AECOM

City of Winnipeg Brady Road Resource Management Facility Area B Design

Geotechnical Report

City of Winnipeg

Project number: 60733855

January 2025

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1. Introduction

1.1 General

AECOM Canada ULC. (AECOM) was retained by the City of Winnipeg (CoW) to provide geotechnical engineering services for the development of Area B due to the closure of Area A at the Brady Road Resource Management Facility (BRRMF). BRRMF is a 790-hectare, Class 1 Waste Disposal Ground and Resource Management Facility, located south of the perimeter highway between Brady Road and Waverly Street in Winnipeg, Manitoba.

Solid waste disposal is currently taking place in Area A at the BRRMF with Cell 34 being the last disposal cell in this area. This cell is anticipated to reach capacity in 2026. The next waste disposal cell to be developed is Cell 35 located within Area B, a 66-hectare site bound by Payette Road to the east, Brady Road to the west, Ethan Boyer Way to the north, and Charette Road to the south. A map of both Area A and Area B sites are provided in **Figure 1.**

Figure 1: Area A and Area B

This report addresses the findings of the geotechnical services for the development of Area B. The services included a geotechnical investigation in Area B to conduct soil profiling, rock coring and laboratory tests. Additionally, addressing geotechnical concerns and providing recommendations related to slope stability, consolidation and other constraints, based on current and proposed design of the landfill.

In this report, the current and proposed design of the landfill will be referred to as CoW Preferred Design (Option 1) and 60-meter Waste Pile Design (Option 2), respectively. Additionally, the findings from the geotechnical investigation in the southeast corner of Area B will be used for several design parameters specified in **Section 6,** as it is AECOM's understanding that the first cell to be developed (Cell 35) will be located in the southeast corner of Area B.

1.2 Project Site

Area B is comprised of long grass and weeds with thick bushes, and several ditches along the edges of the site. There are two berms located along the North and West side of the area. There is a leachate pipe that runs along the perimeter access road on the east side of area B (north to south). During the site investigation the entirety of area B was covered in vegetation and much of the area had standing water with poor drainage. There is also an access road that goes east to west in the middle of area B which was submerged in water in several spots during the geotechnical investigation.

Additionally, the area primarily consists of a thin layer of topsoil, measuring between 0.1 and 0.15 meters thick, underlain by clay that extends to approximately 15 meters deep. Beneath this clay layer, till containing cobbles and boulders are encountered, leading down to bedrock at approximately 25 meters depth.

1.3 Proposed Construction

AECOM understands that a preliminary discussion will be held regarding landfill design options, including road networks, leachate and gas management systems. As part of this proposed construction, AECOM will establish design excavation limits in compliance with landfill standards.

The development in Area B will begin in the southeast corner of the site (Cell 35). The height of the waste pile is measured from the approximate average elevation of the existing field (prairie level) of 233.5 m, measured from two (2) testhole (BH24-06, BH24-12) locations in the southeast corner of Area B. The City of Winnipeg instructed AECOM to design cells with a waste height of 30 meters and an excavation depth of 3.0 to 4.5 meters (Option 1). Alternatively, AECOM is considering a waste height of 60 meters with an excavation depth of 3.0 to 4.5 meters (Option 2). Both Option 1 and Option 2 are designed with a standard clay cap thickness of 0.85 m and a slope ratio of 3H:1V. It is AECOM's understanding that this slope ratio has been used in previous cells at the BRRMF. Further information on previous slope ratios at the BRRMF are presented in **Section 1.4.**

- **CoW Preferred Design (Option 1)**
    - Excavation Depth: 3.0 to 4.5 meters
    - Waste Height: 30 meters
    - Thickness of standard clay cap= 0.85 m
    - Slope Ratio: 3H:1V
- **60-meter Waste Pile Design (Option 2)**
    - Excavation depth: 3.0 to 4.5 meters
    - Waste Height: 60 meters
    - Thickness of standard clay cap= 0.85 m
    - Slope Ratio: 3H:1V

Additionally, the road design has been developed for a 20-year service life. To facilitate this future development, two additional test holes were drilled beneath the gravel road that separated the northern and southern sections of Area B.

1.4 Background

A recent geotechnical report titled, “**Brady Road Resource Management Facility Cell Design and Master Plan Geotechnical Investigation and Stability Assessment for Landfill Area A Development – Final”** (KGS Group, 2019) and an older report “**Hydrogeologic Studies – Brady Road Landfill**” (UMA Engineering Ltd., 1987) was reviewed prior to the field drilling program and the writing of this report.

Notably, previous landfill cells at the Brady Landfill were constructed with slope ratio’s of 3H:1V. Slopes with this configuration were generally stable based on historical observations made by others during the construction of these cells.

1.4.1 Hydrogeologic Studies – Brady Road Landfill (UMA Engineering Ltd. 1987)

The hydrogeologic studies by UMA Engineering for the major landfill expansion include design recommendations for an efficient leachate collection system to prevent contamination of surface and groundwater. The study also recommends an environmental monitoring program to assess the landfill’s design and control features. The objectives of the study were to define these key components:

- The regional geologic and hydrogeologic setting
- The specific hydrologic conditions and key stratigraphic units underlying the proposed development area
- The structure and permeability of the overburden
- The suitability of the overburden for long term containment of leachate
- State-of-the-art landfilling practices and regulatory requirements for environmental protection
- The potential for pollution of surface water or groundwater (GW) by sanitary landfilling
- Recommendations for landfill design parameters, environmental protection measures and monitoring programs.

The investigation program consisted of drilling twenty (20) testholes at selected locations across the site to determine the clay thickness and installation of piezometers at four (4) sites to provide data on the hydrogeology. Drilling at each of the four piezometers sites consisted of a nest of six holes. Four holes were drilled in the clay, one hole in the till and one hole into bedrock. At each of the four piezometer sites, four standpipes’ piezometers were installed in the clay in separate holes, two standpipe piezometers were installed in the till in a single hole and one bedrock monitoring well was installed in the upper aquifer.

Table 1 summarizes the soil layers as recorded by UMA in 1987, detailing their thickness in meters and their elevation ranges in meters.

Table 1: Summary of Soil Layer (UMA, 1987)

Soil Layer	Thickness (m)	Elevations (m)
Topsoil	0.1 to 0.5	234.52 to 232.67
Clay	10.1 to 14.6	232.98 to 232.27
Silt Till	0 to 5.1	223.28 to 218.00

1.4.2 Brady Road Resource Management Facility Cell Design and Master Plan Geotechnical Investigation and Stability Assessment for Landfill Area A Development – Final (KGS Group, 2019)

In 2019, KGS Group conducted a geotechnical investigation to assess subsurface conditions and perform a slope stability analysis for the proposed cell side slopes. This investigation is compliant with the 2016 Standards for Landfills in Manitoba and included performance data from previous Brady Landfill excavations provided by Manitoba Sustainable Development. The study also evaluated excavation base stability and provided information regarding the subsurface soil and potential leachate seepage. The report consisted of the following:

- **Slope Stability Assessment:** A two-dimensional slope stability analysis was conducted on these representative cross sections.
- **Summary Geotechnical Report:** The report provides the following details:
  - An overview of site conditions, including soil stratigraphy, sloughing, and seepage conditions.
  - A description of the field investigation program, summarizing soil sampling and both in-situ and laboratory test results, such as field torvane, moisture content analyses, Atterberg limit tests, grain size analyses, and hydraulic conductivity.
  - Comprehensive test hole log records, incorporating field observations, laboratory test results, and UTM coordinates of the test holes.
  - Results of the slope stability assessment, including recommendations for the side slope geometry of the proposed Cell 31 excavation, addressing both short-term and long-term stability. Recommendations for side slopes are also provided for cells 32 to 34.
  - General construction considerations for excavations, including an evaluation of base heave stability, site drainage, and freeze-thaw susceptibility estimates.

Based on the geotechnical field investigation and stability assessment, the following key findings are summarized:

- The site's stratigraphy mainly consists of high plasticity silty clay underlain by glacial silt till, with some layers of topsoil, organic clay, and low plastic silt encountered in specific test holes.
- The clays are highly expansive, meaning they can swell or shrink with changes in stress or moisture content.

Table 2 summarizes the soil layers recorded by KGS in 2019, detailing their thickness in meters below ground surface (m BGS) and their elevation ranges in meters above sea level (m ASL).

Table 2: Summary of Soil Layer (KGS, 2019)

Soil Types	Thickness (m BGS)	Elevations (m ASL)
Topsoil	0 to 0.1	234.5 to 232.7
Clay	9.0 to 14.0	224.5 to 233.5
Silt Till	0.2 to 2.6	223.3 to 218.0

2. Scope of Work

The geotechnical study was conducted based on the proposal submitted on May 31, 2024, and includes the following work:

- A geotechnical drilling and soil sampling program at the proposed site to identify the existing soil and groundwater conditions. Rock coring was performed in three testholes;
- A laboratory testing program that included moisture contents on all collected grab samples, and Atterberg limits, particle size analysis, hydraulic conductivity, 1-D consolidation, California bearing ratio, and standard proctors on selected soil samples;
- A soil consolidation assessment based on Cow preferred Design (Option 1) and 60-meter Waste Pile Design (Option 2);
- Recommendations for the geometry of the cell design and side slopes based on Cow preferred Design (Option 1) and 60-meter Waste Pile Design (Option 2);
- Recommendations for the waste disposal liner;
- Pavement design options for the roadway base structure/roadway design;
- Preparation of this geotechnical report outlining the existing site conditions, frost penetration, and cell design recommendations;
- Number of testhole that was proposed was sixteen (16). Thirteen (13) were drilled.
- The proposed number of testholes were not drilled due to difficult access of the site, flooding conditions and soft soils; and,
- Use of this report is subject to the Statement of Qualifications and Limitations provided at the beginning of this report.

3. Investigation Program

An intrusive geotechnical investigation program was conducted to identify potential geotechnical constraints and to characterize the subsurface soil stratigraphy and groundwater conditions encountered in Area B. The Geotechnical investigation consisted of the following:

- Drilling 13 geotechnical testholes with depths ranging from 6.40 to 28.04 metres below ground surface (m bgs).
- Monitoring wells installed in clay (BH24-01, BH24-03, BH24-04, BH24-06, BH24-08, BH24-11, BH24-12, BH24-13 and BH24-15).
- Monitoring wells installed in till (BH24-02, BH24-03, BH24-04, BH24-06, BH24-08, BH24-09, BH24-10 and BH24-14).
- Monitoring wells installed in Limestone (BH24-03, BH24-06 and BH24-08)
- Grab samples, shelby tubes and core samples were obtained.
- Conducting laboratory testing on selected samples for classification and determination of engineering properties to be used in later geotechnical analyses.
- Site photos, testhole location plan, and testhole logs are included in **Appendix A, Appendix B and Appendix C** respectively**.** Detailed laboratory testing results, slope stability outputs, and settlement outputs are included in **Appendix D**, **Appendix E,** and **Appendix F**, respectively.

3.1 Testhole Drilling and Soil Sampling

The subsurface drilling and sampling program was conducted from July 10 to July 22, 2024. Drilling services were provided by Paddock Drilling under the supervision of AECOM geotechnical field personnel. The testhole location plan is provided in **Appendix B**. Thirteen testholes (identified as BH24-01 to BH24-15) were drilled on the project site using a track mounted drill rig, which was equipped with 125 mm solid stem augers. Originally the geotechnical investigation program had accounted for 16 testholes to be drilled. However, within the central section of the proposed Area B, north and south of the bisecting access road, standing water was present. The track mounted drill rig was unable to access these testhole locations, therefore BH24-05, BH24-07 and BH24-16 were removed from the geotechnical investigation due to accessibility issues.

Upon completion of the drilling program, testholes BH24-04, BH24-11, BH24-12, BH24-13, and BH24-15 were drilled to depth within the clay layer while BH24-01, BH24-02, BH24-09, BH24-10, and BH24-14 were drilled to depth within the till layer, and BH24-03, BH24-06, BH24-08, were drilled to depth within the bedrock. Auger refusal was encountered at depths ranging from 14.90 meters below ground surface (m BGS) to 15.50 m BGS, requiring coring equipment to advance to further depths. Shelby tubes were collected at select depths in testholes BH24-01, BH24-03, BH24-08, and BH24-09. Standard penetration tests (SPTs) were conducted in the till layer in testholes BH24-03, BH24-06, and BH24-14. Rock coring was performed in testholes BH24-03, BH243-06, and BH24-08 to a final elevation ranging from 207.51 meters above sea level (m ASL) to 212.44 m ASL.

Soil samples were obtained directly from the auger flights at depth intervals ranging from 0.3 m to 1.5 m. Undisturbed soil samples were obtained using a 75 mm diameter Shelby tube. SPTs were conducted to assess the relative density of cohesionless soils. The soil samples were visually classified in the field and returned to our soil laboratory for additional examination and testing. Cohesive soil samples were tested using a torvane and pocket penetrometer to estimate the undrained shear strength and the compressive soil strength.

Upon completion of drilling, testholes were filled with silica sand followed by bentonite pellets to the surface. The testholes were examined for evidence of sloughing and groundwater seepage. Excess cuttings were left at the testhole location on the project site. The detailed testhole records are provided in **Appendix C**, which include a summary sheet outlining the symbols and terms of the testhole record.

3.2 Laboratory Testing

A laboratory testing program was performed on soil samples obtained during the drilling program to determine the relevant engineering properties of the subsurface materials. Testing included moisture contents (ASTM D2216), on all collected soil samples, as well as particle size analysis (ASTM D422), Atterberg limits tests (ASTM D4318), hydraulic conductivity (ASTM D5084), one-dimensional consolidation (ASTM D2435), standard proctor (ASTM D698), and California Bearing Ratio (CBR) (ASTM D1883) on select soil samples. In addition, torvane and pocket penetrometer readings were taken on auger grab samples. The results of the laboratory testing are shown in **Appendix D.**

4. Subsurface Conditions

Subsurface conditions observed during testhole drilling and sampling were visually documented by AECOM geotechnical personnel in accordance with the Unified Soil Classification System (USCS).

The subsurface characteristics of the site have been based on the investigation results obtained during the field and laboratory investigation program. The pertinent results from these investigations are outlined below.

4.1 Soil Stratigraphy

The soil stratigraphy within the project site generally consisted of topsoil, underlain by a clay deposit, till and bedrock. In BH24-02, BH24-04, BH24-08, and BH24-14 a silt layer was observed interbedded within the clay layer. Beneath the clay layer sandy silty clay till was observed, followed by bedrock below the till layer. A description of the soil stratigraphy is provided below. The detailed testhole logs are provided in **Appendix C**, which include a summary sheet outlining the symbols and terms of the testhole record.

4.1.1 Topsoil

Topsoil was encountered at the ground surface in all testholes. The thickness of the topsoil ranged from 0.10 to 0.15 m.

4.1.2 Fat Clay (CH)

Fat clay (CH) was encountered below the topsoil in all testholes except for BH24-02, where the fat clay (CH) was observed below a silt (ML) layer. The fat clay (CH) ranged in thickness from approximately 6.10 m to 14.94 m. The fat clay (CH) layer was observed at elevations ranging from 235.406 m ASL to 218.51 m ASL. The fat clay (CH) was of high plasticity, began as black in color, transitioning to brown between 0.76 m BGS to 1.50 m BGS, and again transitioning to grey at approximately 4.3 m BGS. The fat clay (CH) layer was typically observed to be firm to stiff and transitioned to soft to firm with depth. The moisture content of the fat clay ranged from 13.8% to 67.6% with an average of 45.8%.

4.1.3 Silt (ML)

A silt (ML) layer was observed below the topsoil in BH24-02, while an interbedded silt (ML) layer was encountered within the fat clay (CH) layer in BH24-04, BH24-08, and BH24-14. The silt (ML) ranged in thickness from 0.61 m to 0.76 m. The silt (ML) layer was encountered at elevations ranging from 233.32 m ASL to 232.04 m ASL. The silt (ML) was classified as tan and was soft. The moisture content ranged from 23.7% to 33.7% with an average of 28.2%.

4.1.4 Sandy Silty Clay (CL-ML) Till

Sandy silty clay (CL-ML) TILL was encountered below the fat clay (CH) in BH24-01 to BH24-03, BH24-06, BH24-08 to BH24-10, and BH24-14. The sandy silty clay (CL-ML) TILL was encountered at elevations ranging from 232.80 m ASL to 209.65 m ASL. Auger refusal was met in the sandy silty clay (CL-ML) TILL in this layer (BH24-03, BH24-06) and required coring methods to reach the bedrock layer due to presence of cobbles and boulders. SPTs completed within the sandy silty clay (CL-ML) TILL show uncorrected “N” values ranging from 22 to >91 per 300 mm of penetration, classifying the materials as very stiff to hard in relative density. The moisture content ranged from 6.7% to 35.5% with an average of 16.6%. In the sandy silty clay (CL-ML) TILL layer, it was common to encounter cobbles and boulders.

Table 3 compares the elevation ranges (in meters above sea level) of different soil layers as recorded by UMA in 1987, KGS in 2019, and AECOM in 2024. The silt layer’s elevations are only available for KGS and AECOM, showing similar ranges. The fat clay and silt till layers have comparable elevation ranges across all three sources, with some variations.

Table 3: Comparison of Soil Layers

Layer	Elevation (m ASL)		
	UMA, 1987	KGS, 2019	AECOM, 2024
Silt	-	234.5 to 232.7	233.3 to 232.0
Fat Clay	232.3 to 224.0	233.5 to 224.5	235.4 to 218.5
Glacial Till	223.3 to 218.0	223.3 to 218.0	232.8 to 209.7

4.1.5 Bedrock

Bedrock was encountered below the sandy silty clay (CL-ML) TILL in cored testholes; BH24-03, BH24-06, and BH24-08. The Bedrock was observed to be dolomite; an Upper Fort Garry Member of the Red River Formation. The Bedrock was observed at elevations ranging from 214.57 m ASL to 209.65 m ASL and extended to unknown depths due to termination of the coring within this layer. The dolomite was in parts cherty, some limestone beds, and brecciated. The quality of the bedrock varied significantly which will be discussed further in **Section 4.3**. **Section 4.3.1** describes the total core recovery (TCR), **Section 4.3.2** describes the solid core recovery (SCR), **Section 4.3.3** describes the rock quality designation (RQD), and **Section 4.3.4** describes the bedrock classification results.

4.1.6 Groundwater and Sloughing Conditions

Groundwater seepage or soil sloughing conditions was not observed in most testholes upon completion of drilling. However, based on AECOM’s experience in the Winnipeg area, seepage and sloughing is typically observed in the silt and till layers. Details of the location and nature of the sloughing, seepage, and groundwater encountered are provided on the testhole logs in **Appendix C**.

Standpipe piezometers were installed in all the testholes, excluding BH24-02. Groundwater readings were taken in August 2024. The readings recorded are summarized in **Table 4.**

Table 4: Groundwater Readings

Standpipe	Stratum/Tip Elevation (m ASL) (Depth (BGS m))	Groundwater Elevation (m ASL)	
		Aug. 1, 2024	Aug. 22, 2024
BH24-01	Fat CLAY/224.72 (8.84)	228.56	228.56
BH24-03	Fat CLAY/227.94 (7.62)	228.08	228.18
BH24-03	Sandy Silty CLAY TILL/220.32 (15.24)	223.56	225.61
BH24-03	BEDROCK/207.52 (28.04)	227.87	227.69

Standpipe	Stratum/Tip Elevation (m ASL) (Depth (BGS m))	Groundwater Elevation (m ASL)	
		Aug. 1, 2024	Aug. 22, 2024
BH24-04	Fat CLAY/226.55 (7.62)	232.28	232.32
BH24-06	Fat CLAY/227.47 (6.40)	228.34	228.55
BH24-06	Sandy Silty CLAY TILL/218.53 (15.24)	227.83	227.71
BH24-06	BEDROCK/212.43 (21.34)	227.94	227.80
BH24-08	Fat CLAY/227.63 (6.10)	228.35	228.52
BH24-08	Sandy Silty CLAY TILL/217.88 (15.85)	228.64	228.41
BH24-08	BEDROCK/207.52 (26.21)	227.94	226.82
BH24-09	Sandy Silty CLAY TILL/219.94 (13.72)	232.97	232.98
BH24-10	Sandy Silty CLAY TILL/216.84 (16.76)	227.14	227.57
BH24-11	Fat CLAY/224.76 (9.14)	226.55	225.91
BH24-12	Fat CLAY/225.76 (7.62)	226.82	227.14
BH24-13	Fat CLAY/225.93 (7.62)	232.82	232.551
BH24-14	Sandy Silty CLAY TILL/218.79 (15.24)	228.11	228.074
BH24-15	Fat CLAY/227.27 (6.40)	228.225	228.635

It should be noted that the hydrogeology team suspected that BH24-04, BH24-09 and BH24-13 were compromised due to the unusually high groundwater elevations observed at these locations.

Additionally, only short-term seepage and sloughing conditions were observed in the testholes. Groundwater levels will normally fluctuate during the year and will be dependent on precipitation, surface drainage, and regional groundwater regimes. Groundwater seepage and soil sloughing should be expected from the silt (ML) and the sandy silty clay (CL-ML) TILL layer.

4.2 Laboratory Test Results

A variety of laboratory testing was performed on select samples collected from the field drilling program. Moisture content tests were conducted on soil samples recovered from testholes with the moisture content (ASTM D2216) test results shown on the testhole records provided in **Appendix C**. Select representative soil samples were also tested for particle size analysis (ASTM D422, **Table 5**), Atterberg limits (ASTM D4318, **Table 6**), one-dimensional consolidation (ASTM D2435, **Table 7**), hydraulic conductivity (**Table 8**), standard proctor (ASTM D698, **Table 9**), and CBR (ASTM D1883, **Table 10**).

Table 5: Particle Size Analysis Results

Testhole No.	Sample Depth (m BGS)	Soil Type	Particle Size			
			Gravel (mm)	Sand (mm)	Silt (mm)	Clay (mm)
			75 to 4.75	<4.75 to 0.075	<0.075 to 0.002	<0.002
BH24-01	4.57 – 5.18	CH	0.10%	0.40%	30.80%	68.70%
BH24-01	10.67 – 11.28	CH	0.20%	2.90%	30.60%	66.30%
BH24-08	1.37 – 1.52	CL	0.00%	21.20%	60.70%	18.00%
BH24-10	16.61 – 16.76	CL-ML	3.00%	41.60%	42.40%	13.00%

Table 6: Atterberg Limits Test Results

Testhole No.	Sample Depth (m BGS)	Soil Type	Liquid Limit	Plastic Limit	Plasticity Index	Activity
BH24-01	4.57 – 5.18	CH	85	24	61	0.89
BH24-01	10.67 – 11.28	CH	81	22	59	0.89
BH24-08	1.37 – 1.52	CL	28	16	12	0.67
BH24-10	16.61 – 16.76	CL-ML	17	11	8	0.62

Table 7: One-Dimensional Consolidation Results

Testhole No.	Sample Depth (m BGS)	Saturation (%)	Moisture Content (%)	Initial Void Ratio	Compression Index	Preconsolidation Pressure (kPa)
BH24-09	1.52 - 2.13	96.7	34.2	0.8121	0.214	100
BH24-09	10.7 - 11.3	90.8	59.2	1.797	1.002	232

Table 8: Hydraulic Conductivity Results

Testhole No. Undisturbed Preparation Process	Sample ID	Sample Depth (m BGS)	Average Hydraulic Conductivity (m/sec)
BH24-01	T4	1.52 - 2.13	1.60E-10
BH24-01	T7	4.57 - 5.18	5.90E-11
BH24-01	T13	10.67 - 11.28	8.60E-11
BH24-03	T10	7.62 - 8.23	1.10E-10

Table 9: Standard Proctor Results

Testhole No.	Sample Depth (m BGS)	Soil Type	Maximum Dry Density (kg/m^3)	Optimum Moisture Content (%)
BH24-01 to BH24-15	0.46 - 1.52	Fat Clay (CH)	1595	24.1

Table 10: California Bearing Ratio Results (95% Compaction)

Testhole No.	Sample Depth	Soil Type	Dry Density (kg/m^3)	CBR at 2.54 mm	CBR at 5.08 mm
BH24-01 to BH24-15	0.45 - 1.50	Fat Clay (CH)	1515	2.5	2.1

Note: CBRs tested at 95% of maximum dry density

4.3 Classification of Bedrock

Three methods were employed to calculate the discontinuities in the bedrock, yielding three different percentages. Routine drill core descriptions, including TCR, SCR, and RQD, are primarily designed to provide insights into the rock's discontinuities. The RQD indicates the quality of the rock as a percentage, as illustrated in **Table 12**.

4.3.1 Total Core Recovery (TCR)

Total core recovery (TCR) is the testhole core recovery percentage. TCR is expressed as follows:

$$TCR\ (\%) = \frac{sum\ of\ recovered\ core\ length}{total\ core\ length}\ x\ 100$$

The TCR as calculated for each bedrock core run advanced within the testholes. A summary of TCR values is provided in **Table 12**. The TCR ranged from 70% to 86%.

4.3.2 Solid Core Recovery (SCR)

Solid core recovery (SCR) is the testhole core recovery percentage of solid cylindrical rock. SCR is expressed as follows:

$$SCR\ (\%) = \frac{sum\ of\ recovered\ solid\ cylindrical\ core\ lengths}{total\ core\ length}\ x\ 100$$

The SCR was calculated for each bedrock core run advanced within the testhole. A summary of the SCR values is provided in **Table 12**. The solid core recovery was observed to be between 26% to 81%.

4.3.3 Rock Quality Designation (RQD)

RQD is based on the ISRM classification system. The RQD is an indirect measure of the number of fractures and the amount of jointing in the rock mass. The RQD is expressed as a percentage of the ratio of summed core lengths (greater than 10 cm) to the total length cored. The RQD index is used to provide a classification of the rock quality shown in **Table 11**.

Table 11: Rock Classification Ranges

RQD (%)	Rock Quality Designation
0 – 25	Very Poor
25 – 50	Poor
50 – 75	Fair
75 – 90	Good
90 – 100	Excellent

RQD is expressed as follows:

$$RQD\ (\%) = \frac{sum\ of\ recovered\ core\ lengths\ greather\ than\ 10\ cm}{total\ core\ length}\ x\ 100$$

The RQD was calculated for each core run advanced within BH24-03, BH24-06, and BH24-08. A summary of the RQD values is provided in **Table 12**.

4.3.4 Bedrock Classification Results

Based on the rock classification and laboratory test results, the encountered bedrock classification ranges from poor to fair quality.

Table 12: TCR, SCR, and RQD Results

Testhole ID	Sample Number	Core Run Depth (m BGS)	Elevation (m ALS)	TCR (%)	SCR (%)	RQD (%)	Rock Quality Designation
BH24-03	C17	25.91 – 28.04	209.65 – 207.52	70	35	36	Poor
BH24-06	C14	19.20 – 21.34	214.57 – 212.43	84	26	58	Fair
BH24-08	C17	23.77 – 26.21	209.96 – 207.52	86	81	49	Poor

5. Geotechnical Concerns

Based on the results of the geotechnical investigation and the current understanding of the proposed development of Cell 35, the primary geotechnical concern is the groundwater table at the southeast corner of Area B, as it is AECOMs understanding that Cell 35 will be developed in that location.

The southeast corner has a groundwater elevation of 228.34 m ASL (5.46 m BGS) The geotechnical group confirmed the elevation of the groundwater with AECOM's hydrogeology team.

From a geotechnical perspective, it is ideal to maintain the groundwater table below the excavation depth. As the excavation depth approaches the groundwater elevation (228.34 m ASL), several concerns may arise due to the proximity of the groundwater table. **Section 6.3.3** presents five (5) scenarios for excavation in Cell 35 as the final excavation depth of the cell is unknown at this time.

The following concerns may occur when excavation depths reach near or at the groundwater table:

- Water infiltration: Water can flow in the excavation site, leading to flooding or ponding which can complicate construction.
- Slope Stability: Saturated soils will likely reduce the soil strength, increasing the risk of slumps and slope movements.
- Heaving: The buoyancy of groundwater can cause the bottom of the excavation to heave.

Additionally, high groundwater elevations were observed in Area B at BH24-04 (232.28 m ASL), BH24-09 (232.97 m ASL) and BH24-13 (232.82 m ASL). These groundwater elevations were approximately 1.28 m, 0.69 m and 0.73 m BGS, respectively. Notably, the hydrogeology team suspect these monitoring wells are compromised, and an additional investigation may be required to confirm.

More information on groundwater monitoring is specified in **Section 6.3.2.2.**

6. Recommendations

Based on discussions with the client, it is AECOM's understanding that construction will begin in the southeastern portion of Area B (Cell 35). Therefore, recommendations presented in **Section 6** are based on our investigation findings, including field work conducted in the southeast of Area B (Cell 35), as well as a review of the KGS geotechnical report titled, "Brady Road Resource Management Facility Cell Design and Master Plan Geotechnical Investigation and Stability Assessment for Landfill Area A Development – Final" (KGS Group, 2019).

6.1 Basal Heave Due to Artesian Pressure

According to Canadian Foundation Engineering Manual (CFEM 5e), when an excavation is dug into a clay deposit underlain by a pervious stratum under artesian pressure, pressure and seepage may result, leading to instability of the excavation. Basal heave analysis has been prepared for the design of the excavation, excavation depth and piezometric condition within the underlying fat clay. The basal heave analysis is based on the ratio of total stresses and uplift pore water pressure.

The following calculation was done to represent the soil conditions of the southeast corner of Area B where the first cell (Cell 35) is planned to be developed. The unit weight of clay (17.5 kN/m^3), groundwater (GW) table (228.34 m ASL) and the average existing grade (233.5 m ASL) used values are specified in **Section 6.3.** The approximate elevation of the till layer was determined from the average testholes BH24-06 and BH24-01 (220 m ASL). Additionally, the maximum excavation depth of 4.5 m (229 m ASL) was used in the calculation.

Additionally, a basal heave calculation was done for BH24-09 as it was recorded to have the highest groundwater table recorded in Area B. Groundwater table, existing grade and elevation of till layer for BH24-09 are summarized in **Table 13** and were obtained directly from the gINT logs in **Appendix C**. Excavation depth (4.5 m), unit weight of clay (17.5 kN/m^3) and unit weight of water (9.81 kN/m^3) were used as well in the calculation for BH24-09.

For this approach, The FS of the basal heave is expressed using the following equation:

$$FS = \frac{H_C \gamma_C}{H_w \gamma_w}$$

Where

γ_c = unit weight of fat clay (Brown) = 17.5 kN/m^3

H_c = thickness of the fat clay between the bottom of excavation to the top of the glacial till

γ_w = unit weight of water = 9.81 kN/m^3

H_w = the total head in the glacial till layer (total head)

Table 13: Results of Basal Heave Due to Artesian Pressure

Location	Hc (m)	Hw (m)	FS
Cell 35	9.0	8.34	1.93
BH24-09	7.8	11.78	1.18

As per the CFEM 5e in section 22.3, heave due to artesian pressure at depth is deemed satisfactory if FS is greater than 1.1. Based on the results, the FS due to artesian pressure at the maximum excavation depth of 4.5 m is 1.93 and 1.18 for Cell 35 and BH24-09, respectively. If FS is less than 1.1, the contractor should consider the development of a dewatering plan. The FS for BH24-09 is satisfactory but may require another assessment when future development near this area occurs.

6.2 Frost

This section pertains exclusively to roads and leachate conveyance piping. It is not relevant to and does not impact the waste pile.

6.2.1 Frost Penetration

The depths of frost penetration have been estimated for a range of annual air freezing identified in **Table 14**. The annual average freezing index was inferred from Figure K-4 of the National Building Code of Canada (2020) Commentary document. The ten-year return annual freezing index was calculated using the mean annual freezing index value and recommendations outlined in the Canadian Foundation Engineering Manual (CFEM 5e). The fifty-year return annual freezing index was taken from Figure K-5 of the National Building Code of Canada (2020)

Commentary document. Factors such as snow cover, vegetation at surface, soil type and groundwater conditions can all significantly impact the depth of frost penetration. The predominant soil type on the project site is fat clay.

Table 14: Frost Penetration Depth

Parameter	Period		
	Mean	10-Year Return	50-Year Return
Annual Air Freezing Index (°C-days)	1825	1875	2375
Estimated Frost Penetration (Fat Clay Subgrade) – gravel surface, no snow cover (m)	1.9	2	2.5
Estimated Frost Penetration (Fat Clay Subgrade) – grass with snow cover (m)	1.7	1.9	2.2

It is the responsibility of the design team to select an adequate frost penetration depth to be incorporated into the design.

6.2.2 Frost Susceptibility

The qualitative frost susceptibility of a soil is typically assessed using guidelines developed by Casagrande (1932) based on the percentage by weight of the soil finer than 0.02 mm, and the Plasticity Index. The classification system has been adapted by the U.S. Army Corps of Engineers and the Canadian Foundation Engineering Manual (2023). Soils are classed as F1 through F4 in order of increasing frost susceptibility.

The soils (clay and silt) encountered during the geotechnical investigation fall mostly within the frost groups F3 and F4. The F3 group has high to very high susceptibility to frost and F4 has very high susceptibility. Frost susceptibility has been assigned to the encountered soil type and is summarized in **Table 15**.

Table 15: Frost Susceptibility

Soil Unit	USCS Soil Type	Frost Group	Percentage finer than 0.02 mm, by weight	PI	Frost Susceptibility
Clay/ Clay fill	CL, CH	F3	-	>12	High to very high susceptibility
Silt	ML	F4	-	-	very high susceptibility

***Source**: Canadian Foundation Engineering Manual (CFEM, 5e), Chapter 14 Frost Action*

6.3 Cell Slope Stability Analysis

The analysis and recommendations provided were based on the information acquired from the geotechnical investigation and from review of the KGS geotechnical report titled, “Brady Road Resource Management Facility Cell Design and Master Plan Geotechnical Investigation and Stability Assessment for Landfill Area A Development – Final” (KGS Group, 2019).

6.3.1 Cell Design Details

The development of the landfill will begin at the southeast corner of area B. AECOM understands that Cell 35 (located in the south part of Area B) will be one of the first cells that will be constructed. The design details are presented with two scenarios which includes the CoW Preferred Design (Option 1) and the 60-meter Waste Pile Design (Option 2).

Cell 35 was modeled to determine the stability analysis. The AECOM surveying team provided the elevations being used in the model.

A summary of the preliminary design details are as follows:

6.3.1.1 CoW Preferred Design (Option 1):

- Prairie level = 233.5 m
- Depth of excavation = 3.0 to 4.5 m
- Height of waste above original grade = 30 m
- Slope of excavation and waste = 3H:1V
- Thickness of standard clay cap= 0.85 m
- Containment berm from prairie level with a top of berm elevation of 234.5 m or 235.5 m (provided by AECOM’s preliminary design team)

6.3.1.2 60-meter Waste Pile Design (Option 2)

- Prairie level = 233.5 m
- Depth of excavation = 3.0 to 4.5 m
- Height of waste above original grade = 60 m
- Slope of excavation and waste = 3H:1V
- Thickness of standard clay cap= 0.85 m
- Containment berm from prairie level with a top of berm elevation of 234.5 m or 235.5 m (provided by AECOM’s preliminary design team)

6.3.2 Slope Stability Methodology

The stability assessment was conducted using GeoStudio software, specifically the two-dimensional limit-equilibrium slope stability program SLOPE/W, developed by Geoslope International Inc. The Morgenstern-Price method was used to evaluate potential slip surfaces and calculate factors of safety (FS) for both Option 1 and Option 2. The following methodologies were used to evaluate the slope stability models:

Groundwater Elevations:

1. 228.34 m ASL (provided by the hydrogeology team).
2. 229.34 m ASL (provided by the hydrogeology team to use as a design parameter, representing worst-case seasonal rise in the southeast corner of Area B, simulating spring conditions)

Excavation Scenarios:

- Evaluations were conducted at various excavation depths, with berm heights of 235.5 m and 234.5 m for each groundwater elevation.

Landfill Waste Scenario:

- CoW Preferred Design (Option 1) and 60-meter Waste Pile Design (Option 2) were analyzed for long-term conditions, with different excavation depths.

B-Bar Coefficient:

- A B-Bar coefficient of 0.6 was applied to account for excess porewater pressure during construction.

For the stability evaluation, the target factors of safety (FS) were set at 1.3 for short-term conditions (excavation scenarios) and 1.5 for long-term conditions (landfill waste scenarios). In this analysis, short term has been defined as approximately 6-months. It is our understanding it will take approximately 6-months to fill the cell from the bottom of the excavation to prairie level (approximate elevation, 233.5 m).

6.3.2.1 Soil and Waste Strength Parameters

Soil parameters used for slope stability analysis were estimated from soil index properties (particle size distribution and Atterberg Limits). The properties of waste were based on AECOM's prior experience. The estimated soil parameters used in the preliminary design are provided in **Table 16**.

Table 16: Soil & Waste Parameters

Material type	Unit Weight (kN/m^3)	Cohesion (kPa)	Friction Angle (°)
Landfill Waste	13.7	0	30
Standard Clay Cap	17.5	5	15
Fat Clay (CH)	17.5	5	15
Sandy Silty Clay (CL-ML) Till	21	0	30

6.3.2.2 Groundwater

Groundwater readings were collected from various wells installed at different depths within Cell 35 to assess groundwater interactions in grey clay, till, and limestone. Detailed information about the wells is provided in **Appendix C. Figure 2** represents the groundwater level data obtained on August 1st, 2024, and August 22nd, 2024.

Notably, the monitoring of groundwater elevations should remain an ongoing program to track the stabilization of the groundwater table over time.

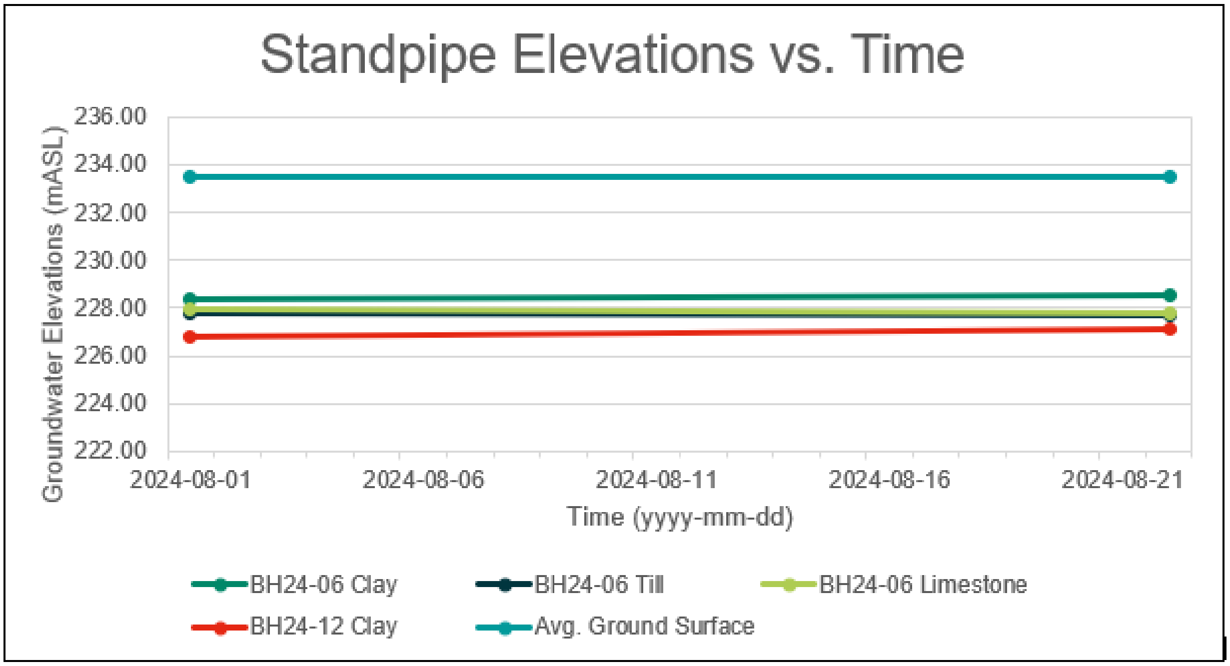


Figure 2: Graph of Groundwater Elevations Versus Time

The groundwater elevation of 228.34 meters (BH24-06 Clay) was chosen as a design groundwater level. Additionally, a 1-meter increase was applied to this value for slope stability analyses to simulate spring conditions, resulting in a groundwater elevation of 229.34 m ASL. Both 228.34 m ASL and 229.34 m ASL were provided by the hydrogeology team. The groundwater elevation of 228.34 meters (BH24-06 Clay) was selected as the highest reading based on a very short monitoring window from piezometer wells installed in the southeast corner of Area B.

6.3.3 Slope Stability Results

The factors of safety obtained from the GeoStudio Slope/W assessment for Excavation scenarios are presented from **Table 17** to **Table 19**. The results for the CoW Preferred Design (Option 1) and the 60-meter Waste Pile Design (Option 2) are presented in **Table 20**, and B-bar factor scenarios are shown in **Table 21** and **Table 22**.

Table 17: Results of Excavation with 228.34 m Groundwater Elevation, Top of Berm 235.5 m

Cell 35	Figure ID	Excavation Depth	Depth of Excavation + Height of Berm	Slope	Factor of Safety (FS)	Comments
Short Term – Max. Depth of Excavation	Fig. 1	3.0 m	5.0 m	3H:1V	1.58	- It is assumed that the water table is below the base of the excavation. - As can be seen at a depth of 5 m, the FS is not satisfied for short-term conditions. - A drainage system that will keep the bottom excavation dry in the cell will not improve the FS.
	Fig. 2	3.5 m	5.5 m		1.49	
	Fig. 3	4.0 m	6.0 m		1.44	
	Fig. 4	4.5 m	6.5 m		1.34	
	Fig. 5	5.0 m	7.0 m		1.24	

As shown in **Table 17**, the maximum depth of excavation is 4.5 m. This is to ensure that the FS satisfies the target FS at 1.30 for short-term conditions. A groundwater elevation of 228.34 m is assumed to be a representative level of Summer, Fall and winter conditions.

Table 18 Results of Excavation at 229.34 m Groundwater Elevation, Top of Berm 235.5 m

Cell 35	Figure ID	Excavation Depth	Depth of Excavation + Height of Berm	Slope	Factor of Safety (FS)	Comments
Short Term – Max. Depth of Excavation	Fig. 6	3.0 m	5.0 m	3H:1V	1.53	- It is assumed that the water table is below the base of the excavation. - As can be seen at a depth of 4.5 m, the FS is not satisfied for short-term conditions. - A drainage system that will keep the bottom excavation dry in the cell will not improve the FS.
	Fig. 7	3.5 m	5.5 m		1.41	
	Fig. 8	4.0 m	6.0 m		1.32	
	Fig. 9	4.5 m	6.5 m		1.23	
	Fig. 10	5.0 m	7.0 m		1.18	

As shown in **Table 18,** the maximum depth of excavation is 4.0 m. This is to ensure that the FS satisfies the target FS at 1.30 for short-term conditions. A groundwater elevation of 229.34 m is representative of spring conditions.

Table 19 Results of Excavation at 229.34 m Groundwater Elevation, Top of Berm 234.5 m

Cell 35	Figure ID	Excavation Depth	Depth of Excavation + Height of Berm	Slope	Factor of Safety (FS)	Comments
Short Term – Max. Depth of Excavation	Fig. 11	3.0 m	4.0 m	3H:1V	1.85	- It is assumed that the water table is below the base of the excavation. - As can be seen, all FS short-term conditions are satisfied. - A drainage system that will keep the bottom excavation dry in the cell will not improve the FS.
	Fig. 12	3.5 m	4.5 m		1.66	
	Fig. 13	4.0 m	5.0 m		1.52	
	Fig. 14	4.5 m	5.5 m		1.39	
	Fig. 15	5.0 m	6.0 m		1.32	

As shown in **Table 19,** a reduction on the berm's elevation increases the resulting factor of safety. All the excavations depth pass for short-term conditions with a groundwater elevation of 229.34 m for spring conditions. The designer should consider the top of the berm as 234.5 m.

Table 20: Slope Stability Results of Landfill Waste

Cell 35	Figure ID	Excavation Depth	Slope	Factor of Safety (FS)	Comments
CoW Preferred Design (Option 1) – Long Term – Landfill	Fig. 16	3.0 m	3H:1V	1.47	- Half of the cell was analyzed, the horizontal footprint of the cell at a height of 30 m is approximately 120 m - Minimum footprint will be 120 x 120 m -Half of the cell was modeled and it is assumed that a mirror image will be identical.
	Fig. 17	3.5 m		1.48	
	Fig. 18	4.0 m		1.49	
	Fig. 19	4.5 m		1.51	
60-meter Waste Pile Design (Option 2) – Long Term – Landfill	Fig. 20	3.0 m	3H:1V	1.41	- Half of the cell was analyzed, the horizontal footprint of the cell at a height of 60 m is approximately 210 m - Minimum footprint will be 210 x 210 m - Half of the cell was modeled and it is assumed that a mirror image will be identical.
	Fig. 21	3.5 m		1.42	
	Fig. 22	4.0 m		1.43	
	Fig. 23	4.5 m		1.43	

As shown in **Table 20**, Option 1 at excavation depth of 4.5 m satisfies the target FS of 1.5 for long-term conditions. Option 2 does not satisfy the Target FS at any excavation depth. The designer should consider reducing the waste pile height or reducing the slope. For details regarding the design outputs, refer for **Appendix E.**

6.3.3.1 Sensitivity Analysis

The results of the slope stability analysis presented in **Table 17 to 20** utilized the groundwater elevations provided/recommended by the hydrogeology team which is at 228.34 m ASL (BH24-06 Clay). For Cell 35, a groundwater elevation of 228.34 m ASL was recorded in BH24-06 approximately 5.16 m BGS. However, this reading may not represent the stabilized groundwater level within the clay layer. Additionally, elevated groundwater elevations were recorded in the piezometers installed in BH24-04, BH24-09 and BH24-13 (232.32 m ASL/1.24 m BGS, 232.98 m ASL/0.68 m BGS, and 232.82 m ASL/0.73 m BGS) respectively. These elevated groundwater elevations were recorded outside the footprint of Cell 35 but within Area B.

Furthermore, the local practice in Winnipeg clay is to assign a groundwater at 2.0 m BGS. Therefore, a sensitivity analysis was completed to study the impact of groundwater level on the FS. The sensitivity analysis is limited to the side slopes of the short-term and long-term of option 1 (30 m landfill waste) and option 2 (60 m landfill waste).

As part of the sensitivity analysis, groundwater depths of 1, 2, 3, 4.16 and 5.16 m (232.5 m ASL, 231.5 m ASL, 230.5 m ASL, 229.34 m ASL and 228.34 m ASL) below prairie elevation (233.5 m ASL) were evaluated. Various excavation depths were used in the analyses to assess changes as the groundwater level increased. For the sensitivity analysis the side slope was 3H:1V for both the berm and landfill waste. Lastly, a berm height of 2 m was incorporated in the model as well. **Figure 3** represents the sensitivity analysis for short-term excavation. **Figure 4** represents a sensitivity analysis for option 1 and **Figure 5** show the sensitivity analysis for option 2.

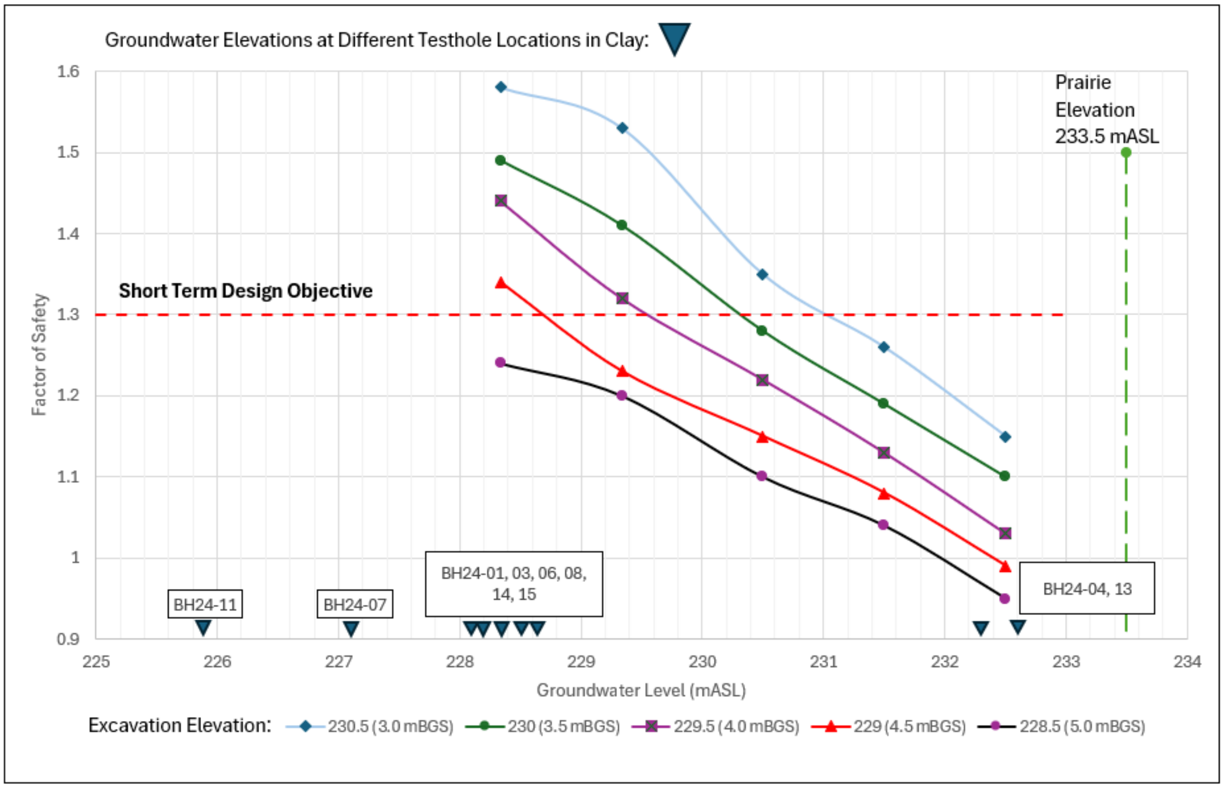


Figure 3: Factor of Safety for Various Excavation Depths and Groundwater Levels – Side Slope 3H:1V and 2 m Berm (Short Term)

As shown in **Figure 3**, an increase in groundwater elevation reduces the FS for the various excavation depths. For excavations ranging from 3.0 to 4.5 m BGS the target FS of 1.3 is met, provided the groundwater elevation remains at approximately 5.16 m BGS (228.34 m ASL). As seen in **Figure 3**, increases in the groundwater elevations have an negative impact on the short-term FS.

