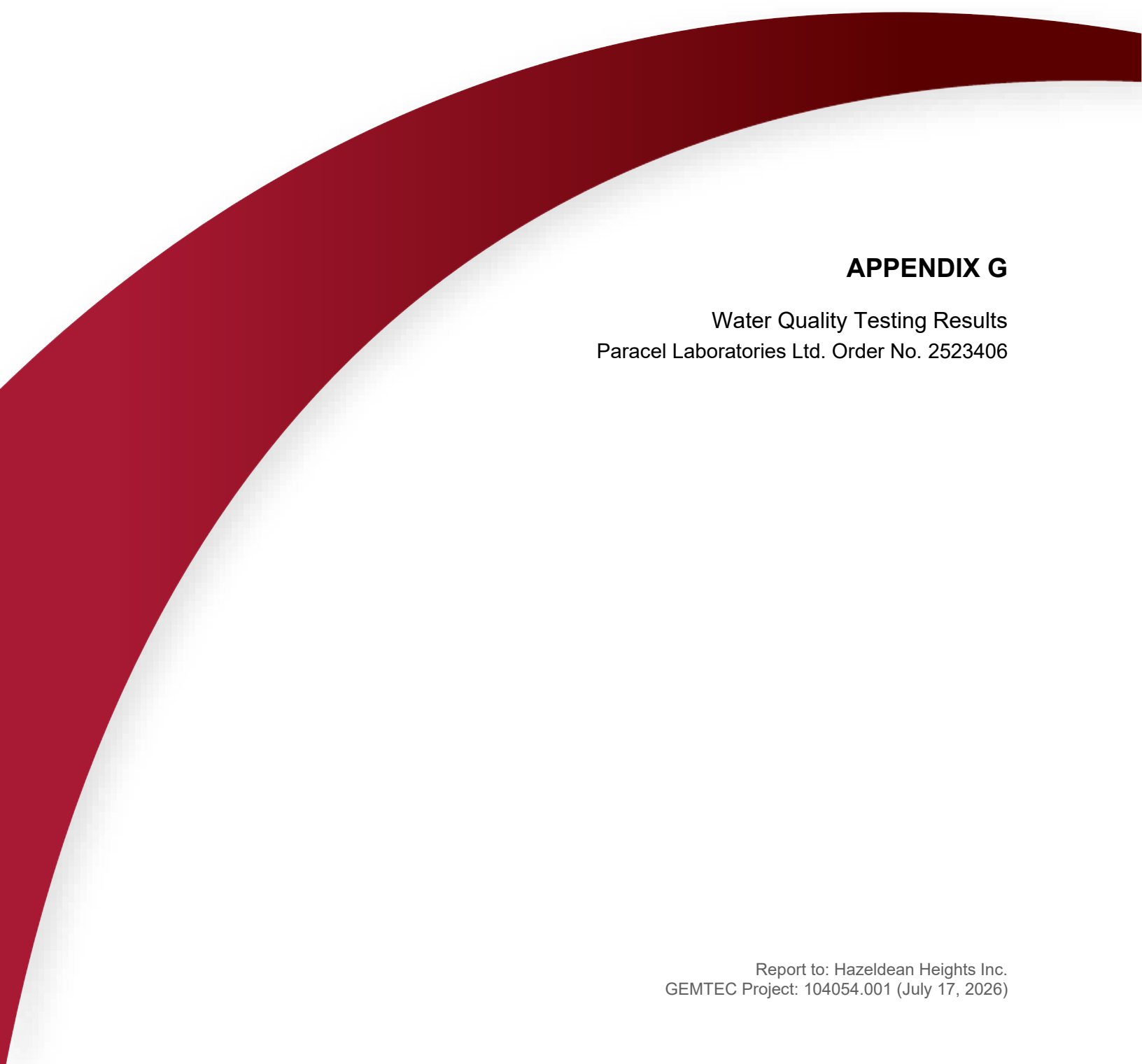
Client ID:	MW25-02 Corrosion	-	-	-	-
Sample Date:	04-Jun-25 09:45	-	-	-	-
Sample ID:	2523391-01	-	-	-	-
Matrix:	Ground Water	-	-	-	-
MDL/Units					

General Inorganics

Conductivity	5 uS/cm	1880	-	-	-	-
pH	0.1 pH Units	7.7	-	-	-	-
Resistivity	0.01 Ohm.m	5.31	-	-	-	-

Anions

Chloride	1 mg/L	416	-	-	-	-
Sulphate	1 mg/L	117	-	-	-	-



APPENDIX G

Water Quality Testing Results
Paracel Laboratories Ltd. Order No. 2523406

Certificate of Analysis

GEMTEC Consulting Engineers and Scientists Limited

32 Steacie Drive
Kanata, ON K2K 2A9
Attn: Andrius Paznekas

Client PO:
Project: 104054.001
Custody: 12645

Report Date: 11-Jun-2025

Order Date: 5-Jun-2025

Order #: 2523406

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

Paracel ID	Client ID
2523406-01	MW25-02
2523406-02	MW25-02 (dissolved)

Approved By:



Mark Foto, M.Sc.
Laboratory Director

Certificate of Analysis

Report Date: 11-Jun-2025

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

Order Date: 5-Jun-2025

Client PO:

Project Description: **104054.001**

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Mercury by CVAA	EPA 245.2 - Cold Vapour AA	6-Jun-25	6-Jun-25
Metals, ICP-MS	EPA 200.8 - ICP-MS	6-Jun-25	9-Jun-25
Ottawa - San/Comb: SVOCs with PAHs	EPA 625 - GC-MS, extraction	10-Jun-25	11-Jun-25
PCBs, total	EPA 608 - GC-ECD	6-Jun-25	6-Jun-25
Pesticides, OC	EPA 8081B - GC-ECD	6-Jun-25	6-Jun-25
pH	SM 4500-H+	9-Jun-25	9-Jun-25
PHC F1	CWS Tier 1 - P&T GC-FID	6-Jun-25	8-Jun-25
PHCs F2 to F4	CWS Tier 1 - GC-FID, extraction	6-Jun-25	9-Jun-25
Phosphorus, total, water	EPA 365.4 - Auto Colour, digestion	10-Jun-25	10-Jun-25
Total Kjeldahl Nitrogen	EPA 351.2 - Auto Colour, digestion	10-Jun-25	10-Jun-25
Total Suspended Solids	SM 2540D - Gravimetric	6-Jun-25	6-Jun-25
Turbidity	SM 2130B - Turbidity meter	6-Jun-25	6-Jun-25
VOCs by P&T GC-MS	EPA 624 - P&T GC-MS	8-Jun-25	8-Jun-25
Volatile Suspended Solids	SM 2540D - Gravimetric, 550C	6-Jun-25	6-Jun-25

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Client ID:	MW25-02	MW25-02 (dissolved)	-	-	
Sample Date:	04-Jun-25 09:45	04-Jun-25 09:45	-	-	-
Sample ID:	2523406-01	2523406-02	-	-	
Matrix:	Ground Water	Ground Water	-	-	
MDL/Units					

General Inorganics

pH	0.1 pH Units	8.1	-	-	-	-
Phosphorus, total	0.01 mg/L	0.02	-	-	-	-
Total Suspended Solids	2 mg/L	90	-	-	-	-
Volatile Suspended Solids	2 mg/L	<2	-	-	-	-
Total Kjeldahl Nitrogen	0.1 mg/L	0.3	-	-	-	-
Turbidity	0.1 NTU	196	-	-	-	-

Metals

Aluminum	0.010 mg/L	-	0.022	-	-	-
Antimony	0.001 mg/L	-	0.001	-	-	-
Arsenic	0.010 mg/L	-	<0.010	-	-	-
Bismuth	0.005 mg/L	-	<0.005	-	-	-
Boron	0.050 mg/L	-	0.268	-	-	-
Cadmium	0.001 mg/L	-	<0.001	-	-	-
Chromium	0.050 mg/L	-	<0.050	-	-	-
Cobalt	0.001 mg/L	-	0.004	-	-	-
Copper	0.005 mg/L	-	0.016	-	-	-
Lead	0.001 mg/L	-	<0.001	-	-	-
Mercury	0.0001 mg/L	-	<0.0001	-	-	-
Manganese	0.050 mg/L	-	0.066	-	-	-
Molybdenum	0.005 mg/L	-	0.008	-	-	-
Nickel	0.005 mg/L	-	0.010	-	-	-
Selenium	0.005 mg/L	-	<0.005	-	-	-
Silver	0.001 mg/L	-	<0.001	-	-	-
Tin	0.010 mg/L	-	0.013	-	-	-

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Client ID:	MW25-02	MW25-02 (dissolved)	-	-	
Sample Date:	04-Jun-25 09:45	04-Jun-25 09:45	-	-	-
Sample ID:	2523406-01	2523406-02	-	-	
Matrix:	Ground Water	Ground Water	-	-	
MDL/Units					

Metals

Titanium	0.010 mg/L	-	<0.010	-	-	-
Vanadium	0.001 mg/L	-	0.003	-	-	-
Zinc	0.020 mg/L	-	<0.020	-	-	-

Metals - Total

Aluminum	0.01 mg/L	<0.01	-	-	-	-
Antimony	0.001 mg/L	0.001	-	-	-	-
Arsenic	0.01 mg/L	<0.01	-	-	-	-
Bismuth	0.005 mg/L	<0.005	-	-	-	-
Boron	0.05 mg/L	<0.05	-	-	-	-
Cadmium	0.001 mg/L	<0.001	-	-	-	-
Chromium	0.05 mg/L	<0.05	-	-	-	-
Cobalt	0.001 mg/L	<0.001	-	-	-	-
Copper	0.005 mg/L	<0.005	-	-	-	-
Lead	0.001 mg/L	<0.001	-	-	-	-
Mercury	0.0001 mg/L	<0.0001	-	-	-	-
Manganese	0.05 mg/L	<0.05	-	-	-	-
Molybdenum	0.005 mg/L	<0.005	-	-	-	-
Nickel	0.005 mg/L	<0.005	-	-	-	-
Selenium	0.005 mg/L	<0.005	-	-	-	-
Silver	0.001 mg/L	<0.001	-	-	-	-
Tin	0.01 mg/L	<0.01	-	-	-	-
Titanium	0.01 mg/L	<0.01	-	-	-	-
Vanadium	0.001 mg/L	<0.001	-	-	-	-
Zinc	0.02 mg/L	<0.02	-	-	-	-

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Client ID:	MW25-02	MW25-02 (dissolved)	-	-	
Sample Date:	04-Jun-25 09:45	04-Jun-25 09:45	-	-	-
Sample ID:	2523406-01	2523406-02	-	-	
Matrix:	Ground Water	Ground Water	-	-	
MDL/Units					

Volatiles

Acetone	0.0050 mg/L	<0.0050	-	-	-	-
Benzene	0.0005 mg/L	<0.0005	-	-	-	-
Bromodichloromethane	0.0005 mg/L	<0.0005	-	-	-	-
Bromoform	0.0005 mg/L	<0.0005	-	-	-	-
Bromomethane	0.0005 mg/L	<0.0005	-	-	-	-
Carbon Tetrachloride	0.0002 mg/L	<0.0002	-	-	-	-
Chlorobenzene	0.0005 mg/L	<0.0005	-	-	-	-
Chloroethane	0.0010 mg/L	<0.0010	-	-	-	-
Chloroform	0.0005 mg/L	<0.0005	-	-	-	-
Chloromethane	0.0030 mg/L	<0.0030	-	-	-	-
Dibromochloromethane	0.0005 mg/L	<0.0005	-	-	-	-
Dichlorodifluoromethane	0.0010 mg/L	<0.0010	-	-	-	-
1,2-Dibromoethane	0.0002 mg/L	<0.0002	-	-	-	-
1,2-Dichlorobenzene	0.0005 mg/L	<0.0005	-	-	-	-
1,3-Dichlorobenzene	0.0005 mg/L	<0.0005	-	-	-	-
1,4-Dichlorobenzene	0.0005 mg/L	<0.0005	-	-	-	-
1,1-Dichloroethane	0.0005 mg/L	<0.0005	-	-	-	-
1,2-Dichloroethane	0.0005 mg/L	<0.0005	-	-	-	-
1,1-Dichloroethylene	0.0005 mg/L	<0.0005	-	-	-	-
cis-1,2-Dichloroethylene	0.0005 mg/L	<0.0005	-	-	-	-
trans-1,2-Dichloroethylene	0.0005 mg/L	<0.0005	-	-	-	-
1,2-Dichloroethylene, total	0.0005 mg/L	<0.0005	-	-	-	-
1,2-Dichloropropane	0.0005 mg/L	<0.0005	-	-	-	-
cis-1,3-Dichloropropylene	0.0005 mg/L	<0.0005	-	-	-	-

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Client ID:	MW25-02	MW25-02 (dissolved)	-	-	
Sample Date:	04-Jun-25 09:45	04-Jun-25 09:45	-	-	-
Sample ID:	2523406-01	2523406-02	-	-	
Matrix:	Ground Water	Ground Water	-	-	
MDL/Units					

Volatiles

trans-1,3-Dichloropropylene	0.0005 mg/L	<0.0005	-	-	-	-
1,3-Dichloropropene, total	0.0005 mg/L	<0.0005	-	-	-	-
Ethylbenzene	0.0005 mg/L	<0.0005	-	-	-	-
Hexane	0.0010 mg/L	<0.0010	-	-	-	-
Methyl Ethyl Ketone (2-Butanone)	0.0050 mg/L	<0.0050	-	-	-	-
Methyl Butyl Ketone (2-Hexanone)	0.0100 mg/L	<0.0100	-	-	-	-
Methyl Isobutyl Ketone	0.0050 mg/L	<0.0050	-	-	-	-
Methyl tert-butyl ether	0.0020 mg/L	<0.0020	-	-	-	-
Methylene Chloride	0.0050 mg/L	<0.0050	-	-	-	-
Styrene	0.0005 mg/L	<0.0005	-	-	-	-
1,1,1,2-Tetrachloroethane	0.0005 mg/L	<0.0005	-	-	-	-
1,1,2,2-Tetrachloroethane	0.0005 mg/L	<0.0005	-	-	-	-
Tetrachloroethylene	0.0005 mg/L	<0.0005	-	-	-	-
Toluene	0.0005 mg/L	<0.0005	-	-	-	-
1,1,1-Trichloroethane	0.0005 mg/L	<0.0005	-	-	-	-
1,1,2-Trichloroethane	0.0005 mg/L	<0.0005	-	-	-	-
Trichloroethylene	0.0005 mg/L	<0.0005	-	-	-	-
Trichlorofluoromethane	0.0010 mg/L	<0.0010	-	-	-	-
1,3,5-Trimethylbenzene	0.0005 mg/L	<0.0005	-	-	-	-
Vinyl chloride	0.0005 mg/L	<0.0005	-	-	-	-
m,p-Xylenes	0.0005 mg/L	<0.0005	-	-	-	-
o-Xylene	0.0005 mg/L	<0.0005	-	-	-	-
Xylenes, total	0.0005 mg/L	<0.0005	-	-	-	-
4-Bromofluorobenzene	Surrogate	102%	-	-	-	-