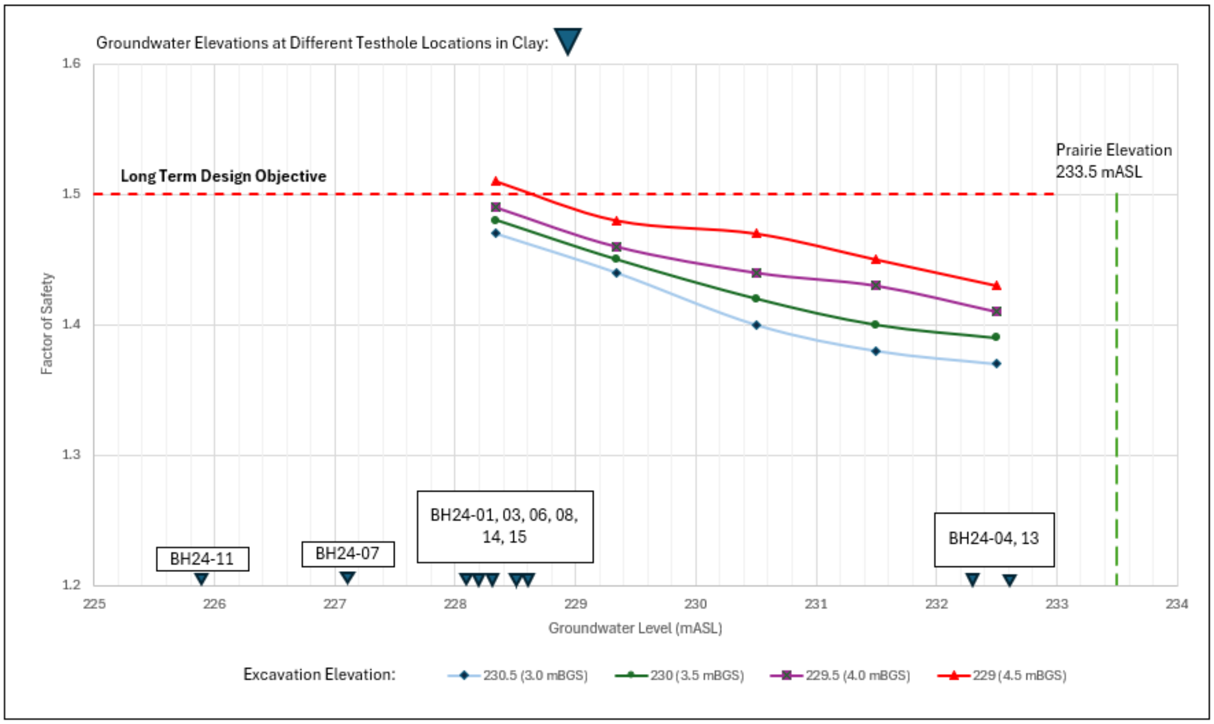


Figure 4: Factor of Safety for Various Excavation Depths and Groundwater Levels – Option 1 (30 m waste pile) With Side Slope 3H:1V and 2 m Berm (Long Term)

As shown in **Figure 4**, an increase in groundwater elevation reduces the FS for the various excavation depths. Only an excavation with a depth of 4.5 m BGS meets the target FS of 1.5, provided the groundwater elevation remains at approximately 5.16 m BGS (228.34 m ASL). As seen in **Figure 4**, increases in the groundwater elevations have an immediate negative impact on the long-term FS.

The long-term and short-term FS for side slopes of 3H:1V, a depth excavation of 4.5 m BGS, a 2 m berm, and a waste pile of 30 m in heights is considered acceptable, provided the groundwater elevation does not exceed 228.34 m ASL.

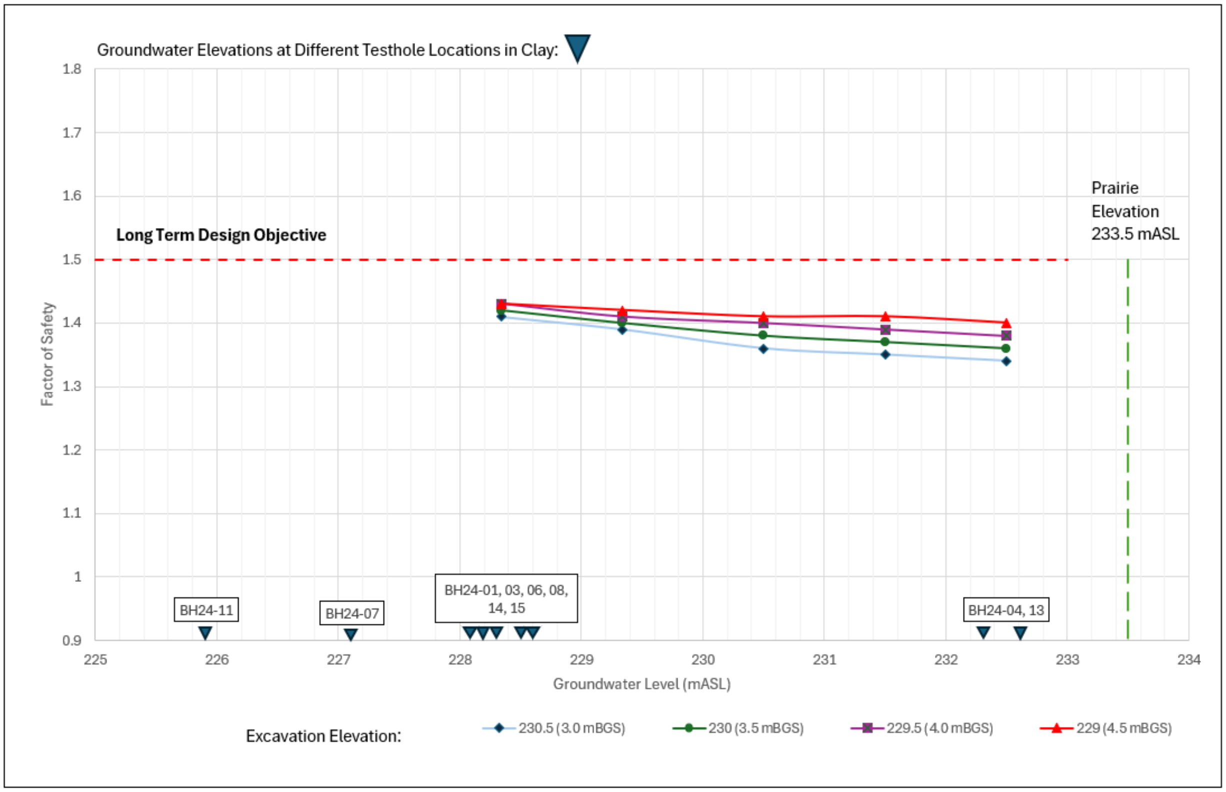


Figure 5: Factor of Safety for Various Excavation Depths and Groundwater Levels – Option 2 (60 m waste pile) With Side Slope 3H:1V and 2 m Berm (Long Term)

As shown in **Figure 5**, an increase in groundwater elevation reduces the FS for the various excavation depths. None of the excavation depths ranging form 3.0 m BGS to 4.5 m BGS met the target FS of 1.5. As seen in **Figure 5**, increases in the groundwater elevations have an immediate negative impact on the long-term FS.

A monitoring program and passive drainage system may be incorporated in the design to maintain the groundwater elevation at 228.34 m ASL.The monitoring plan must include regular readings of the groundwater from the installed piezometers and installing new groundwater piezometers within the clay layer along the footprint of the proposed Cell 35. The side slopes should also be checked regularly during the cell's construction and filling to ensure the slopes' stability.

Additional work (as recommended by the hydrogeology study- AECOM Draft report Area B Hydrogeology Report) to determine if the anomalous water levels observed in BH24-04, BH24-09 and BH24-13 are due to surface water infiltration into the wells may be required.

6.3.3.2 Recommendations During construction of the berm

Excess pore water pressure may temporarily develop in saturated soils when there is a change in applied load during berm construction. As the berm is constructed, the load applied to the soil beneath it increases, which can lead to the development of excess pore water pressure in the saturated soil.

The B-bar coefficient is a parameter that describes the relationship between changes in pore water pressure and changes in total stress during soil loading in saturated conditions. In this case, the B-bar coefficient is used to assess how the applied load influences the FS during berm construction. A target FS of 1.3 was selected for short term conditions with a B-bar coefficient of 0.6 based on AECOM's experience.

Winter construction is not recommended due to the challenges of compacting frozen clays, which can lead to poor compaction and potential instability. Spring construction should also be avoided, as melting snow can increase soil moisture, raising water levels and creating additional geotechnical concerns. The ideal time for construction is during the summer, when drier soil conditions allow for effective compaction and better dissipation of excess pore pressure provided that the design assumption for groundwater level of 228.34 m ASL (5.16 m BGS) is valid.

Table 21: Results of Excavation with 228.34 m Groundwater Elevation, Top of Berm 235.5 m, B-Bar 0.6

Cell 35	Figure ID	Excavation Depth	Depth of Excavation + Height of Berm	Slope	Factor of Safety (FS)	Comments
Short Term – Max. Depth of Excavation	Fig. 24	3.0 m	5.0 m	3H:1V	1.57	- It is assumed that the water table is below the base of the excavation. - As can be seen at a depth of 5 m, the FS is not satisfied for short-term conditions. - A drainage system that will keep the bottom excavation dry in the cell will not improve the FS.
	Fig. 25	3.5 m	5.5 m		1.49	
	Fig. 26	4.0 m	6.0 m		1.42	
	Fig. 27	4.5 m	6.5 m		1.33	
	Fig. 28	5.0 m	7.0 m		1.24	

As shown in **Table 21** the maximum depth of excavation is 4.5 m. This is to ensure that the FS satisfies the target FS at 1.30 for short-term conditions. However, if the groundwater level exceeds the design elevation of 228.34 m ASL (5.16 m BGS), the FS will fall below the design objective 1.3, as discussed and illustrated in **Figure 3**.

Table 22: Results of Excavation with 228.34 m Groundwater Elevation, Top of Berm 234.5 m B-Bar 0.6

Cell 35	Figure ID	Excavation Depth	Depth of Excavation + Height of Berm	Slope	Factor of Safety (FS)	Comments
Short Term – Max. Depth of Excavation	Fig. 29	3.0 m	4.0 m	3H:1V	1.91	- It is assumed that the water table is below the base of the excavation. - As can be seen, all the FS are satisfied for short-term conditions. - A drainage system that will keep the bottom excavation dry in the cell will not improve the FS.
	Fig. 30	3.5 m	4.5 m		1.82	
	Fig. 31	4.0 m	5.0 m		1.67	
	Fig. 32	4.5 m	5.5 m		1.52	
	Fig. 33	5.0 m	6.0 m		1.40	

As shown in **Table 22**, the Target FS for construction of the berm is satisfied at all excavation depths due to the reduction of 1 m height of the berm. The designer should consider the height when designing the berm for the landfill.

6.3.3.3 Recommended Side Slopes for Excavation

The recommended side slope for excavation is 3H:1V with an excavation depth of 3 to 4.5 m BGS (230.5 to 229 m ASL). This configuration offers the optimal factor of safety while maximizing the available space within the landfill. However, if the groundwater level exceeds the design elevation of 228.34 m ASL (5.16 m BGS), the FS will fall below the design objective 1.3, as discussed and illustrated in **Figure 3.**

6.3.3.4 Recommended Side Slopes for Landfill Waste

Option 1: The recommended side slope for the landfill waste is 3H:1V, with a landfill height of 30 meters and an excavation depth ranging from 4.0 to 4.5 meters.

Option 2: The slope stability analysis did not meet the required Target Factor of Safety (FS) at any excavation depth. The designer should consider reducing the height of the waste pile or adjusting the slope to improve stability.

6.4 Consolidation Analysis

The consolidation analysis and recommendations provided were based on information acquired from the geotechnical investigation, laboratory tests and AECOM's experience.

Based on the stratigraphy of area B which primarily consists of a clay layer, there will be settlement of cohesive soils including settlement of the waste material as well. The total settlement that could occur at the end of the lifespan will be calculated in the following section.

As no structures will be constructed on top of the waste hill, settlement will not be a significant factor in the findings and recommendations presented in this report.

6.4.1 Consolidation Cell Design Details

Cell 35 was modeled as AECOM recognizes this to be the next waste disposal cell development within Area B as specified in **Section 1.1.** The design details are presented with two scenarios; Option 1 features the CoW Preferred Design, while Option 2 is the 60-meter Waste Pile Design.

6.4.1.1 CoW Preferred Design (Option 1)

A summary of the preliminary design details are as follows:

- 30 m elevation above grade (prairie level)
- 3.0 to 4.5 m below grade
- 30 m waste thickness
- 13.7 kN/m^3 unit weight of waste (provided by AECOM's environmental team)

6.4.1.2 60-meter Waste Pile Design (Option 2)

A summary of the preliminary design details are as follows:

- 60 m elevation above grade (prairie level)
- 3.0 to 4.5 m below grade
- 60 m waste thickness
- 13.7 kN/m^3 unit weight of waste (provided by AECOM's environmental team)

6.4.2 Consolidation Methodology

6.4.2.1 General

The consolidation assessment was conducted using the geotechnical modeling software Settle3, developed by Rocscience Inc. of Toronto, Ontario. The software utilizes inputs including stratigraphy, groundwater depth, soil parameters and loading conditions to analyze settlement.

Settle3 performs immediate, primary, and secondary consolidation analyses for surface loads such as landfill waste. Data from the geotechnical investigation, laboratory tests, were integrated into Settle3 along with AECOM'S experience on past projects.

For the settlement analysis, which is only applicable to the clay layer, we used Boussineq stress computation method. Site data was gathered, including the thickness and properties of soil layers. The geometry and the loading conditions for the CoW Preferred Design (Option 1) and the 60-meter Waste Pile Design (Option 2) model were used in the design process to calculate settlement.

Using the design parameters specified in **Section 6.4.3** we conducted a settlement analysis for the clay layer at the southeast corner of Area B . This analysis included calculations for both option 1 and option 2.

6.4.2.2 Settlement of Landfill Waste

According to the Prediction of attenuation of landfill settlement rates with time (Coumoulos & Koryalos, 1997); prediction of the long-term settlement behaviour of a landfill closure influences the design and performance of the capping system and the successful future development of the site.

Attenuation of landfill long-term settlement is based on the observation where landfills that are placed rapidly, yield higher settlement rates than a landfill with a longer construction period. This settlement calculation was based on taking the factor for long term compression of solid waste under self weight (C_a). A standard rule of thumb is to estimate the settlement of the waste mass as 20%. C_a = 0.0606 is equivalent to a 20% settlement of the waste mass. It should be noted that a Design life of 20 years was selected based AECOM's previous experience. The following formula and parameters were used for the calculation of waste settlement:

$$\frac{\Delta H}{H} = C_a \log\left(\frac{t}{t_1}\right)$$

Where: **CoW Preferred Design (Option 1)**

ΔH = The settlement of the landfill waste

H = The total height of the landfill waste = 30 m

C_a = Long term compression of solid waste under self weight= 0.0606

t = 20 years (Design life of landfill)

$t_1 \approx$ 0.01 years (Beginning of design life)

and: **60-meter Waste Pile Design (Option 2)**

ΔH = The settlement of the landfill waste

H = The total height of the landfill waste= 60 m

C_a = Long term compression of solid waste under self weight= 0.0606

t = 20 years (Design life of landfill)

$t_1 \approx$ 0.01 (Beginning of design life)

6.4.3 Consolidation Parameters

The values obtained for the consolidation parameters were derived from the laboratory tests results of testhole BH24-09 at depths of 1.5 and 10.6 m below grade.

The estimated consolidation parameters are shown below in **Table 23**.

Table 23: Summary of Consolidation Parameters

Depth Range (m)	Soil Type	Bulk Unit Weight kN/m^3	Elastic Modulus	Initial Void Ratio	Compression Index	Recompression Index	Preconsolidation Pressure (kPa)
			E_s	e_o	C_c	C_r	P_c’
n/a	Waste[1]	13.7	11200	n/a	n/a	n/a	n/a
0.76 - 4.3	Clay (CH) Brown	18.9	n/a	0.81	0.213	0.0852	90
4.3 – 15.0	Clay (CH) grey	15.19	n/a	1.797	1.125	0.2113	300
15.0 - 20.0	Glacial Till	20.59	135000	n/a	n/a	n/a	n/a

Note [1]: Bulk Unit weight for waste was provided by AECOM’s environmental team

6.4.4 Consolidation Results

The analysis presented in **Appendix F** focuses on the total settlement associated with the final landfill waste height, with CoW Preferred Design (Option 1) and 60-meter Waste Pile Design (Option 2) heights being 30 m and 60 m above prairie level of 233.5 m ASL, respectively.

The results of the analysis for the loading cases represent the magnitude of settlement that will occur in the next 20 years of the landfill operations. The analyses accounts for settlement at different excavation depths (3.0 m to 4.5 m), compares settlement from edge of excavation to centre of waste pile settlement and shows the distance between the two (2) settlement points (edge of excavation and centre of waste pile).

Lastly, the table shows the total settlement of clay and waste at different excavation depths. It is important to note that the total settlement does not account for time, it represents only the total settlement. The results are presented in **Table 24.**

Table 24: Settlement of Option 1 and Option 2 Design

Figure ID	Excavation Depth	Edge of Excavation Settlement (Clay) (mm)	Centre of Waste Pile Settlement (Clay) (mm)	Differential settlement (mm)	Horizontal Distance, Between Edge of Excavation and Centre of Waste Pile (m)	Waste [1] Settlement (mm)	Total Settlement (Max Clay + Waste) (mm)	Comments
	CoW Preferred Design (Option 1)							
Fig. 34	3.0 m	320	1786	1466	81.0	6000	7786	Most settlement occurs in the waste. The waste unit weight and consolidation properties are highly variable and hard to predict.
Fig. 35	3.5 m	331	1727	1396	79.5		7727	
Fig. 36	4.0 m	352	1695	1343	78.0		7695	
Fig. 37	4.5 m	375	1604	1229	76.5		7604	
60-meter Waste Pile Design (Option 2)								
Fig. 38	3.0 m	320	2989	2669	171.0	12000	14989	Most of the settlement occurs in the waste. The waste unit weight and consolidation properties are highly variable and hard to predict.
Fig. 39	3.5 m	331	2887	2556	169.5		14887	
Fig. 40	4.0 m	352	2792	2440	168.0		14793	
Fig. 41	4.5 m	375	2625	2250	166.5		14625	

Note: [1] Waste settlement obtained from Section 6.4.2.2 (Coumoulo & Koryalos).

The settlement analysis for CoW Preferred Design (Option 1) shows a maximum differential settlement of 1466 mm, with the center of the waste pile settling 1786 mm and the edge at 320 mm settlement over a horizontal distance of 81 meters. The total maximum settlement for Option 1 is 7786 mm, including the variable waste, with the highest differential settlement occurring at an excavation depth of 3.0 meters.

For 60 m Waste Pile Design (Option 2), the maximum differential settlement at the center of the waste pile is 2,669 mm, with the edge remaining at 320 mm over a horizontal distance of 121 meters. The total maximum settlement in Option 2 is 14989 mm, with the highest differential settlement also occurring at an excavation depth of 3.0 meters.

As the excavation depth increases, the settlement at the center of the waste pile decreases, in both Option 1 and 2. The design team should consider the settlement data in **Table 24** when designing the leachate collection system and HDPE liner.

6.5 Waste Disposal Cell Liner

According to the *2016 Standards for Landfills in Manitoba*, all clay-lined cells or leachate ponds must be designed to achieve a maximum hydraulic conductivity of 1x10^{-9} m/s. Additionally, the clay must have a minimum thickness of 1 meter, measured perpendicular to the slope, unless otherwise approved by the Director. This requirement is detailed on page 24 of the standards, which outlines the criteria for compliance.

As shown in **Table 8** in **Section 4.2**, four hydraulic conductivity tests were conducted. The maximum hydraulic conductivity found was 1.60x10^{-10} m/s in BH24-01, confirming compliance with the Standards for Landfills in Manitoba by remaining below the maximum hydraulic conductivity of 1x10^{-9} m/s. For detailed lab test results, refer to **Appendix D.**

6.6 Access Roads

Access roads are necessary for waste disposal vehicles to reach the landfill cells at the Area B project site. The current site has elevations from 233.3 m ASL to 235.06 m ASL. Based on AECOM's current understanding of the access roads currently in operation for Area A, both asphalt and gravel roads will be utilized within the proposed Area B project site. A flexible pavement design will likely be utilized for the pavement sections.

A bulk sample was combined using the available grab samples between 0.76 m BGS and 1.52 m BGS from all testholes, excluding any silt samples. A standard proctor and CBR test were performed on this bulk sample. The CBR was soaked at 95% maximum dry density. The standard proctor resulted in a maximum dry density of 1595 kg/m^3 and an optimum moisture content (OMC) of 24.1%, and a CBR value was calculated at 1515 kg/m^3.

6.6.1 Traffic

The pavement designs were completed following the American Association of State Highway and Transportation Officials (AASHTO) 1993 *Guide for the Design of Pavement Structure*. Part II of the design guide provides details on pavement design procedures for new construction or reconstruction.

The design of the access road structures is highly dependant upon the number and type of vehicles that will be driving on the roadways. Traffic loadings from different types of vehicles are then equated to the number of Equivalent Single Axle Loads (ESALs), which is defined by the summation of equivalent 18,000-pound single axle loads used to combine mixed traffic to design traffic for the design period. The estimated traffic distribution for gravel and asphalt roads is provided in **Table 25** and **Table 26.**

Table 25: Traffic Data – Gravel Road

Design Parameters	Value
Truck Percentage (%)	100%
Distribution (%): 2 & 3 axles	100%

Table 26: Traffic Data - Asphalt Road

Design Parameters	Value
Truck Percentage (%)	100%
Distribution (%): 2 & 3 axles	100%

The asphalt and gravel areas are designed for the waste disposal vehicles and will be utilized to access each individual landfill cell via a perimeter access road. There, the main vehicles that will utilize the asphalt and gravel roads will be waste disposal vehicles and tandem end dumps. AECOM has estimated a truck percentage of 100%. Of the 100%, AECOM has estimated 100% are 2 & 3 axle trucks.

6.6.2 Pavement Design

The road design has been developed for a 20-year service life and an AADT of 324. To facilitate this future development, two additional test holes were drilled beneath the gravel road that separated the northern and southern sections of Area B.

- 20-year service life
- AADT of 324
- Reliability of 90%
- Standard Deviation of 0.44
- Serviceability (Initial = 4.4 and Terminal 2.2)

Additionally, the design included two lanes; one for incoming traffic and one for outgoing traffic.

Traffic loads were converted to an ESAL used in the AASHTO pavement design procedure. The design ESALs were based on the percentage of trucks in the total cumulative traffic loads over the length of the design life. The access road design parameters are presented in **Table 27** and **Table 28.**

Table 27: Pavement Design Parameters – Gravel Roads

Traffic	AADT: 324 Commercial Vehicles: 100% Number of Lanes: 2 Annual Growth Rate: 1.0% 1,185,000 Design ESALS for 20-year design life
Design Life	20 years (gravel)
Reliability	90%
Standard Deviation	0.44
Serviceability	Gravel – Initial: 4.4 Terminal: 2.2
Structural Layer Coefficients	**New Structures** COW A Base 0.14 COW A Subbase 0.12

Table 28: Pavement Design Parameters – Asphalt Roads

Traffic	AADT: 324 Commercial Vehicles: 100% Number of Lanes: 2 Annual Growth Rate: 1.0% 1,185,000 Design ESALS for 20-year design life
Design Life	20 years (asphalt)
Reliability	90%
Standard Deviation	0.44
Serviceability	Asphalt – Initial: 4.4 Terminal: 2.2
Structural Layer Coefficients	**New Structures** Hot mix asphalt 0.42 COW A Base 0.14 COW A Subbase 0.12

The design parameters noted above were used in the pavement design analysis. Pavement design options developed are presented below in **Table 29**.

Table 29: Pavement Recommendations

Pavement Design Options	Pavement Structure Details	Service Life (yrs)
Gravel Access Roads	• 100 mm – 28 mm granular A base • 900 mm – 50 mm granular A subbase • Geogrid Class A • Separation/Filtration Geotextile separation thickness **1000 mm total thickness**	20
Asphalt Access Roads	• 125 mm – hot mix asphalt • 100 mm – 28 mm granular A base • 500 mm – 50 mm granular A Subbase • Geogrid Class A • Separation/Filtration Geotextile separation thickness **725 mm total thickness**	20

Based on these pavement design thicknesses, it is very likely that the silt (ML) layer will be breached.

Preparation of the subgrade and construction of the subbase and base course for the pavement areas should comply with the City of Winnipeg Standard Construction Specification CW 3110. Supply and installation of geogrid and geotextile should comply with the City of Winnipeg Standard Construction Specifications CW3135 and CW3130, respectively. Additional materials, if required to increase the final grade for the pavements, should consist of crushed subbase material. Sieve analysis and compaction testing of the granular fill materials are recommended to ensure the materials and compaction comply with the specifications.

6.6.3 Construction of Pavement on Various Subgrades

6.6.3.1 Constructing on Clay Subgrades

If clay or clay fill is encountered at the subgrade level (i.e., the bottom of the subbase layer) proceed as follows:

- Topsoil and organic material must be removed prior to pavement construction.
- Preparation of the subgrade and construction of the subbase and base course for the pavement areas should comply with City of Winnipeg Standard Construction Specification CW 3110.
- Install separation/filtration geotextile fabric over the subgrade in accordance with CW 3130 and Section 3.4 and install Geogrid Class A in accordance with CW 3135.
- Placement of 50 mm granular A subbase shall be in accordance with section 3.5 of CW 3110 and be done in lift thicknesses of 200 mm after compaction with at least 100% of standard Proctor Maximum Dry Density (SPMDD).
- Placement of granular A base course shall be in accordance with section 3.6 of CW 3310 and be done in lift thickness of 100 mm after compaction with at least 100% of standard Proctor Maximum Dry Density (SPMDD).

6.6.3.2 Constructing on Silt Subgrades

If silt is encountered at the subgrade level (i.e., the bottom of the subbase layer) proceed as follows:

- Topsoil and organic material must be removed prior to pavement construction.
- Preparation of the subgrade and construction of the subbase and base course for the pavement areas should comply with City of Winnipeg Standard Construction Specification CW 3110.
- Excavate to the required subgrade elevation.
- Proof roll for subgrade will not be required as silt is unsuitable for road construction and is expected to fail the proof roll test. The following steps shall be taken to address the silt:
- Method for soft or unsuitable subgrade materials:
  - ▪ Unsuitable materials must be excavated approximately 0.5 m below the design subgrade elevation. If the unsuitable soil continues deeper than the excavated 0.5 m, placement of a separation/filtration geotextile and geogrid class A is required.
  - ▪ Place a separation/filtration geotextile over the excavated subgrade.
  - ▪ Replace the excavated unsuitable material with 100 mm granular A subbase in two lifts compacting each lift.
    - – Lift 1: 200 mm
    - – Lift 2: 300 mm
- Install separation/filtration geotextile fabric over the subgrade in accordance with CW 3130 and Section 3.4 and Install Geogrid Class A in accordance with CW 3135.
- Placement of 50 mm granular A subbase shall be in accordance with section 3.5 of CW 3110 and be done in lift thicknesses of 200 mm after compaction with at least 100% of standard Proctor Maximum Dry Density (SPMDD).
- Placement of granular A base course shall be in accordance with section 3.6 of CW 3310 and be done in lift thickness of 100 mm after compaction with at least 100% of standard Proctor Maximum Dry Density (SPMDD).
- According to the logs found in **Appendix C**, silt layers are found in BH24-04, BH24-08, and BH24-14.

7. Quality Assurance and Quality Control

During construction, it is recommended that the contractor provides an approved quality control program (QC). AECOM would like to have the opportunity to provide the quality assurance program (QA). This program should include the testing of granular gradation, L.A. abrasion loss materials, standard proctor, and field density tests.

8. Design Review, Construction Monitoring and Testing

The geotechnical department should be retained to review the plans and specifications for conformance with the intent of this report. During construction, it is recommended that an AECOM representative be involved with the following tasks:

- Review of material testing data to confirm acceptability for placement
- Inspection of road construction
- Field density test during the placement and compaction of granular fill material
- Inspection during proof rolling of subgrade
- Inspection during proof rolling sub-base if field density test cannot be performed (CW 3110)

The purpose of the subgrade inspection services would be to provide AECOM the opportunity to observe the soil conditions encountered during construction, evaluate the applicability of the information presented in this report to the soil conditions encountered, and provide appropriate changes in design or construction procedures if conditions differ from those described herein. Additionally, the field density tests are conducted to verify that the fill materials have been compacted to the specified density standards.

9. References

UMA Engineering Ltd. (1987). *Hydrogeologic Studies – Brady Road Landfill. Winnipeg: UMA Engineering Ltd (1987).*

KGS Group (2019). *Brady Road Resource Management Facility Cell Design and Master Plan Geotechnical Investigation and Stability Assessment for Landfill Area A Development – Final. Winnipeg: KGS Group (2019).*

Canadian Commission on Building and Fire Codes, (2020). *National Building Code of Canada (NBCC) 2020.* National Research Council of Canada 2022.

The Canadian Geological Society. (2023). *Canadian Foundation Engineering Manual 5th Edition*.

Muni Budhu, (2010). *Soil Mechanics and Foundations 3rd Edition.*

American Society for Testing and Materials, (2017). *D2487 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classificiation System).*

Coumoulos, D.G., & Koryalos, T.P. (1997). *Prediction of attenuation of landfill settlement rates with time.* International Society for Soil Mechanics and Geotechnical Engineering

Appendix A

Site Photos

Project Name:	Brady Road Resource Management Facility	**Site Location:**	Area B
Client:	City Of Winnipeg	**Project No:**	60733855

Photo No.	**Date**
1	7/17/2024

Direction Photo Taken

Southwest

Description

Intersection of paved and gravel road separating North and South of Area B.

Photo No.	**Date**
2	7/17/2024

Direction Photo Taken

Southwest

Description

Drilling Testhole BH24-14.

Project Name:	Brady Road Resource Management Facility	**Site Location:**	Area B
Client:	City Of Winnipeg	**Project No:**	60733855

Photo No. 3

Date 8/6/2024

Direction Photo Taken

Northeast

Description

Nested wells located at BH24-06 in the Southeast corner of Area B

Photo No. 4

Date 8/6/2024

Direction Photo Taken

South

Well BH24-13 located on the east side of Area B surrounded lots of shrub.

Photo No. 5	**Date** 7/24/2024	
Direction Photo Taken North		
Description Large shrub 6 to 7 ft tall all around the Southeast corner of area B.		
Photo No. 6	**Date** 7/24/2024	
Direction Photo Taken East		
Truck marks on the ground due to very soft wet soil.		

Project Name:	Brady Road Resource Management Facility	**Site Location:**	Area B
Client:	City Of Winnipeg	**Project No:**	60733855

Photo No.	Date	
7	7/24/2024	
Direction Photo Taken Down		
Description Soft soil conditions due to lots of rain and poor drainage of Area B		

Photo No.	Date	
8	8/6/2024	
Direction Photo Taken South		
Nested wells located at BH24-08 in the East side of Area B.		

Appendix B

Testhole Location Plan

METRIC
WHOLE NUMBERS INDICATE MILLIMETRES
DECIMALIZED NUMBERS INDICATE METRES

0.0 60 120 180 240 300

WARNING

IF POWER EQUIPMENT OR EXPLOSIVES ARE TO BE USED FOR EXCAVATION ON THIS PROJECT THE CONTRACTOR MUST:

1) NOTIFY THE GAS COMPANY OF THE PROPOSED LOCATION OF EXCAVATION.

2) TAKE PRECAUTION TO AVOID DAMAGE TO GAS COMPANY INSTALLATIONS.

SEE PROVINCIAL REGULATION 210/72 FOR DETAILS

LOCATION APPROVED
UNDERGROUND STRUCTURES

SUPV. U/G STRUCTURES COMMITTEE
DATE

NOTE:

LOCATION OF UNDERGROUND STRUCTURES AS SHOWN ARE BASED ON THE BEST INFORMATION AVAILABLE BUT NO GUARANTEE IS GIVEN THAT ALL EXISTING UTILITIES ARE SHOWN OR THAT THE GIVEN LOCATIONS ARE EXACT. CONFIRMATION OF EXISTENCE AND EXACT LOCATION OF ALL SERVICES MUST BE OBTAINED FROM THE INDIVIDUAL UTILITIES BEFORE PROCEEDING WITH CONSTRUCTION.

B.M.
ELEV.

CONSTRUCTION COMPLETION DATE: YYYY MM DD

NO.	REVISIONS	DATE	BY

AECOM

DESIGNED BY
CHECKED BY
DRAWN BY
APPROVED BY
SCALE:
HORIZONTAL 1:3000
VERTICAL –
RELEASED FOR CONSTRUCTION
DATE 2024 08 21
DATE

ENGINEER'S SEAL

CONSULTANT DRAWING NUMBER
–

THE CITY OF WINNIPEG
WATER AND WASTE DEPARTMENT
ENGINEERING DIVISION

BRADY ROAD RESOURCE MANAGEMENT FACILITY
AREA–B
TESTHOLE PLAN
–
–

SHEET X OF X

CITY DRAWING NUMBER
–

PLOT DATE: 2024 08 21
Tender No: XXX–XXXX
CONTRACT NUMBER: 10
FILE PATH: C:\Users\lacosteg\DC\ACCDocs\AECOM\EN–AMER(CAN)–60733855–COW Brady Dump\Project Files\900 Design Collaboration\910 CAD\20–SHT\C\
FILE NAME: 60733855–00–C–SITE PLAN.dwg

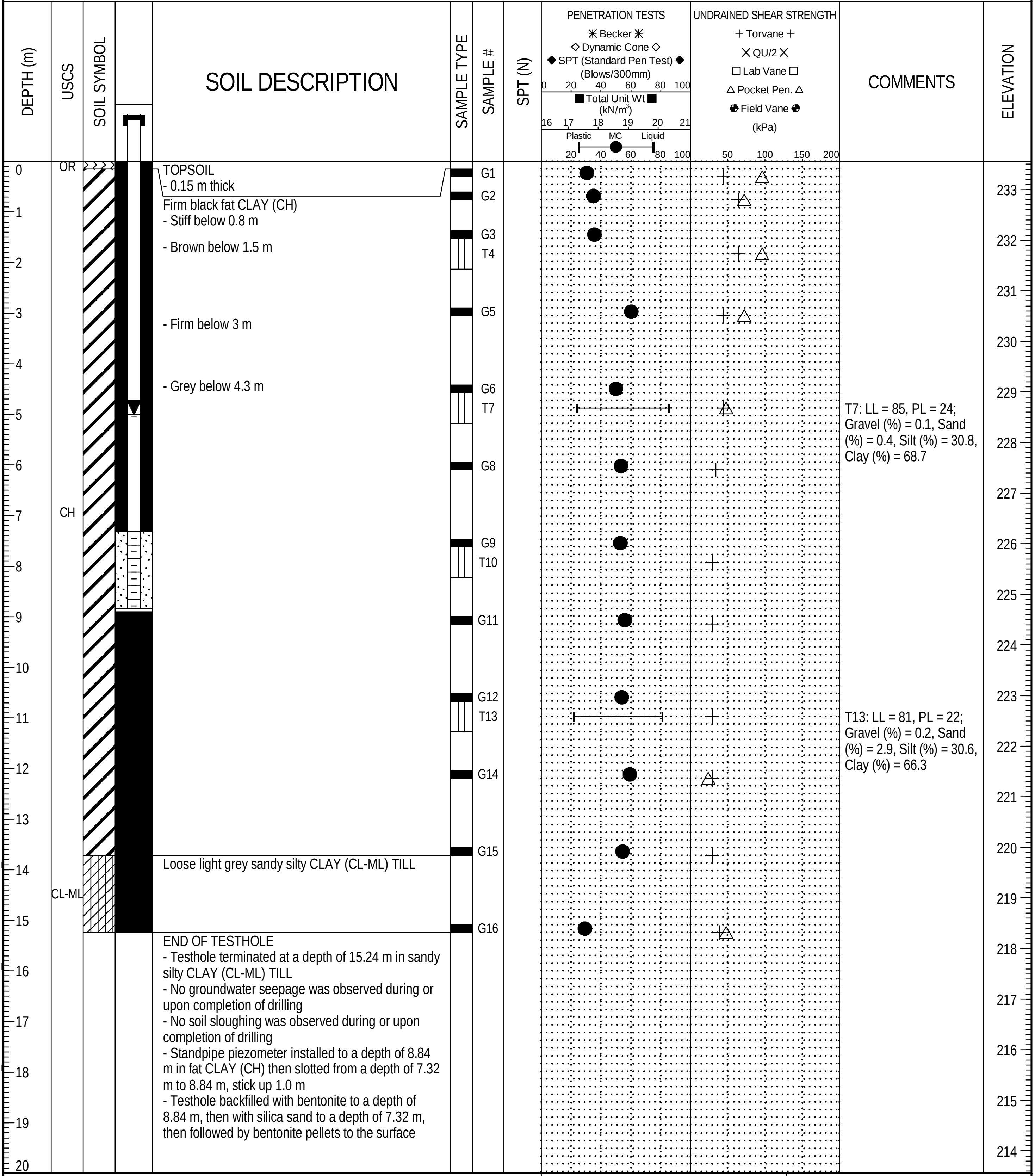
Appendix C

Testhole Logs

PROJECT: Brady Road Recource Managenent Facility - Area B	CLIENT: City of Winnipeg	TESTHOLE NO: BH24-01
LOCATION: Brady Landfill, Winnipeg, MB. UTM: 14U, 5513475.7 m N, 629412.5 m E		PROJECT NO.: 60733855
CONTRACTOR: Paddock Drilling Ltd	METHOD: Solid Stem Auger	ELEVATION (m): 233.56

SAMPLE TYPE: ■ GRAB ▥ SHELBY TUBE ☒ SPLIT SPOON ☰ BULK ▨ NO RECOVERY ▮ CORE

BACKFILL TYPE: ■ BENTONITE ⁙ GRAVEL ▥ SLOUGH ⁙ GROUT ▨ CUTTINGS ⁙ SAND



TOPSOIL
- 0.15 m thick

Firm black fat CLAY (CH)
- Stiff below 0.8 m
- Brown below 1.5 m
- Firm below 3 m
- Grey below 4.3 m

Loose light grey sandy silty CLAY (CL-ML) TILL

END OF TESTHOLE
- Testhole terminated at a depth of 15.24 m in sandy silty CLAY (CL-ML) TILL
- No groundwater seepage was observed during or upon completion of drilling
- No soil sloughing was observed during or upon completion of drilling
- Standpipe piezometer installed to a depth of 8.84 m in fat CLAY (CH) then slotted from a depth of 7.32 m to 8.84 m, stick up 1.0 m
- Testhole backfilled with bentonite to a depth of 8.84 m, then with silica sand to a depth of 7.32 m, then followed by bentonite pellets to the surface

T7: LL = 85, PL = 24; Gravel (%) = 0.1, Sand (%) = 0.4, Silt (%) = 30.8, Clay (%) = 68.7

T13: LL = 81, PL = 22; Gravel (%) = 0.2, Sand (%) = 2.9, Silt (%) = 30.6, Clay (%) = 66.3

LOGGED BY: CO	COMPLETION DEPTH: 15.24 m
REVIEWED BY: GL	COMPLETION DATE: 24-7-17
PROJECT ENGINEER: German Leal	Page 1 of 1

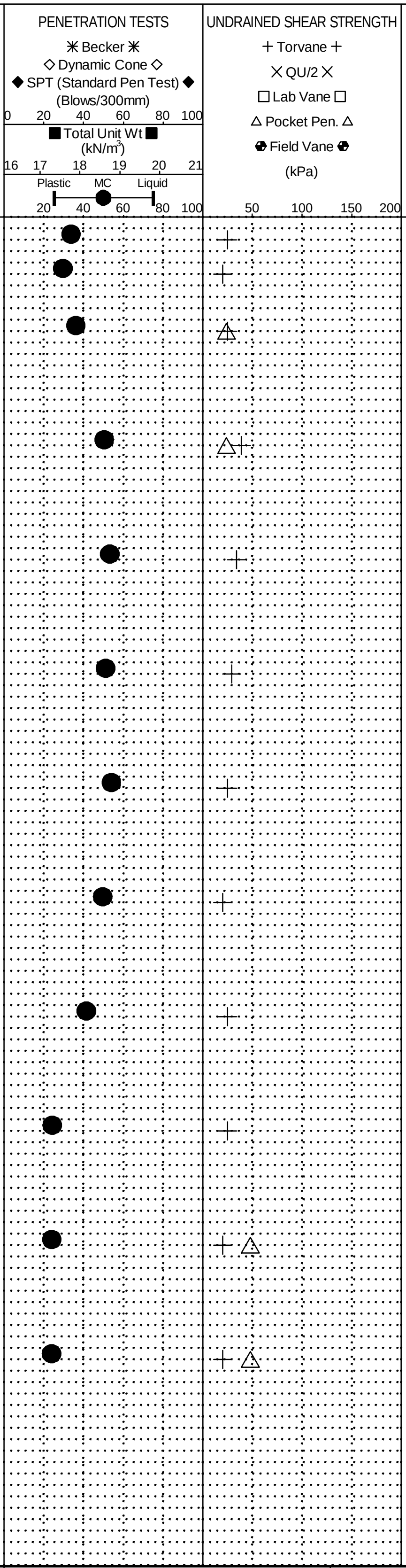
AECOM

PROJECT: Brady Road Recource Management Facility - Area B	CLIENT: City of Winnipeg	TESTHOLE NO: BH24-02
LOCATION: Brady Landfill, Winnipeg, MB. UTM: 14U, 5513047 m N, 629326.6 m E		PROJECT NO.: 60733855
CONTRACTOR: Paddock Drilling Ltd	METHOD: Solid Stem Auger	ELEVATION (m): 233.47

SAMPLE TYPE ■ GRAB ▥ SHELBY TUBE ☒ SPLIT SPOON ☰ BULK ◪ NO RECOVERY ▮ CORE

USCS	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
OR	TOPSOIL - 0.15 m thick	■	G1
ML	Soft tan SILT (ML)	■	G2
CH	soft black fat CLAY (CH) - Brown below 1.5 m - Firm below 3 m - Grey below 4.3 - Soft below 7.6 m	■	G3 G4 G5 G6 G7 G8 G9 G10
CL-ML	Loose grey poorly graded sandy silty CLAY (CL-ML) TILL	■	G11 G12

END OF TESTHOLE
- Testhole terminated at a depth of 15.24 m in sandy silty CLAY (CL-ML) TILL
- Groundwater level was observed at a depth 14.00 m upon completion of drilling
- Soil sloughing was observed in the fat CLAY (CH) at a depth of 6.00 m
- Testhole backfilled with soil cuttings to ground surface



DEPTH (m): 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

ELEVATION: 233 232 231 230 229 228 227 226 225 224 223 222 221 220 219 218 217 216

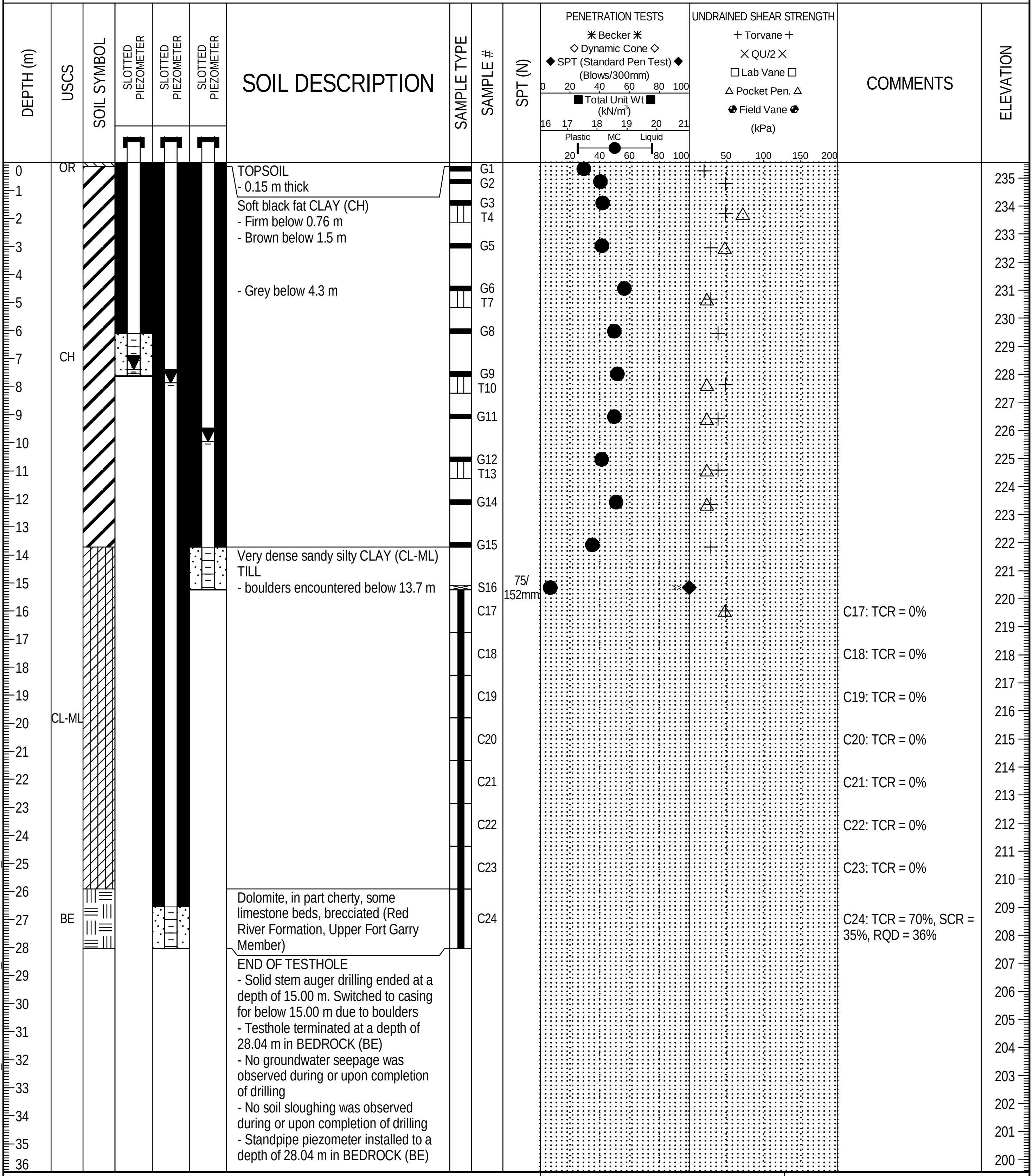
COMMENTS

AECOM	LOGGED BY: CO	COMPLETION DEPTH: 15.24 m
	REVIEWED BY: GL	COMPLETION DATE: 24-7-18
	PROJECT ENGINEER: German Leal	Page 1 of 1

PROJECT: Brady Road Recource Managenent Facility - Area B	CLIENT: City of Winnipeg	TESTHOLE NO: BH24-03
LOCATION: Brady Landfill, Winnipeg, MB. UTM: 14U, 5514212.8 m N, 629326.6 m E		PROJECT NO.: 60733855
CONTRACTOR: Paddock Drilling Ltd	METHOD: Solid Stem Auger	ELEVATION (m): 235.56

SAMPLE TYPE: ■ GRAB | ▥ SHELBY TUBE | ☒ SPLIT SPOON | ☰ BULK | ◪ NO RECOVERY | ▮ CORE

BACKFILL TYPE: ■ BENTONITE | ⁘ GRAVEL | ▥ SLOUGH | ▨ GROUT | ◪ CUTTINGS | ⁘ SAND



TOPSOIL
- 0.15 m thick

Soft black fat CLAY (CH)
- Firm below 0.76 m
- Brown below 1.5 m

- Grey below 4.3 m

Very dense sandy silty CLAY (CL-ML) TILL
- boulders encountered below 13.7 m

Dolomite, in part cherty, some limestone beds, brecciated (Red River Formation, Upper Fort Garry Member)

END OF TESTHOLE
- Solid stem auger drilling ended at a depth of 15.00 m. Switched to casing for below 15.00 m due to boulders
- Testhole terminated at a depth of 28.04 m in BEDROCK (BE)
- No groundwater seepage was observed during or upon completion of drilling
- No soil sloughing was observed during or upon completion of drilling
- Standpipe piezometer installed to a depth of 28.04 m in BEDROCK (BE)

SAMPLE #	SPT (N)	COMMENTS
G1		
G2		
G3		
T4		
G5		
G6		
T7		
G8		
G9		
T10		
G11		
G12		
T13		
G14		
G15		
S16	75/ 152mm	
C17		C17: TCR = 0%
C18		C18: TCR = 0%
C19		C19: TCR = 0%
C20		C20: TCR = 0%
C21		C21: TCR = 0%
C22		C22: TCR = 0%
C23		C23: TCR = 0%
C24		C24: TCR = 70%, SCR = 35%, RQD = 36%

LOGGED BY: CO	COMPLETION DEPTH: 28.04 m
REVIEWED BY: GL	COMPLETION DATE: 24-7-22
PROJECT ENGINEER: German Leal	Page 1 of 2

PROJECT: Brady Road Recource Management Facility - Area B
CLIENT: City of Winnipeg
TESTHOLE NO: BH24-03
LOCATION: Brady Landfill, Winnipeg, MB. UTM: 14U, 5514212.8 m N, 629326.6 m E
PROJECT NO.: 60733855
CONTRACTOR: Paddock Drilling Ltd
METHOD: Solid Stem Auger
ELEVATION (m): 235.56

SAMPLE TYPE: ■ GRAB ▥ SHELBY TUBE ☒ SPLIT SPOON ☰ BULK ▨ NO RECOVERY ▮ CORE

BACKFILL TYPE: ■ BENTONITE ⁘ GRAVEL ▥ SLOUGH ⁘ GROUT ▨ CUTTINGS ⁘ SAND

DEPTH (m)	USCS	SOIL SYMBOL	SLOTTED PIEZOMETER	SLOTTED PIEZOMETER	SLOTTED PIEZOMETER	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 ■ Total Unit Wt ■ (kN/m^3) 16 17 18 19 20 21 Plastic MC Liquid 20 40 60 80 100	UNDRAINED SHEAR STRENGTH + Torvane + × QU/2 × ☐ Lab Vane ☐ △ Pocket Pen. △ ● Field Vane ● (kPa) 50 100 150 200	COMMENTS	ELEVATION
36						then slotted to a depth of 26.52 m to 28.04 m, stick up 0.98 m - Testhole backfilled with silica sand to a depth of 26.5 then followed by bentonite pellets to the surface for the BEDROCK (BE) piezometer - Standpipe piezometer installed to a depth of 15.24 m in sandy silty CLAY (CL-ML) TILL, slotted from a depth 13.72 m to 15.24 m, stick up 0.80 m - Testhole backfilled with silica sand to a depth of 13.72 m then followed by bentonite pellets to the surface for the sandy silty CLAY (CL-ML) TILL - Standpipe piezometer installed to a depth of 7.62 m in fat CLAY (CH), slotted from a depth of 6.10 m to 7.62, stick up 0.80 m - Testhole backfilled with silica sand to a depth of 6.10 m then followed by bentonite pellets to the surface for the fat CLAY (CH)							

Depth (m): 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72

Elevation: 199, 198, 197, 196, 195, 194, 193, 192, 191, 190, 189, 188, 187, 186, 185, 184, 183, 182, 181, 180, 179, 178, 177, 176, 175, 174, 173, 172, 171, 170, 169, 168, 167, 166, 165, 164