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Client ID:	MW25-02	MW25-02 (dissolved)	-	-	
Sample Date:	04-Jun-25 09:45	04-Jun-25 09:45	-	-	-
Sample ID:	2523406-01	2523406-02	-	-	
Matrix:	Ground Water	Ground Water	-	-	
MDL/Units					

Volatiles

Dibromofluoromethane	Surrogate	79.5%	-	-	-	-
Toluene-d8	Surrogate	102%	-	-	-	-

Hydrocarbons

F1 PHCs (C6-C10)	0.025 mg/L	<0.025	-	-	-	-
F2 PHCs (C10-C16)	0.1 mg/L	<0.1	-	-	-	-
F3 PHCs (C16-C34)	0.1 mg/L	<0.1	-	-	-	-
F4 PHCs (C34-C50)	0.1 mg/L	<0.1	-	-	-	-

Semi-Volatiles

1-Methylnaphthalene	0.00005 mg/L	<0.00005	-	-	-	-
2-Methylnaphthalene	0.00005 mg/L	<0.00005	-	-	-	-
7H-Dibenzo[c,g]carbazole	0.00050 mg/L	<0.00050	-	-	-	-
Anthracene	0.00001 mg/L	<0.00001	-	-	-	-
Benzo [a] anthracene	0.00001 mg/L	<0.00001	-	-	-	-
Benzo [a] pyrene	0.00001 mg/L	<0.00001	-	-	-	-
Benzo [b&j] fluoranthene	0.00005 mg/L	<0.00005	-	-	-	-
Benzo [e] pyrene	0.00005 mg/L	<0.00005	-	-	-	-
Benzo [g,h,i] perylene	0.00005 mg/L	<0.00005	-	-	-	-
Benzo [k] fluoranthene	0.00005 mg/L	<0.00005	-	-	-	-
Benzylbutylphthalate	0.00050 mg/L	<0.00050	-	-	-	-
Biphenyl	0.00005 mg/L	<0.00005	-	-	-	-
Bis(2-chloroethoxy)methane	0.00100 mg/L	<0.00100	-	-	-	-
Bis(2-ethylhexyl)phthalate	0.00100 mg/L	<0.00100	-	-	-	-
Chrysene	0.00005 mg/L	<0.00005	-	-	-	-
Dibenzo [a,h] anthracene	0.00005 mg/L	<0.00005	-	-	-	-
Dibenzo [a,i] pyrene	0.00050 mg/L	<0.00050	-	-	-	-

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Client ID:	MW25-02	MW25-02 (dissolved)	-	-	
Sample Date:	04-Jun-25 09:45	04-Jun-25 09:45	-	-	-
Sample ID:	2523406-01	2523406-02	-	-	
Matrix:	Ground Water	Ground Water	-	-	
MDL/Units					

Semi-Volatiles

Dibenzo [a,j] acridine	0.00050 mg/L	<0.00050	-	-	-	-
Diethylphthalate	0.00100 mg/L	<0.00100	-	-	-	-
Di-n-butylphthalate	0.00100 mg/L	0.00400	-	-	-	-
Di-n-octylphthalate	0.00100 mg/L	<0.00100	-	-	-	-
Fluoranthene	0.00001 mg/L	<0.00001	-	-	-	-
Fluorene	0.00005 mg/L	<0.00005	-	-	-	-
Indeno [1,2,3-cd] pyrene	0.00005 mg/L	<0.00005	-	-	-	-
Indole	0.00100 mg/L	<0.00100	-	-	-	-
Naphthalene	0.00005 mg/L	<0.00005	-	-	-	-
Phenanthrene	0.00005 mg/L	<0.00005	-	-	-	-
Perylene	0.00050 mg/L	<0.00050	-	-	-	-
Pyrene	0.00001 mg/L	<0.00001	-	-	-	-
2,4-Dichlorophenol	0.00100 mg/L	<0.00100	-	-	-	-
PAHs, Total	0.0025 mg/L	<0.0025	-	-	-	-
2-Fluorobiphenyl	Surrogate	97.6%	-	-	-	-
Nitrobenzene-d5	Surrogate	89.6%	-	-	-	-
Terphenyl-d14	Surrogate	108%	-	-	-	-
2,4,6-Tribromophenol	Surrogate	103%	-	-	-	-
2-Fluorophenol	Surrogate	27.1% [2]	-	-	-	-
Phenol-d6	Surrogate	27.6% [2]	-	-	-	-

Pesticides, OC

Aldrin	0.01 ug/L	<0.01	-	-	-	-
alpha-BHC	0.01 ug/L	<0.01	-	-	-	-
beta-BHC	0.01 ug/L	<0.01	-	-	-	-
delta-BHC	0.01 ug/L	<0.01	-	-	-	-

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Client ID:	MW25-02	MW25-02 (dissolved)	-	-	
Sample Date:	04-Jun-25 09:45	04-Jun-25 09:45	-	-	-
Sample ID:	2523406-01	2523406-02	-	-	
Matrix:	Ground Water	Ground Water	-	-	
MDL/Units					

Pesticides, OC

gamma-BHC (Lindane)	0.01 ug/L	<0.01	-	-	-	-
alpha-Chlordane	0.01 ug/L	<0.01	-	-	-	-
gamma-Chlordane	0.01 ug/L	<0.01	-	-	-	-
Chlordane	0.01 ug/L	<0.01	-	-	-	-
o,p'-DDD	0.01 ug/L	<0.01	-	-	-	-
p,p'-DDD	0.01 ug/L	<0.01	-	-	-	-
DDD	0.01 ug/L	<0.01	-	-	-	-
o,p'-DDE	0.01 ug/L	<0.01	-	-	-	-
p,p'-DDE	0.01 ug/L	<0.01	-	-	-	-
DDE	0.01 ug/L	<0.01	-	-	-	-
o,p'-DDT	0.01 ug/L	<0.01	-	-	-	-
p,p'-DDT	0.01 ug/L	<0.01	-	-	-	-
DDT	0.01 ug/L	<0.01	-	-	-	-
Dieldrin	0.01 ug/L	<0.01	-	-	-	-
Endrin	0.01 ug/L	<0.01	-	-	-	-
Endrin aldehyde	0.01 ug/L	<0.01	-	-	-	-
Endrin ketone	0.01 ug/L	<0.01	-	-	-	-
Endosulfan I	0.01 ug/L	<0.01	-	-	-	-
Endosulfan II	0.01 ug/L	<0.01	-	-	-	-
Endosulfan I/II	0.01 ug/L	<0.01	-	-	-	-
Endosulfan sulfate	0.02 ug/L	<0.02	-	-	-	-
Heptachlor	0.01 ug/L	<0.01	-	-	-	-
Heptachlor epoxide	0.01 ug/L	<0.01	-	-	-	-
Hexachlorobenzene	0.01 ug/L	<0.01	-	-	-	-

Certificate of Analysis

Report Date: 11-Jun-2025

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

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Client ID:	MW25-02	MW25-02 (dissolved)	-	-	
Sample Date:	04-Jun-25 09:45	04-Jun-25 09:45	-	-	-
Sample ID:	2523406-01	2523406-02	-	-	-
Matrix:	Ground Water	Ground Water	-	-	-
MDL/Units					

Pesticides, OC

Hexachlorobutadiene	0.01 ug/L	<0.01	-	-	-	-
Hexachloroethane	0.01 ug/L	<0.01	-	-	-	-
Methoxychlor	0.01 ug/L	<0.01	-	-	-	-
Decachlorobiphenyl	Surrogate	52.7%	-	-	-	-

PCBs

PCBs, total	0.05 ug/L	<0.05	-	-	-	-
Decachlorobiphenyl	Surrogate	83.2%	-	-	-	-

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	%REC	%REC Limit	RPD	RPD Limit	Notes
General Inorganics								
Phosphorus, total	ND	0.01	mg/L					
Total Suspended Solids	ND	2	mg/L					
Volatile Suspended Solids	ND	2	mg/L					
Total Kjeldahl Nitrogen	ND	0.1	mg/L					
Turbidity	ND	0.1	NTU					
Hydrocarbons								
F1 PHCs (C6-C10)	ND	0.025	mg/L					
F2 PHCs (C10-C16)	ND	0.1	mg/L					
F3 PHCs (C16-C34)	ND	0.1	mg/L					
F4 PHCs (C34-C50)	ND	0.1	mg/L					
Metals								
Aluminum	ND	0.010	mg/L					
Antimony	ND	0.001	mg/L					
Arsenic	ND	0.010	mg/L					
Bismuth	ND	0.005	mg/L					
Boron	ND	0.050	mg/L					
Cadmium	ND	0.001	mg/L					
Chromium	ND	0.050	mg/L					
Cobalt	ND	0.001	mg/L					
Copper	ND	0.005	mg/L					
Lead	ND	0.001	mg/L					
Mercury	ND	0.0001	mg/L					
Manganese	ND	0.050	mg/L					
Molybdenum	ND	0.005	mg/L					
Nickel	ND	0.005	mg/L					
Selenium	ND	0.005	mg/L					
Silver	ND	0.001	mg/L					
Tin	ND	0.010	mg/L					
Titanium	ND	0.010	mg/L					
Vanadium	ND	0.001	mg/L					
Zinc	ND	0.020	mg/L					

Metals - Total

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	%REC	%REC Limit	RPD	RPD Limit	Notes
Aluminum	ND	0.01	mg/L					
Antimony	ND	0.001	mg/L					
Arsenic	ND	0.01	mg/L					
Bismuth	ND	0.005	mg/L					
Boron	ND	0.05	mg/L					
Cadmium	ND	0.001	mg/L					
Chromium	ND	0.05	mg/L					
Cobalt	ND	0.001	mg/L					
Copper	ND	0.005	mg/L					
Lead	ND	0.001	mg/L					
Mercury	ND	0.0001	mg/L					
Manganese	ND	0.05	mg/L					
Molybdenum	ND	0.005	mg/L					
Nickel	ND	0.005	mg/L					
Selenium	ND	0.005	mg/L					
Silver	ND	0.001	mg/L					
Tin	ND	0.01	mg/L					
Titanium	ND	0.01	mg/L					
Vanadium	ND	0.001	mg/L					
Zinc	ND	0.02	mg/L					
PCBs								
PCBs, total	ND	0.05	ug/L					
Surrogate: Decachlorobiphenyl	0.256		%	102	60-140			
Pesticides, OC								
Aldrin	ND	0.01	ug/L					
alpha-BHC	ND	0.01	ug/L					
beta-BHC	ND	0.01	ug/L					
delta-BHC	ND	0.01	ug/L					
gamma-BHC (Lindane)	ND	0.01	ug/L					
alpha-Chlordane	ND	0.01	ug/L					
gamma-Chlordane	ND	0.01	ug/L					
Chlordane	ND	0.01	ug/L					
o,p'-DDD	ND	0.01	ug/L					

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	%REC	%REC Limit	RPD	RPD Limit	Notes
p,p'-DDD	ND	0.01	ug/L					
DDD	ND	0.01	ug/L					
o,p'-DDE	ND	0.01	ug/L					
p,p'-DDE	ND	0.01	ug/L					
DDE	ND	0.01	ug/L					
o,p'-DDT	ND	0.01	ug/L					
p,p'-DDT	ND	0.01	ug/L					
DDT	ND	0.01	ug/L					
Dieldrin	ND	0.01	ug/L					
Endrin	ND	0.01	ug/L					
Endrin aldehyde	ND	0.01	ug/L					
Endrin ketone	ND	0.01	ug/L					
Endosulfan I	ND	0.01	ug/L					
Endosulfan II	ND	0.01	ug/L					
Endosulfan I/II	ND	0.01	ug/L					
Endosulfan sulfate	ND	0.02	ug/L					
Heptachlor	ND	0.01	ug/L					
Heptachlor epoxide	ND	0.01	ug/L					
Hexachlorobenzene	ND	0.01	ug/L					
Hexachlorobutadiene	ND	0.01	ug/L					
Hexachloroethane	ND	0.01	ug/L					
Methoxychlor	ND	0.01	ug/L					
Surrogate: Decachlorobiphenyl	0.183		%	73.0	50-140			
Semi-Volatiles								
1-Methylnaphthalene	ND	0.00005	mg/L					
2-Methylnaphthalene	ND	0.00005	mg/L					
7H-Dibenzo[c,g]carbazole	ND	0.00050	mg/L					
Anthracene	ND	0.00001	mg/L					
Benzo [a] anthracene	ND	0.00001	mg/L					
Benzo [a] pyrene	ND	0.00001	mg/L					
Benzo [b&j] fluoranthene	ND	0.00005	mg/L					
Benzo [e] pyrene	ND	0.00005	mg/L					

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	%REC	%REC Limit	RPD	RPD Limit	Notes
Benzo [g,h,i] perylene	ND	0.00005	mg/L					
Benzo [k] fluoranthene	ND	0.00005	mg/L					
Benzylbutylphthalate	ND	0.00050	mg/L					
Biphenyl	ND	0.00005	mg/L					
Bis(2-chloroethoxy)methane	ND	0.00100	mg/L					
Bis(2-ethylhexyl)phthalate	ND	0.00100	mg/L					
Chrysene	ND	0.00005	mg/L					
Dibenzo [a,h] anthracene	ND	0.00005	mg/L					
Dibenzo [a,i] pyrene	ND	0.00050	mg/L					
Dibenzo [a,j] acridine	ND	0.00050	mg/L					
Diethylphthalate	ND	0.00100	mg/L					
Di-n-butylphthalate	ND	0.00100	mg/L					
Di-n-octylphthalate	ND	0.00100	mg/L					
Fluoranthene	ND	0.00001	mg/L					
Fluorene	ND	0.00005	mg/L					
Indeno [1,2,3-cd] pyrene	ND	0.00005	mg/L					
Indole	ND	0.00100	mg/L					
Naphthalene	ND	0.00005	mg/L					
Phenanthrene	ND	0.00005	mg/L					
Perylene	ND	0.00050	mg/L					
Pyrene	ND	0.00001	mg/L					
2,4-Dichlorophenol	ND	0.00100	mg/L					
Surrogate: 2-Fluorobiphenyl	0.0177		%	88.6	50-140			
Surrogate: Nitrobenzene-d5	0.0159		%	79.4	50-140			
Surrogate: Terphenyl-d14	0.0190		%	95.0	50-140			
Surrogate: 2,4,6-Tribromophenol	0.0327		%	81.6	50-140			
Surrogate: 2-Fluorophenol	0.0115		%	28.8	50-140			S-GC
Surrogate: Phenol-d6	0.0125		%	31.2	50-140			S-GC
Volatiles								
Acetone	ND	0.0050	mg/L					
Benzene	ND	0.0005	mg/L					
Bromodichloromethane	ND	0.0005	mg/L					