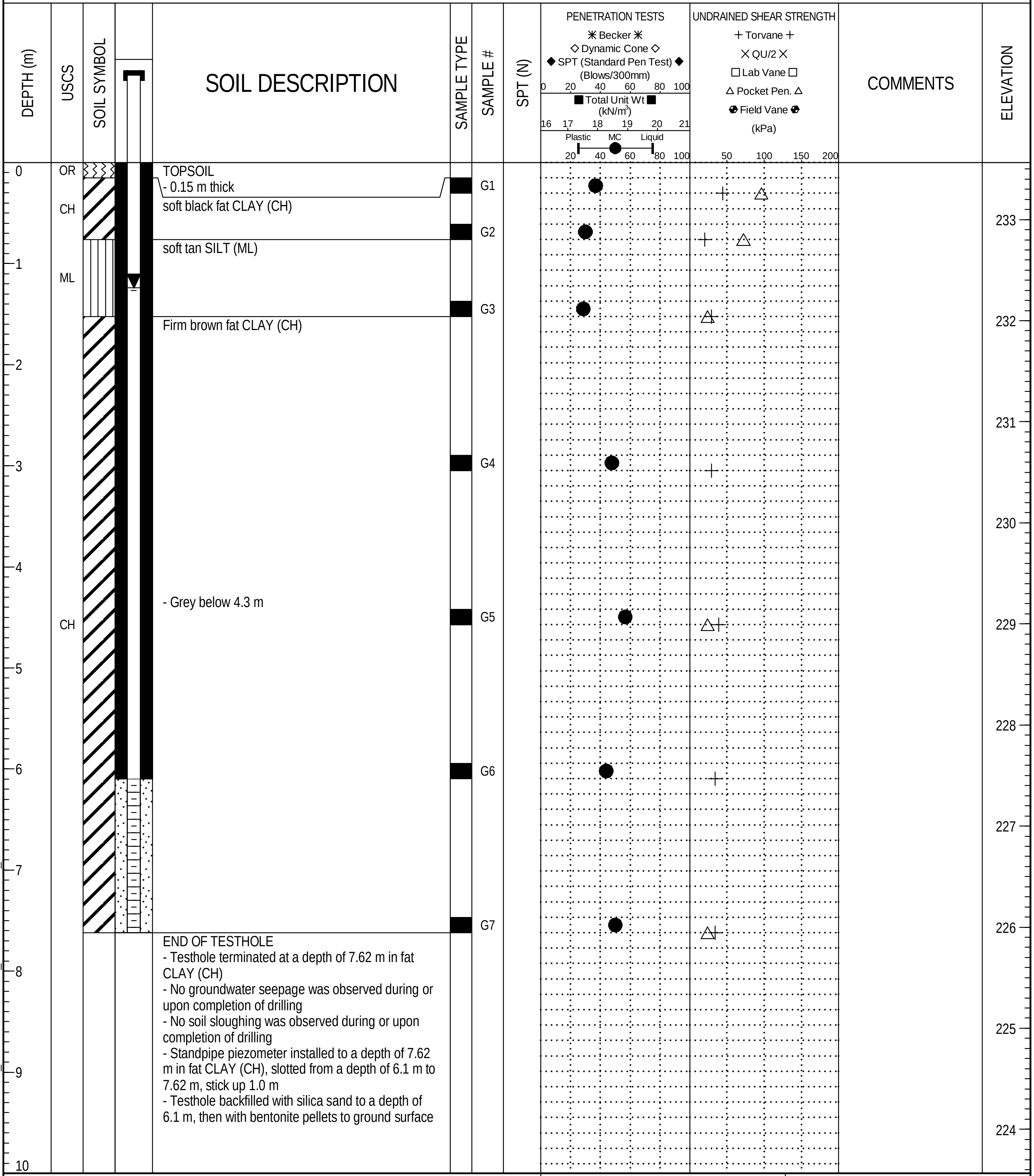
AECOM

LOGGED BY: CO
COMPLETION DEPTH: 28.04 m
REVIEWED BY: GL
COMPLETION DATE: 24-7-22
PROJECT ENGINEER: German Leal

PROJECT: Brady Road Recource Managenent Facility - Area B	CLIENT: City of Winnipeg	TESTHOLE NO: BH24-04
LOCATION: Brady Landfill, Winnipeg, MB. UTM: 14U, 5514057.2 m N, 628754.3 m E		PROJECT NO.: 60733855
CONTRACTOR: Paddock Drilling Ltd	METHOD: Solid Stem Auger	ELEVATION (m): 233.56

SAMPLE TYPE ■ GRAB ▥ SHELBY TUBE ☒ SPLIT SPOON ☰ BULK ◿ NO RECOVERY ▮ CORE

BACKFILL TYPE ■ BENTONITE ⁘ GRAVEL ▥ SLOUGH ⁙ GROUT ▨ CUTTINGS ⁘ SAND



TOPSOIL
- 0.15 m thick

soft black fat CLAY (CH)

soft tan SILT (ML)

Firm brown fat CLAY (CH)

- Grey below 4.3 m

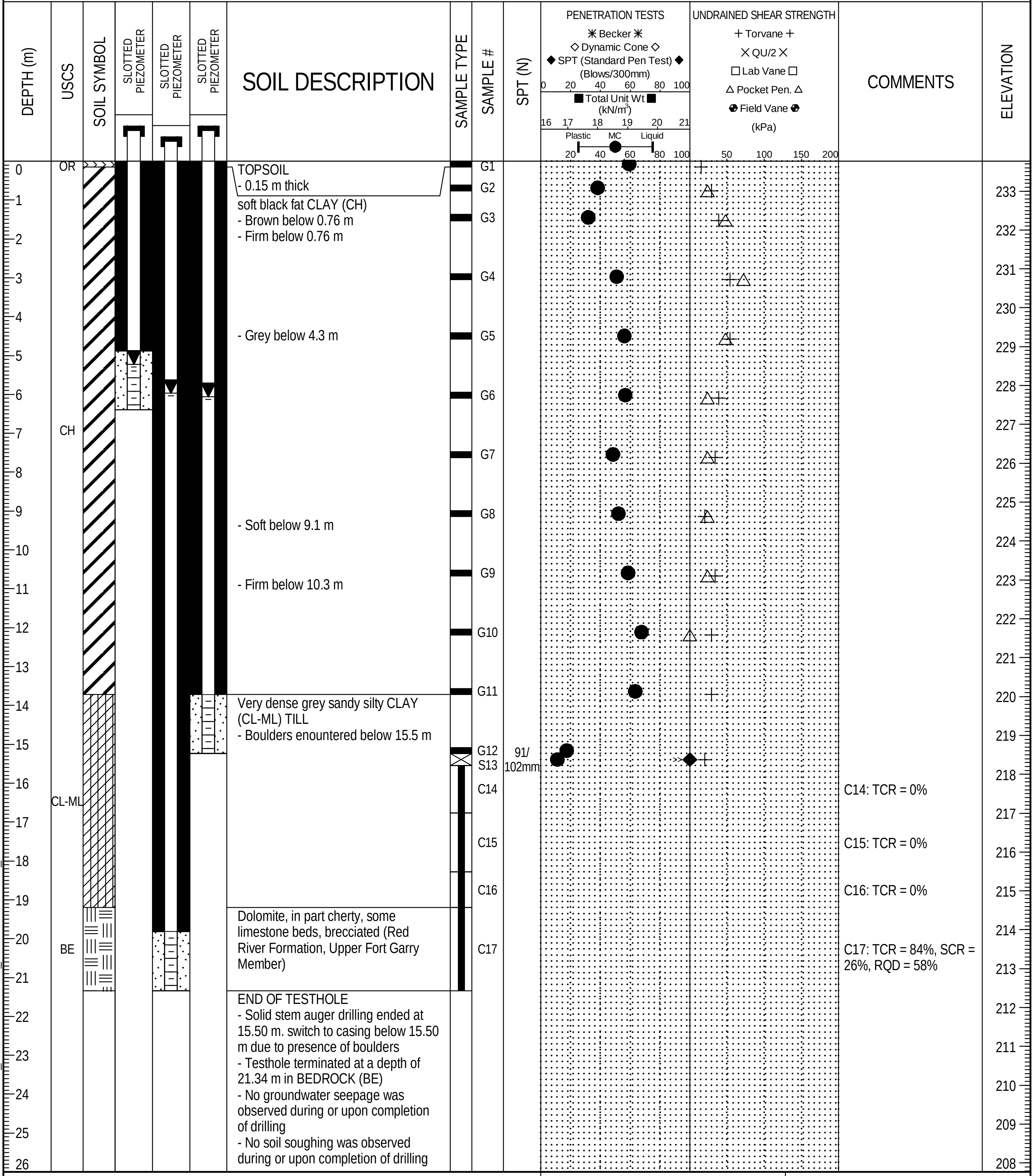
END OF TESTHOLE
- Testhole terminated at a depth of 7.62 m in fat CLAY (CH)
- No groundwater seepage was observed during or upon completion of drilling
- No soil sloughing was observed during or upon completion of drilling
- Standpipe piezometer installed to a depth of 7.62 m in fat CLAY (CH), slotted from a depth of 6.1 m to 7.62 m, stick up 1.0 m
- Testhole backfilled with silica sand to a depth of 6.1 m, then with bentonite pellets to ground surface

AECOM	LOGGED BY: CO	COMPLETION DEPTH: 7.62 m
	REVIEWED BY: GL	COMPLETION DATE: 24-7-18
	PROJECT ENGINEER: German Leal	Page 1 of 1

PROJECT: Brady Road Recource Managenent Facility - Area B	CLIENT: City of Winnipeg	TESTHOLE NO: BH24-06
LOCATION: Brady Landfill, Winnipeg, MB. UTM: 14U, 5513340.3 m N, 629410.6 m E		PROJECT NO.: 60733855
CONTRACTOR: Paddock Drilling Ltd	METHOD: Solid Stem Auger	ELEVATION (m): 233.77

SAMPLE TYPE ■ GRAB ▥ SHELBY TUBE ☒ SPLIT SPOON ☰ BULK ⧄ NO RECOVERY ▮ CORE

BACKFILL TYPE ■ BENTONITE ⁙ GRAVEL ▥ SLOUGH ▨ GROUT ⧄ CUTTINGS ⁙ SAND



TOPSOIL
- 0.15 m thick

soft black fat CLAY (CH)
- Brown below 0.76 m
- Firm below 0.76 m
- Grey below 4.3 m
- Soft below 9.1 m
- Firm below 10.3 m

Very dense grey sandy silty CLAY (CL-ML) TILL
- Boulders enountered below 15.5 m

Dolomite, in part cherty, some limestone beds, brecciated (Red River Formation, Upper Fort Garry Member)

END OF TESTHOLE
- Solid stem auger drilling ended at 15.50 m. switch to casing below 15.50 m due to presence of boulders
- Testhole terminated at a depth of 21.34 m in BEDROCK (BE)
- No groundwater seepage was observed during or upon completion of drilling
- No soil soughing was observed during or upon completion of drilling

C14: TCR = 0%

C15: TCR = 0%

C16: TCR = 0%

C17: TCR = 84%, SCR = 26%, RQD = 58%

AECOM

LOGGED BY: CO	COMPLETION DEPTH: 21.34 m
REVIEWED BY: GL	COMPLETION DATE: 24-7-15
PROJECT ENGINEER: German Leal	Page 1 of 2

PROJECT: Brady Road Recource Managenent Facility - Area B | CLIENT: City of Winnipeg | TESTHOLE NO: BH24-06
LOCATION: Brady Landfill, Winnipeg, MB. UTM: 14U, 5513340.3 m N, 629410.6 m E | PROJECT NO.: 60733855
CONTRACTOR: Paddock Drilling Ltd | METHOD: Solid Stem Auger | ELEVATION (m): 233.77

SAMPLE TYPE ■ GRAB ▥ SHELBY TUBE ☒ SPLIT SPOON ☰ BULK ▧ NO RECOVERY ▮ CORE
BACKFILL TYPE ■ BENTONITE ⁙ GRAVEL ▥ SLOUGH ⁙ GROUT ▧ CUTTINGS ⁙ SAND

DEPTH (m)	USCS	SOIL SYMBOL	SLOTTED PIEZOMETER	SLOTTED PIEZOMETER	SLOTTED PIEZOMETER	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 ■ Total Unit Wt ■ (kN/m^3) 16 17 18 19 20 21 Plastic MC Liquid 20 40 60 80 100	UNDRAINED SHEAR STRENGTH + Torvane + × QU/2 × ☐ Lab Vane ☐ △ Pocket Pen. △ ● Field Vane ● (kPa) 50 100 150 200	COMMENTS	ELEVATION
26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52						- Standpipe piezometer installed to a depth of 21.34 m in BEDROCK (BE), slotted from a depth of 19.81 m to 21.34 m, stick up 0.65 m - Testhole backfilled with silica sand to a depth of 19.81 m, then with bentonite pellets to the surface for the BEDROCK (BE) - Standpipe piezometer installed to a depth of 15.24 m insandy silty CLAY (CL-ML) TILL then slotted to a depth of 13.72 m to 15.24 m, stick up 1.05 m - Testhole backfilled with silica sand to a depth of 13.72 m, then with bentonite pellets to the surface for the sandy silty CLAY (CL-ML) TILL - Standpipe piezometer installed to a depth of 6.40 m in fat CLAY (CH), slotted from a depth of 4.88 m to 6.40 m, stick up 0.93 m - Testhole backfilled with silica sand to a depth of 4.88 m, then with bentonite pellets to the surface for the fat CLAY (CH)							207 206 205 204 203 202 201 200 199 198 197 196 195 194 193 192 191 190 189 188 187 186 185 184 183 182

LOGGED BY: CO | COMPLETION DEPTH: 21.34 m
REVIEWED BY: GL | COMPLETION DATE: 24-7-15
PROJECT ENGINEER: German Leal | Page 2 of 2

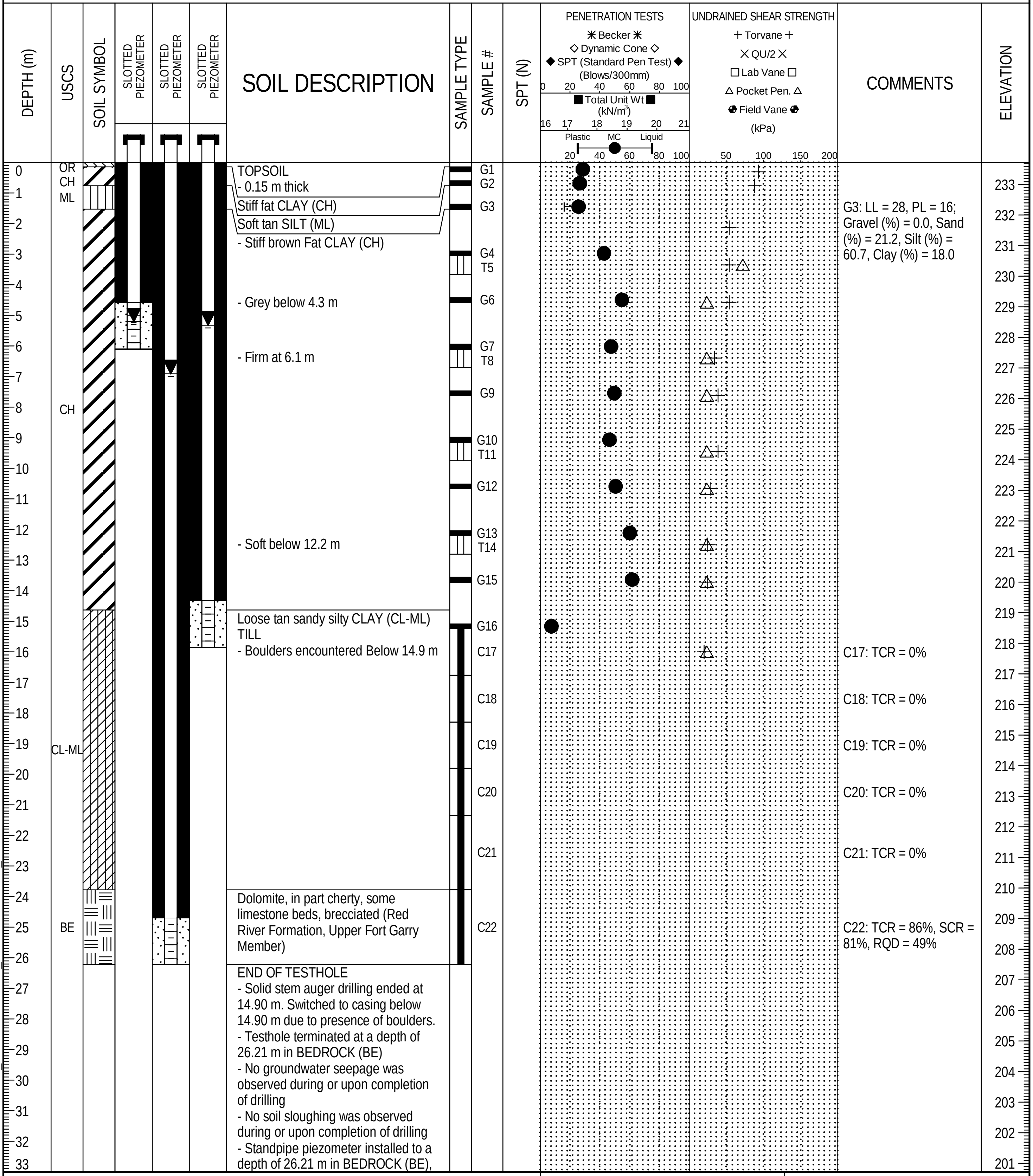
PROJECT: Brady Road Recource Managenent Facility - Area B | CLIENT: City of Winnipeg | TESTHOLE NO: BH24-08

LOCATION: Brady Landfill, Winnipeg, MB. UTM: 14U, 5513525.2 m N, 628754 m E | PROJECT NO.: 60733855

CONTRACTOR: Paddock Drilling Ltd | METHOD: Solid Stem Auger | ELEVATION (m): 233.73

SAMPLE TYPE ■ GRAB ▥ SHELBY TUBE ☒ SPLIT SPOON ☰ BULK ▨ NO RECOVERY ▮ CORE

BACKFILL TYPE ■ BENTONITE ⁖ GRAVEL ▥ SLOUGH ▩ GROUT ▨ CUTTINGS ⁖ SAND



SOIL DESCRIPTION

TOPSOIL
- 0.15 m thick

Stiff fat CLAY (CH)

Soft tan SILT (ML)
- Stiff brown Fat CLAY (CH)
- Grey below 4.3 m
- Firm at 6.1 m
- Soft below 12.2 m

Loose tan sandy silty CLAY (CL-ML) TILL
- Boulders encountered Below 14.9 m

Dolomite, in part cherty, some limestone beds, brecciated (Red River Formation, Upper Fort Garry Member)

END OF TESTHOLE
- Solid stem auger drilling ended at 14.90 m. Switched to casing below 14.90 m due to presence of boulders.
- Testhole terminated at a depth of 26.21 m in BEDROCK (BE)
- No groundwater seepage was observed during or upon completion of drilling
- No soil sloughing was observed during or upon completion of drilling
- Standpipe piezometer installed to a depth of 26.21 m in BEDROCK (BE),

COMMENTS

G3: LL = 28, PL = 16; Gravel (%) = 0.0, Sand (%) = 21.2, Silt (%) = 60.7, Clay (%) = 18.0

C17: TCR = 0%

C18: TCR = 0%

C19: TCR = 0%

C20: TCR = 0%

C21: TCR = 0%

C22: TCR = 86%, SCR = 81%, RQD = 49%

AECOM

LOGGED BY: CO | COMPLETION DEPTH: 26.21 m

REVIEWED BY: GL | COMPLETION DATE: 24-7-10

PROJECT ENGINEER: German Leal | Page 1 of 2

PROJECT: Brady Road Recource Managenent Facility - Area B	CLIENT: City of Winnipeg	TESTHOLE NO: BH24-08
LOCATION: Brady Landfill, Winnipeg, MB. UTM: 14U, 5513525.2 m N, 628754 m E		PROJECT NO.: 60733855
CONTRACTOR: Paddock Drilling Ltd	METHOD: Solid Stem Auger	ELEVATION (m): 233.73

SAMPLE TYPE: ■ GRAB; ▥ SHELBY TUBE; ☒ SPLIT SPOON; ☰ BULK; ▱ NO RECOVERY; ▮ CORE

BACKFILL TYPE: ■ BENTONITE; ⁘ GRAVEL; ▥ SLOUGH; ▨ GROUT; ▨ CUTTINGS; ⁘ SAND

DEPTH (m)	USCS	SOIL SYMBOL	SLOTTED PIEZOMETER	SLOTTED PIEZOMETER	SLOTTED PIEZOMETER	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21 Plastic MC Liquid 20 40 60 80 100	UNDRAINED SHEAR STRENGTH + Torvane + × QU/2 × ☐ Lab Vane ☐ △ Pocket Pen. △ ● Field Vane ● (kPa) 50 100 150 200	COMMENTS	ELEVATION
33						then slotted from a depth of 24.69 m to 26.21 m, stick up 0.95 m - Testhole backfilled with silica sand to a depth of 24.69 m, then with bentonite pellets to the surface for the BEDROCK (BE) - Standpipe piezometer installed to a depth of 15.85 m in sandy silty CLAY (CL-ML) TILL, slotted from a depth of 14.33 m to 15.85 m, stick up 0.95 m - Testhole backfilled with silica sand to a depth of 14.33 m, then with bentonite pellets to the surface for the sandy silty CLAY (CL-ML) TILL - Standpipe piezometer installed to a depth of 6.10 m in fat CLAY (CH), slotted from a depth of 4.57 m to 6.10 m, stick up 0.95 m - Testhole backfilled with silica sand to a depth of 4.57 m, then with bentonite pellets to the surface for the fat CLAY (CH)							
34													200
35													199
36													198
37													197
38													196
39													195
40													194
41													193
42													192
43													191
44													190
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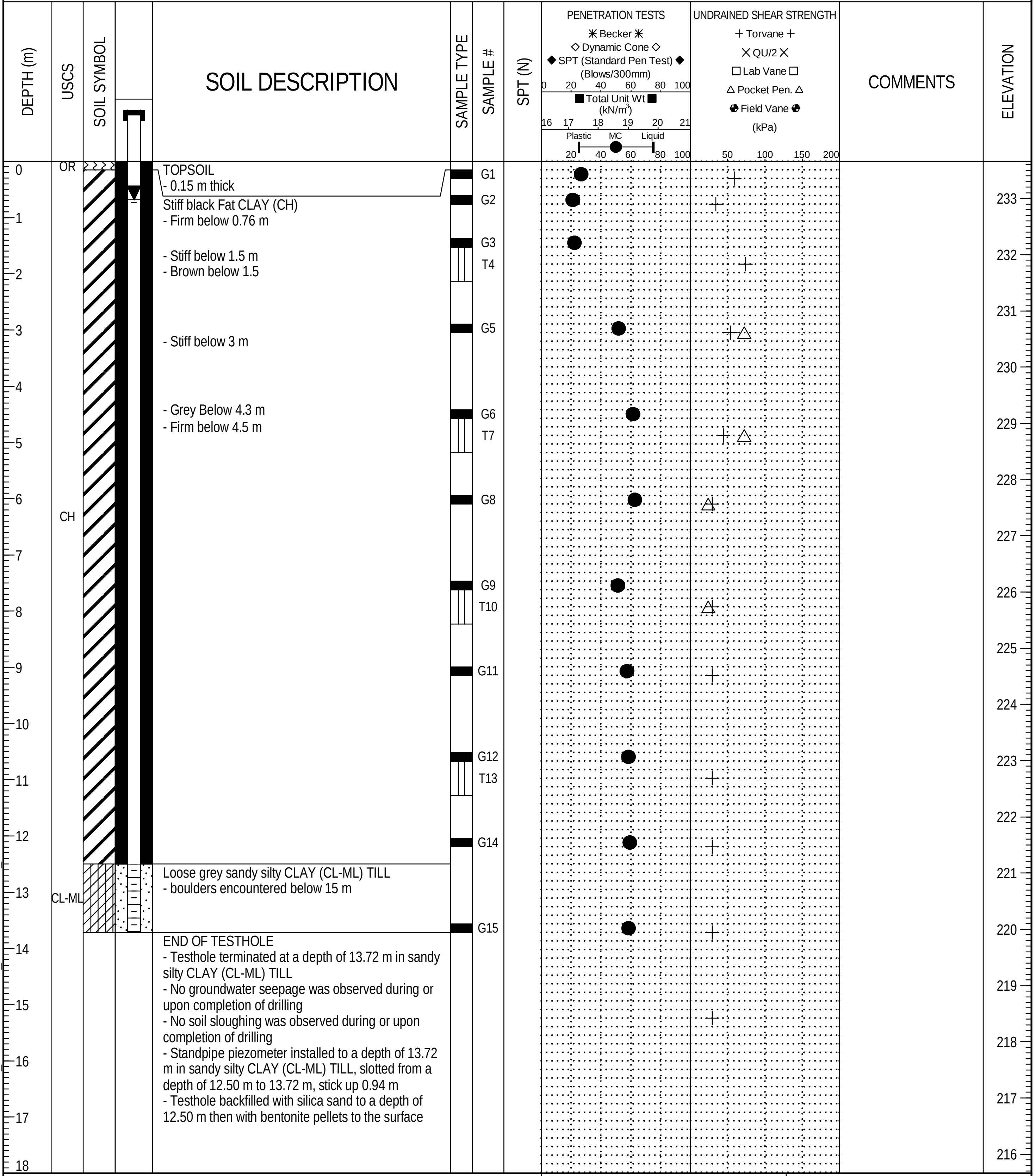
61													173
62													172
63													171
64													170
65													169
66													168

AECOM	LOGGED BY: CO	COMPLETION DEPTH: 26.21 m
	REVIEWED BY: GL	COMPLETION DATE: 24-7-10
	PROJECT ENGINEER: German Leal	Page 2 of 2

PROJECT: Brady Road Recource Management Facility - Area B	CLIENT: City of Winnipeg	TESTHOLE NO: BH24-09
LOCATION: Brady Landfill, Winnipeg, MB. UTM: 14U, 5513503.234 m N, 628919 m E		PROJECT NO.: 60733855
CONTRACTOR: Paddock Drilling Ltd	METHOD: Solid Stem Auger	ELEVATION (m): 233.66

SAMPLE TYPE: ■ GRAB, ▥ SHELBY TUBE, ☒ SPLIT SPOON, ☰ BULK, ◿ NO RECOVERY, ▮ CORE

BACKFILL TYPE: ■ BENTONITE, ⁘ GRAVEL, ▥ SLOUGH, ⁘ GROUT, ▨ CUTTINGS, ⁘ SAND



USCS	SOIL DESCRIPTION
OR	TOPSOIL - 0.15 m thick
CH	Stiff black Fat CLAY (CH) - Firm below 0.76 m - Stiff below 1.5 m - Brown below 1.5 - Stiff below 3 m - Grey Below 4.3 m - Firm below 4.5 m
CL-ML	Loose grey sandy silty CLAY (CL-ML) TILL - boulders encountered below 15 m

END OF TESTHOLE
- Testhole terminated at a depth of 13.72 m in sandy silty CLAY (CL-ML) TILL
- No groundwater seepage was observed during or upon completion of drilling
- No soil sloughing was observed during or upon completion of drilling
- Standpipe piezometer installed to a depth of 13.72 m in sandy silty CLAY (CL-ML) TILL, slotted from a depth of 12.50 m to 13.72 m, stick up 0.94 m
- Testhole backfilled with silica sand to a depth of 12.50 m then with bentonite pellets to the surface

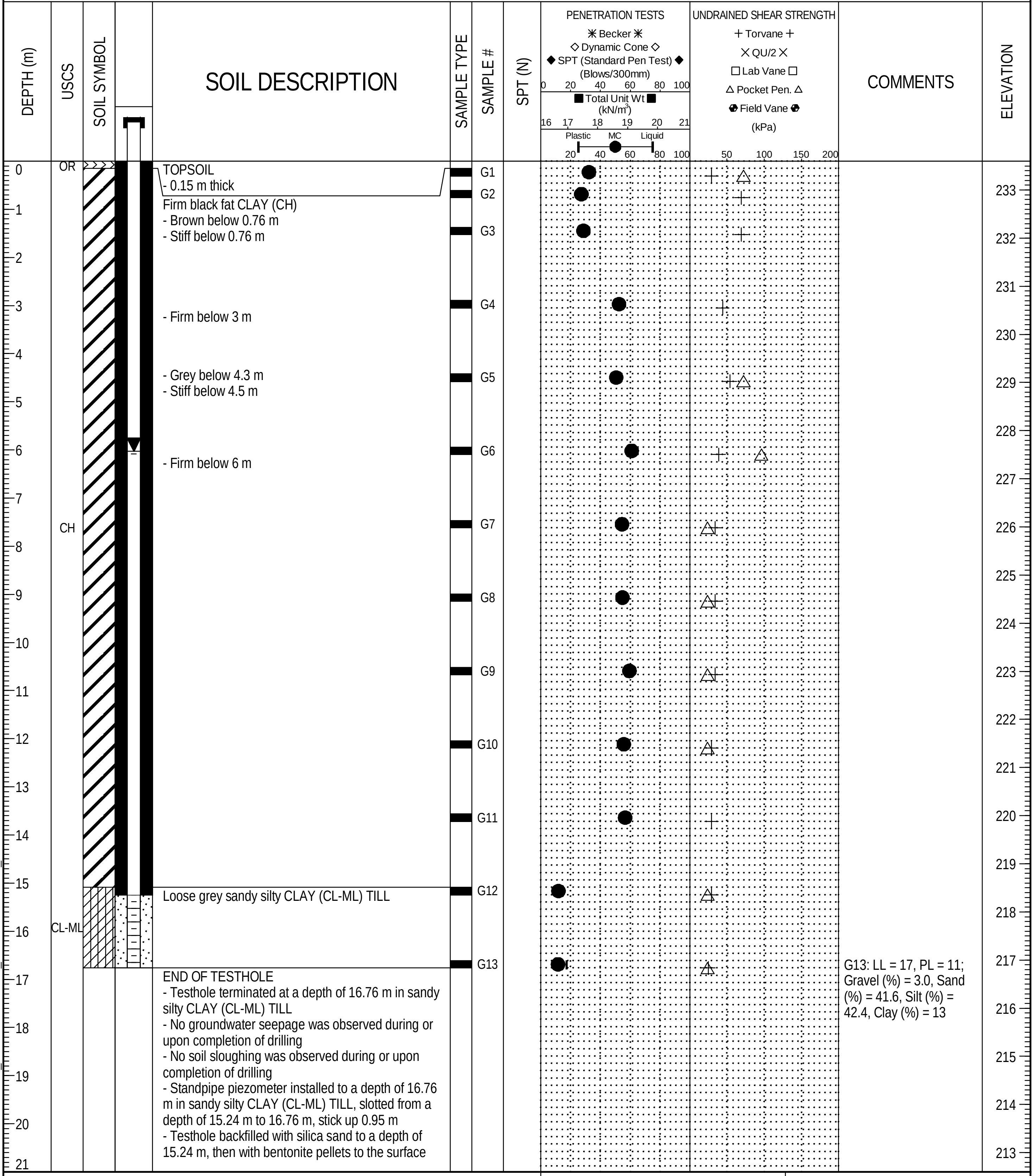
SAMPLE TYPE	SAMPLE #
■	G1
■	G2
■	G3
▥	T4
■	G5
■	G6
▥	T7
■	G8
■	G9
▥	T10
■	G11
■	G12
▥	T13
■	G14
■	G15

LOGGED BY: CO	COMPLETION DEPTH: 13.72 m
REVIEWED BY: GL	COMPLETION DATE: 24-7-11
PROJECT ENGINEER: German Leal	Page 1 of 1

PROJECT: Brady Road Recource Managenent Facility - Area B
CLIENT: City of Winnipeg
TESTHOLE NO: BH24-10
LOCATION: Brady Landfill, Winnipeg, MB. UTM: 14U, 5513585.4 m N, 629056 m E
PROJECT NO.: 60733855
CONTRACTOR: Paddock Drilling Ltd
METHOD: Solid Stem Auger
ELEVATION (m): 233.60

SAMPLE TYPE: ■ GRAB ▥ SHELBY TUBE ☒ SPLIT SPOON ☰ BULK ◪ NO RECOVERY ▮ CORE

BACKFILL TYPE: ■ BENTONITE ⁚ GRAVEL ▥ SLOUGH ▨ GROUT ▨ CUTTINGS ⁚ SAND



TOPSOIL
- 0.15 m thick

Firm black fat CLAY (CH)
- Brown below 0.76 m
- Stiff below 0.76 m

- Firm below 3 m

- Grey below 4.3 m
- Stiff below 4.5 m

- Firm below 6 m

Loose grey sandy silty CLAY (CL-ML) TILL

END OF TESTHOLE
- Testhole terminated at a depth of 16.76 m in sandy silty CLAY (CL-ML) TILL
- No groundwater seepage was observed during or upon completion of drilling
- No soil sloughing was observed during or upon completion of drilling
- Standpipe piezometer installed to a depth of 16.76 m in sandy silty CLAY (CL-ML) TILL, slotted from a depth of 15.24 m to 16.76 m, stick up 0.95 m
- Testhole backfilled with silica sand to a depth of 15.24 m, then with bentonite pellets to the surface

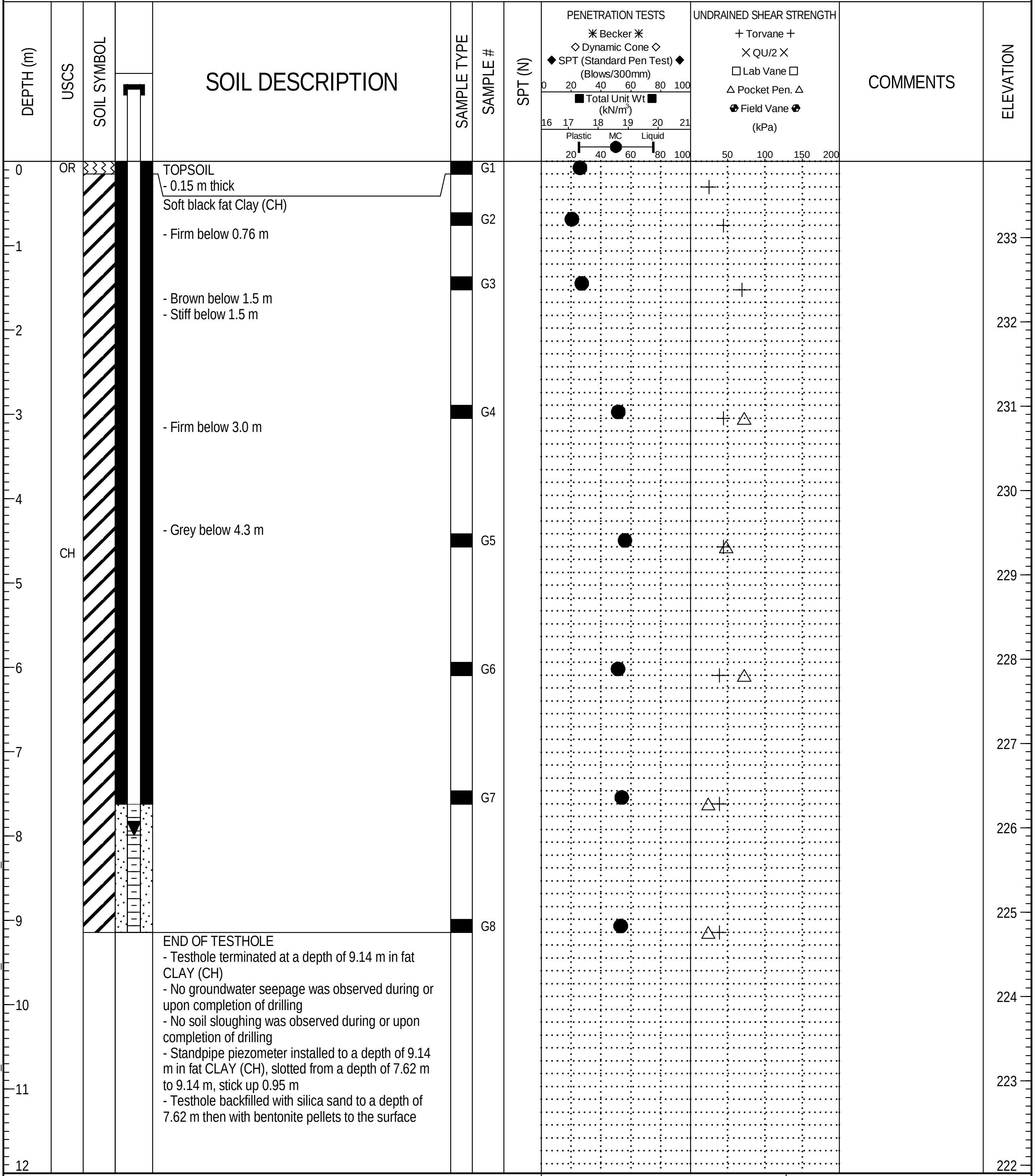
G13: LL = 17, PL = 11; Gravel (%) = 3.0, Sand (%) = 41.6, Silt (%) = 42.4, Clay (%) = 13

LOGGED BY: CO
COMPLETION DEPTH: 16.76 m
REVIEWED BY: GL
COMPLETION DATE: 24-7-12
PROJECT ENGINEER: German Leal

PROJECT: Brady Road Recource Managenent Facility - Area B	CLIENT: City of Winnipeg	TESTHOLE NO: BH24-11
LOCATION: Brady Landfill, Winnipeg, MB. UTM: 14U, 5513716.5 m N, 629283.1 m E		PROJECT NO.: 60733855
CONTRACTOR: Paddock Drilling Ltd	METHOD: Solid Stem Auger	ELEVATION (m): 233.90

SAMPLE TYPE ■ GRAB ▥ SHELBY TUBE ☒ SPLIT SPOON ☰ BULK ▨ NO RECOVERY ▮ CORE

BACKFILL TYPE ■ BENTONITE ⁘ GRAVEL ▥ SLOUGH ⁘ GROUT ▨ CUTTINGS ⁘ SAND



TOPSOIL
- 0.15 m thick

Soft black fat Clay (CH)
- Firm below 0.76 m
- Brown below 1.5 m
- Stiff below 1.5 m
- Firm below 3.0 m
- Grey below 4.3 m

END OF TESTHOLE
- Testhole terminated at a depth of 9.14 m in fat CLAY (CH)
- No groundwater seepage was observed during or upon completion of drilling
- No soil sloughing was observed during or upon completion of drilling
- Standpipe piezometer installed to a depth of 9.14 m in fat CLAY (CH), slotted from a depth of 7.62 m to 9.14 m, stick up 0.95 m
- Testhole backfilled with silica sand to a depth of 7.62 m then with bentonite pellets to the surface

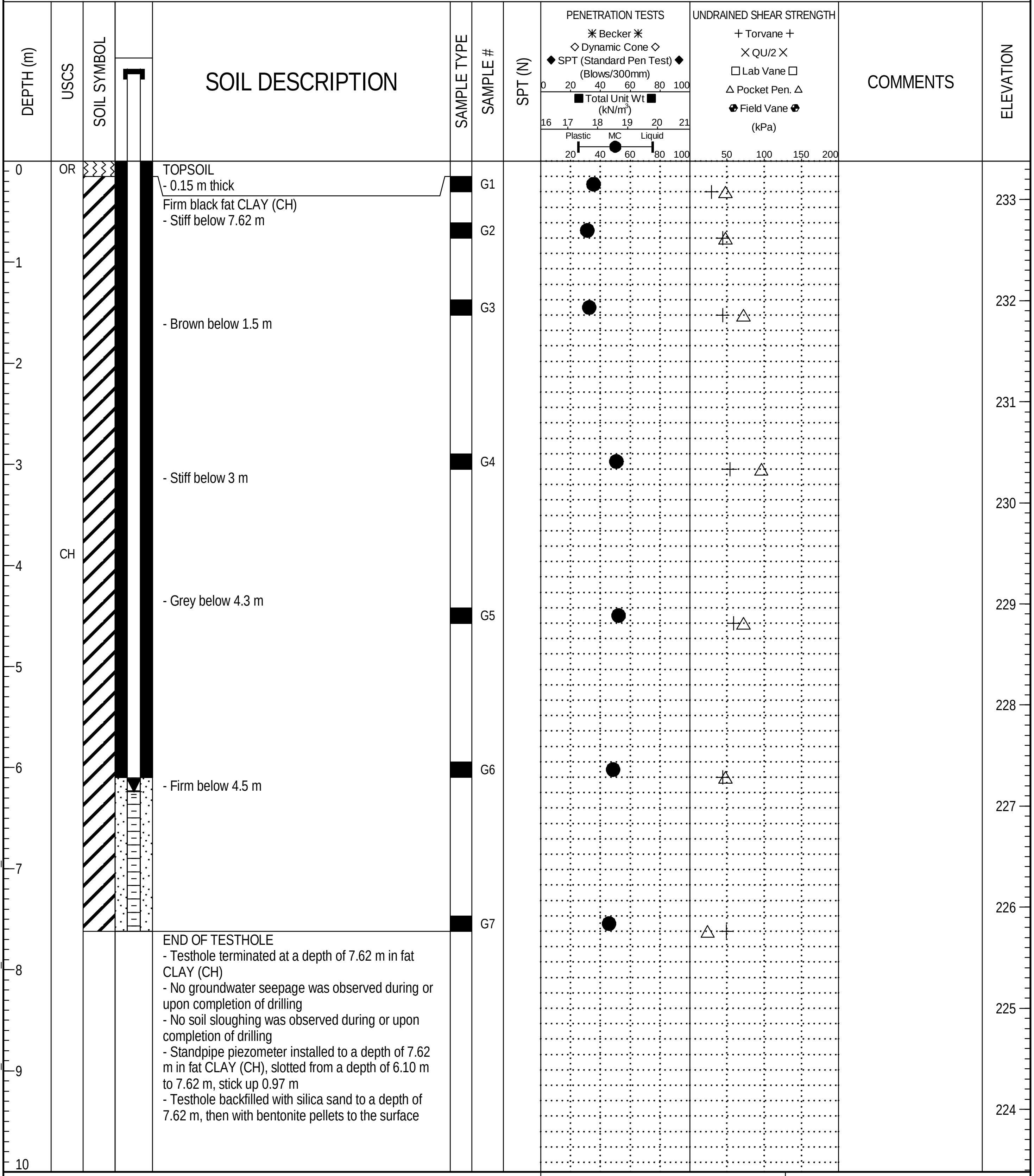
AECOM

LOGGED BY: CO	COMPLETION DEPTH: 9.14 m
REVIEWED BY: GL	COMPLETION DATE: 24-7-12
PROJECT ENGINEER: German Leal	Page 1 of 1

PROJECT: Brady Road Recource Managenent Facility - Area B	CLIENT: City of Winnipeg	TESTHOLE NO: BH24-12
LOCATION: Brady Landfill, Winnipeg, MB. UTM: 14U, 5513143.9 m N, 629191.542 m E		PROJECT NO.: 60733855
CONTRACTOR: Paddock Drilling Ltd	METHOD: Solid Stem Auger	ELEVATION (m): 233.38

SAMPLE TYPE ■ GRAB ▥ SHELBY TUBE ☒ SPLIT SPOON ☰ BULK ▨ NO RECOVERY ▮ CORE

BACKFILL TYPE ■ BENTONITE ⁘ GRAVEL ▥ SLOUGH ⁘ GROUT ▨ CUTTINGS ⁘ SAND



TOPSOIL
- 0.15 m thick

Firm black fat CLAY (CH)
- Stiff below 7.62 m

- Brown below 1.5 m

- Stiff below 3 m

- Grey below 4.3 m

- Firm below 4.5 m

END OF TESTHOLE
- Testhole terminated at a depth of 7.62 m in fat CLAY (CH)
- No groundwater seepage was observed during or upon completion of drilling
- No soil sloughing was observed during or upon completion of drilling
- Standpipe piezometer installed to a depth of 7.62 m in fat CLAY (CH), slotted from a depth of 6.10 m to 7.62 m, stick up 0.97 m
- Testhole backfilled with silica sand to a depth of 7.62 m, then with bentonite pellets to the surface

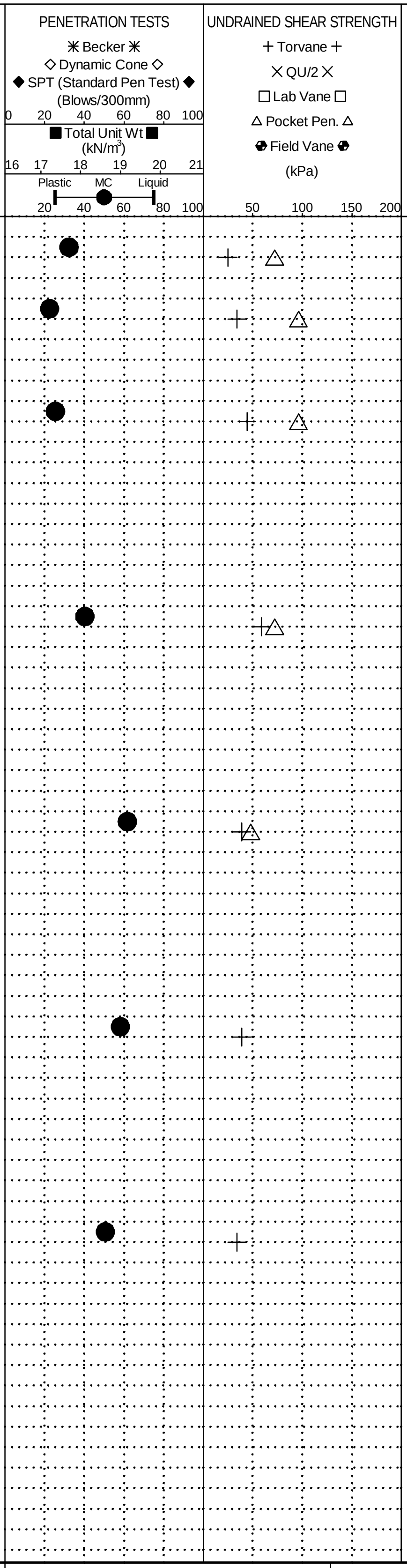
AECOM	LOGGED BY: CO	COMPLETION DEPTH: 7.62 m
	REVIEWED BY: GL	COMPLETION DATE: 24-7-18
	PROJECT ENGINEER: German Leal	Page 1 of 1

PROJECT: Brady Road Recource Managenent Facility - Area B	CLIENT: City of Winnipeg	TESTHOLE NO: BH24-13
LOCATION: Brady Landfill, Winnipeg, MB. UTM: 14U, 5513620.937 m N, 628744.18 m E		PROJECT NO.: 60733855
CONTRACTOR: Paddock Drilling Ltd	METHOD: Solid Stem Auger	ELEVATION (m): 233.55

SAMPLE TYPE: ■ GRAB ▥ SHELBY TUBE ☒ SPLIT SPOON ☰ BULK ▨ NO RECOVERY ▌ CORE

BACKFILL TYPE: ■ BENTONITE ⁙ GRAVEL ▥ SLOUGH ⁘ GROUT ▨ CUTTINGS ⁙ SAND

DEPTH (m)	USCS	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
0	OR	TOPSOIL - 0.15 m thick	■	G1
	CH	Soft black fat CLAY (CH)		
			■	G2
		- Firm below 0.76 m		
1				
			■	G3
		- Brown below 1.5 m		
2				
3			■	G4
		- Stiff below 3 m		
4				
		- Grey below 4.3 m		
			■	G5
		- Firm below 4.5 m		
5				
6			■	G6
7				
			■	G7
8		END OF TESTHOLE - Testhole terminated at a depth of 7.62 m in fat CLAY (CH) - No groundwater seepage was observed during or upon completion of drilling - No soil sloughing was observed during or upon completion of drilling - Standpipe piezometer installed to a depth of 7.62 m in fat CLAY (CH). slotted from a depth of 6.10 m to 7.62 m, stick up 0.9 m - Testhole backfilled with silica sand to a depth of 6.10 m, then with bentonite pellets to the surface		
9				
10				



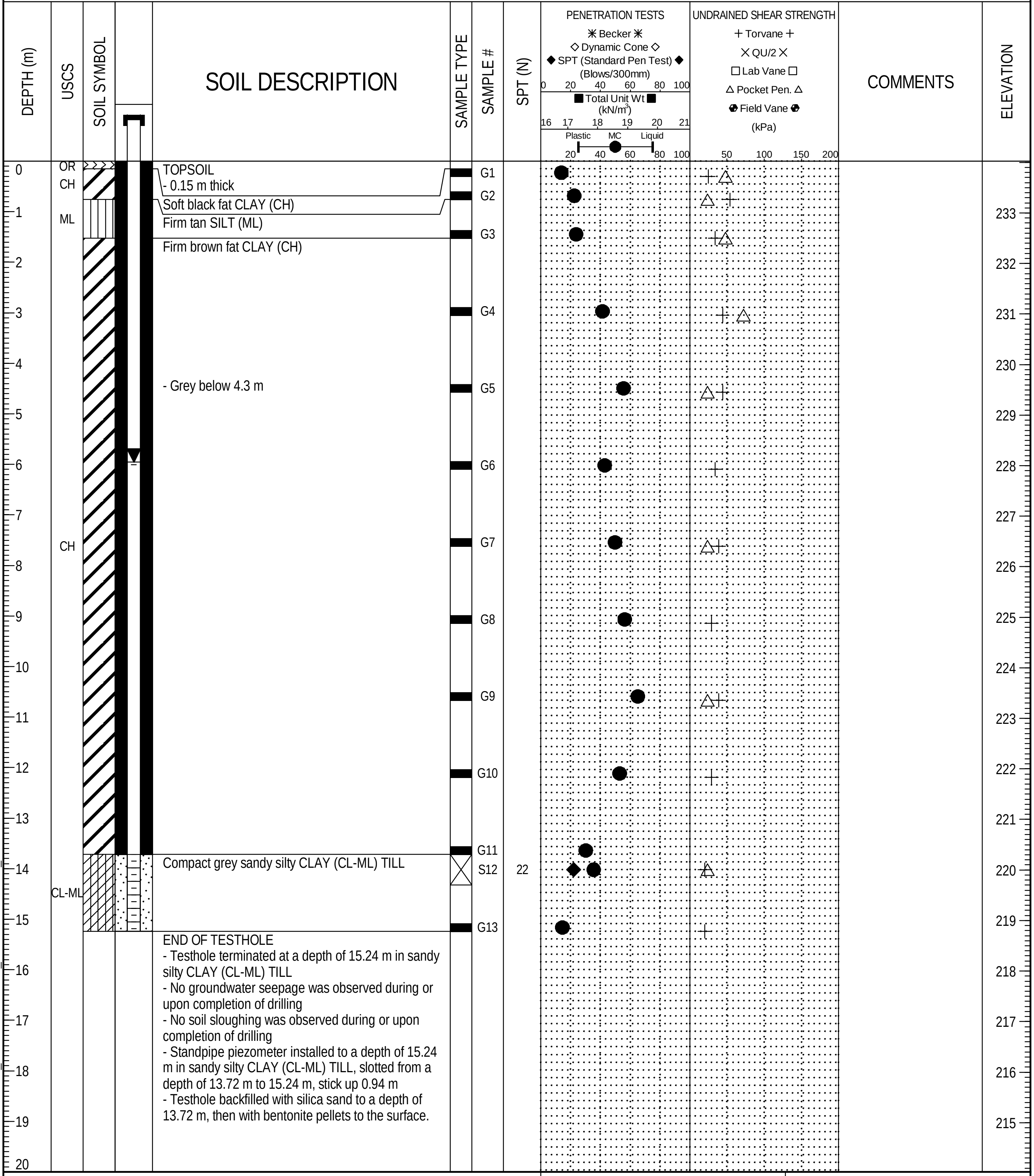
SPT (N) | COMMENTS | ELEVATION: 233, 232, 231, 230, 229, 228, 227, 226, 225, 224

LOGGED BY: CO	COMPLETION DEPTH: 7.62 m
REVIEWED BY: GL	COMPLETION DATE: 24-7-18
PROJECT ENGINEER: German Leal	Page 1 of 1

AECOM

PROJECT: Brady Road Recource Managenent Facility - Area B	CLIENT: City of Winnipeg
TESTHOLE NO: BH24-14	
LOCATION: Brady Landfill, Winnipeg, MB. UTM: 14U, 5513654.2 m N, 629374.5 m E	PROJECT NO.: 60733855
CONTRACTOR: Paddock Drilling Ltd	METHOD: Solid Stem Auger
ELEVATION (m): 234.03	

SAMPLE TYPE	■ GRAB	▥ SHELBY TUBE	☒ SPLIT SPOON	☰ BULK	▧ NO RECOVERY	▌ CORE
BACKFILL TYPE	■ BENTONITE	⁘ GRAVEL	▥ SLOUGH	⁘ GROUT	▨ CUTTINGS	⁘ SAND



TOPSOIL
- 0.15 m thick

Soft black fat CLAY (CH)

Firm tan SILT (ML)

Firm brown fat CLAY (CH)

- Grey below 4.3 m

Compact grey sandy silty CLAY (CL-ML) TILL

END OF TESTHOLE
- Testhole terminated at a depth of 15.24 m in sandy silty CLAY (CL-ML) TILL
- No groundwater seepage was observed during or upon completion of drilling
- No soil sloughing was observed during or upon completion of drilling
- Standpipe piezometer installed to a depth of 15.24 m in sandy silty CLAY (CL-ML) TILL, slotted from a depth of 13.72 m to 15.24 m, stick up 0.94 m
- Testhole backfilled with silica sand to a depth of 13.72 m, then with bentonite pellets to the surface.