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	%REC	%REC Limit	RPD	RPD Limit	Notes
Bromoform	ND	0.0005	mg/L					
Bromomethane	ND	0.0005	mg/L					
Carbon Tetrachloride	ND	0.0002	mg/L					
Chlorobenzene	ND	0.0005	mg/L					
Chloroethane	ND	0.0010	mg/L					
Chloroform	ND	0.0005	mg/L					
Chloromethane	ND	0.0030	mg/L					
Dibromochloromethane	ND	0.0005	mg/L					
Dichlorodifluoromethane	ND	0.0010	mg/L					
1,2-Dibromoethane	ND	0.0002	mg/L					
1,2-Dichlorobenzene	ND	0.0005	mg/L					
1,3-Dichlorobenzene	ND	0.0005	mg/L					
1,4-Dichlorobenzene	ND	0.0005	mg/L					
1,1-Dichloroethane	ND	0.0005	mg/L					
1,2-Dichloroethane	ND	0.0005	mg/L					
1,1-Dichloroethylene	ND	0.0005	mg/L					
cis-1,2-Dichloroethylene	ND	0.0005	mg/L					
trans-1,2-Dichloroethylene	ND	0.0005	mg/L					
1,2-Dichloroethylene, total	ND	0.0005	mg/L					
1,2-Dichloropropane	ND	0.0005	mg/L					
cis-1,3-Dichloropropylene	ND	0.0005	mg/L					
trans-1,3-Dichloropropylene	ND	0.0005	mg/L					
1,3-Dichloropropene, total	ND	0.0005	mg/L					
Ethylbenzene	ND	0.0005	mg/L					
Hexane	ND	0.0010	mg/L					
Methyl Ethyl Ketone (2-Butanone)	ND	0.0050	mg/L					
Methyl Butyl Ketone (2-Hexanone)	ND	0.0100	mg/L					
Methyl Isobutyl Ketone	ND	0.0050	mg/L					
Methyl tert-butyl ether	ND	0.0020	mg/L					
Methylene Chloride	ND	0.0050	mg/L					
Styrene	ND	0.0005	mg/L					
1,1,1,2-Tetrachloroethane	ND	0.0005	mg/L					
1,1,2,2-Tetrachloroethane	ND	0.0005	mg/L					

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	%REC	%REC Limit	RPD	RPD Limit	Notes
Tetrachloroethylene	ND	0.0005	mg/L					
Toluene	ND	0.0005	mg/L					
1,1,1-Trichloroethane	ND	0.0005	mg/L					
1,1,2-Trichloroethane	ND	0.0005	mg/L					
Trichloroethylene	ND	0.0005	mg/L					
Trichlorofluoromethane	ND	0.0010	mg/L					
1,3,5-Trimethylbenzene	ND	0.0005	mg/L					
Vinyl chloride	ND	0.0005	mg/L					
m,p-Xylenes	ND	0.0005	mg/L					
o-Xylene	ND	0.0005	mg/L					
Xylenes, total	ND	0.0005	mg/L					
Surrogate: 4-Bromofluorobenzene	0.0835		%	104	50-140			
Surrogate: Dibromofluoromethane	0.0733		%	91.6	50-140			
Surrogate: Toluene-d8	0.0795		%	99.4	50-140			

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
General Inorganics									
pH	7.4	0.1	pH Units	7.3			0.5	3.3	
Phosphorus, total	0.170	0.01	mg/L	0.169			0.5	15	
Total Suspended Solids	ND	2	mg/L	ND			NC	10	
Volatile Suspended Solids	ND	2	mg/L	ND			NC	10	
Total Kjeldahl Nitrogen	6.88	1.0	mg/L	6.78			1.4	20	
Turbidity	194	0.1	NTU	196			1.0	10	
Hydrocarbons									
F1 PHCs (C6-C10)	ND	0.025	mg/L	ND			NC	30	
Metals									
Aluminum	0.0211	0.010	mg/L	0.0218			3.2	20	
Antimony	0.0013	0.001	mg/L	0.0015			10.7	20	
Arsenic	ND	0.010	mg/L	ND			NC	20	
Bismuth	ND	0.005	mg/L	ND			NC	20	
Boron	0.265	0.050	mg/L	0.268			1.2	20	
Cadmium	ND	0.001	mg/L	ND			NC	20	
Chromium	ND	0.050	mg/L	ND			NC	20	
Cobalt	0.0036	0.001	mg/L	0.0035			1.9	20	
Copper	0.0169	0.005	mg/L	0.0164			3.2	20	
Lead	ND	0.001	mg/L	ND			NC	20	
Mercury	ND	0.0001	mg/L	ND			NC	20	
Manganese	0.0665	0.050	mg/L	0.0656			1.3	20	
Molybdenum	0.0078	0.005	mg/L	0.0076			2.9	20	
Nickel	0.0101	0.005	mg/L	0.0099			1.3	20	
Selenium	ND	0.005	mg/L	ND			NC	20	
Silver	ND	0.001	mg/L	ND			NC	20	
Tin	0.0125	0.010	mg/L	0.0127			1.5	20	
Titanium	ND	0.010	mg/L	ND			NC	20	
Vanadium	0.0030	0.001	mg/L	0.0029			1.2	20	
Zinc	ND	0.020	mg/L	ND			NC	20	

Metals - Total

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Aluminum	0.09	0.01	mg/L	0.08			14.5	20	
Antimony	ND	0.001	mg/L	ND			NC	20	
Arsenic	ND	0.01	mg/L	ND			NC	20	
Bismuth	ND	0.005	mg/L	ND			NC	20	
Boron	0.26	0.05	mg/L	0.25			4.7	20	
Cadmium	ND	0.001	mg/L	ND			NC	20	
Chromium	ND	0.05	mg/L	ND			NC	20	
Cobalt	ND	0.001	mg/L	ND			NC	20	
Copper	ND	0.005	mg/L	ND			NC	20	
Lead	ND	0.001	mg/L	ND			NC	20	
Mercury	ND	0.0001	mg/L	ND			NC	20	
Manganese	ND	0.05	mg/L	ND			NC	20	
Molybdenum	0.012	0.005	mg/L	0.012			0.3	20	
Nickel	0.009	0.005	mg/L	0.009			1.9	20	
Selenium	ND	0.005	mg/L	ND			NC	20	
Silver	ND	0.001	mg/L	ND			NC	20	
Tin	ND	0.01	mg/L	ND			NC	20	
Titanium	ND	0.01	mg/L	ND			NC	20	
Vanadium	ND	0.001	mg/L	ND			NC	20	
Zinc	ND	0.02	mg/L	ND			NC	20	
Volatiles									
Acetone	ND	0.0050	mg/L	ND			NC	30	
Benzene	ND	0.0005	mg/L	ND			NC	30	
Bromodichloromethane	ND	0.0005	mg/L	ND			NC	30	
Bromoform	ND	0.0005	mg/L	ND			NC	30	
Bromomethane	ND	0.0005	mg/L	ND			NC	30	
Carbon Tetrachloride	ND	0.0002	mg/L	ND			NC	30	
Chlorobenzene	ND	0.0005	mg/L	ND			NC	30	
Chloroethane	ND	0.0010	mg/L	ND			NC	30	
Chloroform	ND	0.0005	mg/L	ND			NC	30	
Chloromethane	ND	0.0030	mg/L	ND			NC	30	