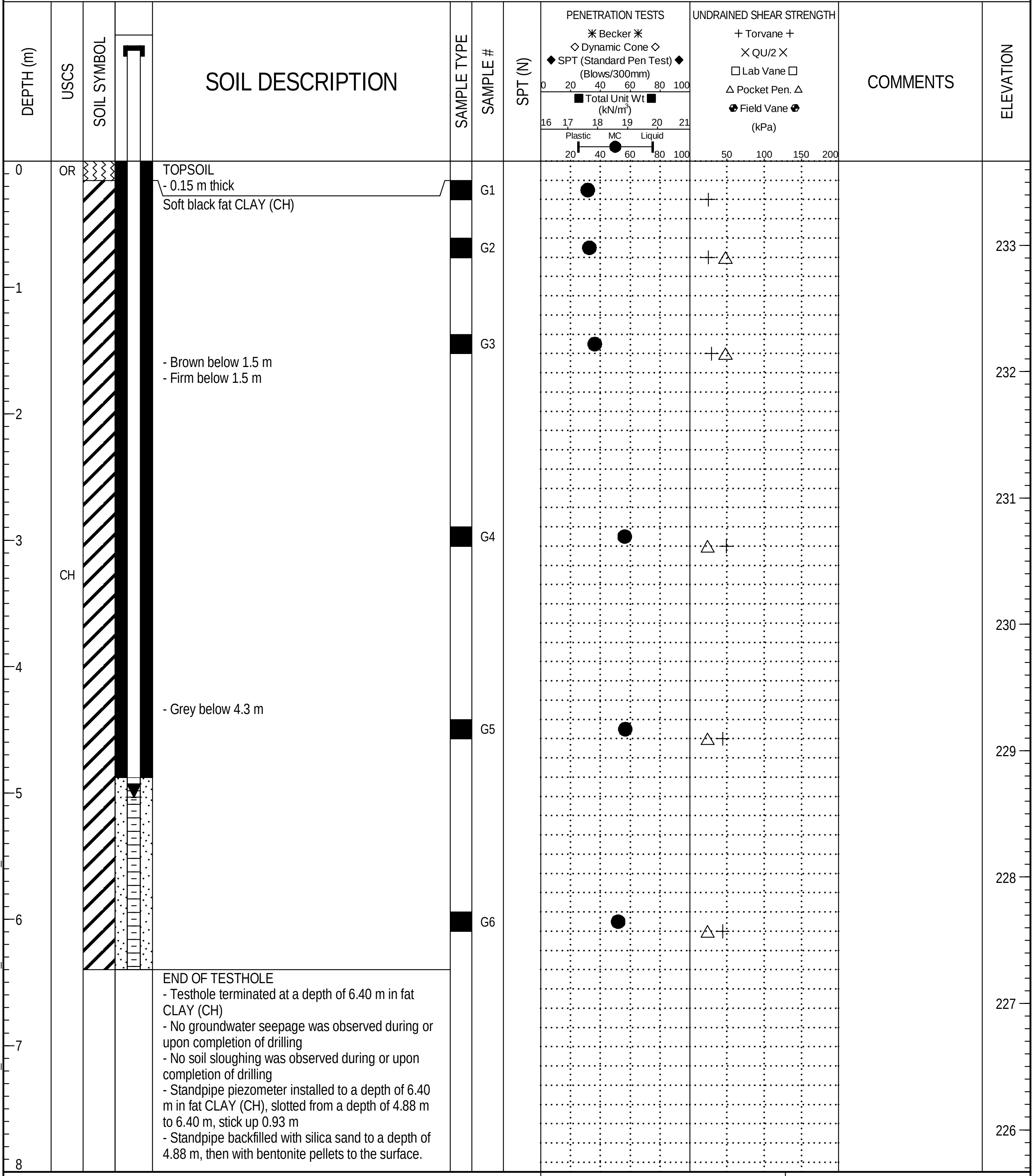
AECOM

LOGGED BY: CO	COMPLETION DEPTH: 15.24 m
REVIEWED BY: GL	COMPLETION DATE: 24-7-17
PROJECT ENGINEER: German Leal	Page 1 of 1

PROJECT: Brady Road Recource Managenent Facility - Area B	CLIENT: City of Winnipeg	TESTHOLE NO: BH24-15
LOCATION: Brady Landfill, Winnipeg, MB. UTM: 14U, 5513222.07 m N, 628823.7 m E		PROJECT NO.: 60733855
CONTRACTOR: Paddock Drilling Ltd	METHOD: Solid Stem Auger	ELEVATION (m): 233.67

SAMPLE TYPE ■ GRAB ▥ SHELBY TUBE ☒ SPLIT SPOON ☰ BULK ▱ NO RECOVERY ▌ CORE

BACKFILL TYPE ■ BENTONITE ⁘ GRAVEL ▥ SLOUGH ▩ GROUT ▨ CUTTINGS ⁘ SAND



SOIL DESCRIPTION

TOPSOIL
- 0.15 m thick

Soft black fat CLAY (CH)

- Brown below 1.5 m
- Firm below 1.5 m

- Grey below 4.3 m

END OF TESTHOLE
- Testhole terminated at a depth of 6.40 m in fat CLAY (CH)
- No groundwater seepage was observed during or upon completion of drilling
- No soil sloughing was observed during or upon completion of drilling
- Standpipe piezometer installed to a depth of 6.40 m in fat CLAY (CH), slotted from a depth of 4.88 m to 6.40 m, stick up 0.93 m
- Standpipe backfilled with silica sand to a depth of 4.88 m, then with bentonite pellets to the surface.

LOGGED BY: CO	COMPLETION DEPTH: 6.40 m
REVIEWED BY: GL	COMPLETION DATE: 24-7-17
PROJECT ENGINEER: German Leal	Page 1 of 1

AECOM

EXPLANATION OF FIELD & LABORATORY TEST DATA

The field and laboratory test results, as shown for each hole, are described below.

1. EXPLANATION OF SOIL

Each soil stratum is classified and described noting any special conditions. The Modified Unified Classification System (MUCS) is used. The soil profile refers to the existing ground level at the time the hole was done. Where available, the ground elevation is shown. The soil symbols used are shown in detail on the soil classification chart.

1.1 Tests on Soil Samples

Laboratory and field tests are identified by the following and are on the logs:

γ_D - Dry Unit Weight. Usually expressed in kN/m^3.

γ_T - Total (moist, wet, or bulk) Unit Weight. Usually expressed in kN/m^3.

C_U - Undrained Shear Strength. Usually expressed in kPa. This value can be determined by a field vane shear test and may also be used in determining the allowable bearing capacity of the soil.

C_{PEN} - Pocket Penetrometer Reading. Usually expressed in kPa. Estimate of the undrained shear strength as determined by a pocket penetrometer.

N - Standard Penetration Test (SPT) Blow Count. The SPT is conducted in the field to assess the in-situ consistency of cohesive soils and the relative density of non-cohesive soils. The N value recorded is the number of blows from a 63.5 kg hammer free falling of 760 mm (30 in.) which is required to drive a 50 mm (2 in.) split spoon sampler 300 mm (12 in.) into the soil.

Q_U - Unconfined Compressive Strength. Usually expressed in kPa and may be used in determining allowable bearing capacity of the soil.

The following tests may also be performed on selected soil samples and the results are given on separate sheets enclosed with the logs:

- Grain Size Analysis
- Standard or Modified Proctor Compaction Test
- California Bearing Ratio Test
- Direct Shear Test
- Permeability Test
- Consolidation Test
- Triaxial Test

1.2 Natural Moisture Content

The relationship between the natural moisture content and depth is significant in determining the subsurface moisture conditions. The Atterberg Limits for a sample should be compared to its natural moisture content and plotted on the Plasticity Chart to determine the soil classification.

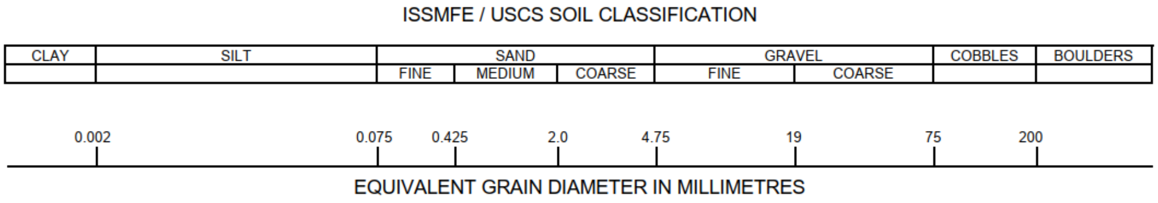
Descriptive Term	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually in coarse-grained soils below the water table

1.3 Grian Size Distrubtion

Laboratory grain size analyses provided by AECOM follow the following system. Note that, with the exception of those samples where a grain size distribution analysis has been completed, all samples have been classified by visual inspection. Visual inspection classification is not sufficient to provide exact gain sizing.

SOIL COMPONENTS

FRACTION		SIEVE SIZE (mm)		DEFINING RANGES OF PERCENTAGE BY WEIGHT OF MINOR COMPONENTS	
		PASSING	RETAINED	PERCENT	IDENTIFIER
GRAVEL	COARSE	75	19	50 – 35	AND
	FINE	19	4.75		
SAND	COARSE	4.75	2.00	35 – 20	ADJECTIVE
	MEDIUM	2.00	0.425		
	FINE	0.425	0.075	20 – 10	SOME
SILT (non-plastic) or CLAY (plastic)		0.075		10 – 1	TRACE
OVERSIZE MATERIALS					
ROUNDED OR SUB-ROUNDED COBBLES 75 mm TO 200 mm BOULDERS >200 mm			ANGULAR ROCK FRAGMENTS ROCKS > 0.75 m3 IN VOLUME		



1.4 Soil Compactness and Consistency

The standard terminology to describe cohesive soils includes consistency, which is based on undrained shear strength as measured by in-situ vane tests, penetrometer tests, unconfined compression tests, or similar field and laboratory analysis. Standard Penetration Test ‘N’ values can also be used to provide an approximate indication of the consistency and shear strength of fine-grained, cohesive soils.

The standard terminology to describe cohesionless soils includes the compactness condition as determined by the Standard Penetration Test ‘N’ value. These approximate relationships are summarized in the following tables:

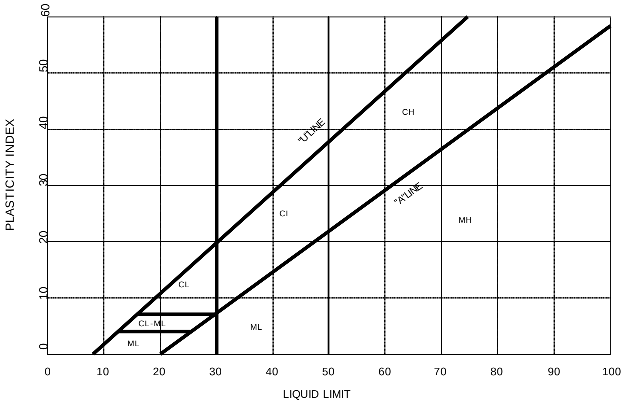
Table 1 Cohesive Soils

Consistency	SPT N (blows/0.3m)	C_u (kPa) approx.
Very Soft	<2	<12
Soft	2 - 4	12 - 25
Firm	4 - 8	25 - 50
Stiff	8 - 15	50 - 100
Very Stiff	15 - 30	100 - 200
Hard	>30	>200

Table 2 Cohesionless Soils

Compactness Condition	SPT N (blows/0.3m)
Very Loose	0 – 4
Loose	4 - 10
Compact	10 - 30
Dense	30 - 50
Very Dense	>50

MAJOR DIVISION			UCS	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
COARSE GRAINED SOILS	GRAVELS (MORE THAN HALF COARSE GRAINS LARGER THAN 4.75 mm)	CLEAN GRAVELS (LITTLE OR NO FINES)	GW	WELL GRADED GRAVELS, LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}} > 4 \quad C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			GP	POORLY GRADED GRAVELS AND GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		GRAVELS WITH FINES	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW 'A' LINE W_p LESS THAN 4
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE 'A' LINE W_p MORE THAN 7
	SANDS (MORE THAN HALF COARSE GRAINS SMALLER THAN 4.75 mm)	CLEAN SANDS (LITTLE R NO FINES)	SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}} > 6 \quad C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			SP	POORLY GRADED SANDS, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		SANDS WITH FINES	SM	SILTY SANDS, SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW 'A' LINE W_p LESS THAN 4
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE 'A' LINE W_p MORE THAN 7
FINE GRAINED SOILS	SILTS (BELOW 'A' LINE NEGLIGIBLE ORGANIC CONTENT)	$W_L < 50$	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (SEE BELOW)	
		$W_L > 50$	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS		
	CLAYS (ABOVE 'A' LINE NEGLIGIBLE ORGANIC CONTENT)	$W_L < 30$	CL	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAYS, LEAN CLAYS	WHENEVER THE NATURE OF THE FINE CONTENT HAS NOT BEEN DETERMINED, IT IS DESIGNATED BY THE LETTER 'F'. E.G. SF IS A MIXTURE OF SAND WITH SILT OR CLAY	
		$30 < W_L < 50$	CI	INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS		
		$W_L > 50$	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS		
	ORGANIC SILTS & CLAYS (BELOW 'A' LINE)	$W_L < 50$	OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY		
		$W_L > 50$	OH	ORGANIC CLAYS OF HIGH PLASTICITY		
HIGHLY ORGANIC SOILS			Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOUR OR ODOUR, AND OFTEN FIBROUS TEXTURE	
BEDROCK			BR	SEE REPORT DESCRIPTION		
FILL			FILL	SEE REPORT DESCRIPTION		



NOTE:

1. BOUNDARY CLASSIFICATION POSSESSING CHARACTERISTICS OF TWO GROUPS ARE GIVEN GROUP SYMBOLS, E.G. GW-GC IS A WELL GRADED GRAVEL MIXTURE WITH CLAY BINDER BETWEEN 5% AND 12%

SOIL COMPONENTS

FRACTION		SIEVE SIZE (mm)		DEFINING RANGES OF PERCENTAGE BY WEIGHT OF MINOR COMPONENTS	
		PASSING	RETAINED	PERCENT	IDENTIFIER
GRAVEL	COARSE	75	19	50 – 35	AND
	FINE	19	4.75		
SAND	COARSE	4.75	2.00	35 – 20	_____Y
	MEDIUM	2.00	0.425		
	FINE	0.425	0.075	20 – 10	SOME
SILT (non-plastic) or CLAY (plastic)		0.075		10 – 1	TRACE

OVERSIZE MATERIALS

ROUNDED OR SUB-ROUNDED COBBLES 75 mm TO 200 mm BOULDERS >200 mm	ANGULAR ROCK FRAGMENTS ROCKS > 0.75 m3 IN VOLUME

MODIFIED UNIFIED SOIL
CLASSIFICATION SYSTEM

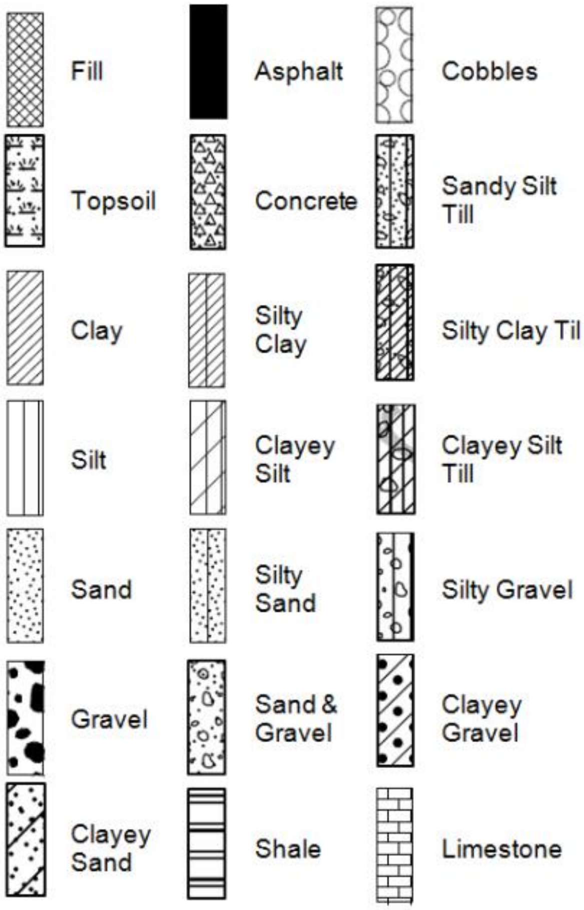
February 2022

1.5 Sample Type, Symbols and Abbreviations

The depth, type, and condition of samples are indicated on the logs by the following symbols or abbreviations:

Sample abbreviations:	Symbols:
GS: Grab Sample	■ Grab ▤ Bulk ⧄ No Recovery ▥ Shelby Tube ⊠ Split Spoon ◫ Core Sample
BK: Bulk Sample	
NR: No Recovery	
ST: Shelby Tube	
SS: Split Spoon	
Core: Core Samples	
FV: Field Vane	
PP: Pocket Penetrometer	
DCPT: Dynamic cone penetration test	

1.6 STRATA/Graphic Plot (Shall be Changed For Different Guidelines)



2. EXPLANATION OF ENVIROMENTAL SAMPLE

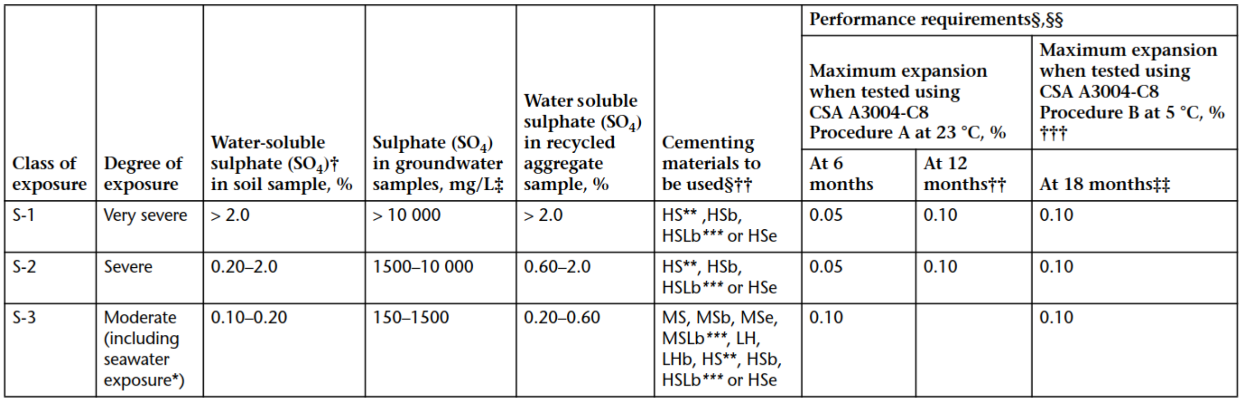
2.1 Contaminant Abbreviations

Contaminant Abbreviations	
BNAE	Base/neutral/acid extractables
BTEX	Benzene, toluene, ethylbenzene, xylenes
OCP	Organochlorine pesticides
MI	Metals and inorganics
PAH	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyls
PHC	CCME petroleum hydrocarbons (fractions 1-4)
VOC	Volatile organic compounds (includes BTEX)
SO_4	Water Soluble Sulphate Content

2.2 Water Soluble Sulphate Concentration

The following table, from CSA Standard A23.1-14, indicates the requirements for concrete subjected to sulphate attack based upon the percentage of water-soluble sulphate as presented on the logs. CSA Standard A23.1-14 should be read in conjunction with the table.

Table 3 Requirements for Concrete Subjected to Sulphate Attack*



Class of exposure	Degree of exposure	Water-soluble sulphate (SO_4)† in soil sample, %	Sulphate (SO_4) in groundwater samples, mg/L‡	Water soluble sulphate (SO_4) in recycled aggregate sample, %	Cementing materials to be used§††	Performance requirements§,§§		
						Maximum expansion when tested using CSA A3004-C8 Procedure A at 23 °C, %		Maximum expansion when tested using CSA A3004-C8 Procedure B at 5 °C, % †††
						At 6 months	At 12 months††	At 18 months‡‡
S-1	Very severe	> 2.0	> 10 000	> 2.0	HS** ,HSb, HSLb*** or HSe	0.05	0.10	0.10
S-2	Severe	0.20–2.0	1500–10 000	0.60–2.0	HS**, HSb, HSLb*** or HSe	0.05	0.10	0.10
S-3	Moderate (including seawater exposure*)	0.10–0.20	150–1500	0.20–0.60	MS, MSb, MSe, MSLb***, LH, LHb, HS**, HSb, HSLb*** or HSe	0.10		0.10

*For sea water exposure, also see Clause 4.1.1.5.

†In accordance with CSA A23.2-3B.

‡In accordance with CSA A23.2-2B.

§Where combinations of supplementary cementing materials and portland or blended hydraulic cements are to be used in the concrete mix design instead of the cementing materials listed, and provided they meet the performance requirements demonstrating equivalent performance against sulphate exposure, they shall be designated as MS equivalent (MSe) or HS equivalent (HSe) in the relevant sulphate exposures (see Clauses 4.1.1.6.2, 4.2.1.1, and 4.2.1.3, and 4.2.1.4).

**Type HS cement shall not be used in reinforced concrete exposed to both chlorides and sulphates, including seawater. See Clause 4.1.1.6.3.

††The requirement for testing at 5 °C does not apply to MS, HS, MSb, HSb, and MSe and HSe combinations made without portland limestone cement.

‡‡ If the increase in expansion between 12 and 18 months exceeds 0.03%, the sulphate expansion at 24 months shall not exceed 0.10% in order for the cement to be deemed to have passed the sulphate resistance requirement.

§§For demonstrating equivalent performance, use the testing frequency in Table 1 of CSA A3004-A1 and see the applicable notes to Table A3 in A3001 with regard to re-establishing compliance if the composition of the cementing materials used to establish compliance changes.

***Where MSLb or HSLb cements are proposed for use, or where MSe or HSe combinations include Portland-limestone cement, they must also contain a minimum of 25% Type F fly ash or 40% slag or 15% metakaolin (meeting Type N pozzolan requirements) or a combination of 5% Type SF silica fume with 25% slag or a combination of 5% Type SF silica fume with 20% Type F fly ash. For some proposed MSLb, HSLb, and MSe or HSe combinations that include Portland-limestone cement, higher SCM replacement levels may be required to meet the A3004-C8 Procedure B expansion limits. Due to the 18-month test period, SCM replacements higher than the identified minimum levels should also be tested. In addition, sulphate resistance testing shall be run on MSLb and HSLb cement and MSe or HSe combinations that include Portland-limestone cement at both 23 °C and 5 °C as specified in the table.

†††If the expansion is greater than 0.05% at 6 months but less than 0.10% at 1 year, the cementing materials combination under test shall be considered to have passed.

2.3 Soil Corrosivity

The following table, from the Handbook of Corrosion Engineering (Roberge, 1999) indicates the corrosivity rating can be obtained from the soil resistivity, presented on the logs.

Table 4 Corrosivity Ratings Based on Soil Resistivity

Soil Resistivity (ohm-cm)	Corrosivity Rating
>20,000	Essentially non-corrosive
10,000 – 20,000	Mildly corrosive
5,000 – 10,000	Moderately corrosive
3,000 – 5,000	Corrosive
1,000 – 3,000	Highly corrosive
<1,000	Extremely corrosive

3. HYDROGEOLOGICAL

The groundwater table is indicated by the equilibrium level of water in a standpipe installed in a test hole or test pit. This level is generally taken at least 24 hours after installation of the standpipe. The groundwater level is subject to seasonal variations and is usually highest in the spring. The symbol on the logs indicating the groundwater level is an inverted solid triangle (▼).

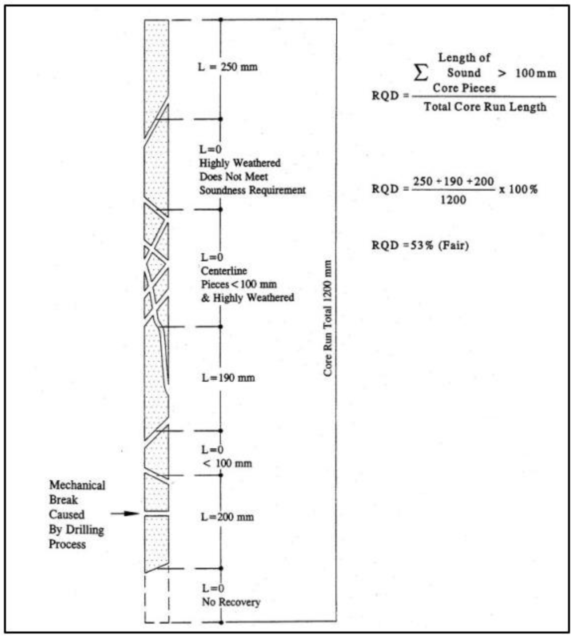
4. EXPLANATION OF ROCK

4.1 General Description and Terms

General Description of Geotechnical Unit including: Quantitative description including rock type (s), percentage of rock types, frequency and sizes of interbeds, colour, texture, weathering, strength and general joint spacing

Total Core Recovery (TCR): Total length of core recovered expressed as percentage of core run length.
Solid Core Recovery (SCR): Total length of solid full diameter core expressed as percentage of core run length.
Rock Quality Designation (RQD): Sum of lengths of solid core pieces longer than 100 mm expressed as percentage of core run length.
Fracture Index (FI): Number of fractures per meter of core.

4.2 Rock Quality Designation (RQD)

RQD(%)	RQD Classification	
0 – 25	Very Poor Quality	
25 – 50	Poor Quality	
50 – 75	Fair Quality	
75 – 90	Good Quality	
90 – 100	Excellent Quality	

4.3 Classification of Strength

Grade	Description	Field identification	Approximate range of Uniaxial compression strength (MPa)
R0	Extremely weak rock	Indented by thumbnail	0.25-1.0
R1	Very weak rock	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife	1.0-5.0

R2	Weak rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer	5.0-25
R3	Medium strong rock	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer	25-50
R4	Strong rock	Specimen requires more than one blow of geological hammer to fracture it	50-100
R5	Very strong rock	Specimen requires many blows of geological hammer to fracture it	100-250
R6	Extremely strong rock	Specimen can only be chipped with geological hammer	>250

4.4 Classification of Weathering

Grade	Description	Field identification
W1	Fresh	No visible sign of rock material weathering; perhaps slight discolouration on major discontinuity surface
W2	Slightly Weathered	Discolouration indicates weathering of rock material and discontinuity surface. All the rock material may be discoloured by weathering and may be somewhat weaker externally than in its fresh condition
W3	Moderately Weathered	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a continuous framework or as corestones.
W4	Highly Weathered	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a continuous framework or as corestones.
W5	Completely Weathered	All rock material is decomposed and/or disintegrated to a soil. The original mass structure is still largely intact. All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but soil has not been significantly transported.
W6	Residual Soil	Residual Soil

4.5 Type of discontinuity

Symbol	Description
F	Fault
J	Joint
Sh	Shear
Fo	Foliation
V	Vein
B	Bedding

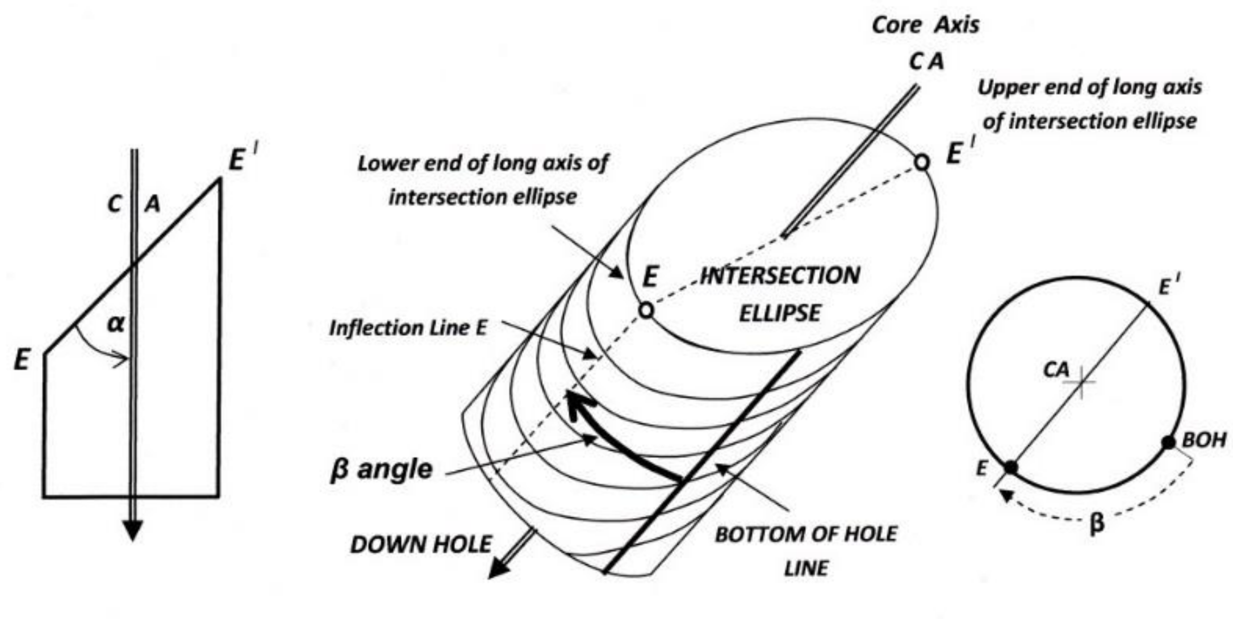
4.6 Spacing of discontinuity

Spacing Classification	Spacing width
Extremely close	<0.02m

Very close	0.02-0.06m
Close	0.06-0.2m
Moderately Close	0.2-0.6m
Wide	0.6-2.0m
Very Wide	2.0-6.0m
Extremely Wide	>6.0m

4.7 Joint Orientation

The orientation of a planar surface intersected by drill core can be defined by two angles called alpha (α) and beta (β). The definition of these angles is shown in the diagram below:



4.8 Inclination

Term	Inclination (degrees from the horizontal)
Sub-horizontal	0-5
Gently Inclined	6-15
Moderately Inclined	16-30
Steeply Inclined	31-60
Very Steeply Inclined	61-80
Sub-vertical	81-90

4.9 Stratification/foliation

Term	Spacing
Very Thickly Bedded	>2m
Thickly Bedded	600mm-2m
Medium Bedded	200mm-600mm
Thinly Bedded	60mm-200mm

Term	Spacing
Very Thinly Bedded	20mm-60mm
Laminated	6mm-20mm
Thinly Laminated	2mm-6mm
Fissile	<2mm

4.10 Grain Size

Term	Size
Very Coarse Grained	>60 mm
Coarse Grained	2mm-60mm
Medium Grained	60 microns – 2mm
Fine Grained	2 microns – 60 microns
Very Fine Grained	<2 microns

4.11 Aperture of open discontinuity

Symbol	Aperture Opening	Description	
VT	<0.1 mm	Very tight	Closed Features
T	0.1-0.25mm	Tight	
PO	0.25-0.5mm	Partly open	
O	0.5-2.5mm	Open	Gapped Features
MW	2.5-10mm	Moderately open	
W	>10mm	Wide	
VW	1-10cm	Very wide	Open Features
EW	10-100cm	Extremely wide	
C	>1m	Cavernous	

4.12 Width of filled discontinuity

Symbol	Width	Description
W	12.5-50mm	Wide
MW	2.5-12.5mm	Moderately Wide
N	1.25-2.5mm	Narrow
VN	<1.25mm	Very Narrow
T	0mm	Tight

4.13 Roughness of discontinuity

Symbol	Description
Slk	Slickenside (surface has smooth, glassy finish with visual evidence of striations)
S	Smooth (surface appears smooth and feels so to the touch)
SR	Slightly rough (asperities on the discontinuity surfaces are distinguishable and can be felt)
R	Rough (some ridges and side-angle steps are evident; asperities are clearly visible, and discontinuity surface feels very abrasive)

Symbol	Description
VR	Very rough (near-vertical steps and ridges occur on the discontinuity surface)

4.14 Shape of discontinuity

Symbol	Description
Pl	Planar
St	Stepped
Un	Undulating
Ir	Irregular

4.15 Filling amount

Symbol	Description
Su	Surface Stain
Sp	Spotty
Pa	Partially Filled
Fi	Filled
No	None

4.16 Filling Type

Symbol	Term	Hard/Soft
Ab	Albite	Hard
Ah	Anhydrite	Hard
Bt	Biotite	Soft
Bn	Bornite	Hard
Ca	Calcite	Hard
Cb	Carbonate	Hard
Ch	Chlorite	Soft
Cpy	Chalcopyrite	Hard
Cy	Clay	Soft
Do	Dolomite	Hard
Ep	Epidote	Hard
Fd	Feldspar	Hard
FeOx	Iron Oxide	Hard
Go	Gouge	Soft
Gr	Graphite	Soft
Gy	Gypsum	Soft
He	Hematite	Hard
Ka	Kaolinite	Soft
Kf	K-feldspar	Hard

Symbol	Term	Hard/Soft
Lm	Limonite/FeOx	Soft
Ms	Muscovite	Soft
Mt	Magnetite	Hard
Py	Pyrite	Hard
Qz	Quartz	Hard
Rb	Rubble	Hard
Sa	Sand	Hard
Se	Sericite/Illite	Soft
Si	Silt	Hard
Sm	Smectite	Soft
Su	Sulphide	Hard
Ta	Talc	Soft
UH	Unknown Hard	Hard
US	Unknown Soft	Soft
OTH - see comments		

Appendix D

Laboratory Results

AECOM Canada Ltd.
Winnipeg Geotechnical Laboratory
99 Commerce Drive
Winnipeg, Manitoba
R3P 0Y7
Phone: 204 477 5381 Fax: 204 284 2040

Project Name:	Brady Landfill	Supplier:	AECOM
Project Number:	60733855	Specification:	N/A
Client:	City of Winnipeg	Field Technician:	COlivar
Sample Location:	Brady Landfill	Sample Date:	July 8, 2024
Sample Depth:	Varies	Lab Technician:	JEnriquez
Sample Number:	Varies	Date Tested:	July 22, 2024

Moisture Content (ASTM D2216-10)

Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

Location	Sample	Depth (m)	**Moisture Content (%)**
BH24-01	G1	0.15 - 0.30 m	**30.5%**
	G2	0.61 - 0.76 m	**35.0%**
	G3	1.37 - 1.52 m	**35.6%**
	T4	0.00 - 0.00 m	**-**
	G5	2.90 - 3.05 m	**60.3%**
	G6	4.42 - 4.57 m	**50.0%**
	T7	0.00 - 0.00 m	**-**
	G8	5.94 - 6.10 m	**53.3%**
	G9	7.47 - 7.62 m	**52.9%**
	T10	0.00 - 0.00 m	**-**
	G11	8.99 - 9.14 m	**55.9%**
	G12	10.52 - 10.67 m	**53.8%**
	T13	0.00 - 0.00 m	**-**
	G14	12.04 - 12.19 m	**59.3%**
	G15	13.56 - 13.72 m	**54.4%**
	G16	15.09 - 15.24 m	**29.2%**
BH24-02	G1	0.15 - 0.30 m	**33.7%**
	G2	0.61 - 0.76 m	**29.6%**
	G3	1.37 - 1.52 m	**36.1%**
	G4	2.90 - 3.05 m	**50.4%**
	T5	0.00 - 0.00 m	**-**
	G6	4.42 - 4.57 m	**53.2%**
	G7	5.94 - 6.10 m	**51.1%**
	T8	0.00 - 0.00 m	**-**
	G9	7.47 - 7.62 m	**54.0%**
	G10	8.99 - 9.14 m	**49.6%**
	T11	0.00 - 0.00 m	**-**
	G12	10.52 - 10.67 m	**41.4%**
	G13	12.04 - 12.19 m	**24.2%**
	T14	0.00 - 0.00 m	**-**
	G15	13.56 - 13.72 m	**24.0%**
	G16	15.09 - 15.24 m	**23.9%**
BH24-03	G1	0.15 - 0.30 m	**29.2%**
	G2	0.61 - 0.76 m	**40.4%**
	G3	1.37 - 1.52 m	**41.9%**
	T4	0.00 - 0.61 m	**-**

Location	Sample	Depth (m)	**Moisture Content (%)**
	G5	2.90 - 3.05 m	**41.4%**
	G6	4.42 - 4.57 m	**56.5%**
	T7	0.00 - 0.61 m	**-**
	G8	5.94 - 6.10 m	**49.7%**
	G9	7.47 - 7.62 m	**51.8%**
	T10	0.00 - 0.61 m	**-**
	G11	8.99 - 9.14 m	**49.7%**
	G12	10.52 - 10.67 m	**41.2%**
	T13	0.00 - 0.61 m	**-**
	G14	12.04 - 12.19 m	**50.9%**
	G15	13.56 - 13.72 m	**35.0%**
	G16	15.09 - 15.24 m	**6.7%**
BH24-04	G1	0.15 - 0.30 m	**36.8%**
	G2	0.61 - 0.76 m	**29.9%**
	G3	1.37 - 1.52 m	**28.5%**
	G4	2.90 - 3.05 m	**47.7%**
	G5	4.42 - 4.57 m	**56.7%**
	G6	5.94 - 6.10 m	**43.9%**
	G7	7.47 - 7.62 m	**50.0%**
BH24-06	G1	0.00 - 0.15 m	**59.3%**
	G2	0.61 - 0.76 m	**38.1%**
	G3	1.37 - 1.52 m	**31.8%**
	G4	2.90 - 3.05 m	**50.9%**
	G5	4.42 - 4.57 m	**56.1%**
	G6	5.94 - 6.10 m	**56.7%**
	G7	7.47 - 7.62 m	**48.4%**
	G8	8.99 - 9.14 m	**52.1%**
	G9	10.52 - 10.67 m	**58.6%**
	G10	12.04 - 12.19 m	**67.6%**
	G11	13.56 - 13.72 m	**63.4%**
	G12	15.09 - 15.24 m	**17.3%**
	G13	15.24 - 15.39 m	**11.1%**
BH24-08	G1	0.15 - 0.30 m	**28.5%**
	G2	0.61 - 0.76 m	**26.5%**
	G3	1.37 - 1.52 m	**25.7%**

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Project Name: Brady Landfill
Project Number: 60733855
Client: City of Winnipeg
Sample Location: Brady Landfill
Sample Depth: Varies
Sample Number: Varies

Supplier: AECOM
Specification: N/A
Field Technician: COlivar
Sample Date: July 8, 2024
Lab Technician: JEnriquez
Date Tested: July 22, 2024

Moisture Content (ASTM D2216-10)

Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

Location	Sample	Depth (m)	**Moisture Content (%)**
	G4	2.90 - 3.05 m	**42.8%**
	T5	0.00 - 0.00 m	**-**
	G6	4.42 - 4.57 m	**54.8%**
	G7	5.94 - 6.10 m	**47.6%**
	T8	0.00 - 0.00 m	**-**
	G9	7.47 - 7.62 m	**49.7%**
	G10	8.99 - 9.14 m	**46.5%**
	T11	0.00 - 0.00 m	**-**
	G12	10.52 - 10.67 m	**50.6%**
	G13	12.04 - 12.19 m	**60.2%**
	T14	0.00 - 0.00 m	**-**
	G15	13.56 - 13.72 m	**61.7%**
	G16	15.09 - 15.24 m	**7.5%**
BH24-09	G1	0.15 - 0.30 m	**26.7%**
	G2	0.61 - 0.76 m	**21.1%**
	G3	1.37 - 1.52 m	**22.2%**
	T4	0.00 - 0.00 m	**-**
	G5	2.90 - 3.05 m	**51.8%**
	G6	4.42 - 4.57 m	**61.4%**
	T7	0.00 - 0.00 m	**-**
	G8	5.94 - 6.10 m	**62.7%**
	G9	7.47 - 7.62 m	**51.3%**
	T10	0.00 - 0.00 m	**-**
	G11	8.99 - 9.14 m	**57.4%**
	G12	10.52 - 10.67 m	**58.4%**
	G13	12.04 - 12.19 m	**59.3%**
	G14	13.56 - 13.72 m	**58.5%**
	G15	15.09 - 15.24 m	**13.7%**
BH24-10	G1	2.74 - 0.15 m	**32.3%**
	G2	0.61 - 0.76 m	**27.2%**
	G3	1.37 - 1.52 m	**28.6%**
	G4	2.90 - 3.05 m	**52.5%**
	G5	4.42 - 4.57 m	**50.6%**
	G6	5.94 - 6.10 m	**61.0%**
	G7	7.47 - 7.62 m	**54.5%**
	G8	8.99 - 9.14 m	**54.8%**

Location	Sample	Depth (m)	**Moisture Content (%)**
	G9	10.52 - 10.67 m	**59.5%**
	G10	12.04 - 12.19 m	**55.7%**
	G11	13.56 - 13.72 m	**56.6%**
	G12	15.09 - 15.24 m	**11.8%**
	G13	16.61 - 16.76 m	**11.5%**
BH24-11	G1	0.00 - 0.15 m	**25.9%**
	G2	0.61 - 0.76 m	**20.5%**
	G3	1.37 - 1.52 m	**27.1%**
	G4	2.90 - 3.05 m	**51.6%**
	G5	4.42 - 4.57 m	**56.1%**
	G6	5.94 - 6.10 m	**51.4%**
	G7	7.47 - 7.62 m	**53.9%**
	G8	8.99 - 9.14 m	**53.2%**
BH24-12	G1	0.15 - 0.30 m	**35.4%**
	G2	0.61 - 0.76 m	**31.2%**
	G3	1.37 - 1.52 m	**32.5%**
	G4	2.90 - 3.05 m	**50.7%**
	G5	4.42 - 4.57 m	**52.2%**
	G6	5.94 - 6.10 m	**48.5%**
	G7	7.47 - 7.62 m	**45.8%**
BH24-13	G1	0.15 - 0.30 m	**32.3%**
	G2	0.61 - 0.76 m	**22.5%**
	G3	1.37 - 1.52 m	**25.4%**
	G4	2.90 - 3.05 m	**40.3%**
	G5	4.42 - 4.57 m	**61.7%**
	G6	5.94 - 6.10 m	**58.2%**
	G7	7.47 - 7.62 m	**50.6%**
BH24-14	G1	0.15 - 0.30 m	**13.8%**
	G2	0.61 - 0.76 m	**22.4%**
	G3	1.37 - 1.52 m	**23.7%**
	G4	2.90 - 3.05 m	**41.4%**
	G5	4.42 - 4.57 m	**55.5%**
	G6	5.94 - 6.10 m	**42.9%**
	G7	7.47 - 7.62 m	**49.8%**

Project Name:	Brady Landfill	Supplier:	AECOM
Project Number:	60733855	Specification:	N/A
Client:	City of Winnipeg	Field Technician:	COlivar
Sample Location:	Brady Landfill	Sample Date:	45481
Sample Depth:	Varies	Lab Technician:	JEnriquez
Sample Number:	Varies	Date Tested:	July 22, 2024

Moisture Content (ASTM D2216-10)

Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

Location	Sample	Depth (m)	**Moisture Content (%)**	Location	Sample	Depth (m)	**Moisture Content (%)**
	G8	8.99 - 9.14 m	**56.3%**				
	G9	10.52 - 10.67 m	**65.1%**				
	G10	12.04 - 12.19 m	**52.9%**				
	G11	13.56 - 13.72 m	**30.2%**				
	S12	13.72 - 14.17 m	**35.5%**				
	G13	15.09 - 15.24 m	**14.5%**				
BH24-15	G1	0.00 - 0.15 m	**31.5%**				
	G2	0.61 - 0.76 m	**32.6%**				
	G3	1.37 - 1.52 m	**36.2%**				
	G4	2.90 - 3.05 m	**56.3%**				
	G5	4.42 - 4.57 m	**56.7%**				
	G6	5.94 - 6.10 m	**51.9%**				

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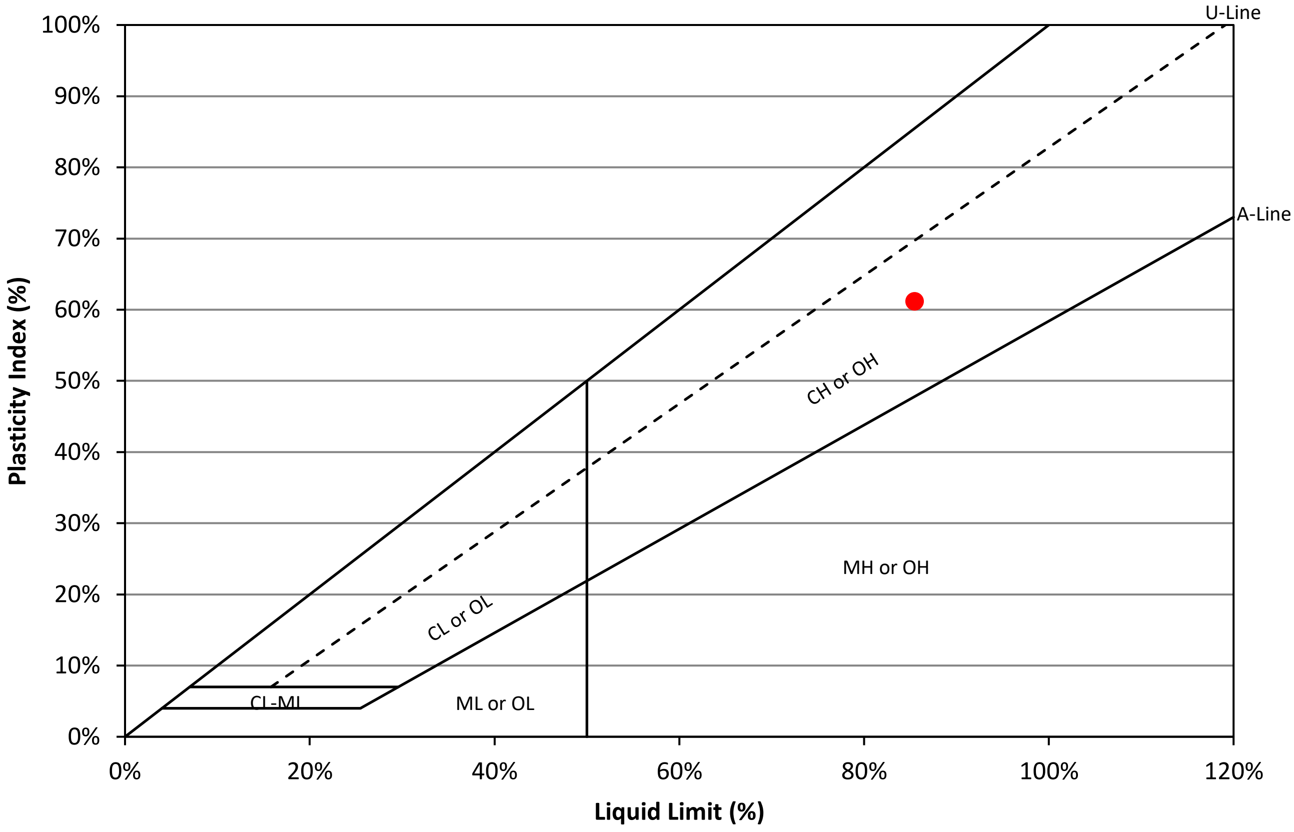
Project Name:	Brady Landfill		
Project Number:	60733855	Supplier/Location:	Winnipeg, Manitoba
Client:	City of Winnipeg	Field Technician:	COlivar
Sample Location:	BH24-01	Sample Date:	July 24, 2024
Sample Depth:	4.57 - 5.18 m	Lab Technician:	JEnriquez
Sample Number:	T7	Date Tested:	August 19, 2024

Atterberg Limits (ASTM D4318)

Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

Liquid Limit			
Blows	29	24	16
Wet Sample (g)	11.4	11.6	12.1
Dry Sample (g)	6.2	6.2	6.4
Water Content (%)	84.3%	86.3%	87.7%

Plastic Limit		
Trial	1	2
Wet Sample (g)	6.6	6.5
Dry Sample (g)	5.3	5.2
Water Content (%)	24.4%	24.3%



Liquid Limit:	**85**	**Plastic Limit:**	**24**	**Plasticity Index:**	**61**

Reviewed by: Lee Boughton
Laboratory Manager

Approved by: German Leal, M.Eng., P.Eng.
Geotechnical Discipline Lead

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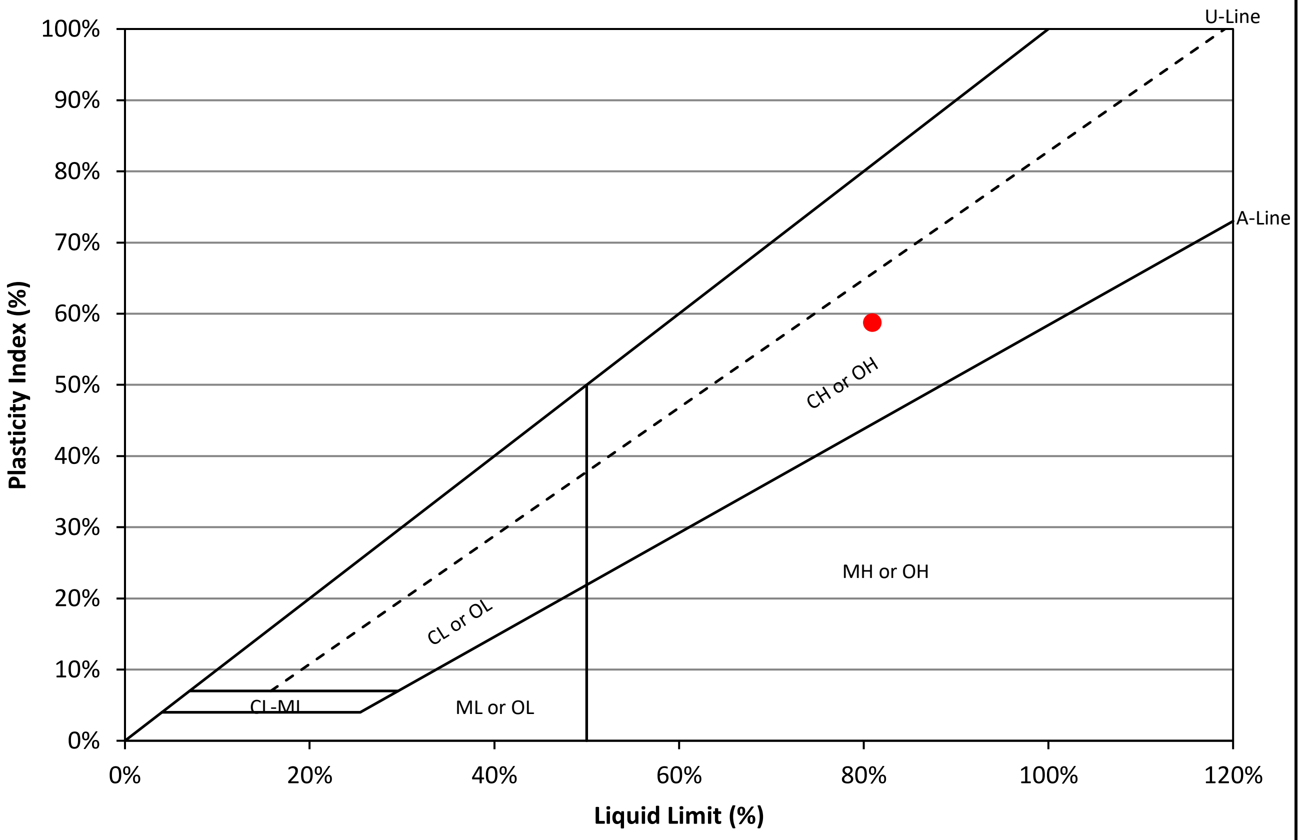
Project Name:	Brady Landfill		
Project Number:	60733855	Supplier/Location:	Winnipeg, Manitoba
Client:	City of Winnipeg	Field Technician:	COlivar
Sample Location:	BH24-01	Sample Date:	July 24, 2024
Sample Depth:	10.67 - 11.28 m	Lab Technician:	JEnriquez
Sample Number:	T13	Date Tested:	August 19, 2024

Atterberg Limits (ASTM D4318)

Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

Liquid Limit			
Blows	26	21	19
Wet Sample (g)	13.9	11.9	14.2
Dry Sample (g)	7.7	6.5	7.6
Water Content (%)	80.9%	82.0%	87.0%

Plastic Limit		
Trial	1	2
Wet Sample (g)	6.0	6.9
Dry Sample (g)	5.0	5.6
Water Content (%)	21.6%	22.8%



Liquid Limit:	**81**	**Plastic Limit:**	**22**	**Plasticity Index:**	**59**

Reviewed by: Lee Boughton
Laboratory Manager

Approved by: German Leal, M.Eng., P.Eng.
Geotechnical Discipline Lead

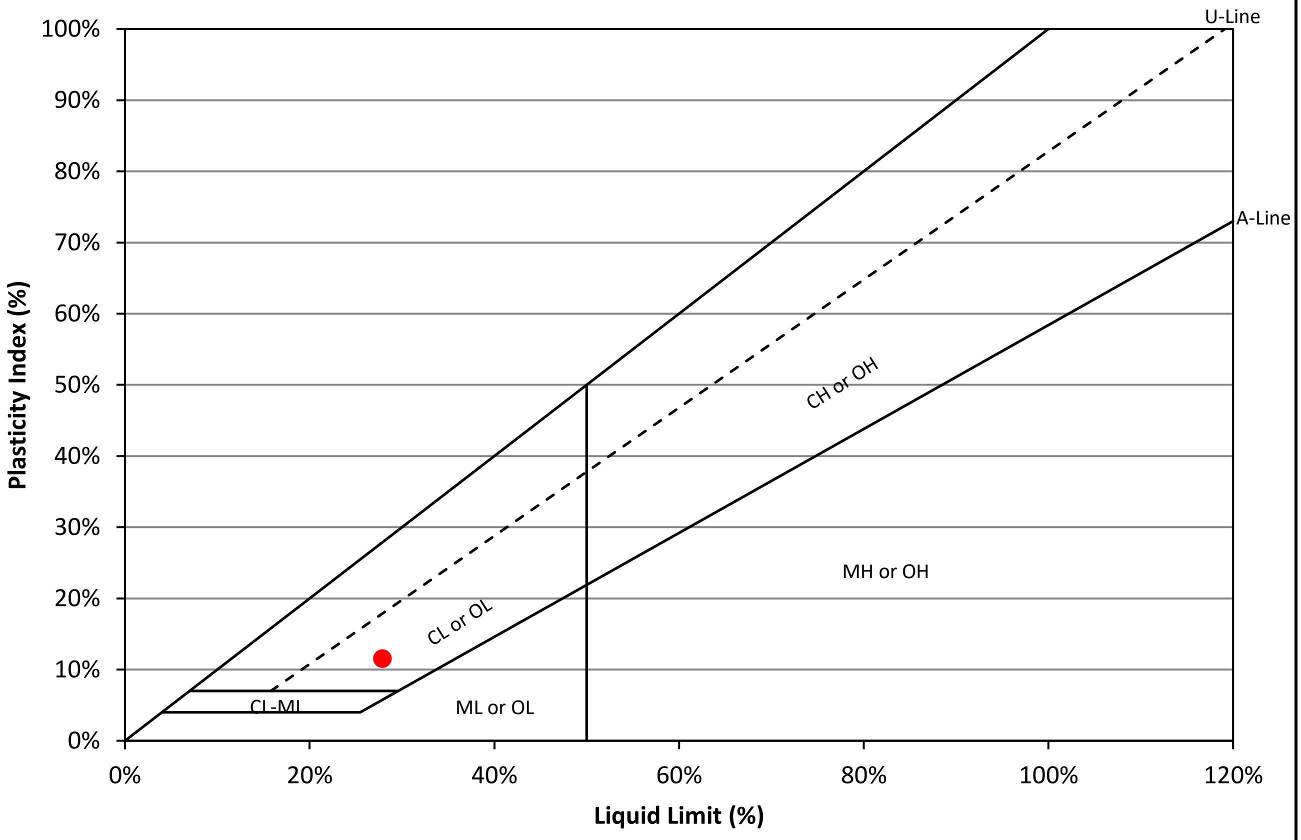
Project Name:	Brady Landfill		
Project Number:	60733855	Supplier/Location:	Winnipeg, Manitoba
Client:	City of Winnipeg	Field Technician:	COlivar
Sample Location:	BH24-08C	Sample Date:	July 24, 2024
Sample Depth:	1.37 - 1.52 m	Lab Technician:	JEnriquez
Sample Number:	G3	Date Tested:	August 19, 2024

Atterberg Limits (ASTM D4318)

Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

Liquid Limit			
Blows	28	22	18
Wet Sample (g)	14.7	12.9	14.4
Dry Sample (g)	11.5	10.1	11.1
Water Content (%)	27.4%	28.4%	29.1%

Plastic Limit		
Trial	1	2
Wet Sample (g)	7.5	7.1
Dry Sample (g)	6.5	6.1
Water Content (%)	16.5%	16.2%



Liquid Limit:	**28**	**Plastic Limit:**	**16**	**Plasticity Index:**	**12**

Reviewed by: Lee Boughton
Laboratory Manager

Approved by: German Leal, M.Eng., P.Eng.
Geotechnical Discipline Lead

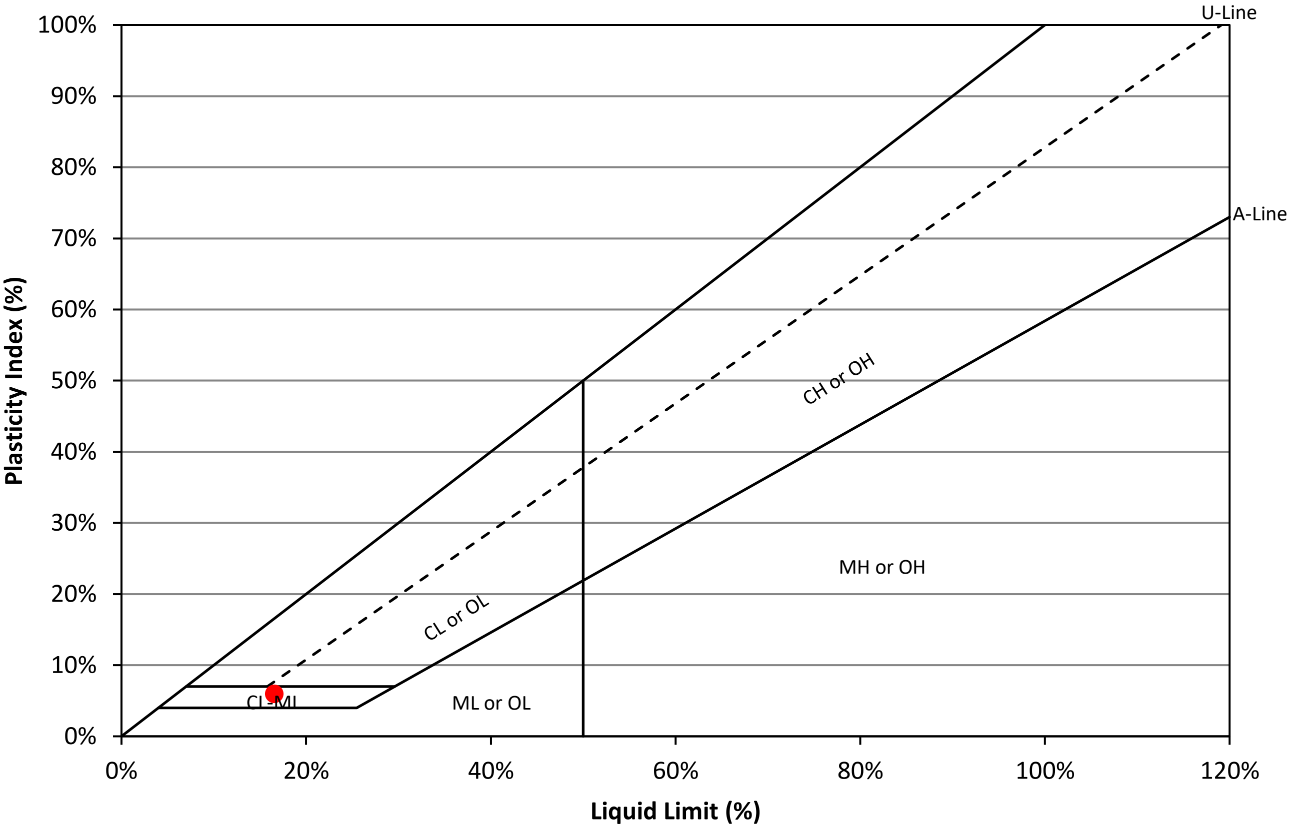
Project Name:	Brady Landfill		
Project Number:	60733855	Supplier/Location:	Winnipeg, Manitoba
Client:	City of Winnipeg	Field Technician:	COlivar
Sample Location:	BH24-10	Sample Date:	July 24, 2024
Sample Depth:	16.61 - 16.76 m	Lab Technician:	JEnriquez
Sample Number:	G13	Date Tested:	August 19, 2024

Atterberg Limits (ASTM D4318)

Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

Liquid Limit			
Blows	31	25	21
Wet Sample (g)	14.5	13.2	12.5
Dry Sample (g)	12.6	11.4	10.6
Water Content (%)	15.3%	16.2%	17.8%

Plastic Limit		
Trial	1	2
Wet Sample (g)	6.9	6.5
Dry Sample (g)	6.2	5.9
Water Content (%)	10.9%	10.3%



Liquid Limit:	**17**	**Plastic Limit:**	**11**	**Plasticity Index:**	**8**

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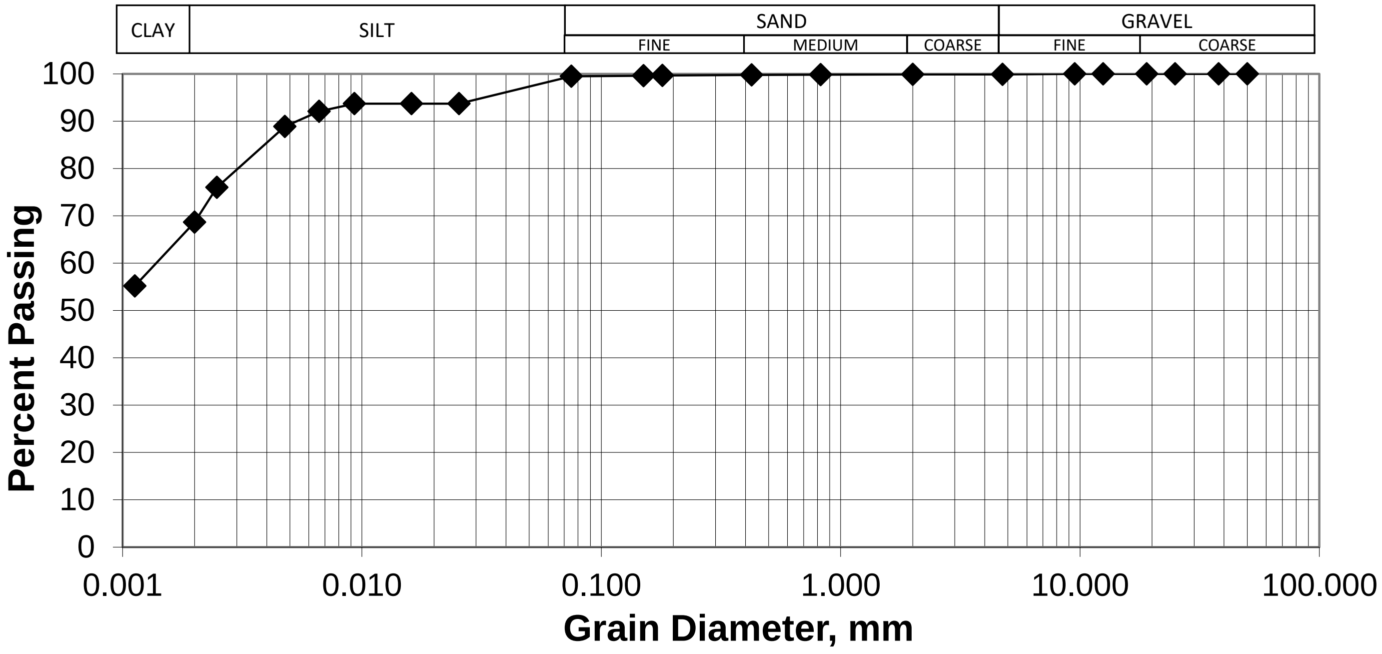
Project Name:	Brady Landfill		
Project Number:	60733855	Supplier/Location:	Brady Landfill
Client:	City of Winnipeg	Field Technician:	COlivar
Sample Location:	BH24-01	Sample Date:	22-Jul-24
Sample Depth :	4.57 - 5.18 m	Lab Technician:	JEnriquez
Sample Number:	T7	Date Tested:	14-Aug-24

Hydrometer (AASHTO T88)

Standard Test Methods for Particle Size Analysis of Soils

GRAVEL SIZES		SAND SIZES		FINES	
Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing
50.0	100.0	4.75	99.9	0.0750	99.5
38.0	100.0	2.00	99.9	0.0255	93.8
25.0	100.0	0.825	99.8	0.0161	93.8
19.0	100.0	0.425	99.8	0.0093	93.8
12.5	100.0	0.18	99.7	0.0066	92.2
9.5	100.0	0.15	99.6	0.0048	89.0
4.75	99.9	0.075	99.5	0.0025	76.1
				0.0020	68.7
				0.0011	55.2

GRAIN SIZE DISTRIBUTION CURVE



Gravel	**0.1%**	**Silt**	**30.8%**
Sand	**0.4%**	**Clay**	**68.7%**

Reviewed by: Lee Boughton
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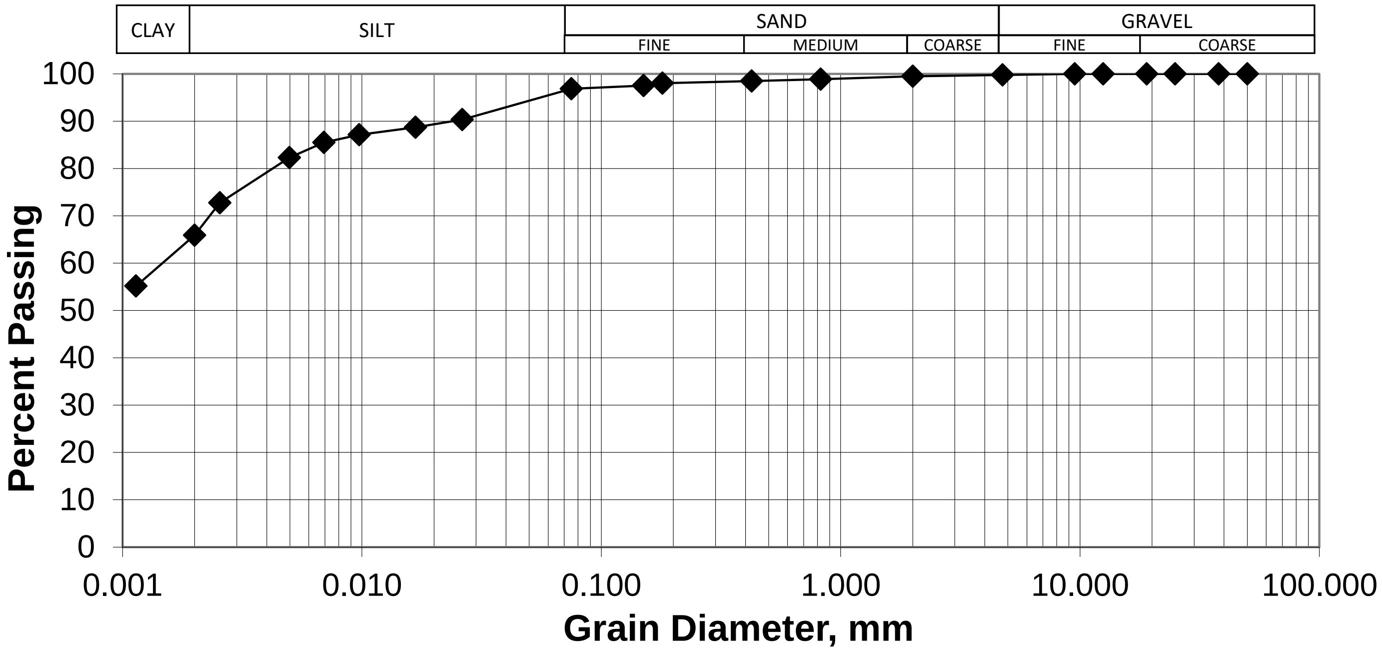
Project Name:	Brady Landfill		
Project Number:	60733855	Supplier/Location:	Brady Landfill
Client:	City of Winnipeg	Field Technician:	COlivar
Sample Location:	BH24-01	Sample Date:	22-Jul-24
Sample Depth :	10.67 - 11.28 m	Lab Technician:	JEnriquez
Sample Number:	T13	Date Tested:	14-Aug-24

Hydrometer (AASHTO T88)

Standard Test Methods for Particle Size Analysis of Soils

GRAVEL SIZES		SAND SIZES		FINES	
Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing
50.0	100.0	4.75	99.8	0.0750	96.9
38.0	100.0	2.00	99.5	0.0262	90.8
25.0	100.0	0.825	98.9	0.0167	89.2
19.0	100.0	0.425	98.5	0.0097	87.6
12.5	100.0	0.18	98.0	0.0069	86.0
9.5	100.0	0.15	97.5	0.0050	82.8
4.75	99.8	0.075	96.9	0.0025	73.1
				0.0020	66.3
				0.0011	55.5

GRAIN SIZE DISTRIBUTION CURVE



Gravel	**0.2%**	**Silt**	**30.6%**
Sand	**2.9%**	**Clay**	**66.3%**

Reviewed by: Lee Boughton
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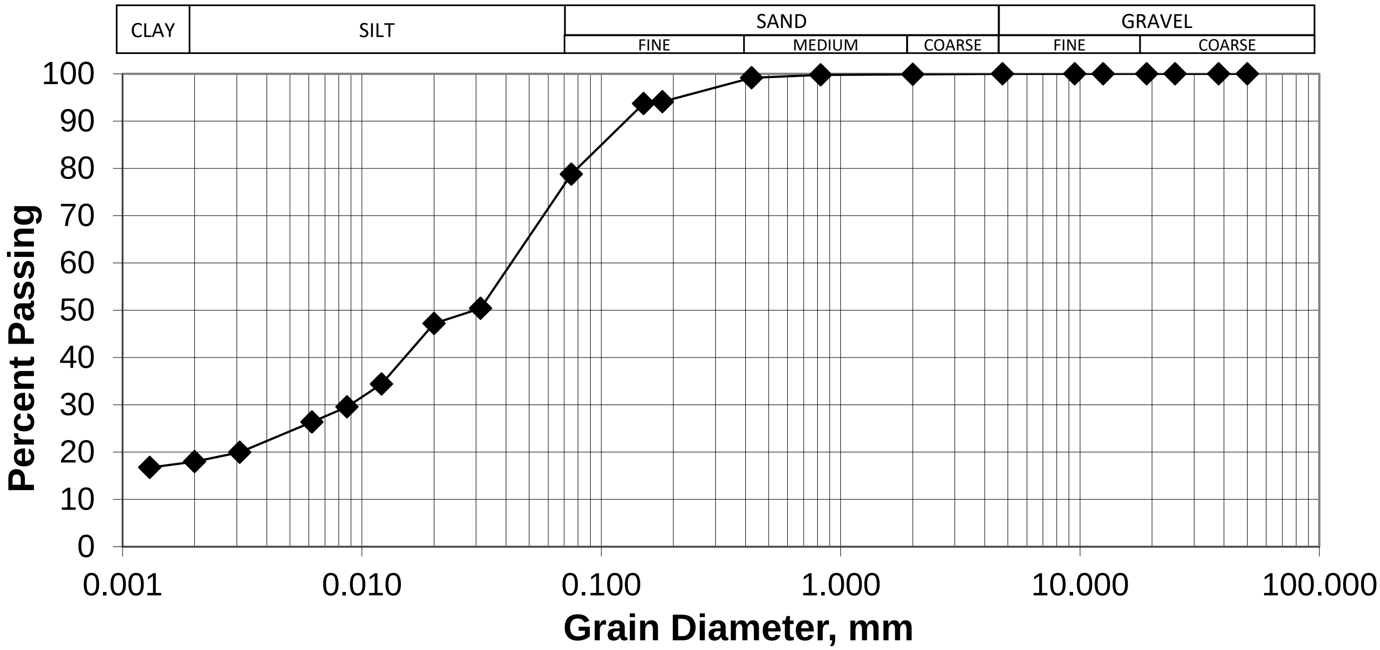
Project Name:	Brady Landfill		
Project Number:	60733855	Supplier/Location:	Brady Landfill
Client:	City of Winnipeg	Field Technician:	COlivar
Sample Location:	BH24-08C	Sample Date:	22-Jul-24
Sample Depth :	1.37 - 1.52 m	Lab Technician:	JEnriquez
Sample Number:	G3	Date Tested:	14-Aug-24

Hydrometer (AASHTO T88)

Standard Test Methods for Particle Size Analysis of Soils

GRAVEL SIZES		SAND SIZES		FINES	
Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing
50.0	100.0	4.75	100.0	0.0750	78.8
38.0	100.0	2.00	99.9	0.0313	50.5
25.0	100.0	0.825	99.8	0.0200	47.3
19.0	100.0	0.425	99.2	0.0121	34.4
12.5	100.0	0.18	94.1	0.0087	29.6
9.5	100.0	0.15	93.7	0.0062	26.4
4.75	100.0	0.075	78.8	0.0031	20.0
				0.0020	18.0
				0.0013	16.8

GRAIN SIZE DISTRIBUTION CURVE



Gravel	**0.0%**	**Silt**	**60.7%**
Sand	**21.2%**	**Clay**	**18.0%**

Reviewed by: Lee Boughton
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Approved by: German Leal, M.Eng., P.Eng.
Geotechnical Discipline Lead

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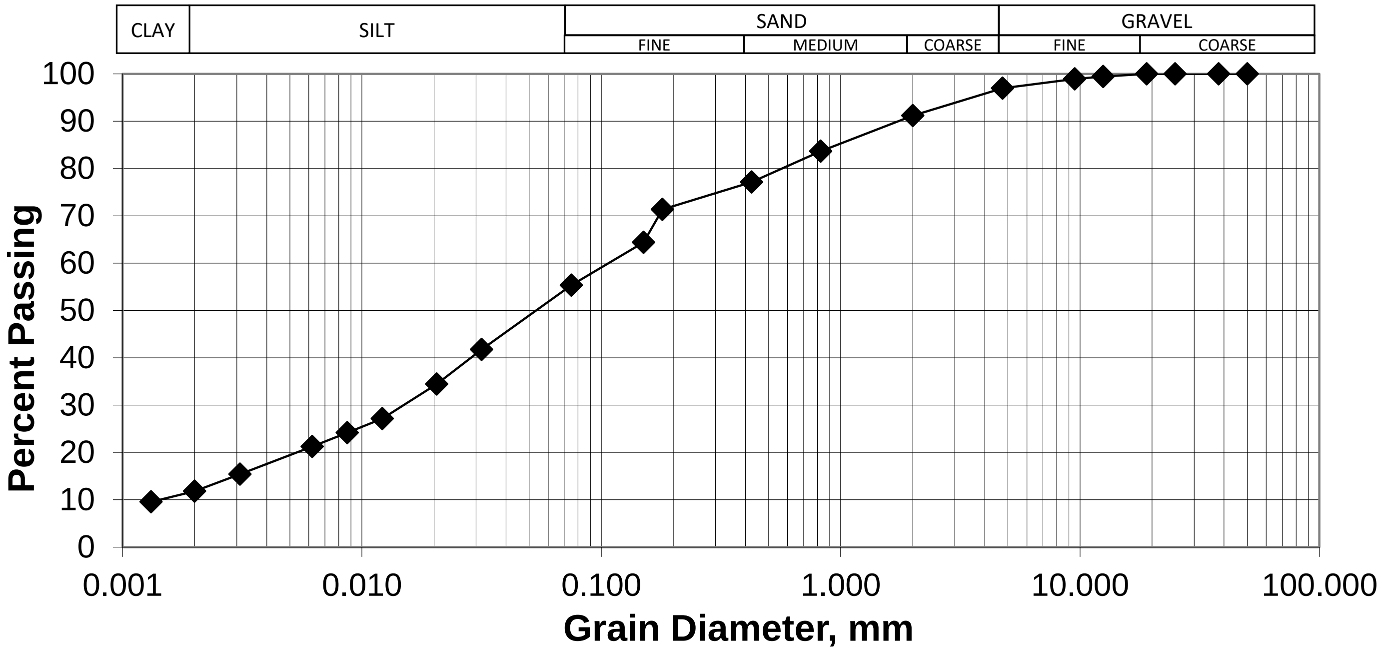
Project Name:	Brady Landfill		
Project Number:	60733855	Supplier/Location:	Brady Landfill
Client:	City of Winnipeg	Field Technician:	COlivar
Sample Location:	BH24-10	Sample Date:	22-Jul-24
Sample Depth :	16.61 - 16.76 m	Lab Technician:	JEnriquez
Sample Number:	G13	Date Tested:	14-Aug-24

Hydrometer (AASHTO T88)

Standard Test Methods for Particle Size Analysis of Soils

GRAVEL SIZES		SAND SIZES		FINES	
Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing
50.0	100.0	4.75	97.0	0.0750	55.3
38.0	100.0	2.00	91.2	0.0316	45.8
25.0	100.0	0.825	83.6	0.0205	37.8
19.0	100.0	0.425	77.1	0.0122	29.8
12.5	99.5	0.18	71.4	0.0087	26.5
9.5	98.9	0.15	64.4	0.0062	23.3
4.75	97.0	0.075	55.3	0.0031	16.9
				0.0020	13.0
				0.0013	10.5

GRAIN SIZE DISTRIBUTION CURVE



Gravel	**3.0%**	**Silt**	**42.4%**
Sand	**41.6%**	**Clay**	**13.0%**

Reviewed by: Lee Boughton
Laboratory Manager

Approved by: German Leal, M.Eng., P.Eng.
Geotechnical Discipline Lead

AECOM

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Phone: 204 477 5381

Project Name:	Brady Landfill Area B		
Project Number:	60733855	Supplier/Location:	N/A
Client:	City of Winnipeg	Field Technician:	Camilo Olivar
Sample Location:	BH24-09	Sample Date:	July 24, 2024
Sample Depth :	5	Lab Technician:	LB-LC
Sample Number:	T4	Date Range Tested:	August 15, 2024 September 2, 2024

Consolidation Test Report (ASTM D2435) - Method "A"

Standard Test Methods for One-dimensional Consolidation Properties of Soil Using Incremental Loading

Sample Information and Test Parameters

Equipment

Oedometer No:	2
Lever Multiplier:	11
Avg. Ring Diam. [mm]:	70
Ring Height [mm]:	19.1
Ring Weight [g]:	79.899
Ring In. Area [mm2]:	3848
Ring In. Vol [mm3]:	73505
Apparatus Deformation Corr [mm]:	0
Deform Ind Conv Factor (mm/0.0001"):	0.0025
Density of Test Water [g/cm3]:	0.9980

Soil Parameters/Characteristics

Specific Gravity:	2.70
Soil Description:	Clay
Dry Mass of Solids (Md) [g]:	109.30
Vol of Solids (Vs) [cm3]:	40.56
Ht of Solids (Hs) [mm]:	10.54

Specimen	Initial	Final
Weight of Ring + Soil [g]:	221.531	221
Weight of Soil [g]:	141.632	141.101
Void Ratio (e) []:	0.8121	0.6983
Deg of Saturation (S) [%]:	98.3%	96.7%
Height of Specim. [mm]:	19.1	17.9
Vol. of Specimen [mm3]:	73505	68887
Bulk Density [g/cm3]:	1.927	2.048
Dry Density [g/cm3]:	1.436	1.587
Bulk Unit Wt [kN/m3]:	18.90	20.09
Dry Unit Wt [kN/m3]:	14.08	15.56

Moisture Content	Initial	Final
Tare Number:	t16	**b29**
Weight of Tare [g]:	8.4	88.499
Wt of Wet Soil + Tare [g]:	246.7	229.6
Wt of Dry Soil + Tare [g]:	186.0	197.8
% Moisture:	34.2%	29.1%

Consolidation Test Summary

Stage No.	Load (kPa)	Deformation, h (mm)	Strain, ε (kPa)	cv (log-method)	cv (sqrt-method)	Void Ratio	Type	
0								
1	10	0.1321	-1.50%			0.8247	Load	
2	19.5	0.0152	-0.61%	0.0154	0.3184	0.8136	Load	
3	40.5	-0.1346	-0.78%	0.0114	0.3675	0.7994	Load	
4	80	-0.4597	-1.71%	0.0486	0.5388	0.7685	Load	
5	160	-0.9119	-2.43%	0.0374	0.0656	0.7256	Load	
6	320	-1.4783	-3.11%	0.0416	0.1400	0.6719	Load	
7	630	-2.1336	-3.72%	0.0368	0.0881	0.6097	Load	
8	1270	-2.8296	-4.10%	0.0389	0.0548	0.5437	Load	
9	320	-2.3901	2.70%			0.5854	Unload	
10	80	-1.7856	3.62%			0.6427	Unload	
11	19.5	-1.2002	3.38%			0.6983	Unload	

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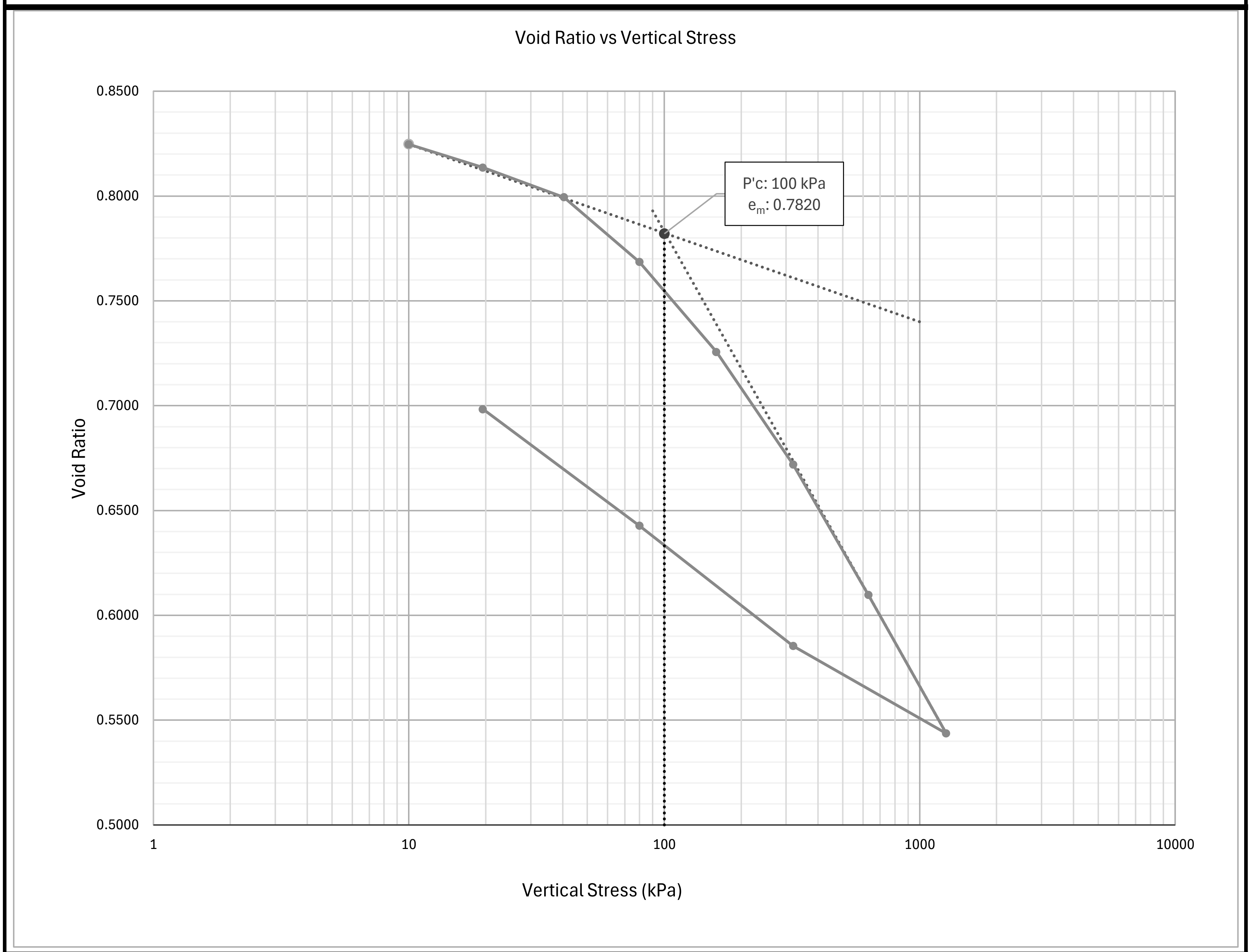
Phone: 204 477 5381



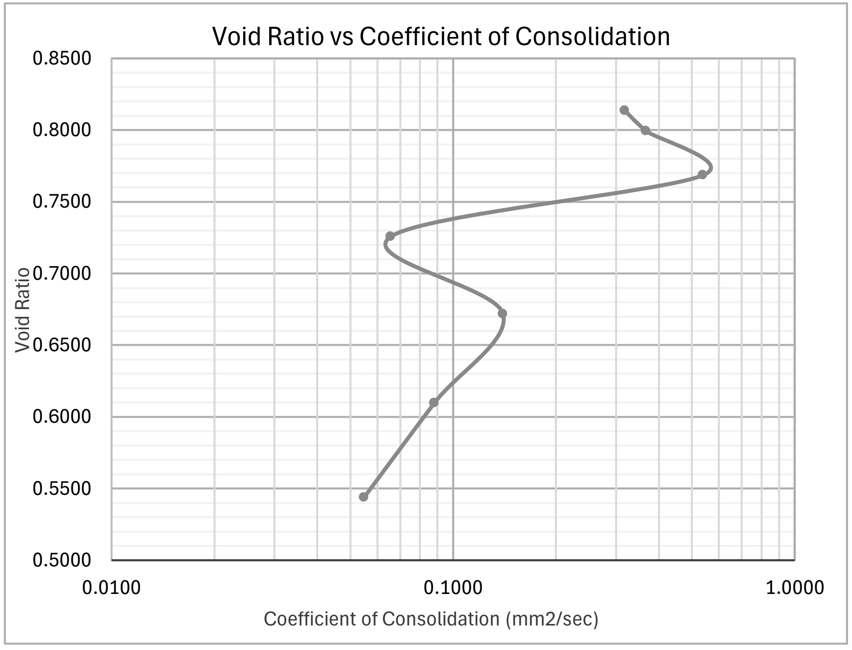
Consolidation Parameters

Preconsolidation Pressure, P'$_c$ [kPa]:	100
Compression Index, C$_c$:	0.214
Void Ratio @ P'$_c$, e$_m$:	0.7820

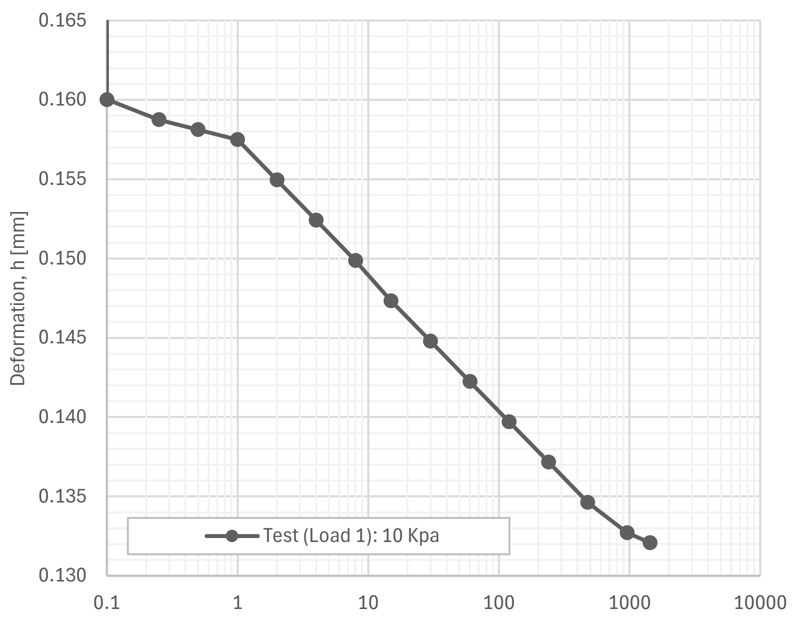
Recompression index, C$_r$:	0.085
Overconsolidation Ratio, OCR:	3.474

Notes

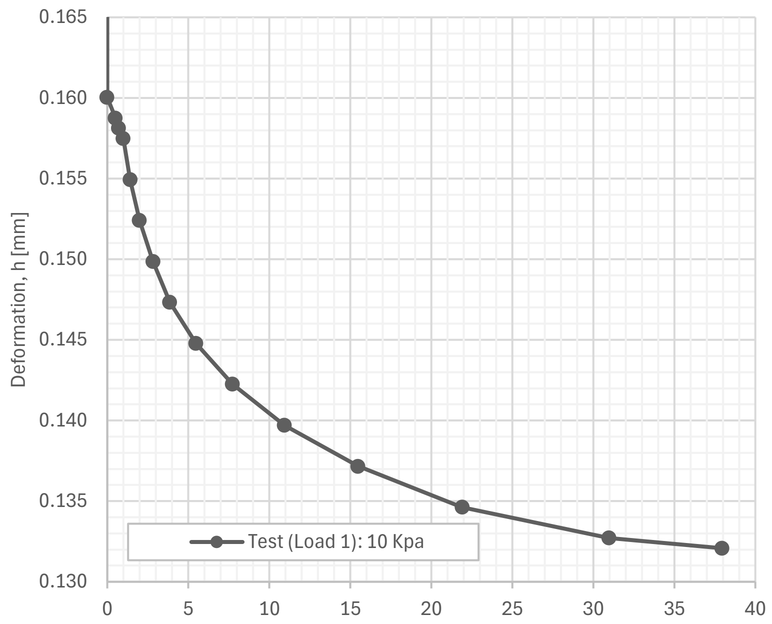
Preconsolidation pressure P'$_c$ estimated using Pacheco-Silva' Method.



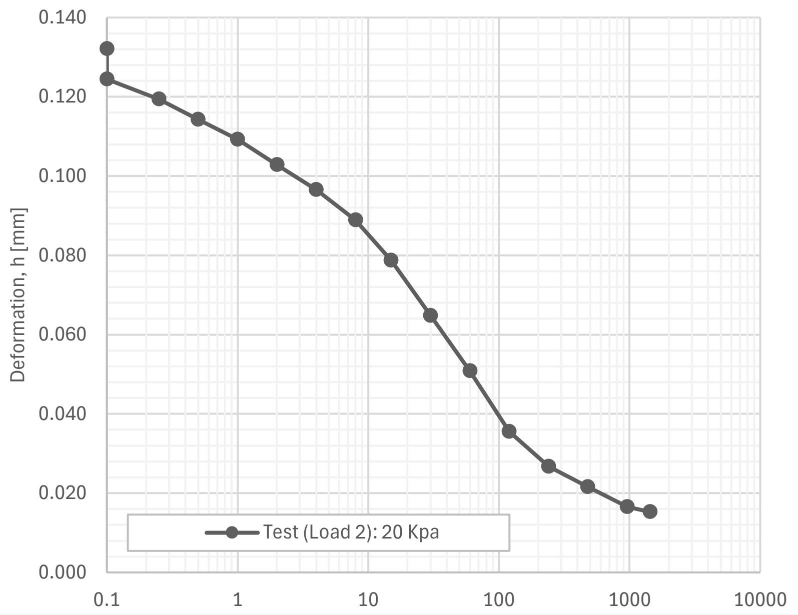
Time-Deformation Curve Using Log Time



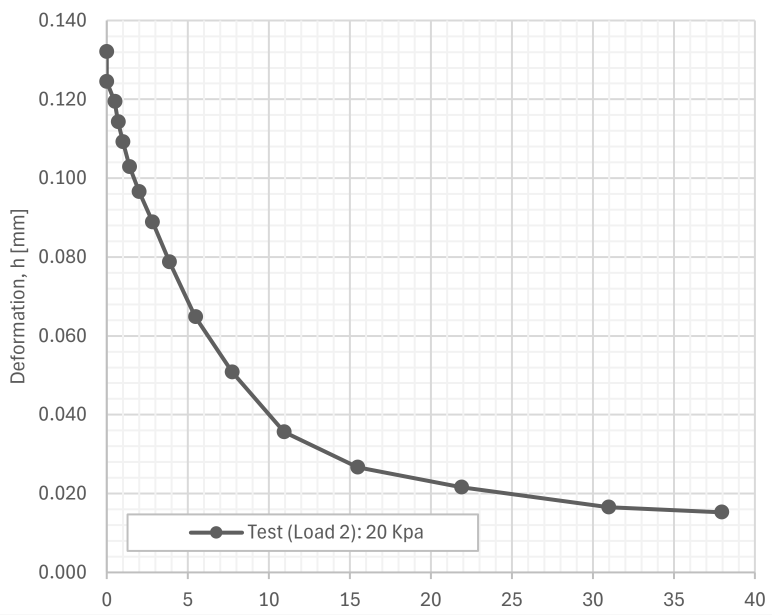
Time-Deformation Curve Using Square Root of Time



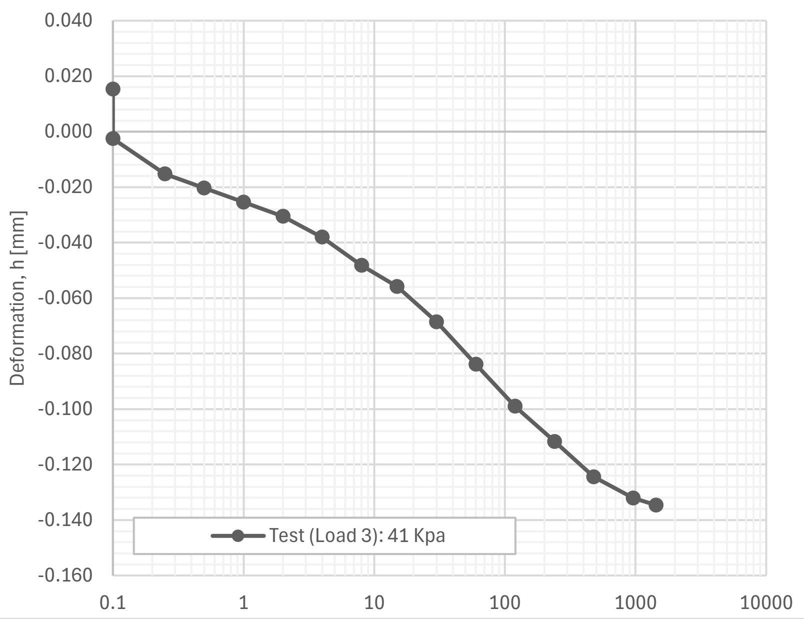
Time-Deformation Curve Using Log Time



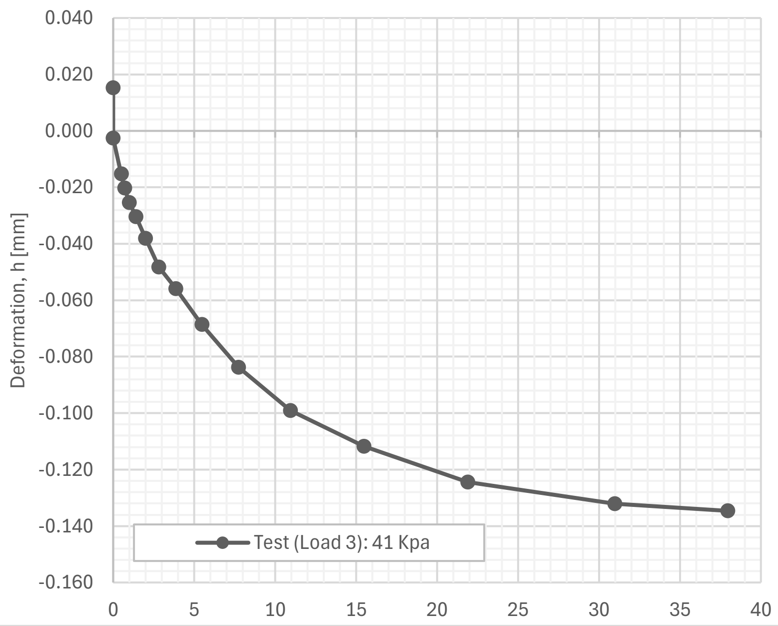
Time-Deformation Curve Using Square Root of Time

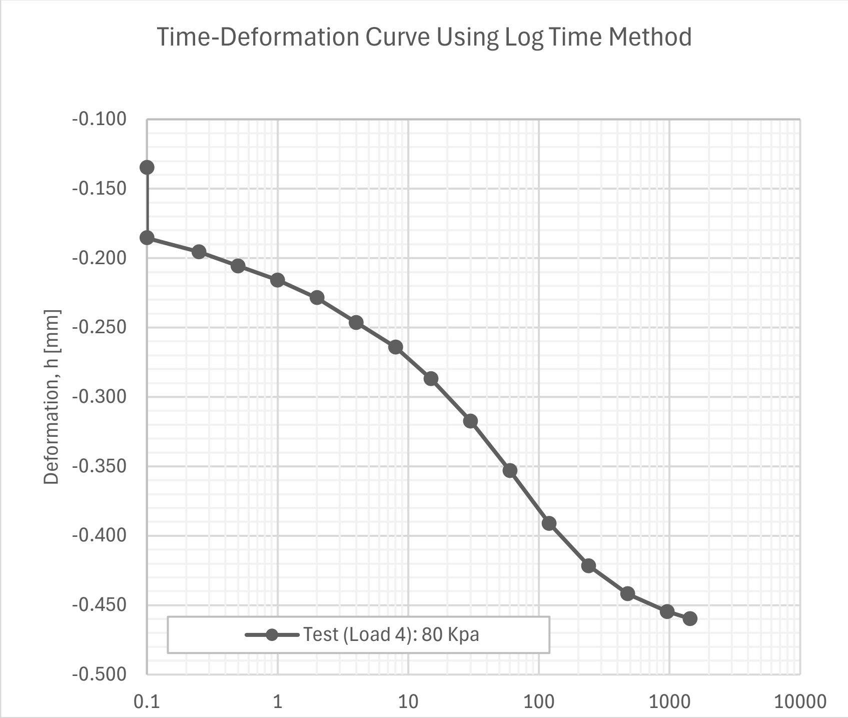


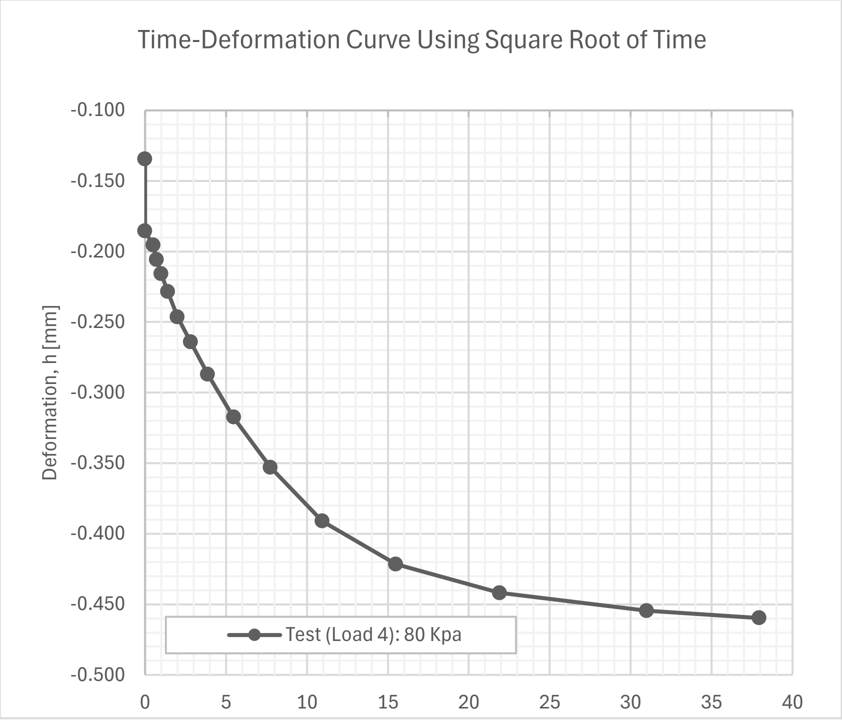
Time-Deformation Curve Using Log Time Method