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Dibromochloromethane	ND	0.0005	mg/L	ND			NC	30	
Dichlorodifluoromethane	ND	0.0010	mg/L	ND			NC	30	
1,2-Dibromoethane	ND	0.0002	mg/L	ND			NC	30	
1,2-Dichlorobenzene	ND	0.0005	mg/L	ND			NC	30	
1,3-Dichlorobenzene	ND	0.0005	mg/L	ND			NC	30	
1,4-Dichlorobenzene	ND	0.0005	mg/L	ND			NC	30	
1,1-Dichloroethane	ND	0.0005	mg/L	ND			NC	30	
1,2-Dichloroethane	ND	0.0005	mg/L	ND			NC	30	
1,1-Dichloroethylene	ND	0.0005	mg/L	ND			NC	30	
cis-1,2-Dichloroethylene	ND	0.0005	mg/L	ND			NC	30	
trans-1,2-Dichloroethylene	ND	0.0005	mg/L	ND			NC	30	
1,2-Dichloropropane	ND	0.0005	mg/L	ND			NC	30	
cis-1,3-Dichloropropylene	ND	0.0005	mg/L	ND			NC	30	
trans-1,3-Dichloropropylene	ND	0.0005	mg/L	ND			NC	30	
Ethylbenzene	ND	0.0005	mg/L	ND			NC	30	
Hexane	ND	0.0010	mg/L	ND			NC	30	
Methyl Ethyl Ketone (2-Butanone)	ND	0.0050	mg/L	ND			NC	30	
Methyl Butyl Ketone (2-Hexanone)	ND	0.0100	mg/L	ND			NC	30	
Methyl Isobutyl Ketone	ND	0.0050	mg/L	ND			NC	30	
Methyl tert-butyl ether	ND	0.0020	mg/L	ND			NC	30	
Methylene Chloride	ND	0.0050	mg/L	ND			NC	30	
Styrene	ND	0.0005	mg/L	ND			NC	30	
1,1,1,2-Tetrachloroethane	ND	0.0005	mg/L	ND			NC	30	
1,1,2,2-Tetrachloroethane	ND	0.0005	mg/L	ND			NC	30	
Tetrachloroethylene	ND	0.0005	mg/L	ND			NC	30	
Toluene	ND	0.0005	mg/L	ND			NC	30	
1,1,1-Trichloroethane	ND	0.0005	mg/L	ND			NC	30	
1,1,2-Trichloroethane	ND	0.0005	mg/L	ND			NC	30	
Trichloroethylene	ND	0.0005	mg/L	ND			NC	30	
Trichlorofluoromethane	ND	0.0010	mg/L	ND			NC	30	
1,3,5-Trimethylbenzene	ND	0.0005	mg/L	ND			NC	30	

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Vinyl chloride	ND	0.0005	mg/L	ND			NC	30	
m,p-Xylenes	ND	0.0005	mg/L	ND			NC	30	
o-Xylene	ND	0.0005	mg/L	ND			NC	30	
Surrogate: 4-Bromofluorobenzene	0.0826		%		103	50-140			
Surrogate: Dibromofluoromethane	0.0679		%		84.9	50-140			
Surrogate: Toluene-d8	0.0807		%		101	50-140			

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
General Inorganics									
Phosphorus, total	1.16	0.01	mg/L	0.169	99.3	80-120			
Total Suspended Solids	24.0	2	mg/L	ND	112	75-125			
Total Kjeldahl Nitrogen	1.02	0.1	mg/L	ND	102	84-116			
Hydrocarbons									
F1 PHCs (C6-C10)	1.87	0.025	mg/L	ND	93.4	85-115			
F2 PHCs (C10-C16)	1.6	0.1	mg/L	ND	101	60-140			
F3 PHCs (C16-C34)	4.4	0.1	mg/L	ND	111	60-140			
F4 PHCs (C34-C50)	2.8	0.1	mg/L	ND	114	60-140			
Metals									
Aluminum	43.2	0.010	mg/L	2.2	81.9	80-120			
Antimony	42.9	0.001	mg/L	0.1	85.5	80-120			
Arsenic	51.8	0.010	mg/L	0.1	103	80-120			
Bismuth	35.0	0.005	mg/L	0.008	69.9	80-120			QM-07
Boron	62.0	0.050	mg/L	26.8	70.4	80-120			QM-07
Cadmium	43.7	0.001	mg/L	0.008	87.4	80-120			
Chromium	57.1	0.050	mg/L	0.3	114	80-120			
Cobalt	51.7	0.001	mg/L	0.4	103	80-120			
Copper	48.8	0.005	mg/L	1.6	94.3	80-120			
Lead	38.7	0.001	mg/L	0.02	77.5	80-120			QM-07
Mercury	0.00282	0.0001	mg/L	ND	94.1	70-130			
Manganese	58.5	0.050	mg/L	6.6	104	80-120			
Molybdenum	49.8	0.005	mg/L	0.8	98.0	80-120			
Nickel	49.9	0.005	mg/L	1.0	97.7	80-120			
Selenium	44.7	0.005	mg/L	0.2	88.9	80-120			
Silver	42.2	0.001	mg/L	ND	84.4	80-120			
Tin	52.1	0.010	mg/L	1.3	102	80-120			
Titanium	58.0	0.010	mg/L	0.04	116	80-120			
Vanadium	59.4	0.001	mg/L	0.3	118	80-120			
Zinc	42.0	0.020	mg/L	1.8	80.4	80-120			

Metals - Total

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Aluminum	68.6	0.01	mg/L	7.81	122	80-120			QM-07
Antimony	52.6	0.001	mg/L	0.073	105	80-120			
Arsenic	59.5	0.01	mg/L	0.035	119	80-120			
Bismuth	41.5	0.005	mg/L	0.005	83.0	80-120			
Boron	78.6	0.05	mg/L	25.1	107	80-120			
Cadmium	54.3	0.001	mg/L	0.001	109	80-120			
Chromium	66.7	0.05	mg/L	0.066	133	80-120			QM-07
Cobalt	61.3	0.001	mg/L	0.025	123	80-120			QM-07
Copper	57.1	0.005	mg/L	0.155	114	80-120			
Lead	44.6	0.001	mg/L	0.019	89.1	80-120			
Mercury	0.0029	0.0001	mg/L	ND	97.8	70-130			
Manganese	65.0	0.05	mg/L	0.524	129	80-120			QM-07
Molybdenum	59.3	0.005	mg/L	1.18	116	80-120			
Nickel	60.0	0.005	mg/L	0.886	118	80-120			
Selenium	53.4	0.005	mg/L	0.030	107	80-120			
Silver	52.8	0.001	mg/L	ND	106	80-120			
Tin	61.7	0.01	mg/L	0.072	123	80-120			QM-07
Titanium	67.7	0.01	mg/L	0.256	135	80-120			QM-07
Vanadium	66.8	0.001	mg/L	0.031	133	80-120			QM-07
Zinc	54.2	0.02	mg/L	0.923	107	80-120			
PCBs									
PCBs, total	1.14	0.05	ug/L	ND	114	65-135			
Surrogate: Decachlorobiphenyl	0.231		%		92.5	60-140			
Pesticides, OC									
Aldrin	0.40	0.01	ug/L	ND	80.6	50-140			
alpha-BHC	0.47	0.01	ug/L	ND	93.5	50-140			
beta-BHC	0.36	0.01	ug/L	ND	72.6	50-140			
delta-BHC	0.42	0.01	ug/L	ND	83.3	50-140			
gamma-BHC (Lindane)	0.41	0.01	ug/L	ND	81.3	50-140			
alpha-Chlordane	0.36	0.01	ug/L	ND	72.9	50-140			
gamma-Chlordane	0.36	0.01	ug/L	ND	72.1	50-140			

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
o,p'-DDD	0.48	0.01	ug/L	ND	95.2	50-140			
p,p'-DDD	0.43	0.01	ug/L	ND	86.9	50-140			
o,p'-DDE	0.42	0.01	ug/L	ND	83.6	50-140			
p,p'-DDE	0.37	0.01	ug/L	ND	74.5	50-140			
o,p'-DDT	0.52	0.01	ug/L	ND	104	50-140			
p,p'-DDT	0.40	0.01	ug/L	ND	80.8	50-140			
Dieldrin	0.40	0.01	ug/L	ND	80.8	50-140			
Endrin	0.63	0.01	ug/L	ND	125	50-140			
Endrin aldehyde	0.43	0.01	ug/L	ND	85.8	50-140			
Endrin ketone	0.32	0.01	ug/L	ND	63.8	50-140			
Endosulfan I	0.39	0.01	ug/L	ND	77.7	50-140			
Endosulfan II	0.38	0.01	ug/L	ND	76.9	50-140			
Endosulfan sulfate	0.41	0.02	ug/L	ND	81.3	50-140			
Heptachlor	0.40	0.01	ug/L	ND	79.6	50-140			
Heptachlor epoxide	0.41	0.01	ug/L	ND	82.3	50-140			
Hexachlorobenzene	0.61	0.01	ug/L	ND	121	50-140			
Hexachlorobutadiene	0.67	0.01	ug/L	ND	133	50-140			
Hexachloroethane	0.60	0.01	ug/L	ND	121	50-140			
Methoxychlor	0.47	0.01	ug/L	ND	93.6	50-140			
Surrogate: Decachlorobiphenyl	0.175		%		70.0	50-140			
Semi-Volatiles									
1-Methylnaphthalene	0.00894	0.00005	mg/L	ND	89.4	50-140			
2-Methylnaphthalene	0.0102	0.00005	mg/L	ND	102	50-140			
7H-Dibenzo[c,g]carbazole	0.0104	0.00050	mg/L	ND	104	50-140			
Anthracene	0.00809	0.00001	mg/L	ND	80.9	50-140			
Benzo [a] anthracene	0.00988	0.00001	mg/L	ND	98.8	50-140			
Benzo [a] pyrene	0.00782	0.00001	mg/L	ND	78.2	50-140			
Benzo [b&j] fluoranthene	0.0110	0.00005	mg/L	ND	110	50-140			
Benzo [e] pyrene	0.0113	0.00005	mg/L	ND	113	50-140			
Benzo [g,h,i] perylene	0.00880	0.00005	mg/L	ND	88.0	50-140			
Benzo [k] fluoranthene	0.00810	0.00005	mg/L	ND	81.0	50-140			

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Benzylbutylphthalate	0.0103	0.00050	mg/L	ND	103	50-140			
Biphenyl	0.0107	0.00005	mg/L	ND	107	50-140			
Bis(2-chloroethoxy)methane	0.0103	0.00100	mg/L	ND	103	50-140			
Bis(2-ethylhexyl)phthalate	0.0105	0.00100	mg/L	ND	105	50-140			
Chrysene	0.00944	0.00005	mg/L	ND	94.4	50-140			
Dibenzo [a,h] anthracene	0.00909	0.00005	mg/L	ND	90.9	50-140			
Dibenzo [a,i] pyrene	0.0117	0.00050	mg/L	ND	117	50-140			
Dibenzo [a,j] acridine	0.00505	0.00050	mg/L	ND	50.5	50-140			
Diethylphthalate	0.0109	0.00100	mg/L	ND	109	50-140			
Di-n-butylphthalate	0.0116	0.00100	mg/L	ND	116	50-140			
Di-n-octylphthalate	0.0106	0.00100	mg/L	ND	106	50-140			
Fluoranthene	0.00994	0.00001	mg/L	ND	99.4	50-140			
Fluorene	0.00966	0.00005	mg/L	ND	96.6	50-140			
Indeno [1,2,3-cd] pyrene	0.00924	0.00005	mg/L	ND	92.4	50-140			
Indole	0.00906	0.00100	mg/L	ND	90.6	50-140			
Naphthalene	0.00915	0.00005	mg/L	ND	91.5	50-140			
Phenanthrene	0.00969	0.00005	mg/L	ND	96.9	50-140			
Perylene	0.0105	0.00050	mg/L	ND	105	50-140			
Pyrene	0.0101	0.00001	mg/L	ND	101	50-140			
2,4-Dichlorophenol	0.0107	0.00100	mg/L	ND	107	50-140			
Surrogate: 2-Fluorobiphenyl	0.0201		%		101	50-140			
Surrogate: Nitrobenzene-d5	0.0211		%		106	50-140			
Surrogate: Terphenyl-d14	0.0202		%		101	50-140			
Surrogate: 2,4,6-Tribromophenol	0.0444		%		111	50-140			
Surrogate: 2-Fluorophenol	0.0225		%		56.1	50-140			
Surrogate: Phenol-d6	0.0224		%		55.9	50-140			
Volatiles									
Acetone	0.112	0.0050	mg/L	ND	112	50-140			
Benzene	0.0468	0.0005	mg/L	ND	117	60-130			
Bromodichloromethane	0.0469	0.0005	mg/L	ND	117	60-130			
Bromoform	0.0476	0.0005	mg/L	ND	119	60-130			

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Bromomethane	0.0477	0.0005	mg/L	ND	119	50-140			
Carbon Tetrachloride	0.0475	0.0002	mg/L	ND	119	60-130			
Chlorobenzene	0.0484	0.0005	mg/L	ND	121	60-130			
Chloroethane	0.0485	0.0010	mg/L	ND	121	50-140			
Chloroform	0.0459	0.0005	mg/L	ND	115	60-130			
Chloromethane	0.0473	0.0030	mg/L	ND	118	50-140			
Dibromochloromethane	0.0462	0.0005	mg/L	ND	115	60-130			
Dichlorodifluoromethane	0.0381	0.0010	mg/L	ND	95.2	50-140			
1,2-Dibromoethane	0.0457	0.0002	mg/L	ND	114	60-130			
1,2-Dichlorobenzene	0.0493	0.0005	mg/L	ND	123	60-130			
1,3-Dichlorobenzene	0.0500	0.0005	mg/L	ND	125	60-130			
1,4-Dichlorobenzene	0.0483	0.0005	mg/L	ND	121	60-130			
1,1-Dichloroethane	0.0418	0.0005	mg/L	ND	105	60-130			
1,2-Dichloroethane	0.0459	0.0005	mg/L	ND	115	60-130			
1,1-Dichloroethylene	0.0475	0.0005	mg/L	ND	119	60-130			
cis-1,2-Dichloroethylene	0.0451	0.0005	mg/L	ND	113	60-130			
trans-1,2-Dichloroethylene	0.0423	0.0005	mg/L	ND	106	60-130			
1,2-Dichloropropane	0.0475	0.0005	mg/L	ND	119	60-130			
cis-1,3-Dichloropropylene	0.0496	0.0005	mg/L	ND	124	60-130			
trans-1,3-Dichloropropylene	0.0460	0.0005	mg/L	ND	115	60-130			
Ethylbenzene	0.0475	0.0005	mg/L	ND	119	60-130			
Hexane	0.0378	0.0010	mg/L	ND	94.6	60-130			
Methyl Ethyl Ketone (2-Butanone)	0.105	0.0050	mg/L	ND	105	50-140			
Methyl Butyl Ketone (2-Hexanone)	0.110	0.0100	mg/L	ND	110	50-140			
Methyl Isobutyl Ketone	0.120	0.0050	mg/L	ND	120	50-140			
Methyl tert-butyl ether	0.0936	0.0020	mg/L	ND	93.6	50-140			
Methylene Chloride	0.0504	0.0050	mg/L	ND	126	60-130			
Styrene	0.0480	0.0005	mg/L	ND	120	60-130			
1,1,1,2-Tetrachloroethane	0.0459	0.0005	mg/L	ND	115	60-130			
1,1,2,2-Tetrachloroethane	0.0486	0.0005	mg/L	ND	121	60-130			
Tetrachloroethylene	0.0487	0.0005	mg/L	ND	122	60-130			