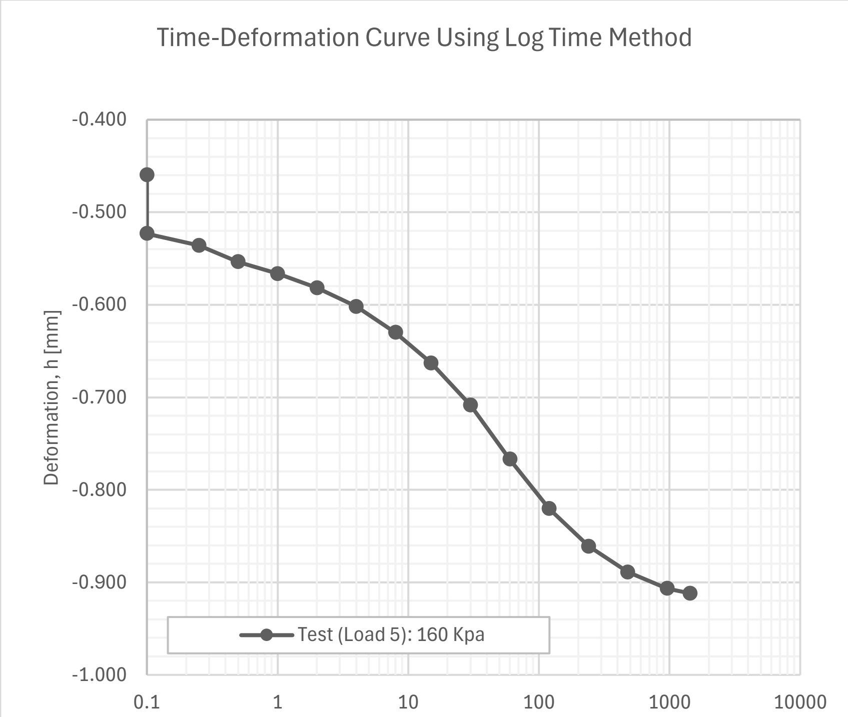


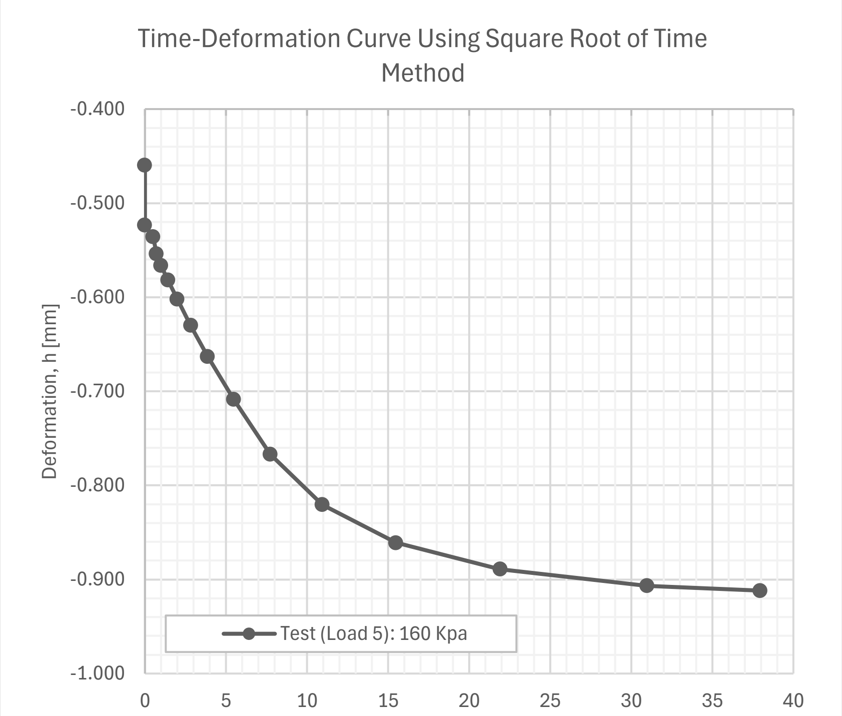
Time-Deformation Curve Using Square Root of Time

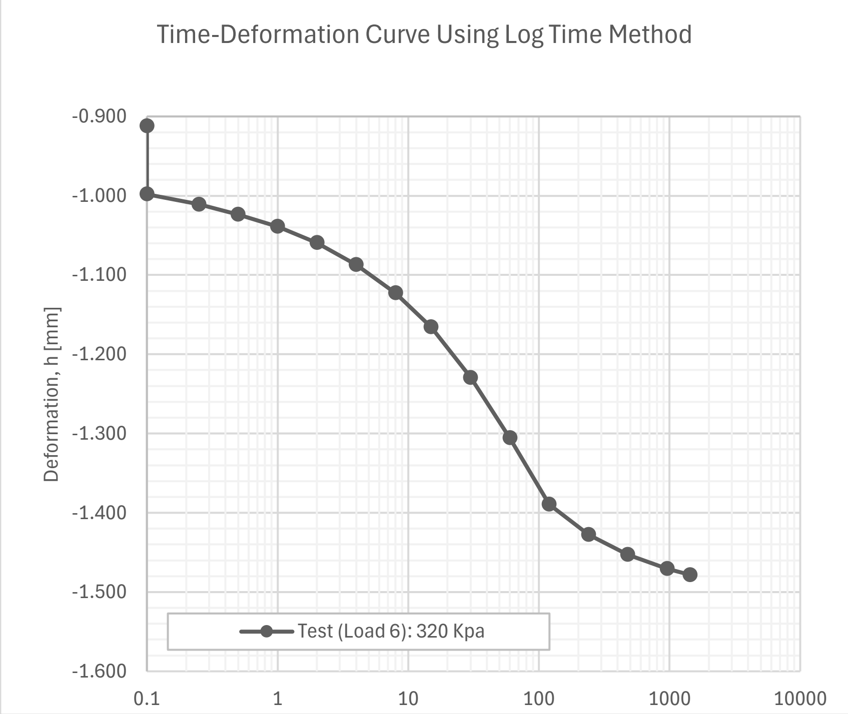


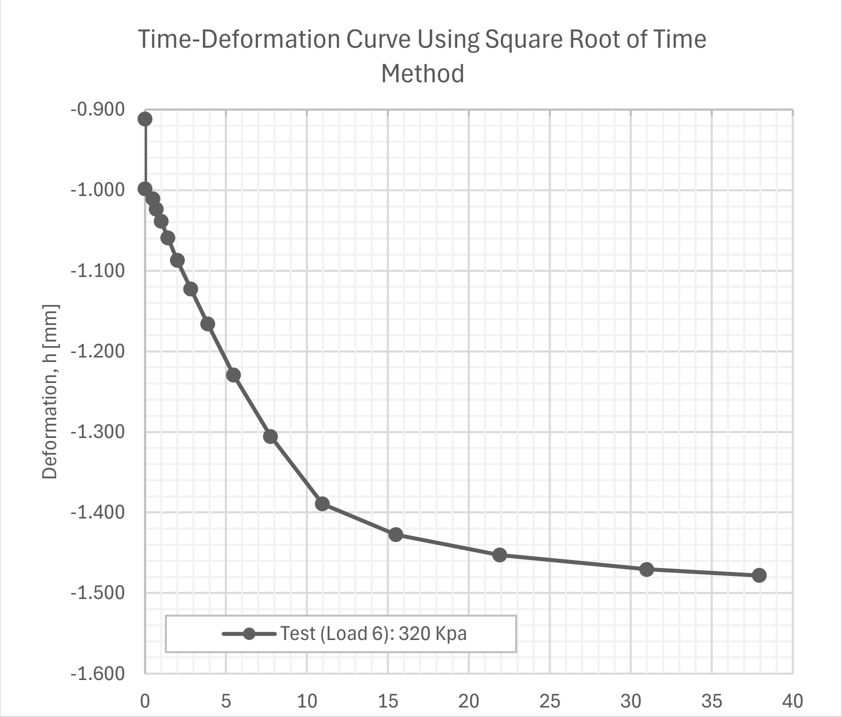

Time-Deformation Curve Using Log Time Method


Time-Deformation Curve Using Square Root of Time

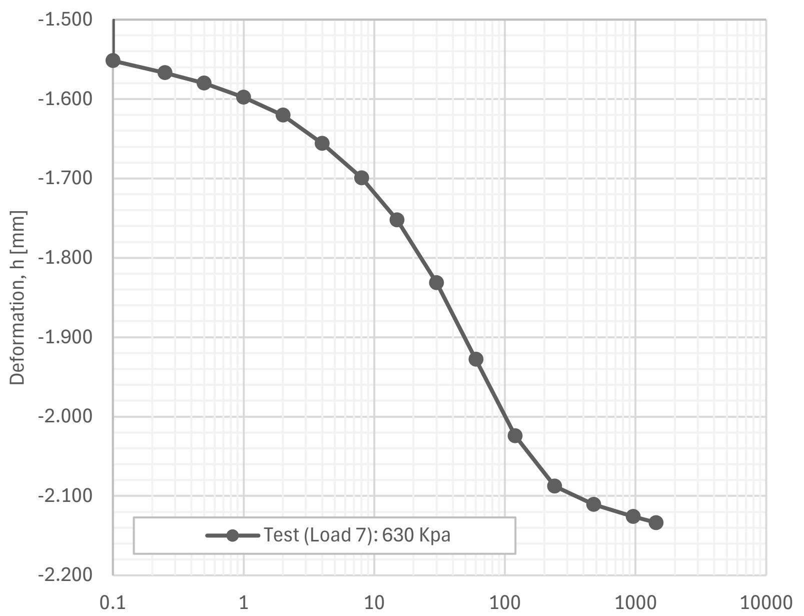

Time-Deformation Curve Using Log Time Method


Time-Deformation Curve Using Square Root of Time Method

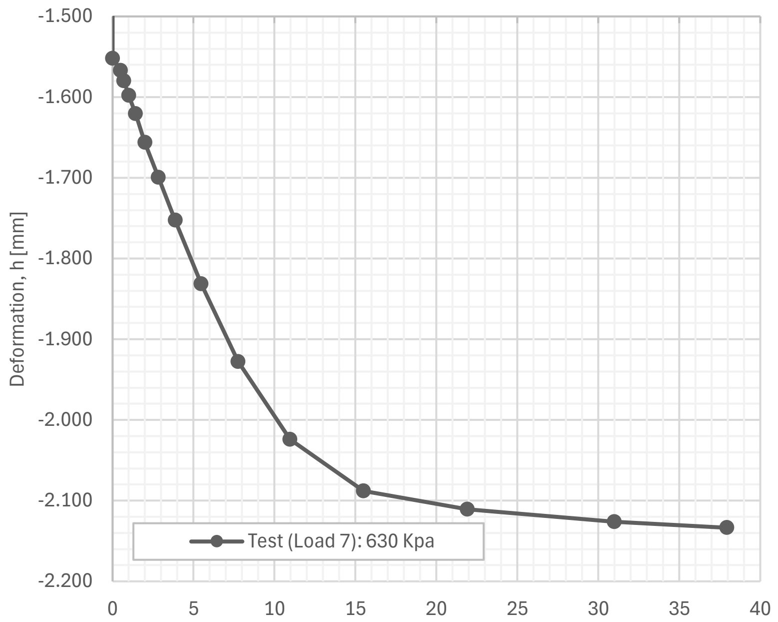

Time-Deformation Curve Using Log Time Method


Time-Deformation Curve Using Square Root of Time Method

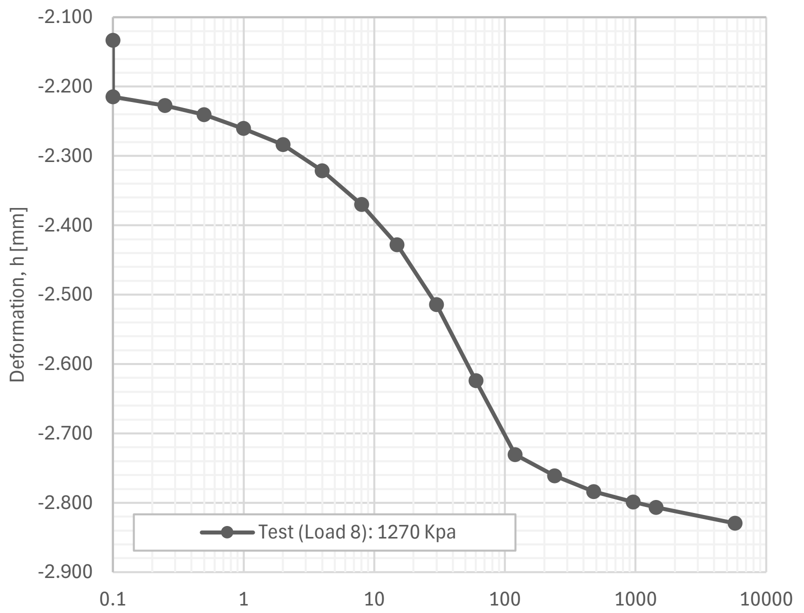
Time-Deformation Curve Using Log Time Method



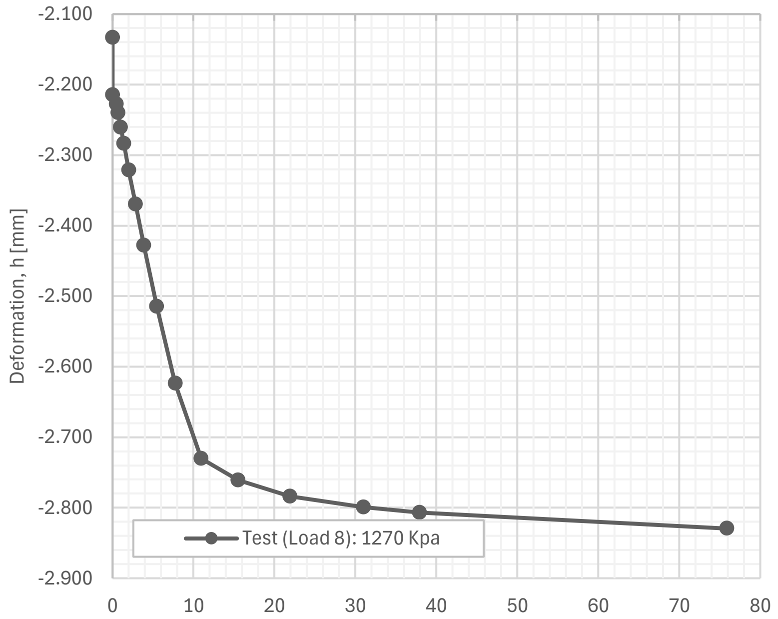
Time-Deformation Curve Using Square Root of Time Method



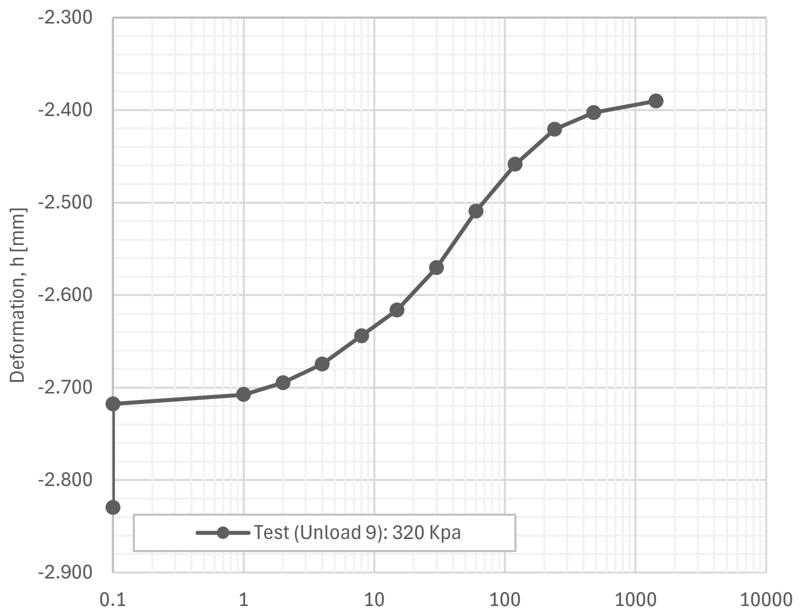
Time-Deformation Curve Using Log Time Method



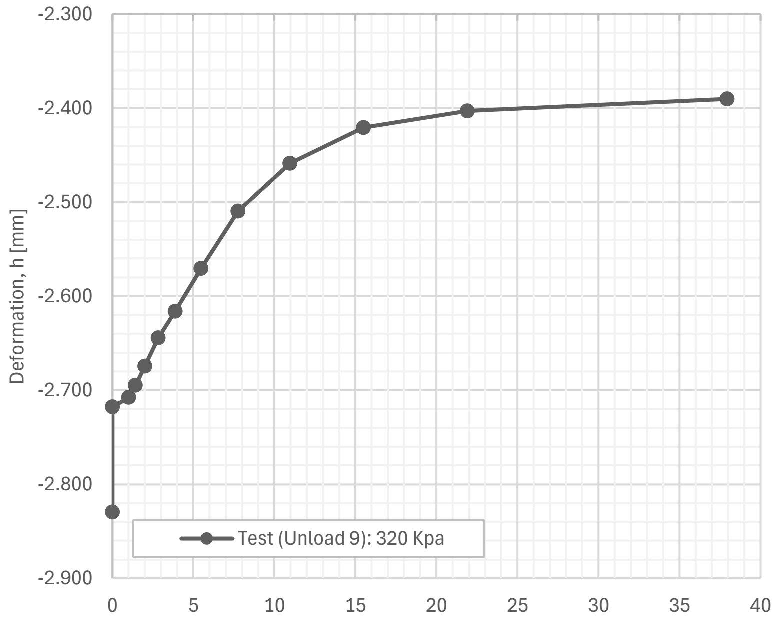
Time-Deformation Curve Using Square Root of Time Method

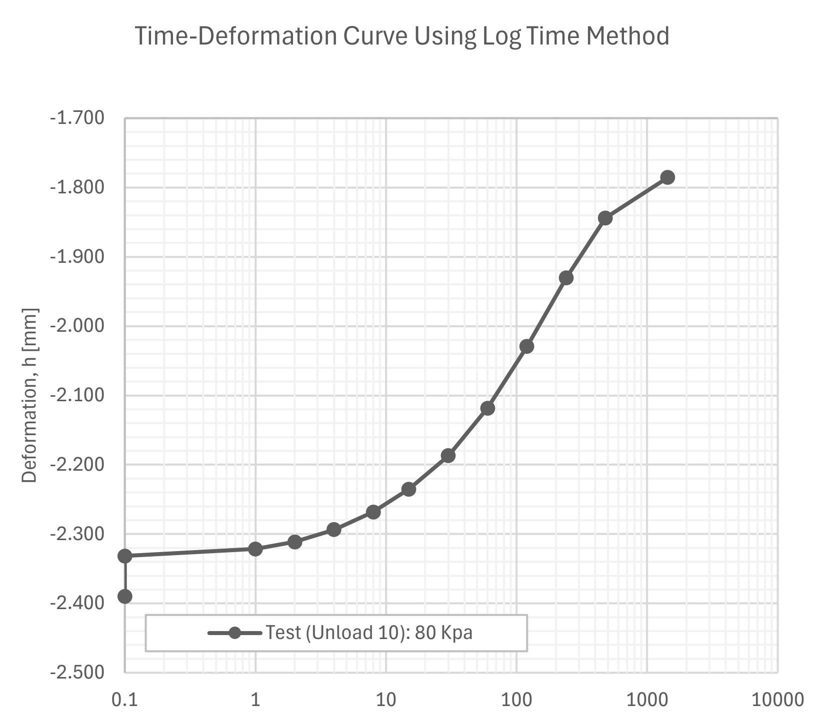


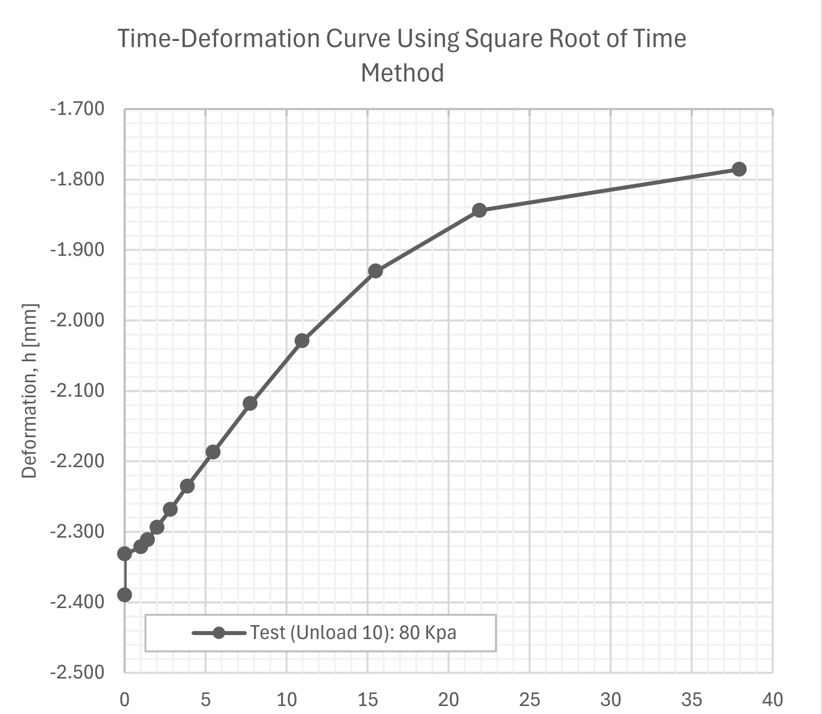
Time-Deformation Curve Using Log Time Method

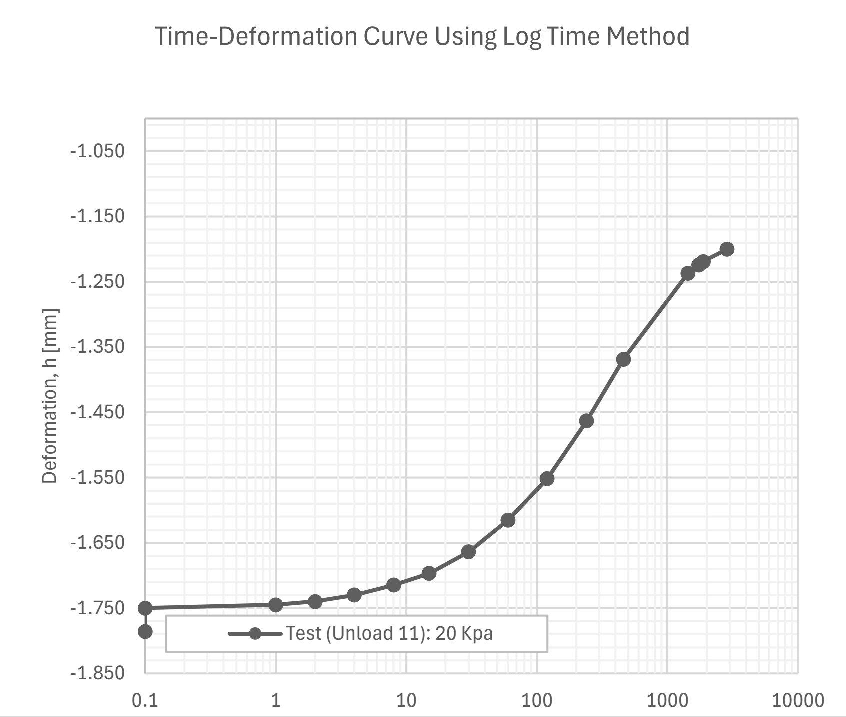


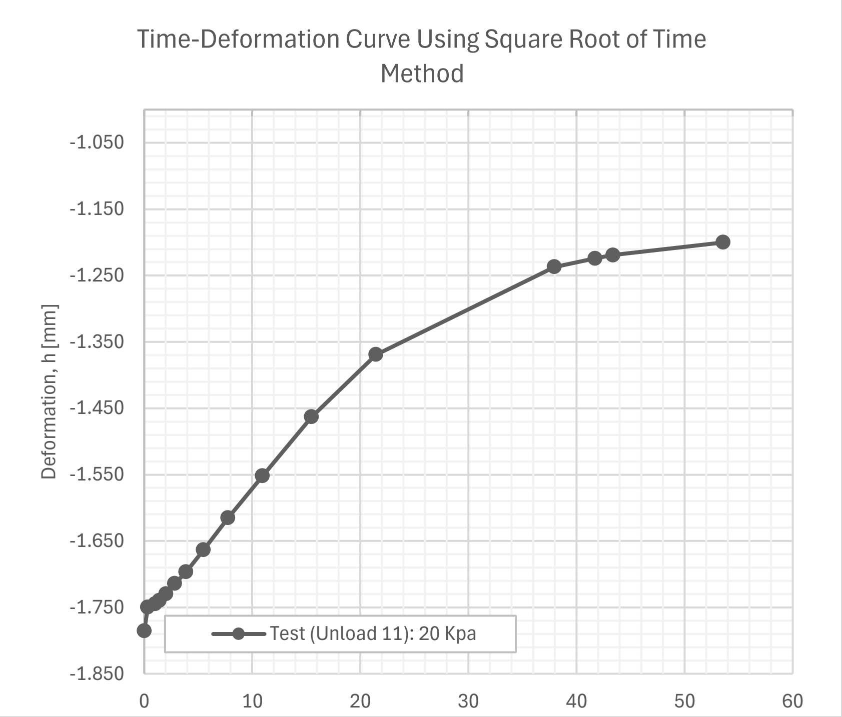
Time-Deformation Curve Using Square Root of Time Method




Time-Deformation Curve Using Log Time Method
Deformation, h [mm]
-1.700
-1.800
-1.900
-2.000
-2.100
-2.200
-2.300
-2.400
-2.500
0.1
1
10
100
1000
10000
Test (Unload 10): 80 Kpa


Time-Deformation Curve Using Square Root of Time Method
Deformation, h [mm]
-1.700
-1.800
-1.900
-2.000
-2.100
-2.200
-2.300
-2.400
-2.500
0
5
10
15
20
25
30
35
40
Test (Unload 10): 80 Kpa


Time-Deformation Curve Using Log Time Method
Deformation, h [mm]
-1.050
-1.150
-1.250
-1.350
-1.450
-1.550
-1.650
-1.750
-1.850
0.1
1
10
100
1000
10000
Test (Unload 11): 20 Kpa


Time-Deformation Curve Using Square Root of Time Method
Deformation, h [mm]
-1.050
-1.150
-1.250
-1.350
-1.450
-1.550
-1.650
-1.750
-1.850
0
10
20
30
40
50
60
Test (Unload 11): 20 Kpa

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Winnipeg Geotechnical Laboratory
99 Commerce Drive, Winnipeg, MB R3P 0Y7
Phone: 204 477 5381

Project Name:	Brady Landfill Area B			
Project Number:	60733855	Supplier/Location:	N/A	
Client:	City of Winnipeg	Field Technician:	Camilo Olivar	
Sample Location:	BH24-09	Sample Date:	July 24, 2024	
Sample Depth :	35	Lab Technician:	LB-LC	
Sample Number:	T13	Date Range Tested:	August 15, 2024	September 2, 2024

Consolidation Test Report (ASTM D2435) - Method "A"

Standard Test Methods for One-dimensional Consolidation Properties of Soil Using Incremental Loading

Sample Information and Test Parameters

Equipment

Oedometer No:	1
Lever Multiplier:	11
Avg. Ring Diam. [mm]:	70
Ring Height [mm]:	19.7
Ring Weight [g]:	104.355
Ring In. Area [mm2]:	3848
Ring In. Vol [mm3]:	75814
Apparatus Deformation Corr [mm]:	0
Deform Ind Conv Factor (mm/0.0001"):	0.0025
Density of Test Water [g/cm3]:	0.9980

Moisture Content

	Initial	Final
Tare Number:	1	**X55**
Weight of Tare [g]:	8.4	112.76
Wt of Wet Soil + Tare [g]:	211.7	224.4
Wt of Dry Soil + Tare [g]:	136.1	185.8
% Moisture:	59.2%	52.8%

Soil Parameters/Characteristics

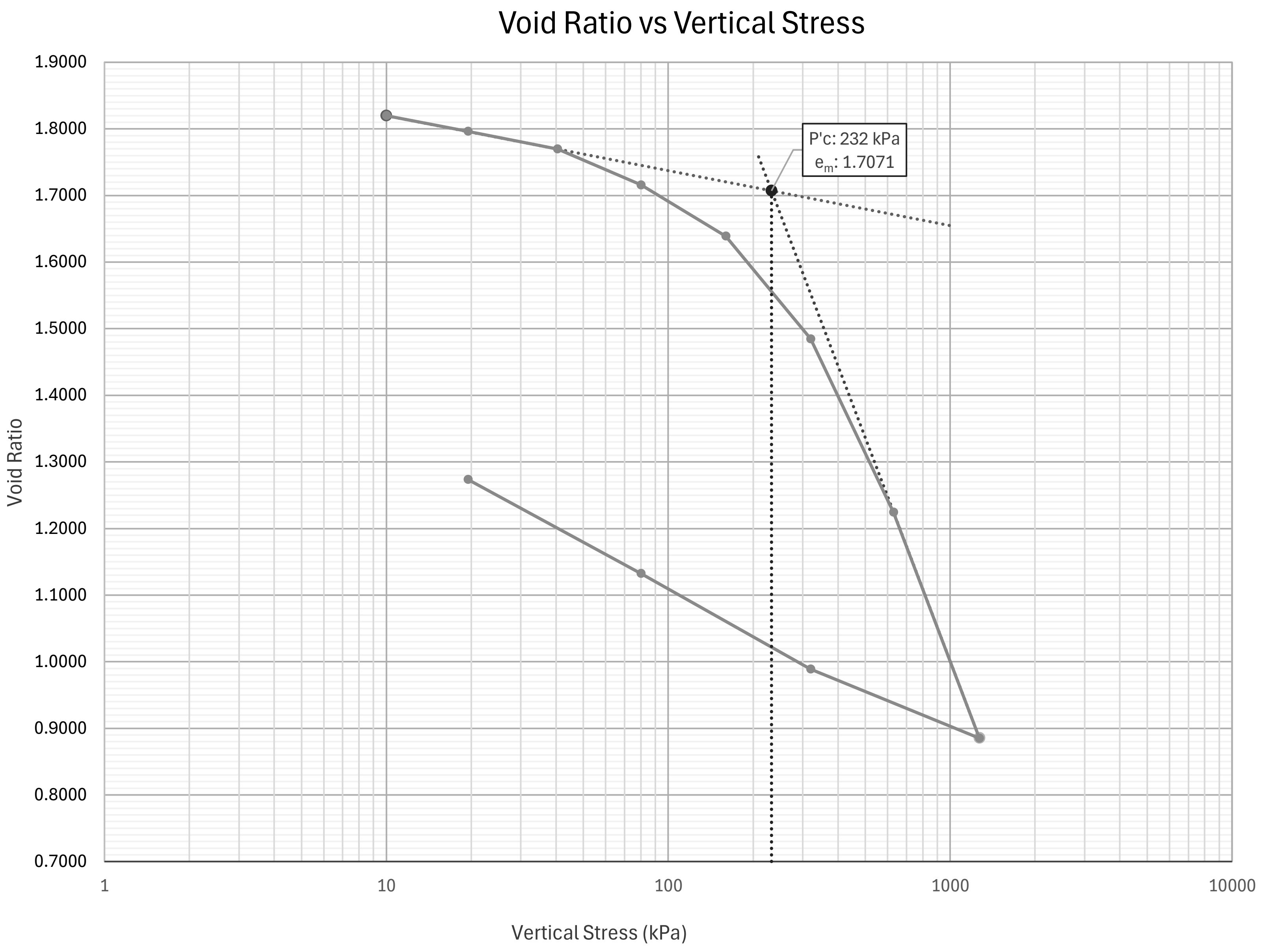
Specific Gravity:	2.70
Soil Description:	Clay
Dry Mass of Solids (Md) [g]:	73.05
Vol of Solids (Vs) [cm3]:	27.11
Ht of Solids (Hs) [mm]:	7.04

Specimen

	Initial	Final
Weight of Ring + Soil [g]:	221.531	216
Weight of Soil [g]:	117.176	111.645
Void Ratio (e) []:	1.797	1.268
Deg of Saturation (S) [%]:	90.8%	79.4%
Height of Specim. [mm]:	19.7	16.0
Vol. of Specimen [mm3]:	75814	61494
Bulk Density [g/cm3]:	1.546	1.816
Dry Density [g/cm3]:	0.971	1.188
Bulk Unit Wt [kN/m3]:	15.16	17.80
Dry Unit Wt [kN/m3]:	9.52	11.65

Consolidation Test Summary

Stage No.	Load (kPa)	Deformation, h (mm)	Strain, ε (kPa)	cv (log-method)	cv (sqrt-method)	Void Ratio	Type	
0								
1	10	0.1626	-0.19%	0.0597	0.1563	1.820	Load	
2	19.5	-0.0025	-0.83%	0.0243	0.0482	1.796	Load	
3	40.5	-0.1905	-0.95%	0.0244	0.3443	1.770	Load	
4	80	-0.5690	-1.94%	0.0868	0.4350	1.716	Load	
5	160	-1.1125	-2.84%	0.0951	0.2847	1.639	Load	
6	320	-2.1971	-5.84%	0.0483	0.1526	1.485	Load	
7	630	-4.0310	-10.48%	0.0291	0.0268	1.224	Load	
8	1270	-6.4211	-15.25%	0.0157	0.0117	0.885	Load	
9	320	-5.6896	5.51%			0.989	Unload	
10	80	-4.6787	7.22%			1.133	Unload	
11	19.5	-3.6855	6.61%			1.274	Unload	



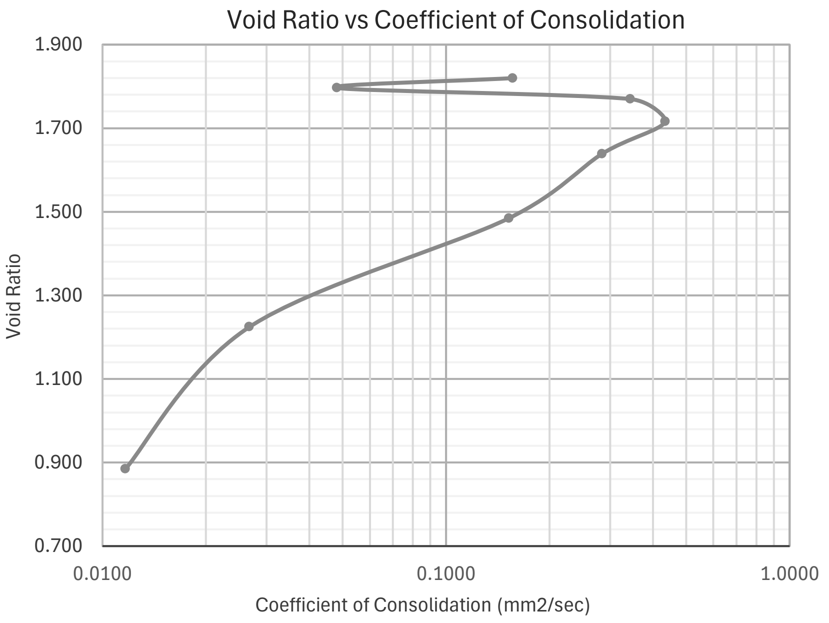
Consolidation Parameters

Preconsolidation Pressure, P'_c [kPa]:	232
Compression Index, C_c:	1.002
Void Ratio @ P'_c, e_m:	1.7071

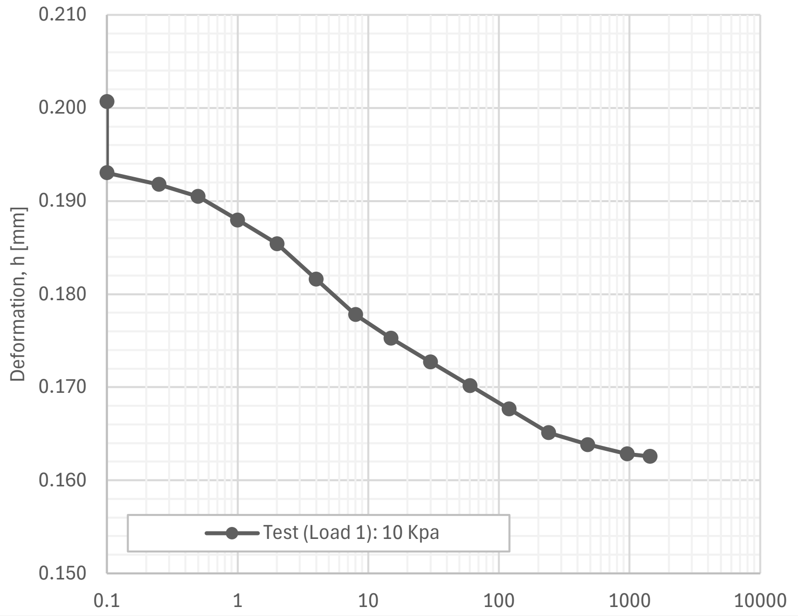
Recompression index, C_r:	0.214
Overconsolidation Ratio, OCR:	1.437

Notes

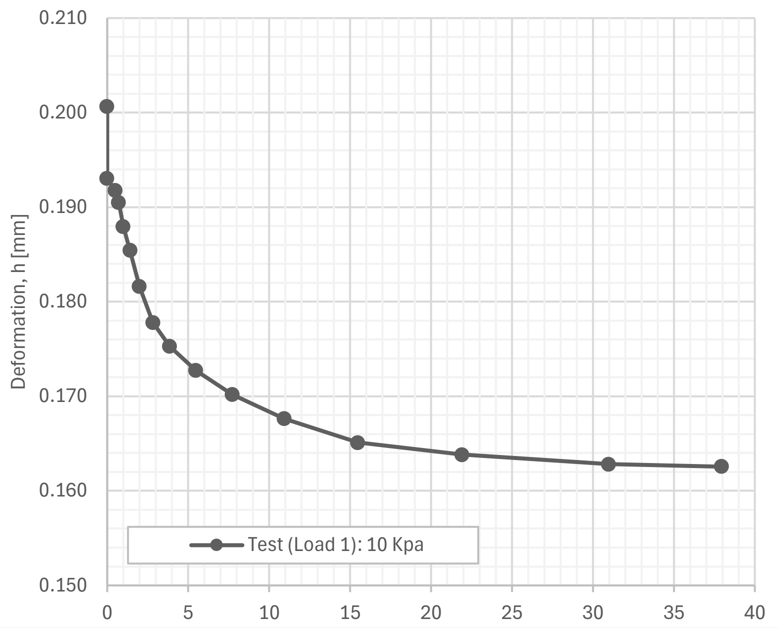
Preconsolidation pressure P'_c estimated using Pacheco-Silva' Method.



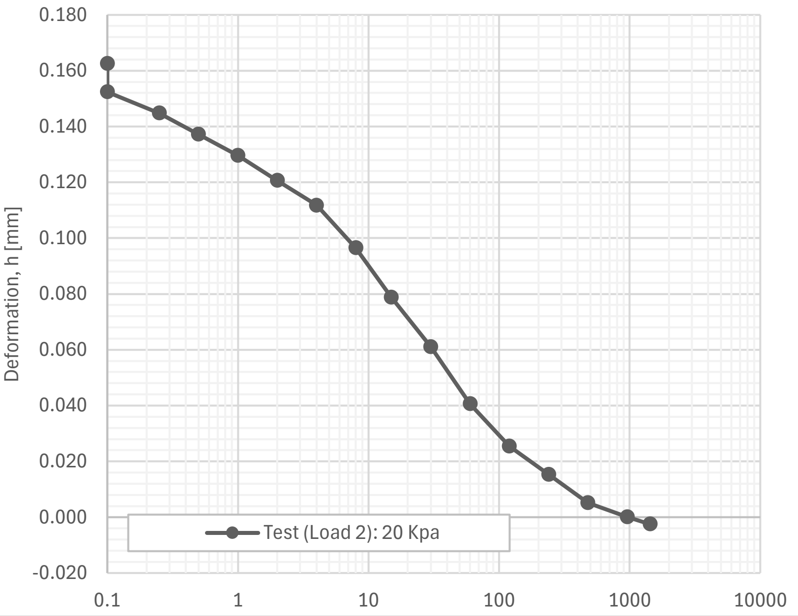
Time-Deformation Curve Using Log Time



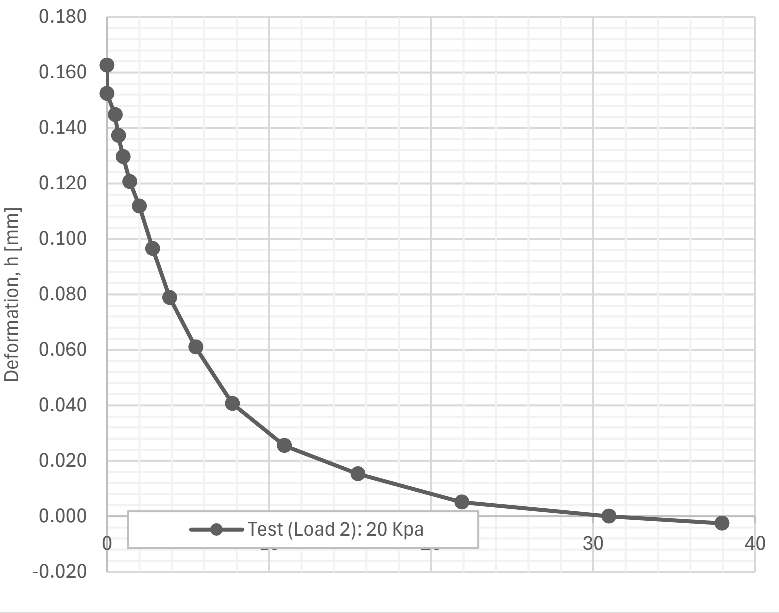
Time-Deformation Curve Using Square Root of Time



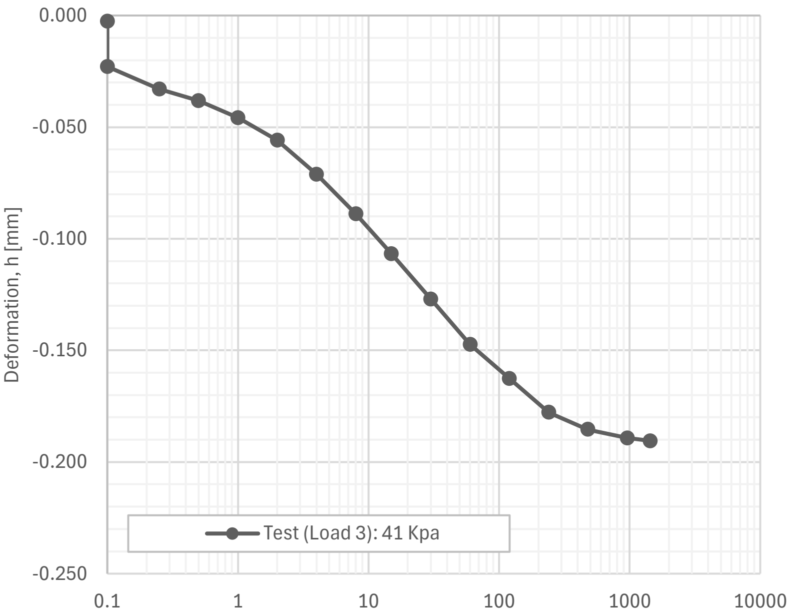
Time-Deformation Curve Using Log Time



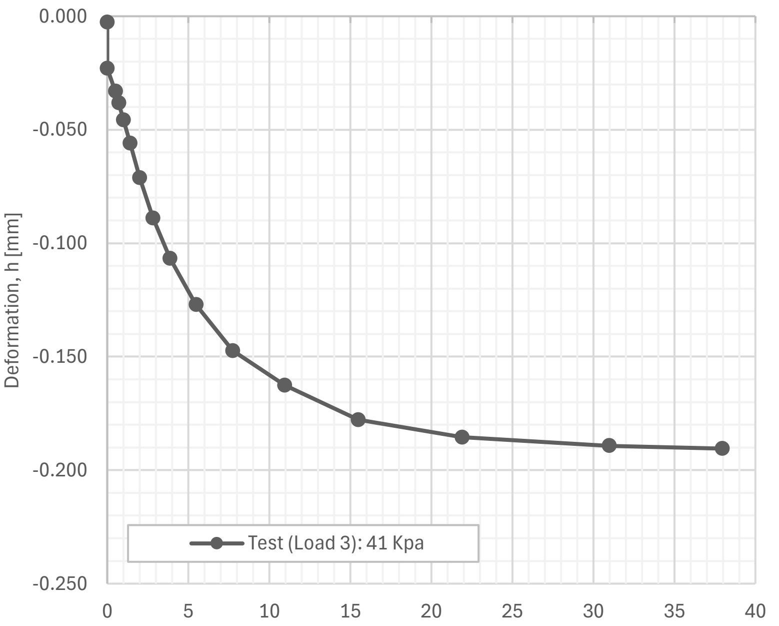
Time-Deformation Curve Using Square Root of Time

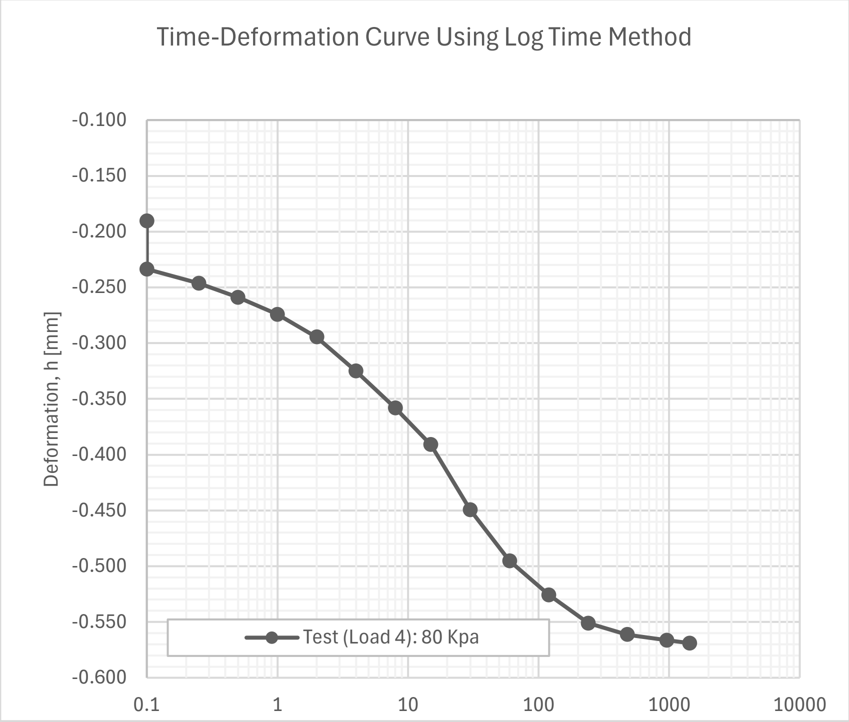


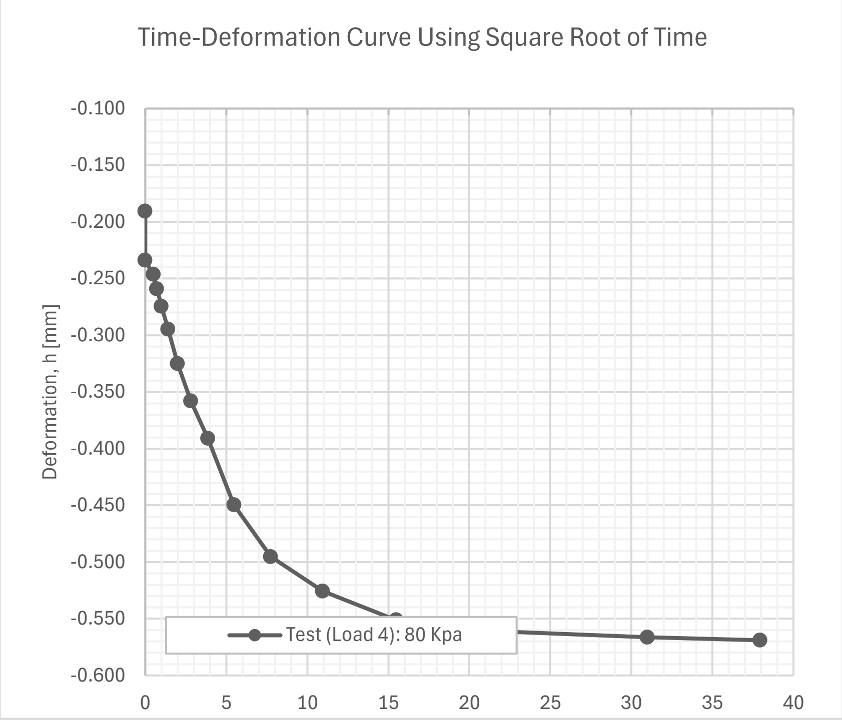
Time-Deformation Curve Using Log Time Method

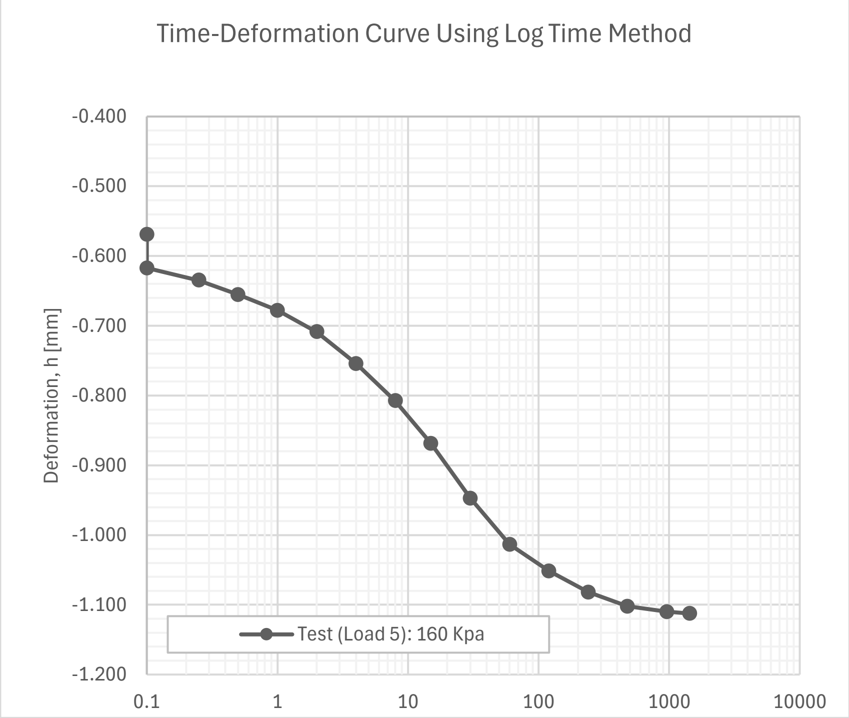


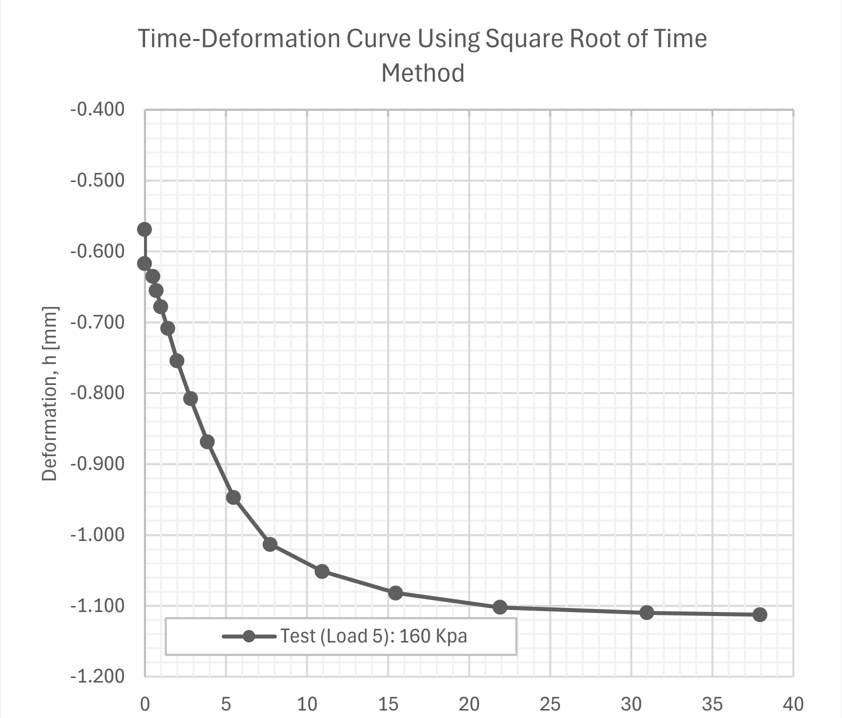
Time-Deformation Curve Using Square Root of Time