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Toluene	0.0443	0.0005	mg/L	ND	111	60-130			
1,1,1-Trichloroethane	0.0470	0.0005	mg/L	ND	118	60-130			
1,1,2-Trichloroethane	0.0490	0.0005	mg/L	ND	123	60-130			
Trichloroethylene	0.0473	0.0005	mg/L	ND	118	60-130			
Trichlorofluoromethane	0.0485	0.0010	mg/L	ND	121	60-130			
1,3,5-Trimethylbenzene	0.0482	0.0005	mg/L	ND	121	60-130			
Vinyl chloride	0.0440	0.0005	mg/L	ND	110	50-140			
m,p-Xylenes	0.0924	0.0005	mg/L	ND	115	60-130			
o-Xylene	0.0477	0.0005	mg/L	ND	119	60-130			
Surrogate: 4-Bromofluorobenzene	0.0800		%		100	50-140			
Surrogate: Dibromofluoromethane	0.0828		%		104	50-140			
Surrogate: Toluene-d8	0.0814		%		102	50-140			

Certificate of Analysis

Report Date: 11-Jun-2025

Client: GEMTEC Consulting Engineers and Scientists Limited

Order Date: 5-Jun-2025

Client PO:

Project Description: 104054.001

Qualifier Notes:

Sample Qualifiers :

2: Surrogate recovery outside of control limits. The data was accepted based on valid recovery of the remaining surrogate.

QC Qualifiers:

QM-07 The spike recovery was outside acceptance limits for the MS and/or MSD. The batch was accepted based on other acceptable QC.

S-GC Surrogate recovery outside of control limits. The data was accepted based on valid recovery of the remaining surrogate.

Sample Data Revisions:

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable

ND: Not Detected

MDL: Method Detection Limit

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

%REC: Percent recovery.

RPD: Relative percent difference.

NC: Not Calculated

CCME PHC additional information:

- The method for the analysis of PHCs complies with the Reference Method for the CWS PHC and is validated for use in the laboratory. All prescribed quality criteria identified in the method has been met.

- F1 range corrected for BTEX.

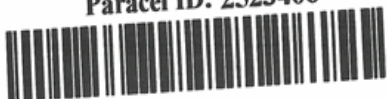
- F2 to F3 ranges corrected for appropriate PAHs where available.

- The gravimetric heavy hydrocarbons (F4G) are not to be added to C6 to C50 hydrocarbons.

- In the case where F4 and F4G are both reported, the greater of the two results is to be used for comparison to CWS PHC criteria.

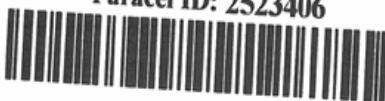
- When reported, data for F4G has been processed using a silica gel cleanup.

Any use of these results implies your agreement that our total liability in connection with this work, however arising, shall be limited to the amount paid by you for this work, and that our employees or agents shall not under any circumstances be liable to you in connection with this work.



Client Name:	GEMTEC	Project Ref:	104054.001	Waterworks Name:		Samples Taken By:	
Contact Name:	Andrius Paznekas	Quote #:		Waterworks Number:		Name:	Jeffrey Gauthier
Address:	32 Stelac Drive	PO #:		Address:		Signature:	
After Hours Contact:		E-mail:	andrius.paznekas@gemtec.ca			Page	1 of 1
Telephone:		Fax:		Public Health Unit:		Turn Around Time Required:	☐ 1 day ☐ 2 day ☐ 3 day ☒ 4 day

Samples Submitted Under: (Indicate ONLY one) ☐ ON REG 170/03 ☐ ON REG 319/08 ☐ Private Well ☐ ON REG 243/07 ☒ Other <u>sewer use</u>				Sample Type: R = Raw; T = Treated; D = Distribution; P = Plumbing Source Type: G = Ground Water; S = Surface Water Reportable: Requires AWQI reporting as per Regulation - Y = Yes; N = No				Required Analyses							
Have LSN forms been submitted to MOE/MOHLTC?: ☐ Yes ☐ No ☒ N/A Are these samples for human consumption?: ☐ Yes ☒ No All information must be completed before samples will be processed.															
LOCATION NAME	SAMPLE ID	Sample Type: R/T/D/P	Source Type: G/S	Reportable: Y/N	Resample	SAMPLE COLLECTED		# of Containers	Free/Combined Chlorine Residual mg/L	Standing / Flushed: S/F (REG 243)	Total Coliform/E. Coli	HPC	Lead	THM	Other
						DATE	TIME								
1	MW25-02	R	G	N		June 4/25	9:45	12							1
2															
3															
4															
5															
6															
7															
8															
9															
10															
Comments:										Method of Delivery: <u>WALKIN</u>					
Relinquished By (Sign):		Received By Driver/Depot: <u>DBLOOM</u>		Received at Lab: <u>LTT</u>		Verified By: <u>SO</u>									
Relinquished By (Print): <u>Jeffrey Gauthier</u>		Date/Time: <u>June 5, 2025 2:25</u>		Date/Time: <u>05/06/25, 16:15</u>		Date/Time: <u>June 6, 2025 9:23am</u>									
Date/Time: <u>June 5/25 2:25</u>		Temperature: <u>6.9</u> °C		Temperature: <u>8.0</u> °C		pH Verified: ☒ By: <u>LTT</u>									



Office
119 St. Laurent Blvd.
A, Ontario K1G 4J8
607-619-1947
info@paracelabs.com
paracelabs.com

Paracel Order Number
(Lab Use Only)

2523406

Chain Of Custody
(Lab Use Only)

Client Name: GEMTEC	Project Ref: 104054.001	Page 1 of 1
Contact Name: Andrius Paznekas	Quote #:	Turnaround Time ☐ 1 day ☐ 3 day ☐ 2 day ☒ Regular
Address: 32 Steacie Drive	PO #:	
Telephone:	E-mail: andrius.paznekas@gemtec.ca	
		Date Required:

☐ REG 153/04 ☐ REG 406/19		Other Regulation		Matrix Type: S (Soil/Sed.) GW (Ground Water)		Required Analysis															
☐ Table 1 ☐ Agri/Other ☐ Med/Fine ☐ Table 2 ☐ Res/Park ☐ Coarse ☐ Table 3 ☐ Ind/Comm ☐ Table _____ For RSC: ☐ Yes ☒ No		☐ REG 558 ☐ PWQO ☐ CCME ☐ MISA ☒ SU - Sani ☐ SU - Storm Mun: _____ ☐ Other: _____		SW (Surface Water) SS (Storm/Sanitary Sewer) P (Paint) A (Air) O (Other)																	
Sample ID/Location Name				Matrix	Air Volume	# of Containers	Field Filtered	Sample Taken		Gemtec sewer use	with filtered metals										
								Date	Time												
1	MW25-02			GW	-	12		June 4/2025	9:45	X	X										
2																					
3																					
4																					
5																					
6																					
7																					
8																					
9																					
10																					

Comments: Has field filtered metals		Revised COC		Method of Delivery: Parcel Courier	
Relinquished By (Sign): Jeffrey Gauthier	Received at Depot:	Received at Lab: LTJ	Verified By: SO		
Relinquished By (Print): Jeffrey Gauthier	Date/Time:	Date/Time: 05/06/25 16:15	Date/Time: June 6, 2025 9:23am		
Date/Time: June 5/2025	Temperature: °C	Temperature: 8.0°C	pH Verified: ☒	By: LTJ	

experience • knowledge • integrity



civil	civil
geotechnical	géotechnique
environmental	environnement
structural	structures
field services	surveillance de chantier
materials testing	service de laboratoire des matériaux

expérience • connaissance • intégrité