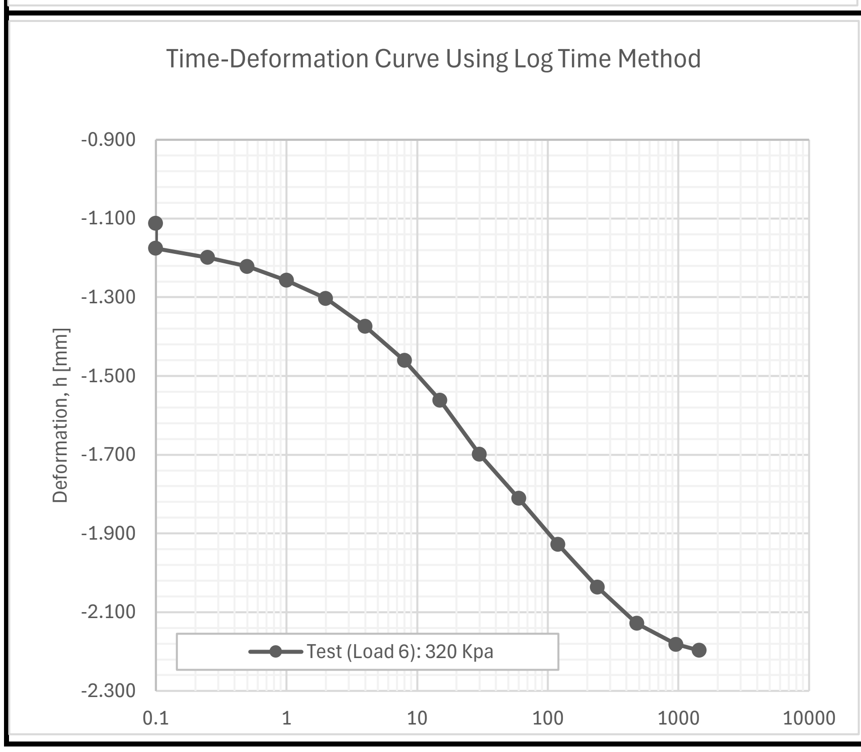


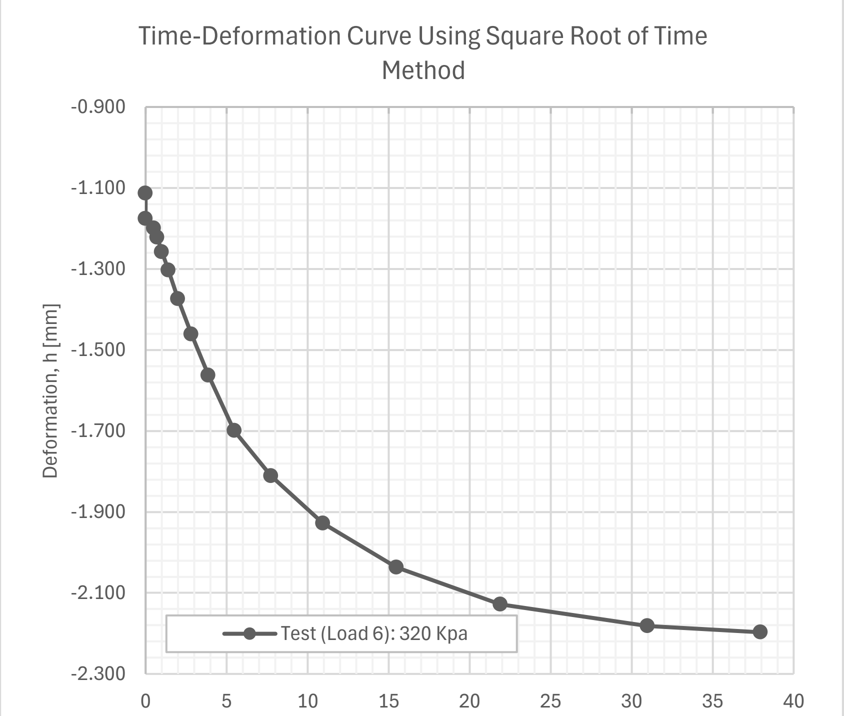

Time-Deformation Curve Using Log Time Method
Deformation, h [mm]
-0.100
-0.150
-0.200
-0.250
-0.300
-0.350
-0.400
-0.450
-0.500
-0.550
-0.600
0.1
1
10
100
1000
10000
Test (Load 4): 80 Kpa

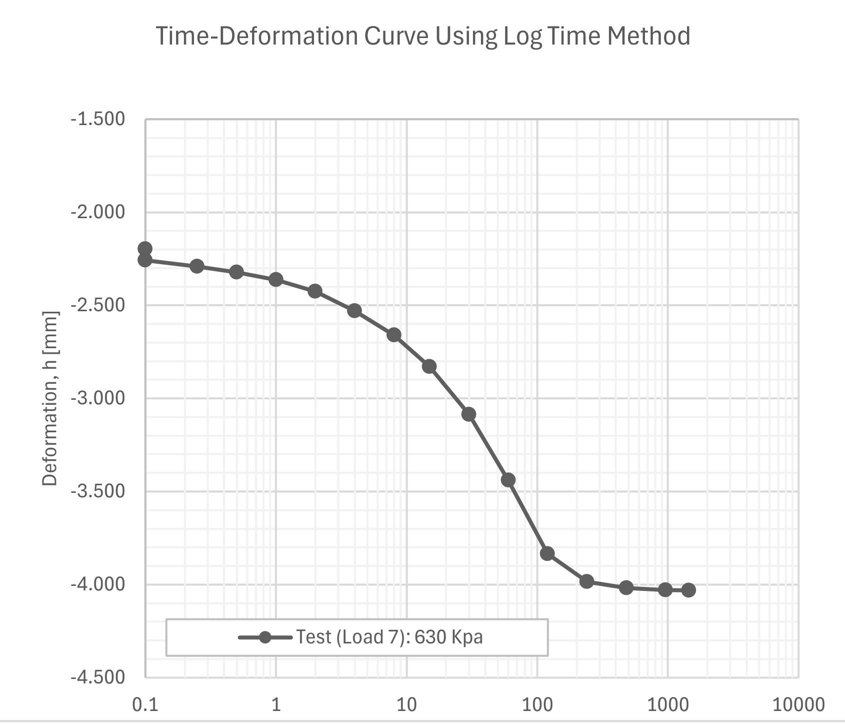

Time-Deformation Curve Using Square Root of Time
Deformation, h [mm]
-0.100
-0.150
-0.200
-0.250
-0.300
-0.350
-0.400
-0.450
-0.500
-0.550
-0.600
0
5
10
15
20
25
30
35
40
Test (Load 4): 80 Kpa

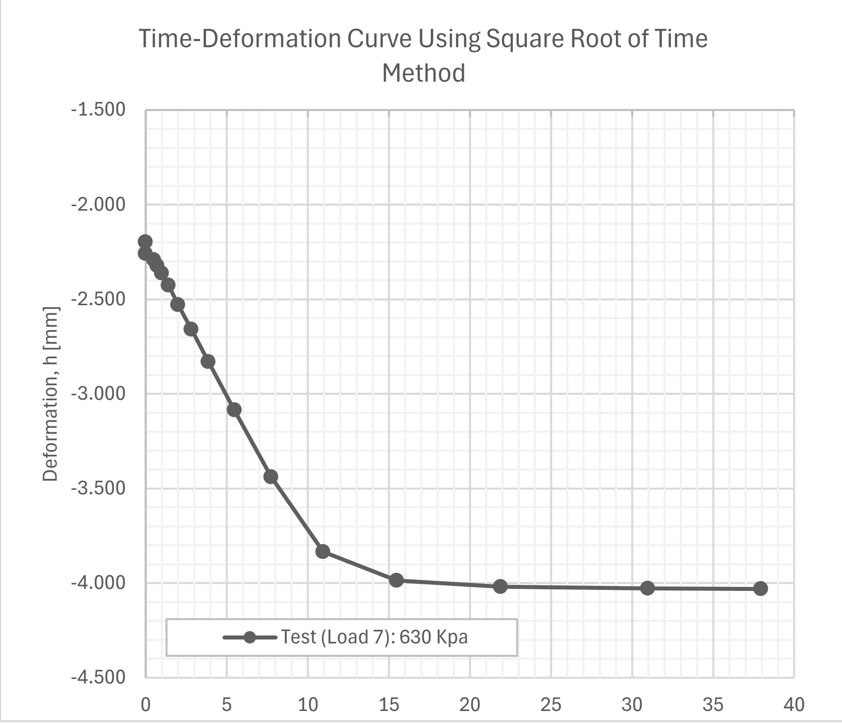

Time-Deformation Curve Using Log Time Method
Deformation, h [mm]
-0.400
-0.500
-0.600
-0.700
-0.800
-0.900
-1.000
-1.100
-1.200
0.1
1
10
100
1000
10000
Test (Load 5): 160 Kpa

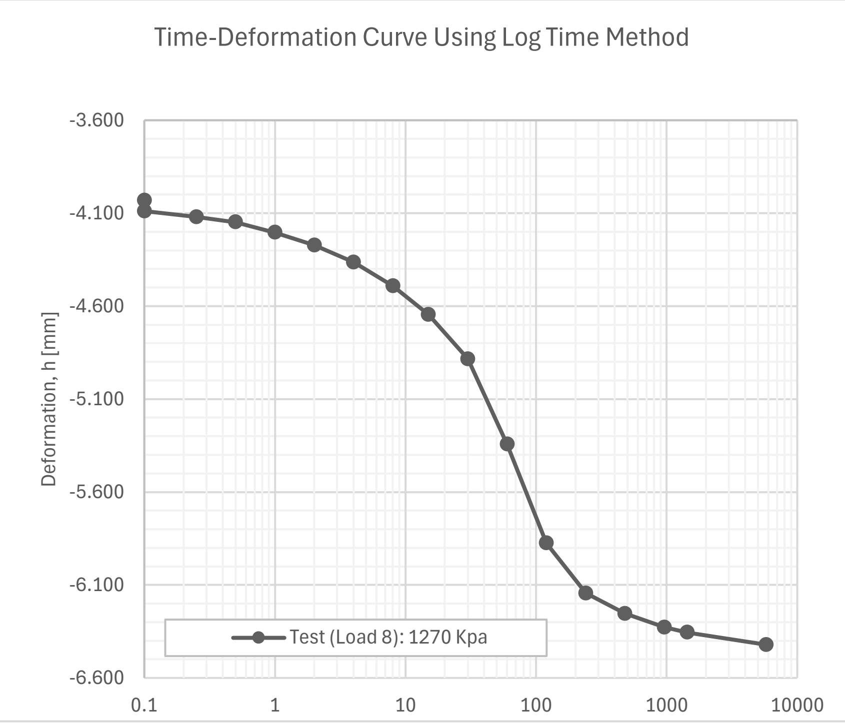

Time-Deformation Curve Using Square Root of Time Method
Deformation, h [mm]
-0.400
-0.500
-0.600
-0.700
-0.800
-0.900
-1.000
-1.100
-1.200
0
5
10
15
20
25
30
35
40
Test (Load 5): 160 Kpa

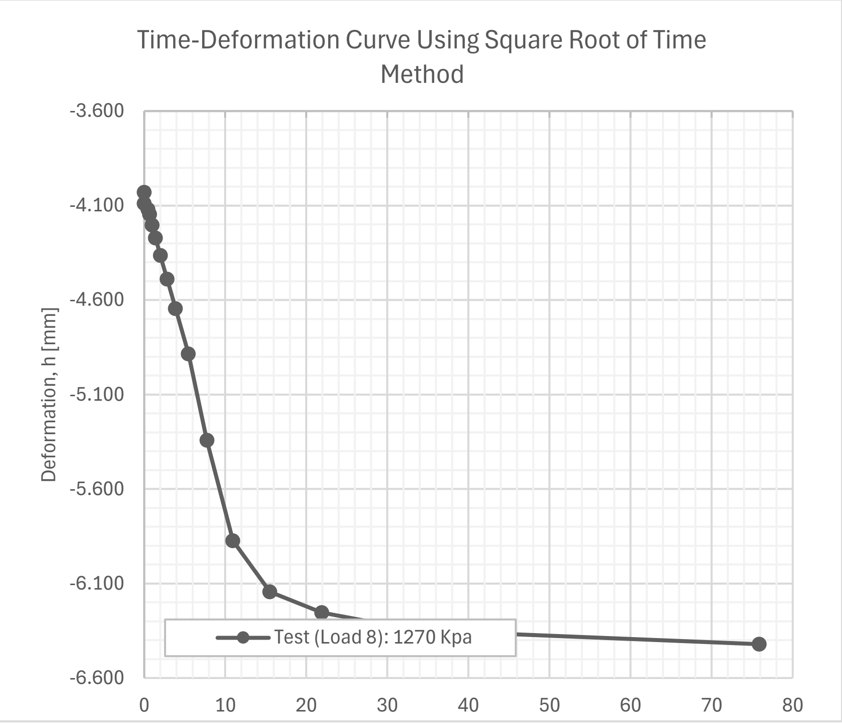

Time-Deformation Curve Using Log Time Method
Deformation, h [mm]
-0.900
-1.100
-1.300
-1.500
-1.700
-1.900
-2.100
-2.300
0.1
1
10
100
1000
10000
Test (Load 6): 320 Kpa

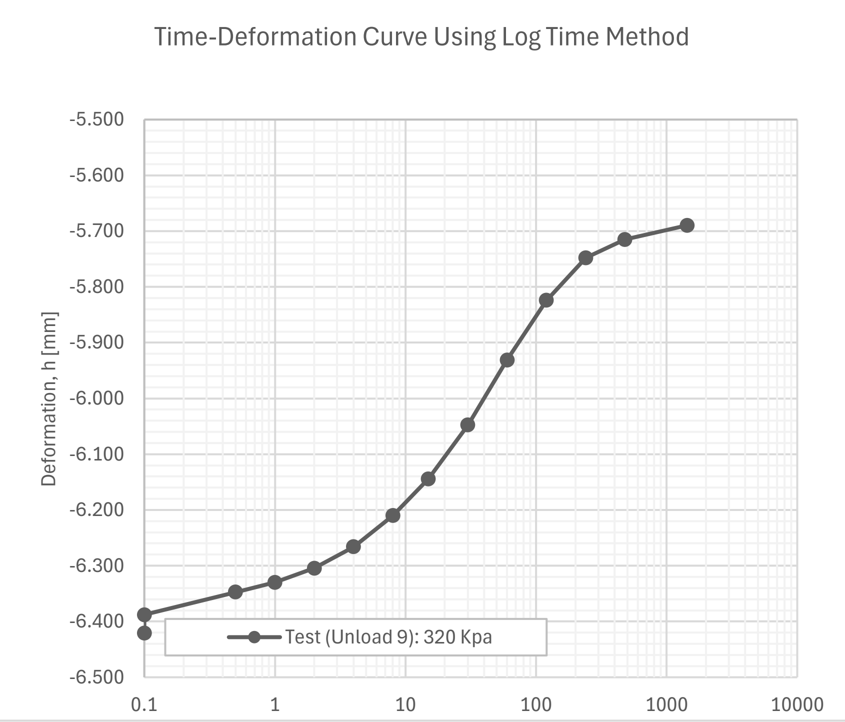

Time-Deformation Curve Using Square Root of Time Method
Deformation, h [mm]
-0.900
-1.100
-1.300
-1.500
-1.700
-1.900
-2.100
-2.300
0
5
10
15
20
25
30
35
40
Test (Load 6): 320 Kpa

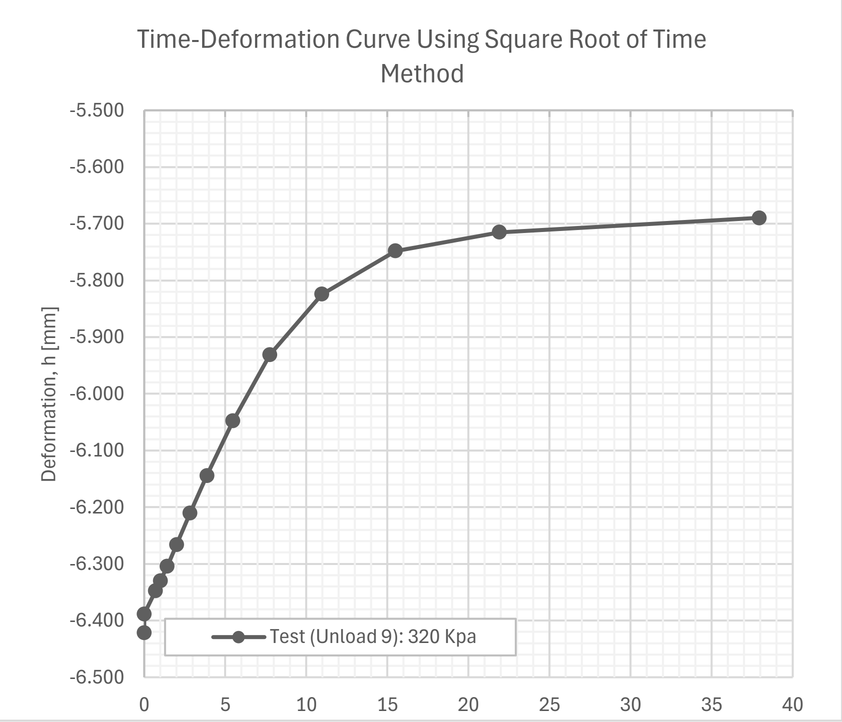

Time-Deformation Curve Using Log Time Method
Deformation, h [mm]
-1.500
-2.000
-2.500
-3.000
-3.500
-4.000
-4.500
0.1
1
10
100
1000
10000
Test (Load 7): 630 Kpa

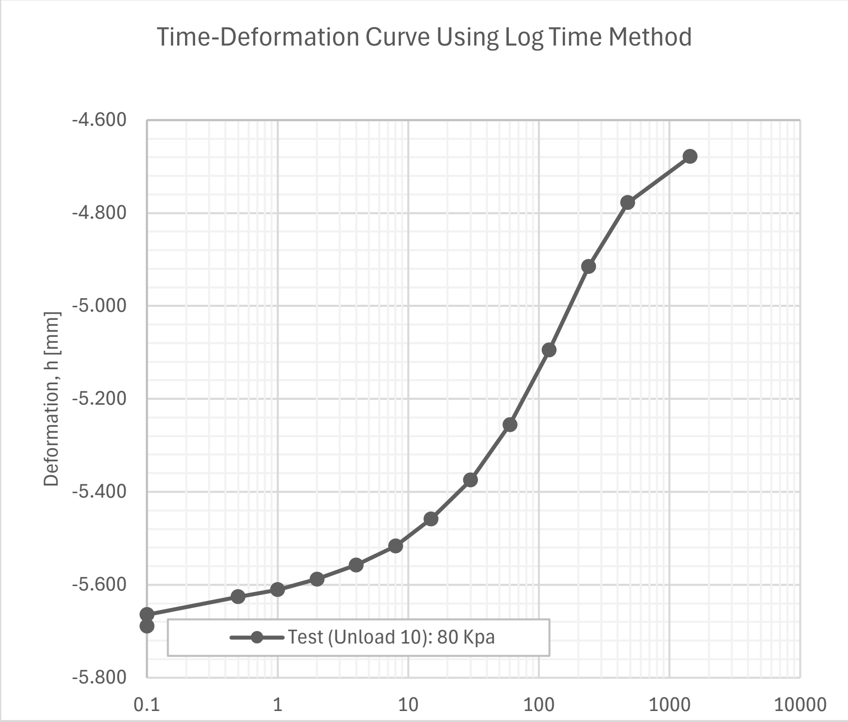

Time-Deformation Curve Using Square Root of Time Method
Deformation, h [mm]
-1.500
-2.000
-2.500
-3.000
-3.500
-4.000
-4.500
0
5
10
15
20
25
30
35
40
Test (Load 7): 630 Kpa

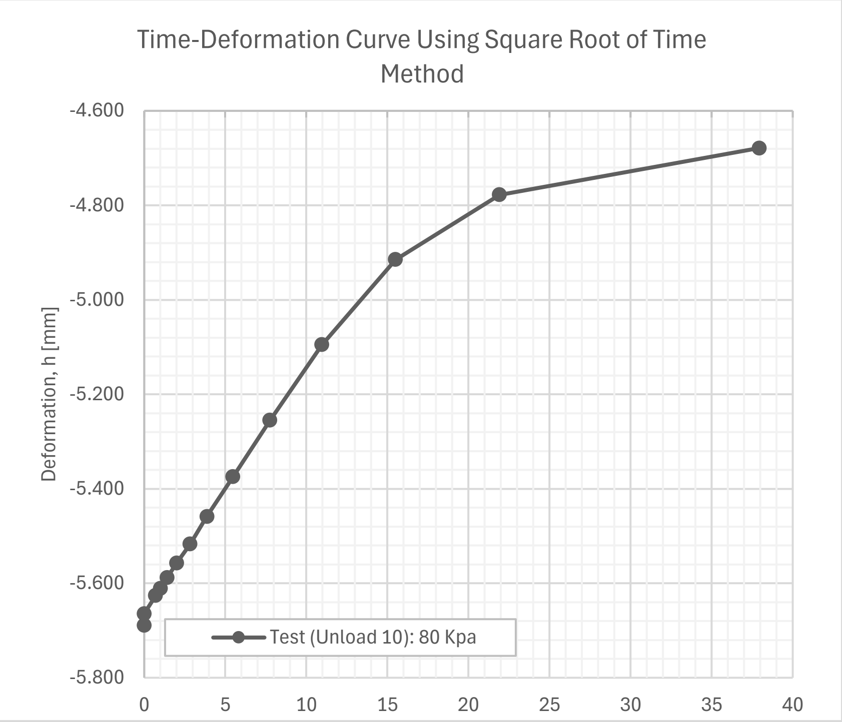

Time-Deformation Curve Using Log Time Method
Deformation, h [mm]
-3.600
-4.100
-4.600
-5.100
-5.600
-6.100
-6.600
0.1
1
10
100
1000
10000
Test (Load 8): 1270 Kpa

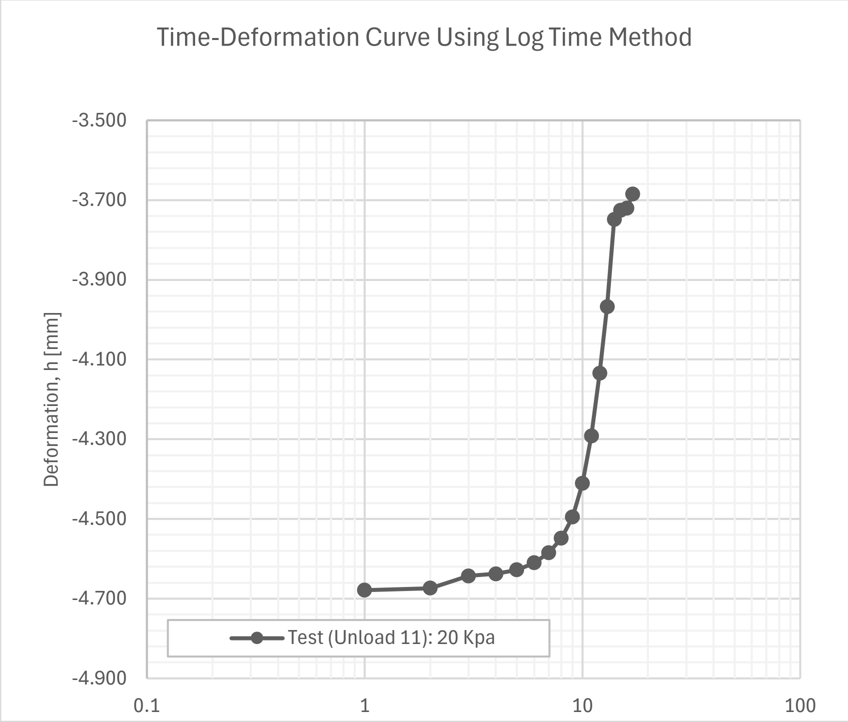

Time-Deformation Curve Using Square Root of Time Method
Deformation, h [mm]
-3.600
-4.100
-4.600
-5.100
-5.600
-6.100
-6.600
0
10
20
30
40
50
60
70
80
Test (Load 8): 1270 Kpa

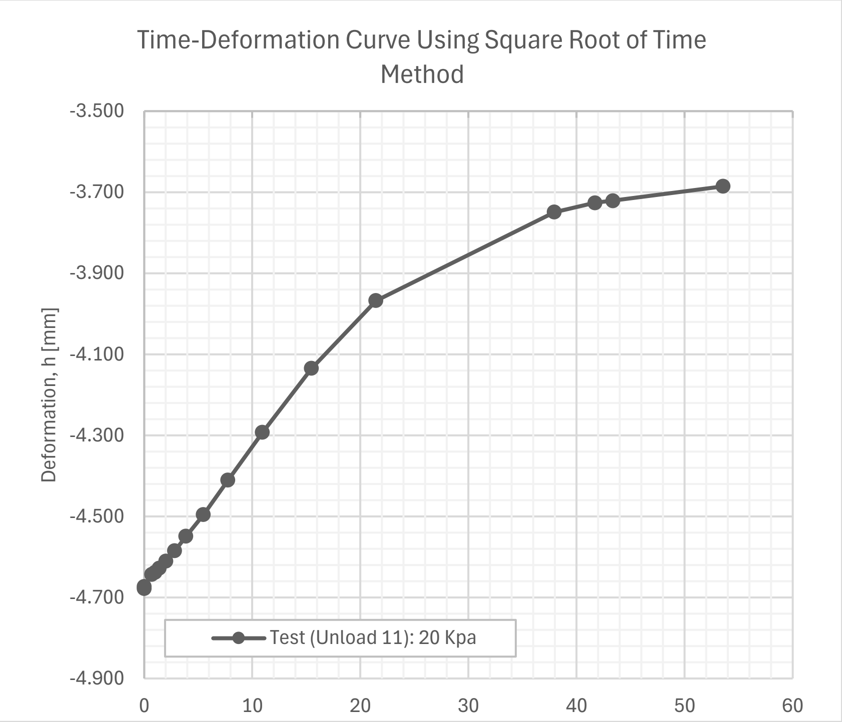

Time-Deformation Curve Using Log Time Method
Deformation, h [mm]
-5.500
-5.600
-5.700
-5.800
-5.900
-6.000
-6.100
-6.200
-6.300
-6.400
-6.500
0.1
1
10
100
1000
10000
Test (Unload 9): 320 Kpa


Time-Deformation Curve Using Square Root of Time Method
Deformation, h [mm]
-5.500
-5.600
-5.700
-5.800
-5.900
-6.000
-6.100
-6.200
-6.300
-6.400
-6.500
0
5
10
15
20
25
30
35
40
Test (Unload 9): 320 Kpa


Time-Deformation Curve Using Log Time Method
Deformation, h [mm]
-4.600
-4.800
-5.000
-5.200
-5.400
-5.600
-5.800
0.1
1
10
100
1000
10000
Test (Unload 10): 80 Kpa


Time-Deformation Curve Using Square Root of Time Method
Deformation, h [mm]
-4.600
-4.800
-5.000
-5.200
-5.400
-5.600
-5.800
0
5
10
15
20
25
30
35
40
Test (Unload 10): 80 Kpa


Time-Deformation Curve Using Log Time Method
Deformation, h [mm]
-3.500
-3.700
-3.900
-4.100
-4.300
-4.500
-4.700
-4.900
0.1
1
10
100
Test (Unload 11): 20 Kpa


Time-Deformation Curve Using Square Root of Time Method
Deformation, h [mm]
-3.500
-3.700
-3.900
-4.100
-4.300
-4.500
-4.700
-4.900
0
10
20
30
40
50
60
Test (Unload 11): 20 Kpa

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Winnipeg Geotechnical Laboratory
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Phone: 204 477 5381

Project Name:	Brady Landfill		
Project Number:	60733855	Supplier/Location:	N/A
Client:	City of Winnipeg	Field Technician:	COlivar
Sample Location:	BH24-01	Sample Date:	July 24, 2024
Sample Depth:	1.52 - 2.13 m	Lab Technician:	LBoughton
Sample Number:	T4	Date Tested:	August 20, 2024

Flexible Wall Permeameter (ASTM D5084-10)

Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

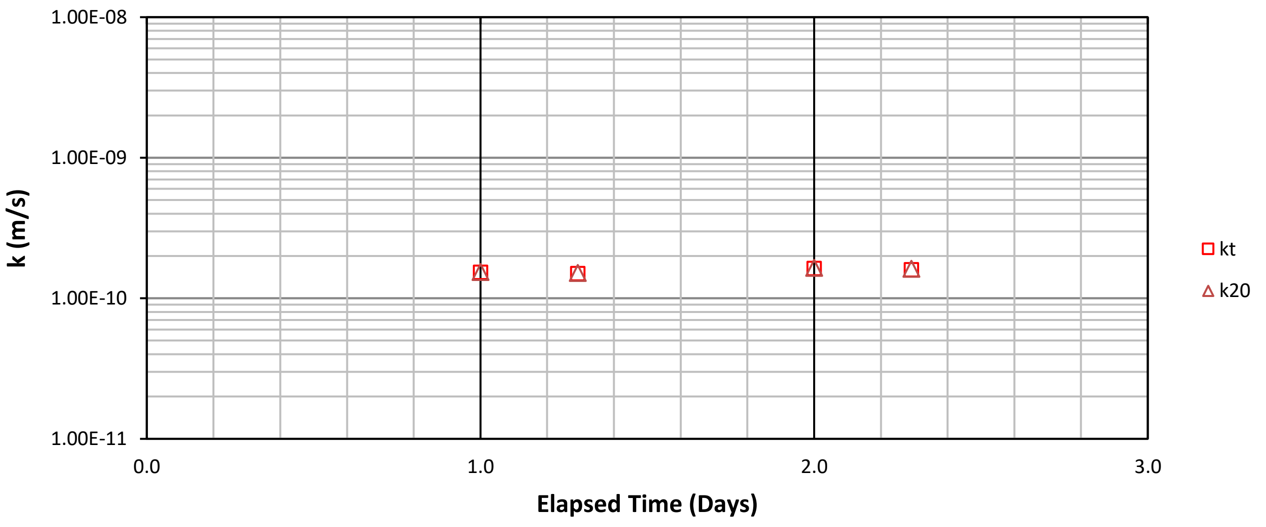
Soil Description:	CLAY - grey, firm, moist, silty, trace organics, high plasticity
Preparation Process:	Undisturbed
Type of Permeant Liquid:	Deaired Water
Type of Liquid Reservoir:	Burrettes
Confining Pressure (kPa):	172.37
Effective Saturation Stress (kPa):	137.90
Hydraulic Gradient:	53.07
Hydraulic Conductivity, "k" (m/s):	1.6E-10
Hydraulic Conductivity, "k_{20}" (m/s):	**1.6E-10**

Initial Sample Characteristics

Height (mm):	71.58	Dry Density (kg/m^3):	1307.3
Diameter (mm):	52.88	Water Content (%):	37.4
Wet Mass (g):	382.20	Assumed Specific Gravity:	2.613
Area (cm^2):	4.024E-03	Satuartion (%):	97.9
Volume (cm^3):	2.127E-04		

Final Sample Characteristics

Height (mm):	72.10	Dry Density (kg/m^3):	1283.7
Diameter (mm):	53.07	Water Content (%):	39.6
Wet Mass (g):	388.40	Assumed Specific Gravity:	2.613
Area (cm^2):	4.083E-03	Satuartion (%):	100.0
Volume (cm^3):	2.167E-04		



Reviewed by: Lee Boughton
Laboratory Manager

Approved by: German Leal, M.Eng., P.Eng.
Geotechnical Discipline Lead

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Phone: 204 477 5381

Project Name:	Brady Landfill		
Project Number:	60733855	Supplier/Location:	N/A
Client:	City of Winnipeg	Field Technician:	COlivar
Sample Location:	BH24-01	Sample Date:	July 24, 2024
Sample Depth:	4.57 - 5.18 m	Lab Technician:	LBoughton
Sample Number:	T7	Date Tested:	August 8, 2024

Flexible Wall Permeameter (ASTM D5084-10)

Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

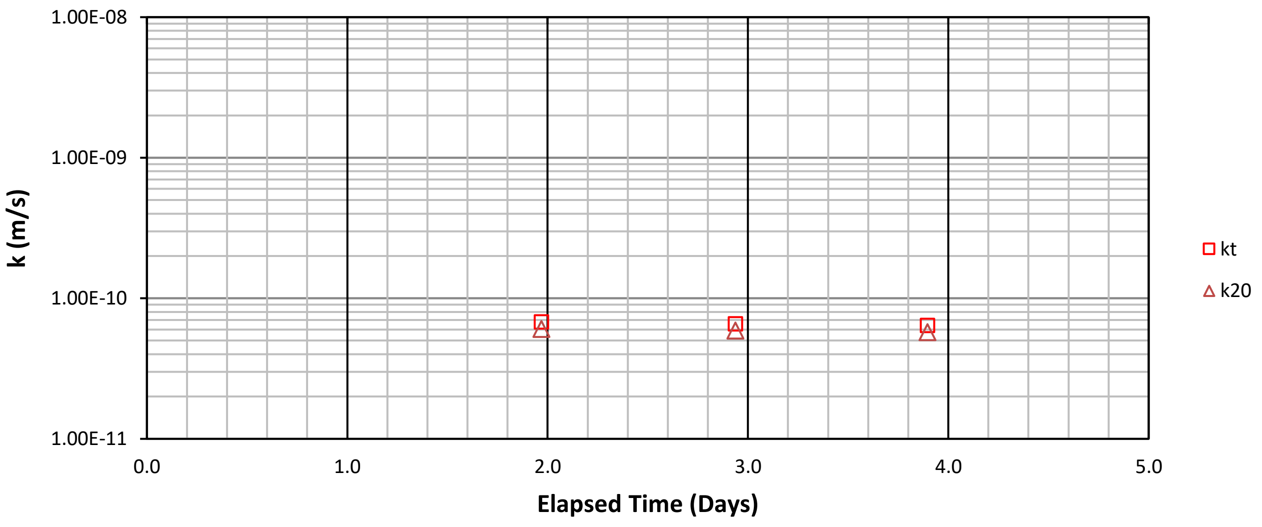
Soil Description:	CLAY - grey, firm, moist, silty, high plasticity
Preparation Process:	Undisturbed
Type of Permeant Liquid:	Deaired Water
Type of Liquid Reservoir:	Burrettes
Confining Pressure (kPa):	172.37
Effective Saturation Stress (kPa):	137.90
Hydraulic Gradient:	53.63
Hydraulic Conductivity, "k" (m/s):	6.6E-11
Hydraulic Conductivity, "k_{20}" (m/s):	**5.9E-11**

Initial Sample Characteristics

Height (mm):	72.48	Dry Density (kg/m^3):	1091.1
Diameter (mm):	52.17	Water Content (%):	54.6
Wet Mass (g):	363.00	Assumed Specific Gravity:	2.738
Area (cm^2):	4.126E-03	Satuartion (%):	99.0
Volume (cm^3):	2.152E-04		

Final Sample Characteristics

Height (mm):	72.65	Dry Density (kg/m^3):	1077.6
Diameter (mm):	52.68	Water Content (%):	56.3
Wet Mass (g):	367.70	Assumed Specific Gravity:	2.738
Area (cm^2):	4.145E-03	Satuartion (%):	100.0
Volume (cm^3):	2.184E-04		



Reviewed by: Lee Boughton
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Approved by: German Leal, M.Eng., P.Eng.
Geotechnical Discipline Lead

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Phone: 204 477 5381

Project Name:	Brady Landfill		
Project Number:	60733855	Supplier/Location:	N/A
Client:	City of Winnipeg	Field Technician:	COlivar
Sample Location:	BH24-01	Sample Date:	July 24, 2024
Sample Depth:	10.67 - 11.28 m	Lab Technician:	LBoughton
Sample Number:	T13	Date Tested:	August 8, 2024

Flexible Wall Permeameter (ASTM D5084-10)

Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

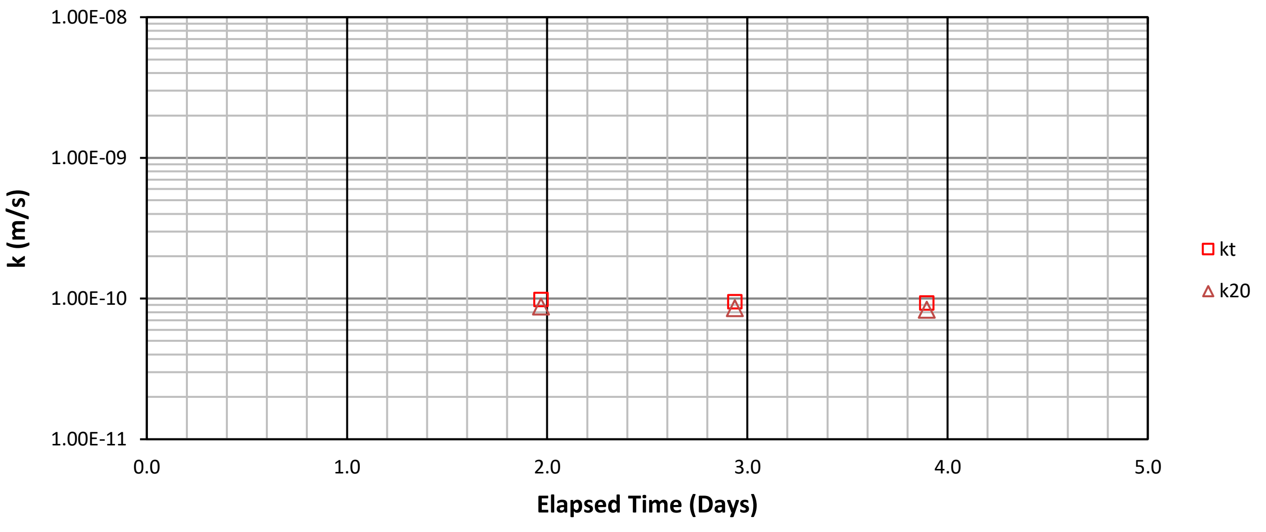
Soil Description:	CLAY - brown, firm, moist, silty, high plasticity
Preparation Process:	Undisturbed
Type of Permeant Liquid:	Deaired Water
Type of Liquid Reservoir:	Burrettes
Confining Pressure (kPa):	172.37
Effective Saturation Stress (kPa):	137.90
Hydraulic Gradient:	52.49
Hydraulic Conductivity, "k" (m/s):	9.6E-11
Hydraulic Conductivity, "k_{20}" (m/s):	**8.6E-11**

Initial Sample Characteristics

Height (mm):	71.17	Dry Density (kg/m^3):	1117.9
Diameter (mm):	53.53	Water Content (%):	55.1
Wet Mass (g):	369.10	Assumed Specific Gravity:	2.675
Area (cm^2):	3.978E-03	Satuartion (%):	105.8
Volume (cm^3):	2.129E-04		

Final Sample Characteristics

Height (mm):	71.67	Dry Density (kg/m^3):	1119.2
Diameter (mm):	53.60	Water Content (%):	52.0
Wet Mass (g):	367.80	Assumed Specific Gravity:	2.675
Area (cm^2):	4.035E-03	Satuartion (%):	100.0
Volume (cm^3):	2.163E-04		



Reviewed by: Lee Boughton
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Approved by: German Leal, M.Eng., P.Eng.
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Project Name:	Brady Landfill		
Project Number:	60733855	Supplier/Location:	N/A
Client:	City of Winnipeg	Field Technician:	COlivar
Sample Location:	BH24-03	Sample Date:	July 24, 2024
Sample Depth:	7.62 - 8.23 m	Lab Technician:	LBoughton
Sample Number:	T10	Date Tested:	August 20, 2024

Flexible Wall Permeameter (ASTM D5084-10)

Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

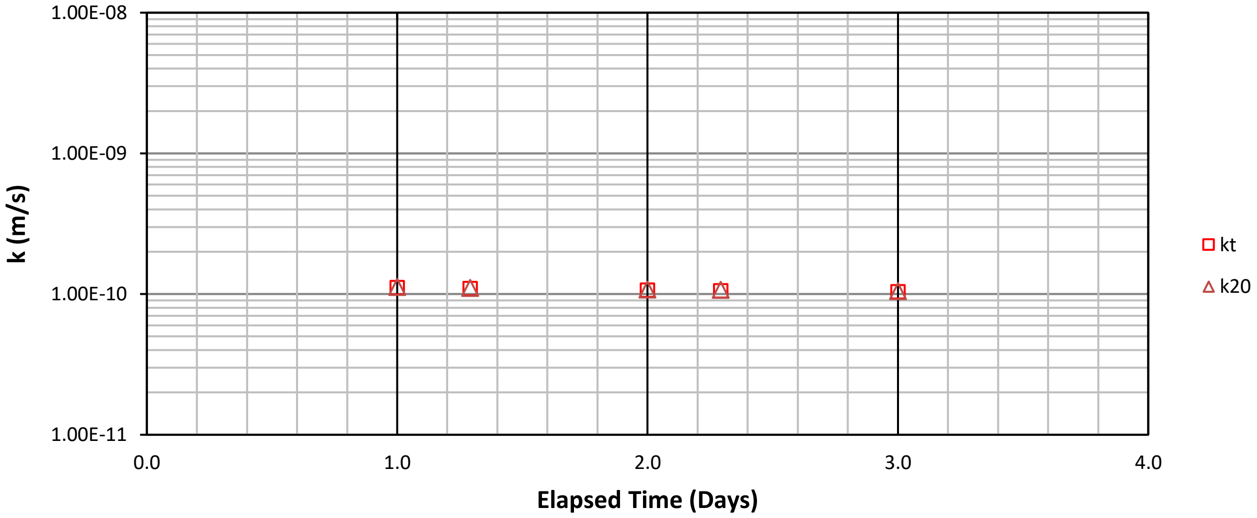
Soil Description:	CLAY - grey, firm, moist, silty, high plasticity
Preparation Process:	Undisturbed
Type of Permeant Liquid:	Deaired Water
Type of Liquid Reservoir:	Burrettes
Confining Pressure (kPa):	172.37
Effective Saturation Stress (kPa):	137.90
Hydraulic Gradient:	52.24
Hydraulic Conductivity, "k" (m/s):	1.1E-10
Hydraulic Conductivity, "k$_{20}$" (m/s):	**1.1E-10**

Initial Sample Characteristics

Height (mm):	72.43	Dry Density (kg/m^3):	1203.9
Diameter (mm):	53.48	Water Content (%):	46.6
Wet Mass (g):	389.00	Assumed Specific Gravity:	2.725
Area (cm^2):	4.121E-03	Satuartion (%):	100.6
Volume (cm^3):	2.204E-04		

Final Sample Characteristics

Height (mm):	73.02	Dry Density (kg/m^3):	1174.4
Diameter (mm):	54.15	Water Content (%):	48.4
Wet Mass (g):	395.30	Assumed Specific Gravity:	2.725
Area (cm^2):	4.188E-03	Satuartion (%):	100.0
Volume (cm^3):	2.268E-04		



Reviewed by: Lee Boughton
Laboratory Manager

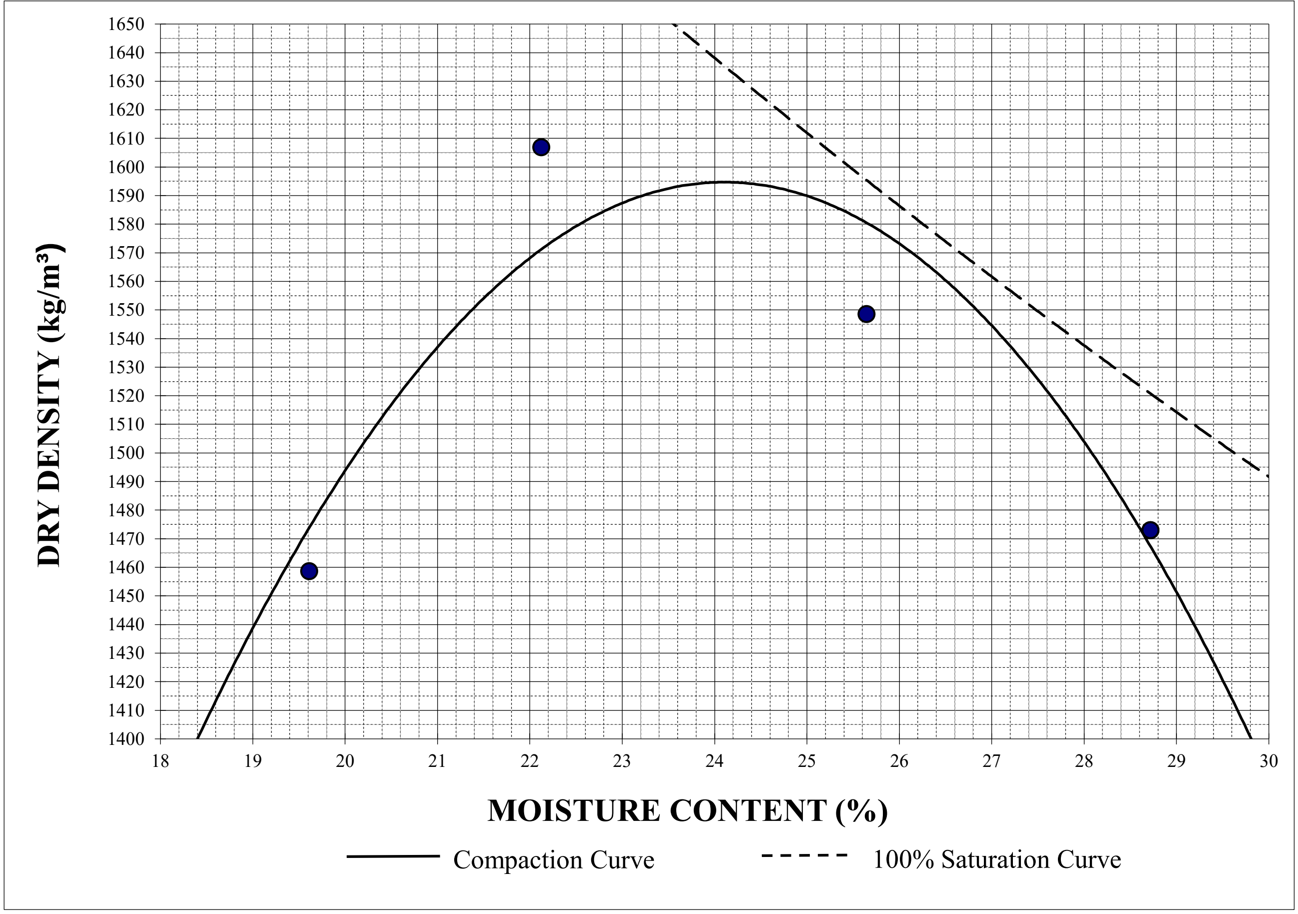
Approved by: German Leal, M.Eng., P.Eng.
Geotechnical Discipline Lead

Project Name:	Brady Landfill		
Project Number:	60733855	Supplier/Location:	Brady Landfill
Client:	City of Winnipeg	Field Technician:	COlivar
Sample Location:	BH24-01 to BH24-15	Sample Date:	22-Jul-24
Sample Depth :	0.46 - 1.52 m	Lab Technician:	JEnriquez
Sample Number:	Varies	Date Tested:	15-Aug-24

Standard Proctor (ASTM D698)

Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³))

TRIAL NUMBER	1	2	3	4	5
Wet Unit Weight (kg/m³)	1745	1962	1946	1896	
Dry Unit Weight (kg/m³)	1459	1607	1549	1473	
Moisture Content (%)	19.6	22	26	29	



Description / Remarks:	
Received moisture content (%)	N/A
Specific Gravity (Assumed)	2.70
Method Used	A
Method of Preparation	Moist
Type of Rammer	Manual
Soil Description	Fat Clay (CH)
Soil Colour	Black

MAXIMUM DRY DENSITY (kg/m³):	**1595**
OPTIMUM MOISTURE (%):	**24.1**
PROCTOR No.:	P0001

Reviewed by: Lee Boughton
Laboratory Manager

Approved by: German Leal, M.Eng., P.Eng.
Geotechnical Discipline Lead

CALIFORNIA BEARING RATIO (CBR) TEST

ASTM D1883

Client: City of Winnipeg
Project Name: Brady Landfill
Project Number: 60733855
Location: Winnipeg, MB

Test Hole ID: See Note
Sample ID: *B1*
Sample Depth (m): 0.45m to 1.50 m
Soil Description: Clay (CH)
Tested By: JE
Tested Date: August 16, 2024

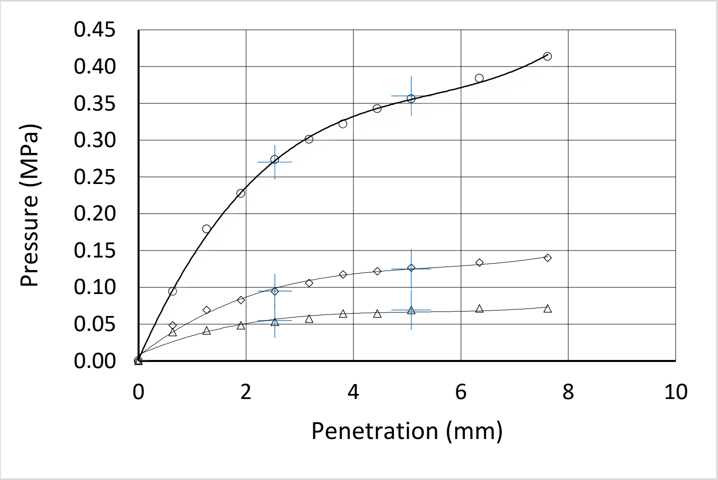
PROCTOR DATA	
Optimum Moisture Content (%)	20.4
Maximum Dry Density (kg/m3)	1595
Proctor Test Method	Standard
Tested by:	LB

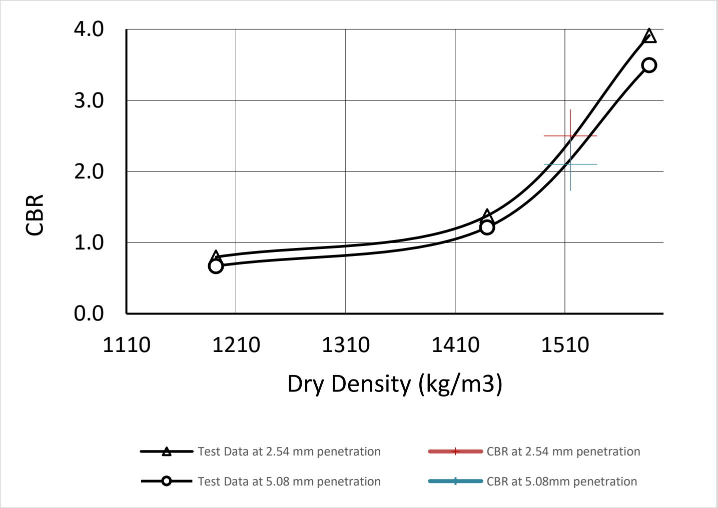
Remark:

Soaked CBR at 95% of SPMDD

CBR DATA	10 blows	25 blows	56 blows
Moisture Content, MC (%)	21.1%	21.5%	20.8%
Wet Density (kg/m3)	1444.0	1748.8	1917.9
Dry Density (kg/m3)	1191.9	1439.1	1587.0
Compaction Degree (%)	75%	90%	100%
Surcharge Weight (g)	4506	4506	4506
Soaked for (days)	4	4	4
Swell (%)	0.1%	0.6%	0.3%

PENETRATION DATA





Penetration (mm)	Pressure (MPa)		
0	0.0	0.0	0.0
0.635	0.04	0.05	0.09
1.27	0.04	0.07	0.18
1.905	0.05	0.08	0.23
2.54	**0.05**	**0.09**	**0.27**
3.175	0.06	0.11	0.30
3.81	0.06	0.12	0.32
4.445	0.06	0.12	0.34
5.08	**0.07**	**0.13**	**0.36**
6.35	0.07	0.13	0.38
7.62	0.07	0.14	0.41
10.16	0.07	0.16	0.47
12.7	0.08	0.17	0.52
Corrected Pressure (MPa)			
at 2.54 mm	0.06	0.10	0.27
at 5.08 mm	0.07	0.13	0.36
Corrected Bearing Ratio			
at 2.54 mm	0.8	1.4	3.9
at 5.08 mm	0.7	1.2	3.5

Standard pressure: 6.9 Mpa at 2.54 mm penetration

10.3 Mpa at 5.08mm penetration

CBR Value

CBR at **95 % of** **maximum dry density**
Dry density, kg/m3: **1515**
CBR at 2.54 mm: **2.5**
CBR at 5.08 mm: **2.1**

Note

PROCTOR NUMBER: 2401

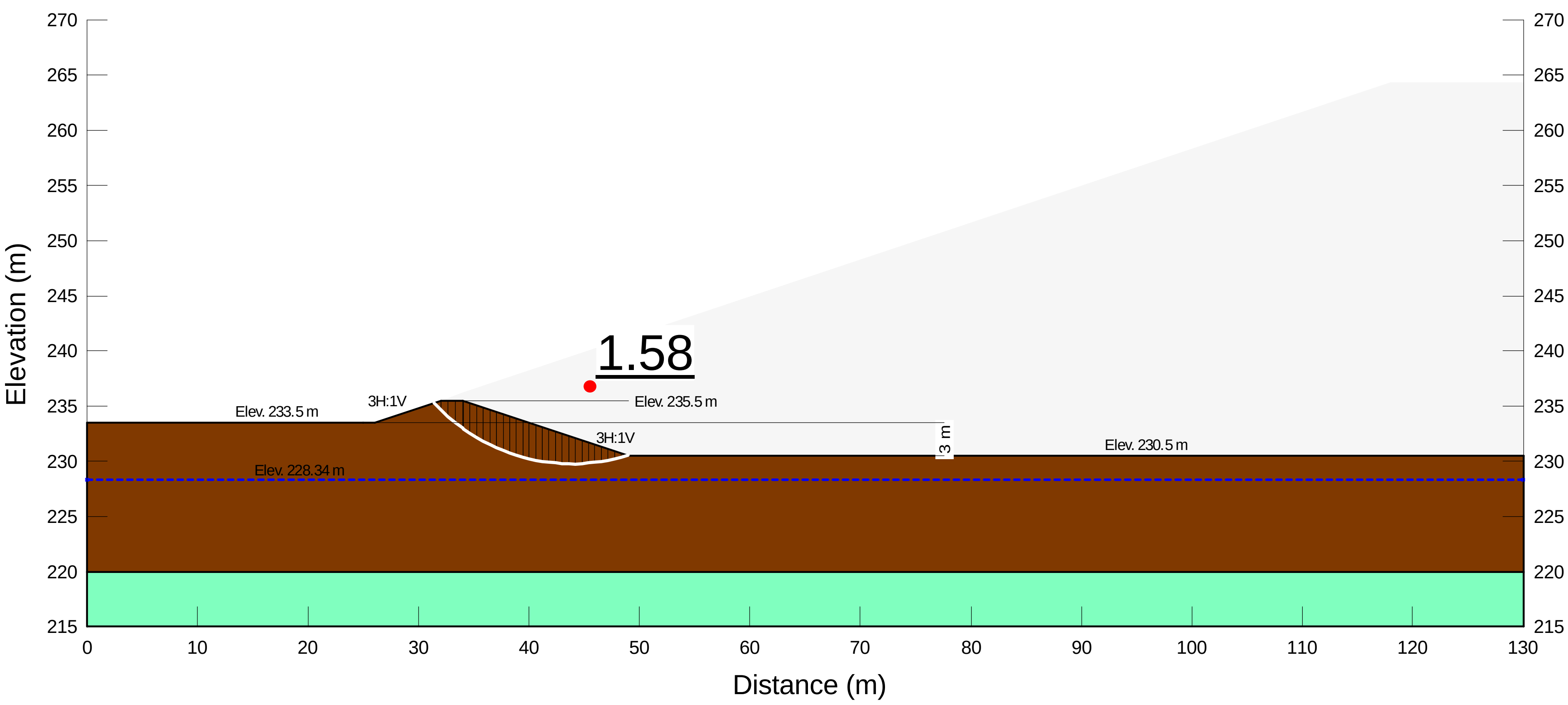
Reviewed and Approved by:

German Leal, M.Eng., P.Eng.
Geotechnical Discipline Lead

Appendix E

Slope Stability Design Outputs

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1

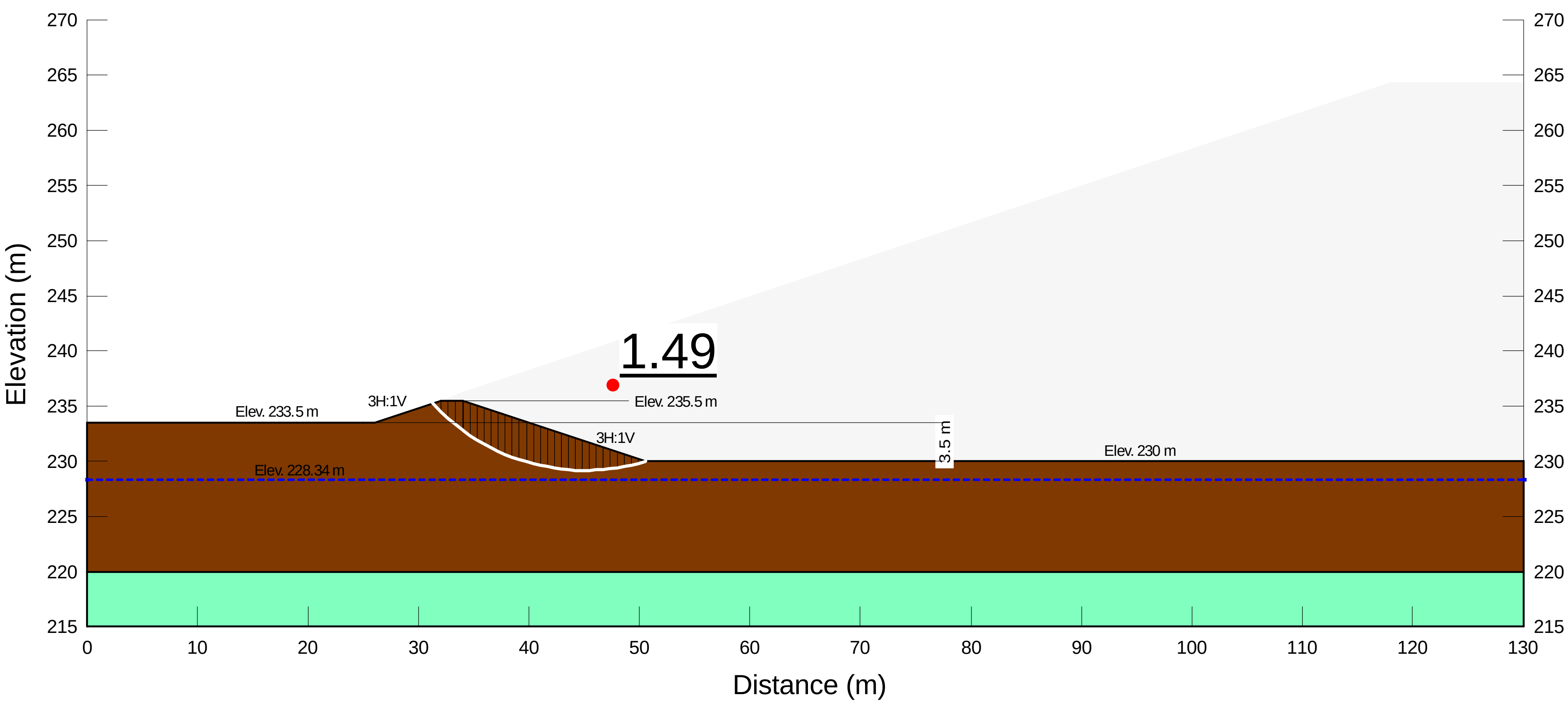


Cell 35: West Berm Cross-Section GW 228.34, Berm 235.5

Short Term - 3.0 m Excavation

2024-12-13 Figure 1 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1

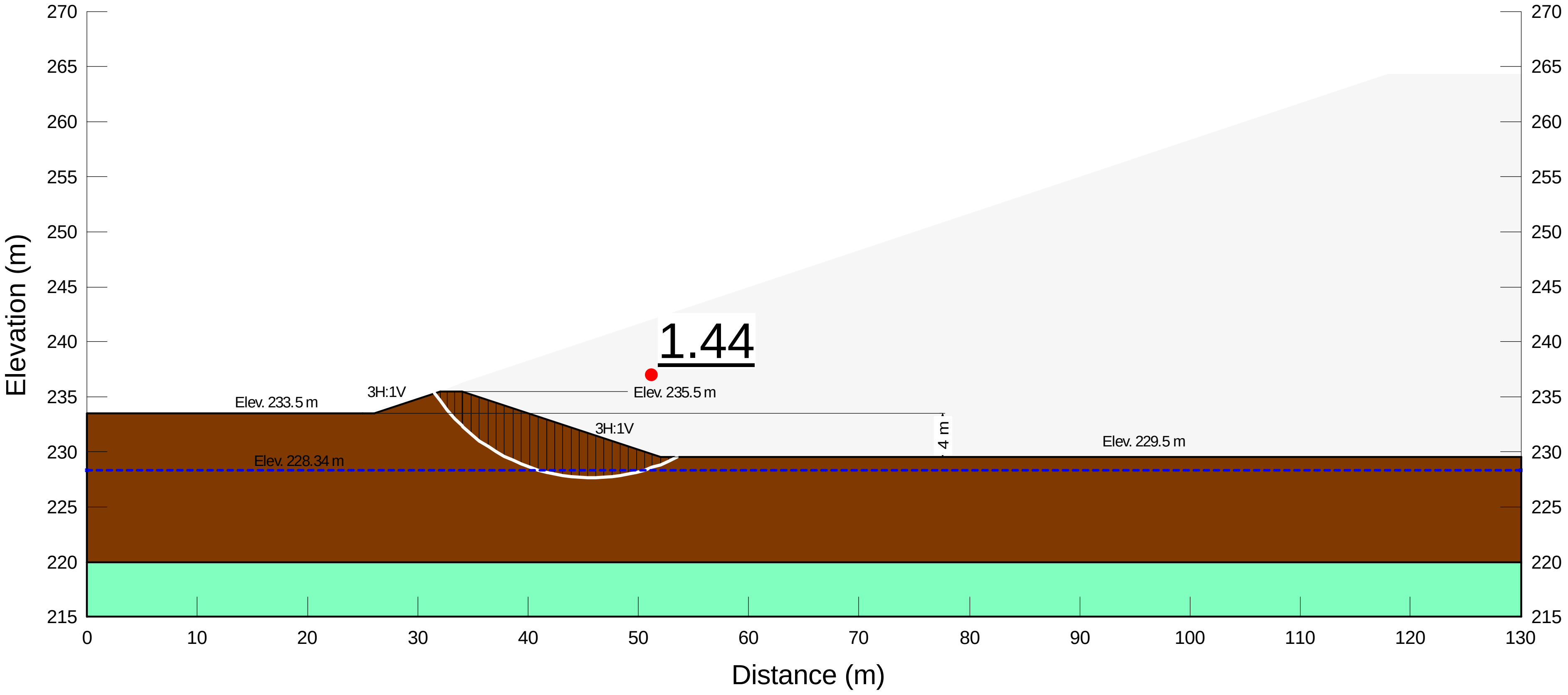


Cell 35: West Berm Cross-Section GW 228.34, Berm 235.5

Short Term - 3.5 m Excavation

2024-12-13 Figure 2 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1

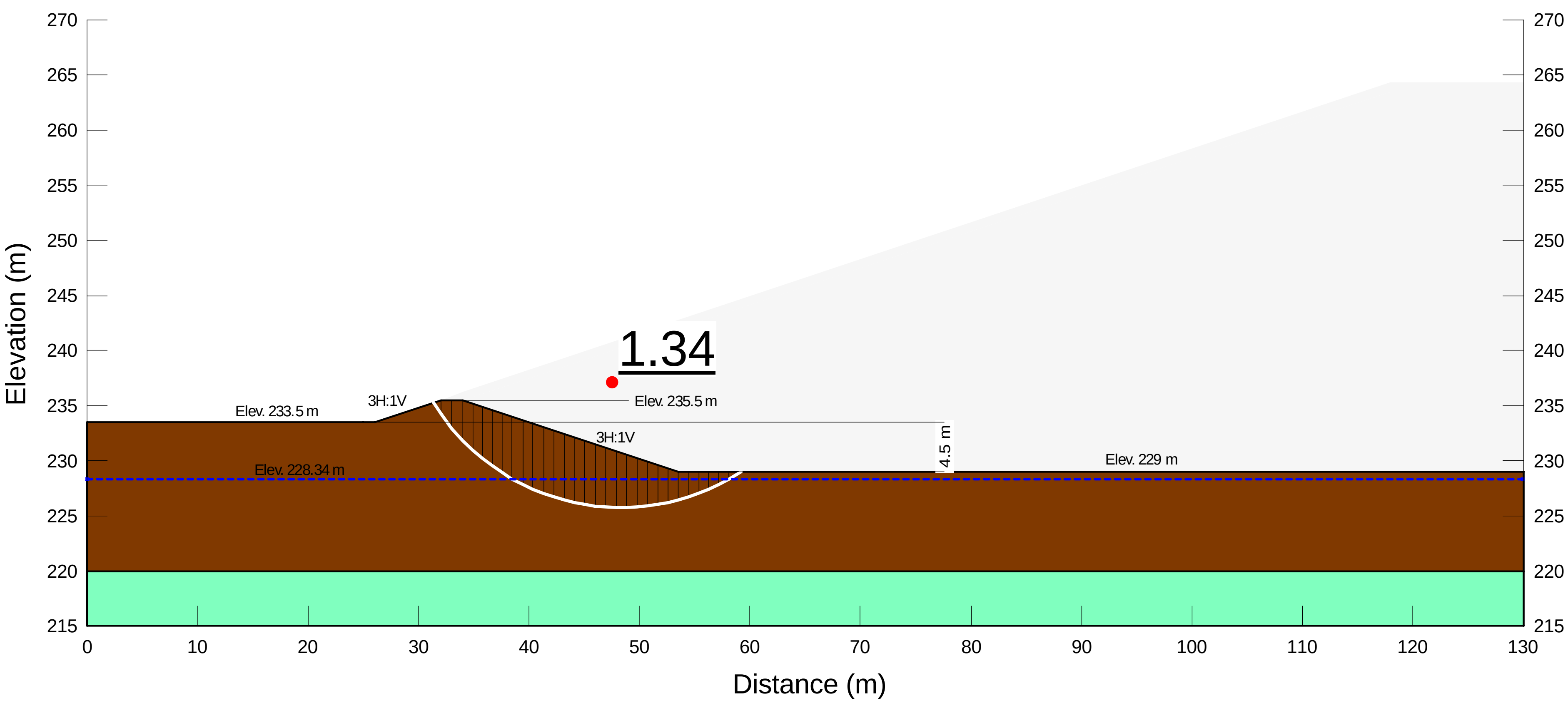


Cell 35: West Berm Cross-Section GW 228.34, Berm 235.5

Short Term - 4.0 m Excavation

2024-12-13 Figure 3 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1

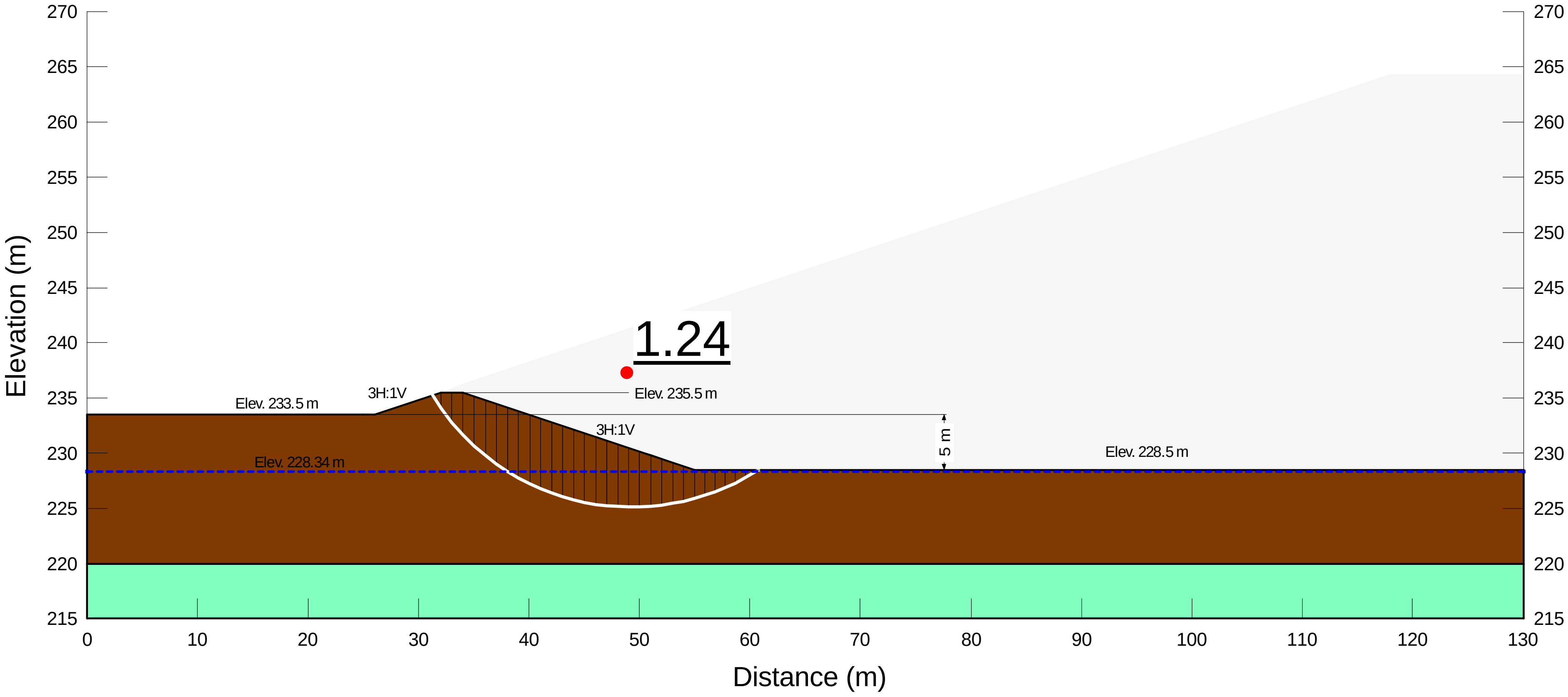


Cell 35: West Berm Cross-Section GW 228.34, Berm 235.5

Short Term - 4.5 m Excavation

2024-12-13 Figure 4 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1

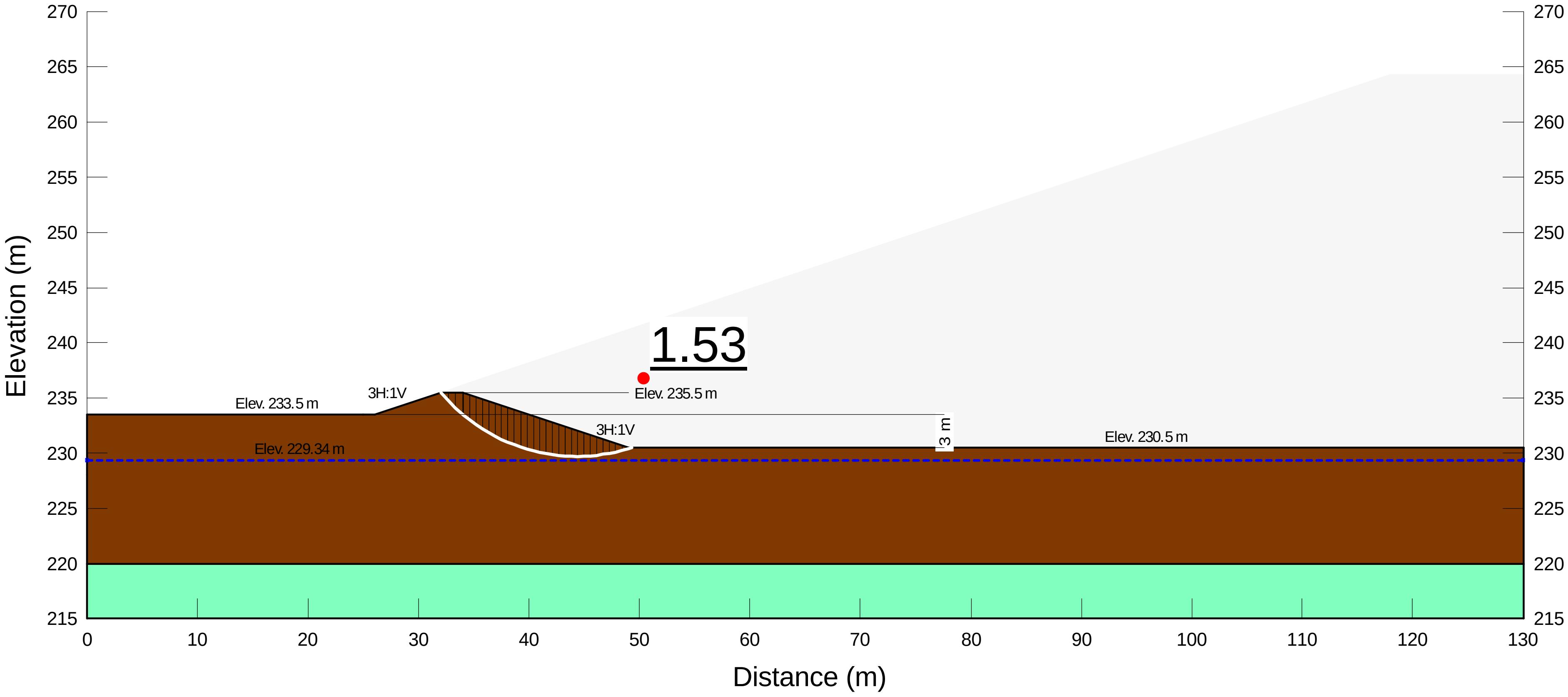


Cell 35: West Berm Cross-Section GW 228.34, Berm 235.5

Short Term - 5.0 m Excavation

2024-12-13 Figure 5 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1

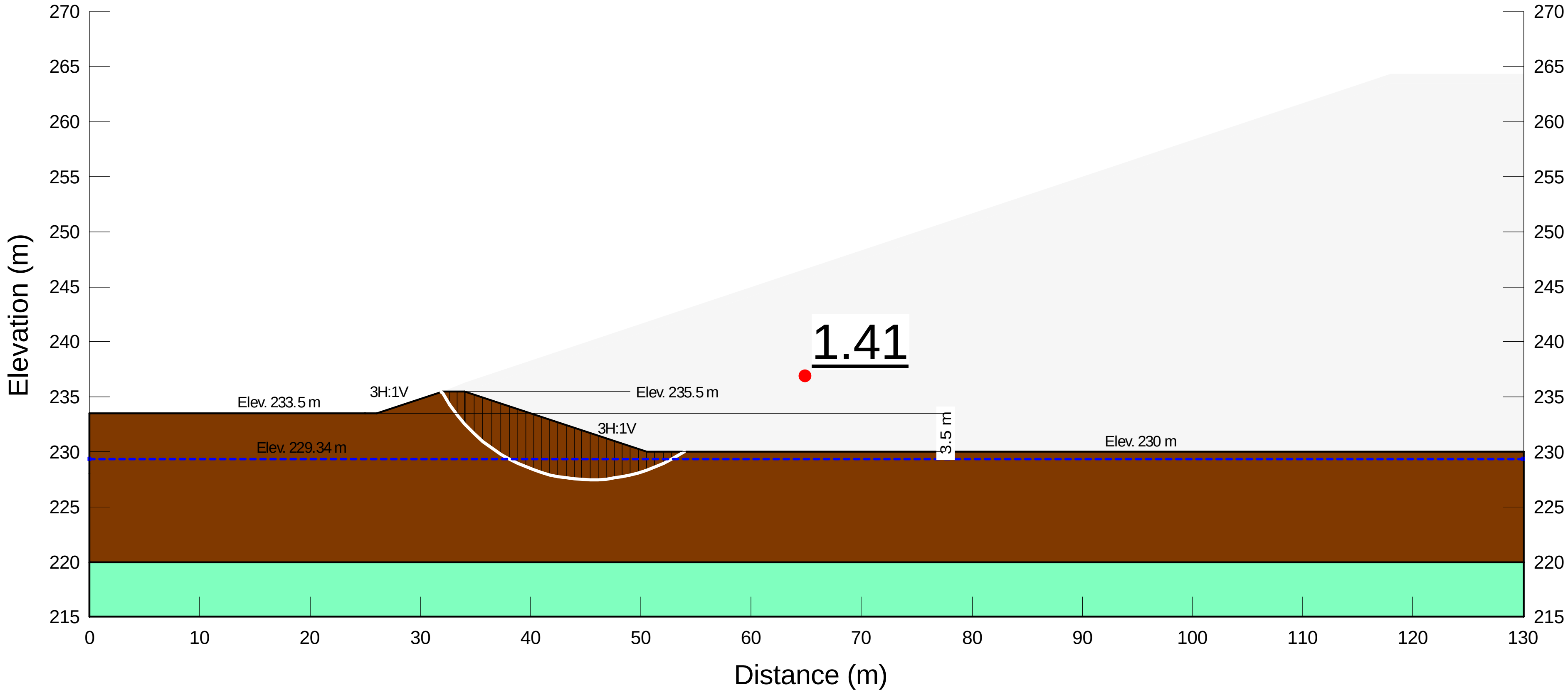


Cell 35: West Berm Cross-Section GW 229.34, Berm 235.5

Short Term - 3.0 m Excavation

2024-12-13 Figure 6 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1

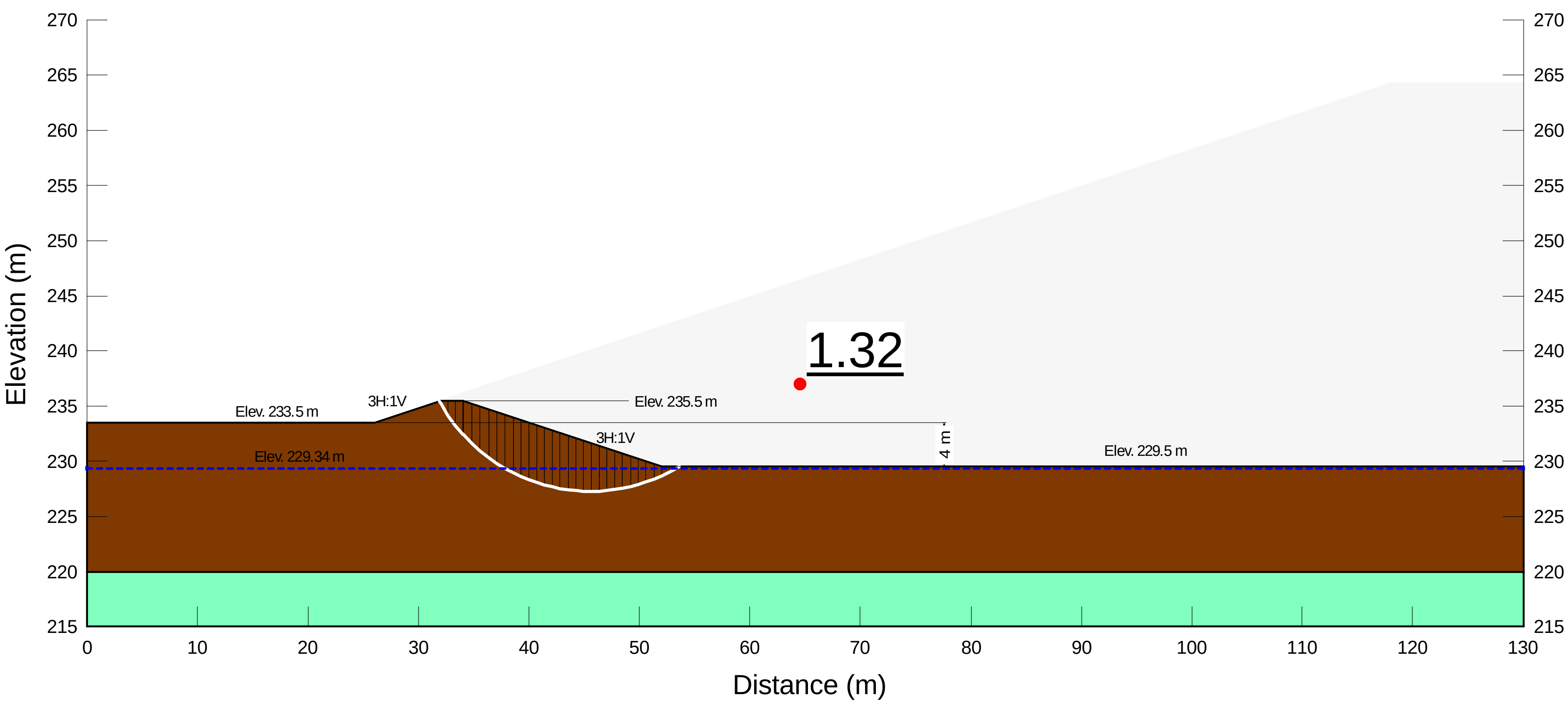


Cell 35: West Berm Cross-Section GW 229.34, Berm 235.5

Short Term - 3.5 m Excavation

2024-12-13 Figure 7 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1

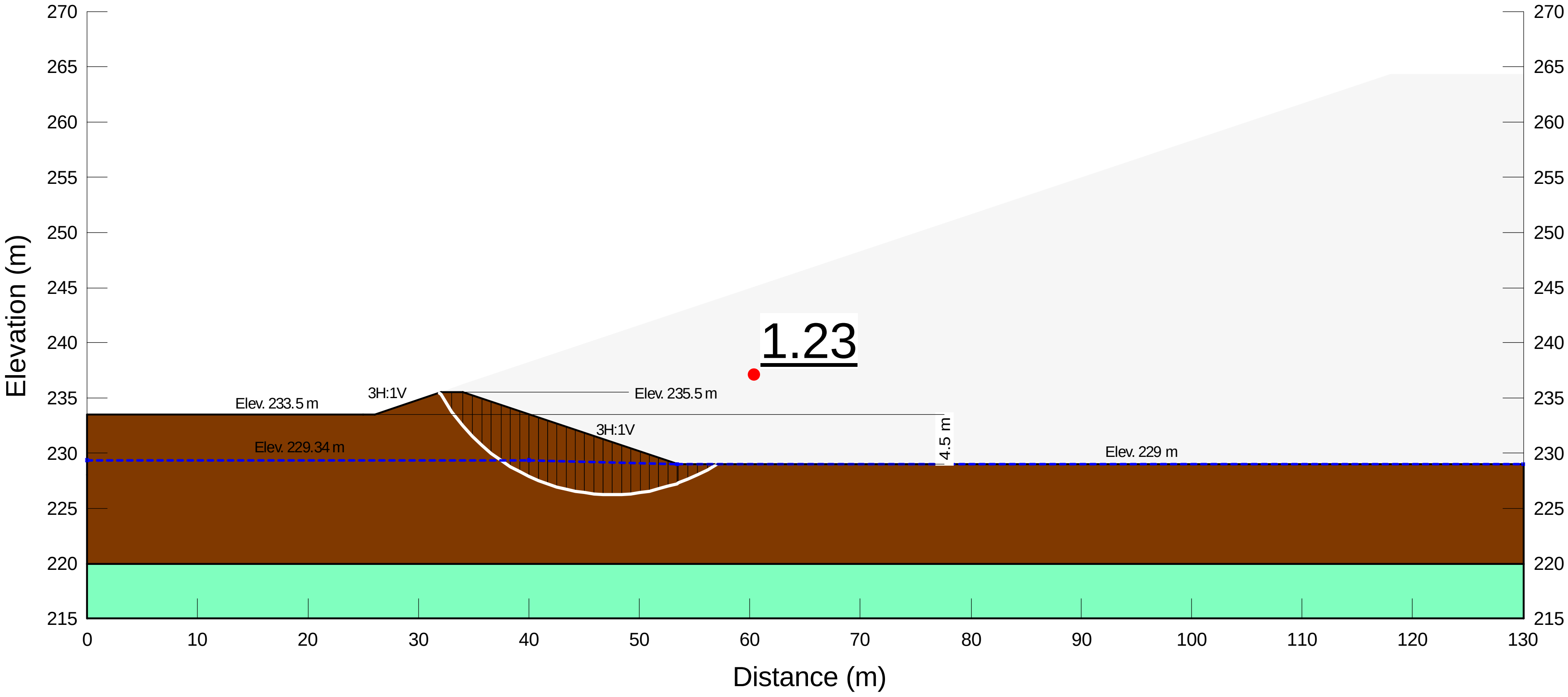


Cell 35: West Berm Cross-Section GW 229.34, Berm 235.5

Short Term - 4.0 m Excavation

2024-12-13 Figure 8 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1

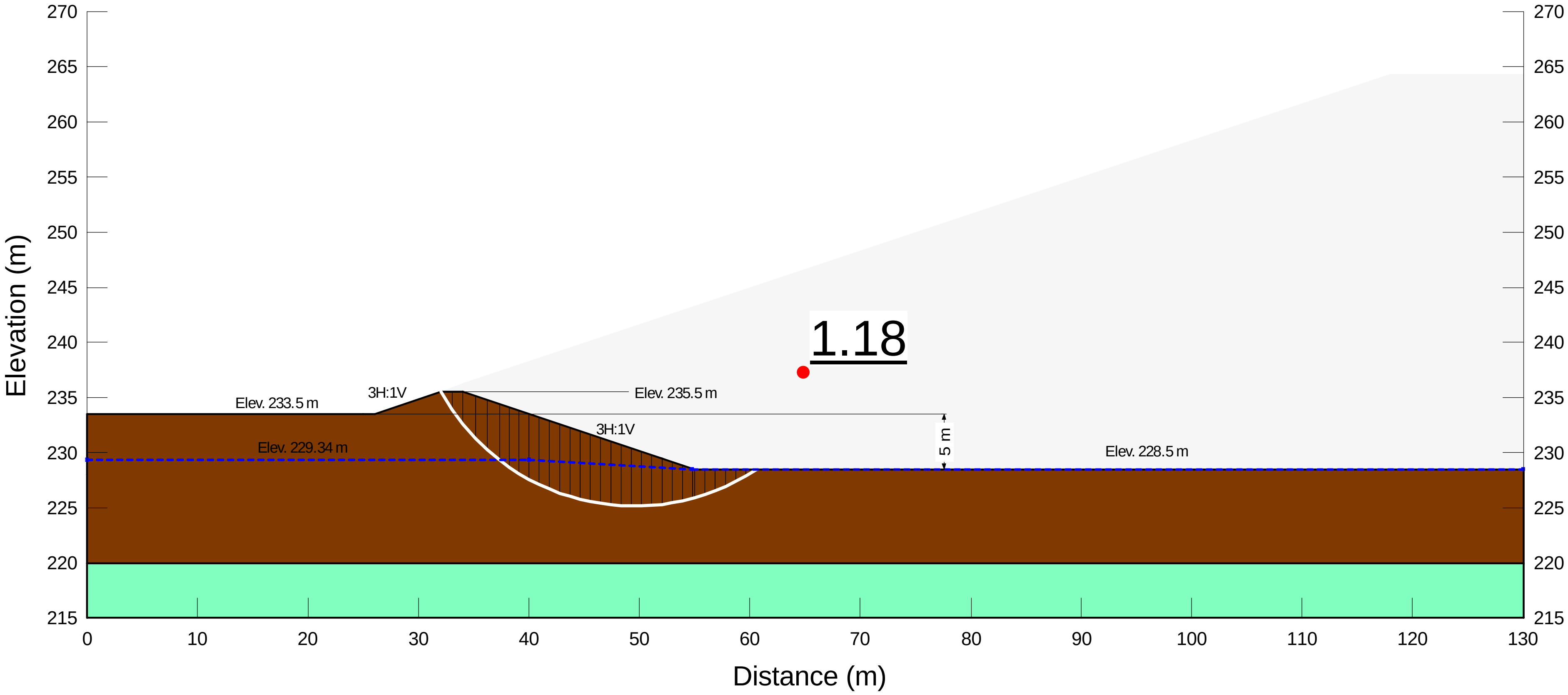


Cell 35: West Berm Cross-Section GW 229.34, Berm 235.5

Short Term - 4.5 m Excavation

2025-01-20 Figure 9 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1

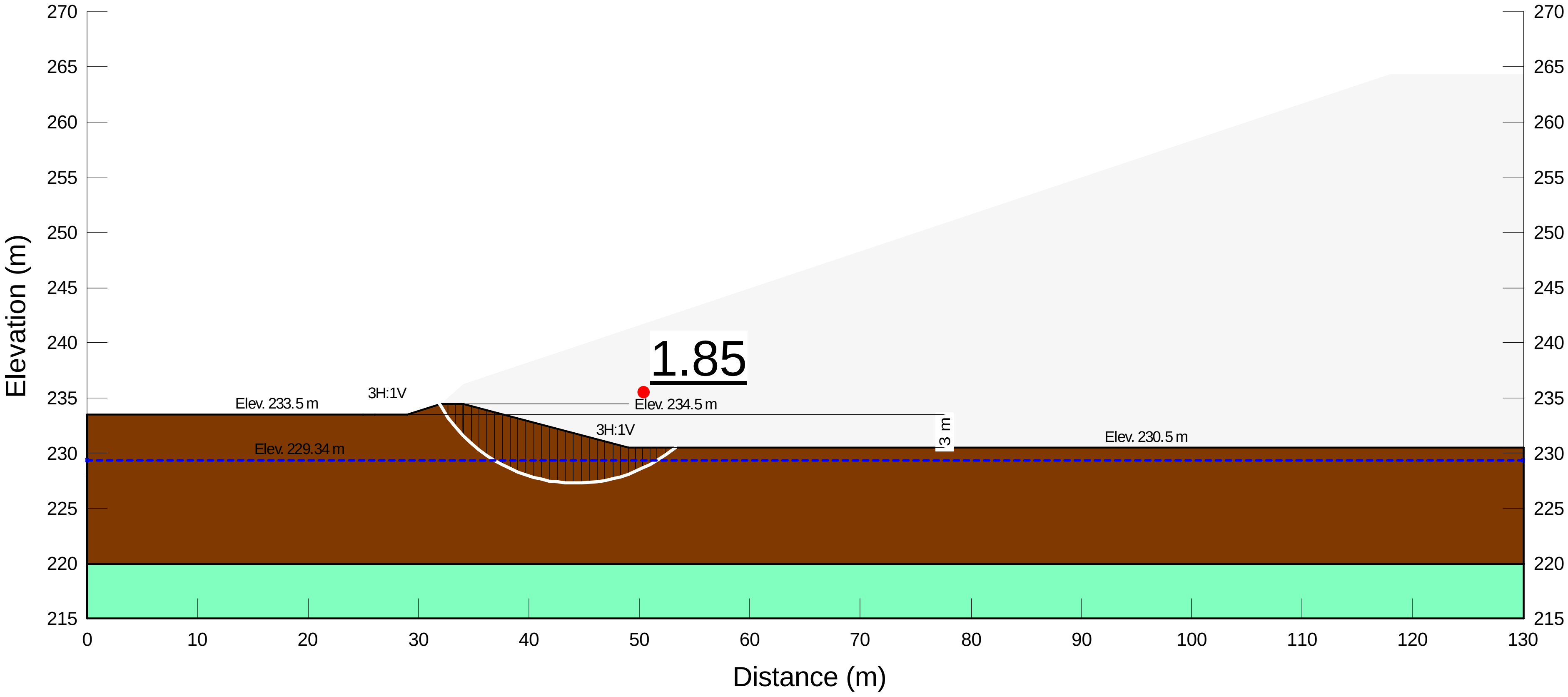


Cell 35: West Berm Cross-Section GW 229.34, Berm 235.5

Short Term - 5.0 m Excavation

2025-01-20 Figure 10 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1

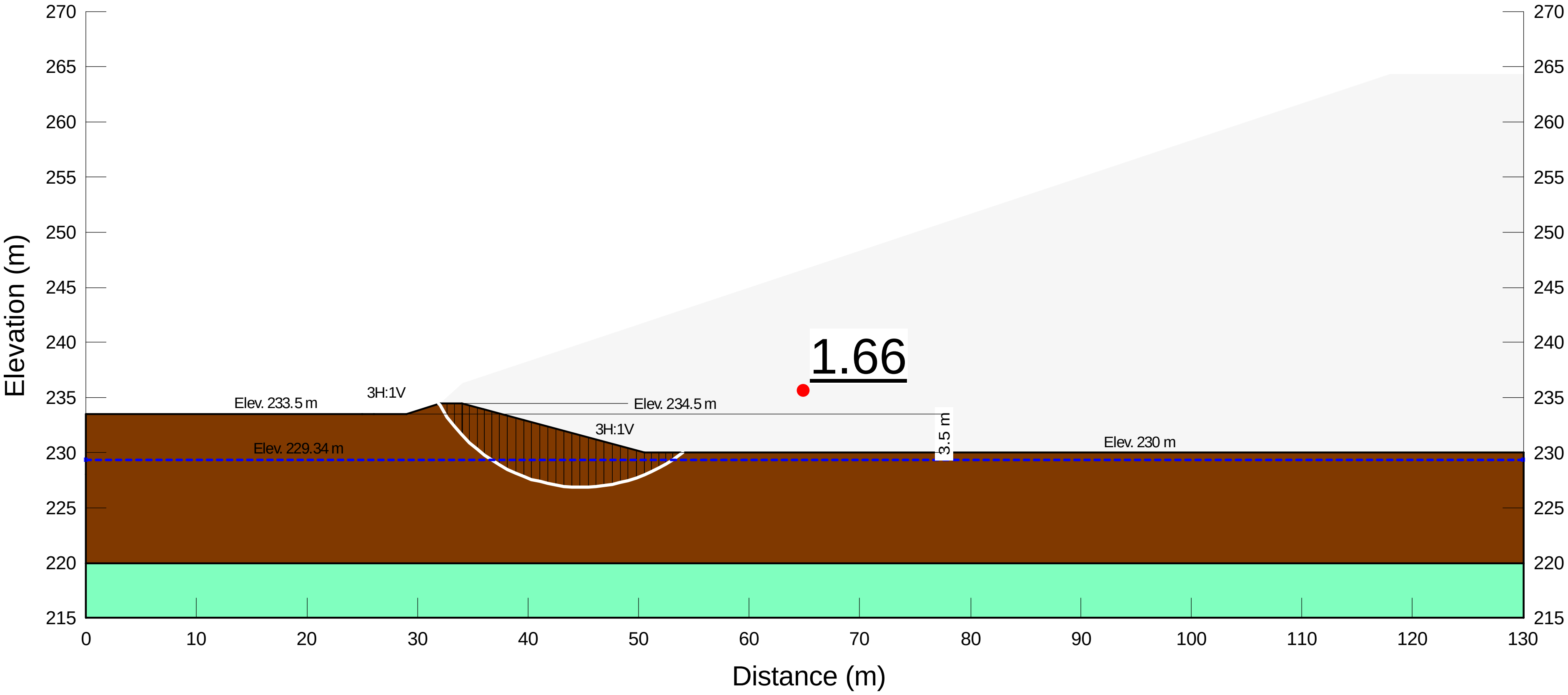


Cell 35: West Berm Cross-Section GW 229.34, Berm 234.5

Short Term - 3.0 m Excavation

2024-12-12 Figure 11 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1

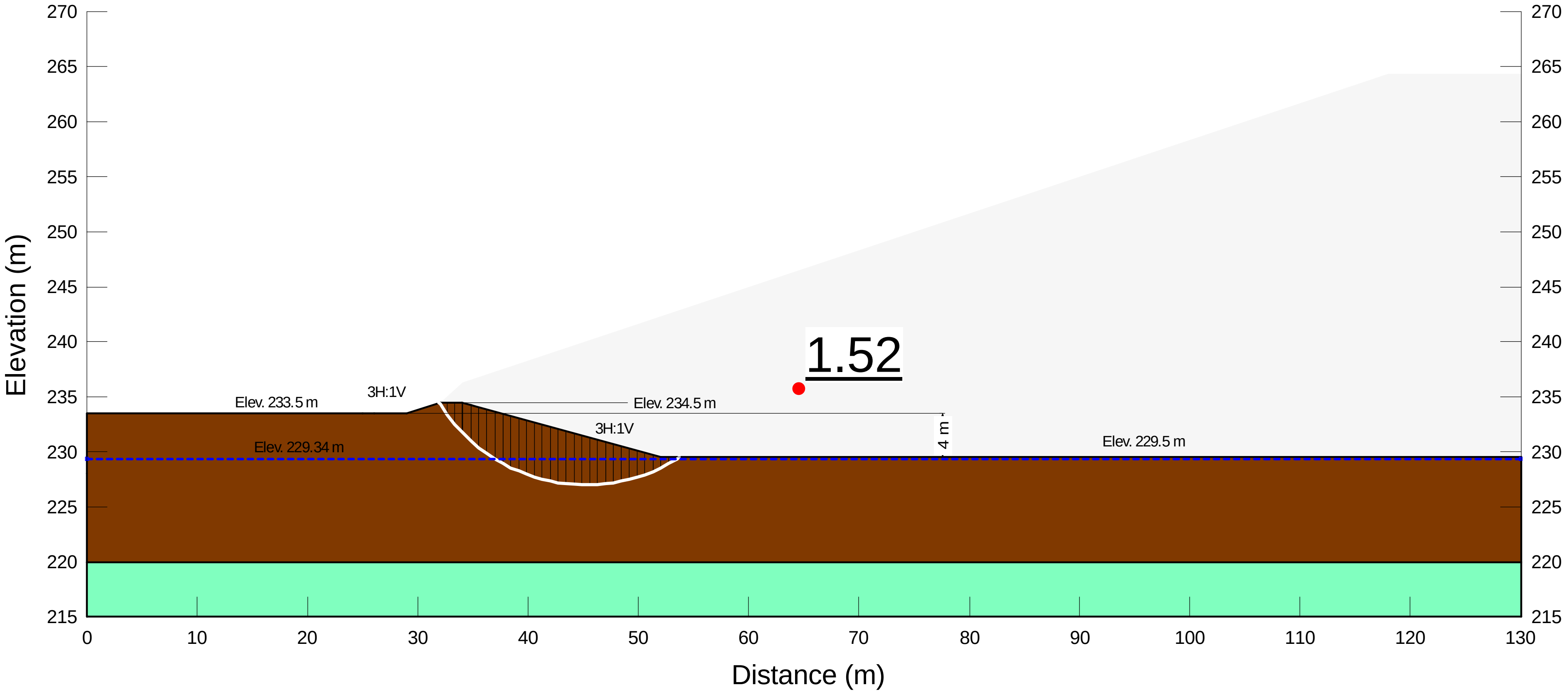


Cell 35: West Berm Cross-Section GW 229.34, Berm 234.5

Short Term - 3.5 m Excavation

2024-12-12 Figure 12 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1

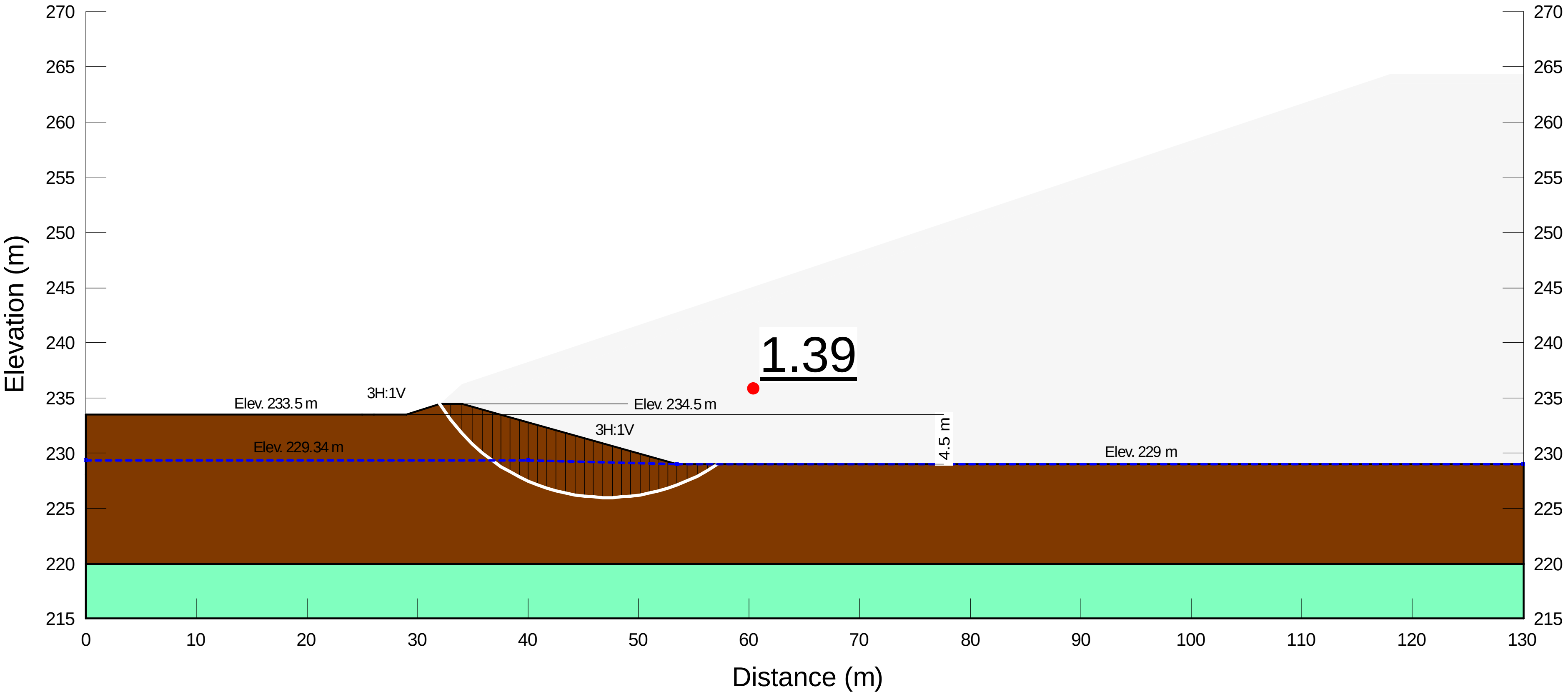


Cell 35: West Berm Cross-Section GW 229.34, Berm 234.5

Short Term - 4.0 m Excavation

2024-12-12 Figure 13 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1

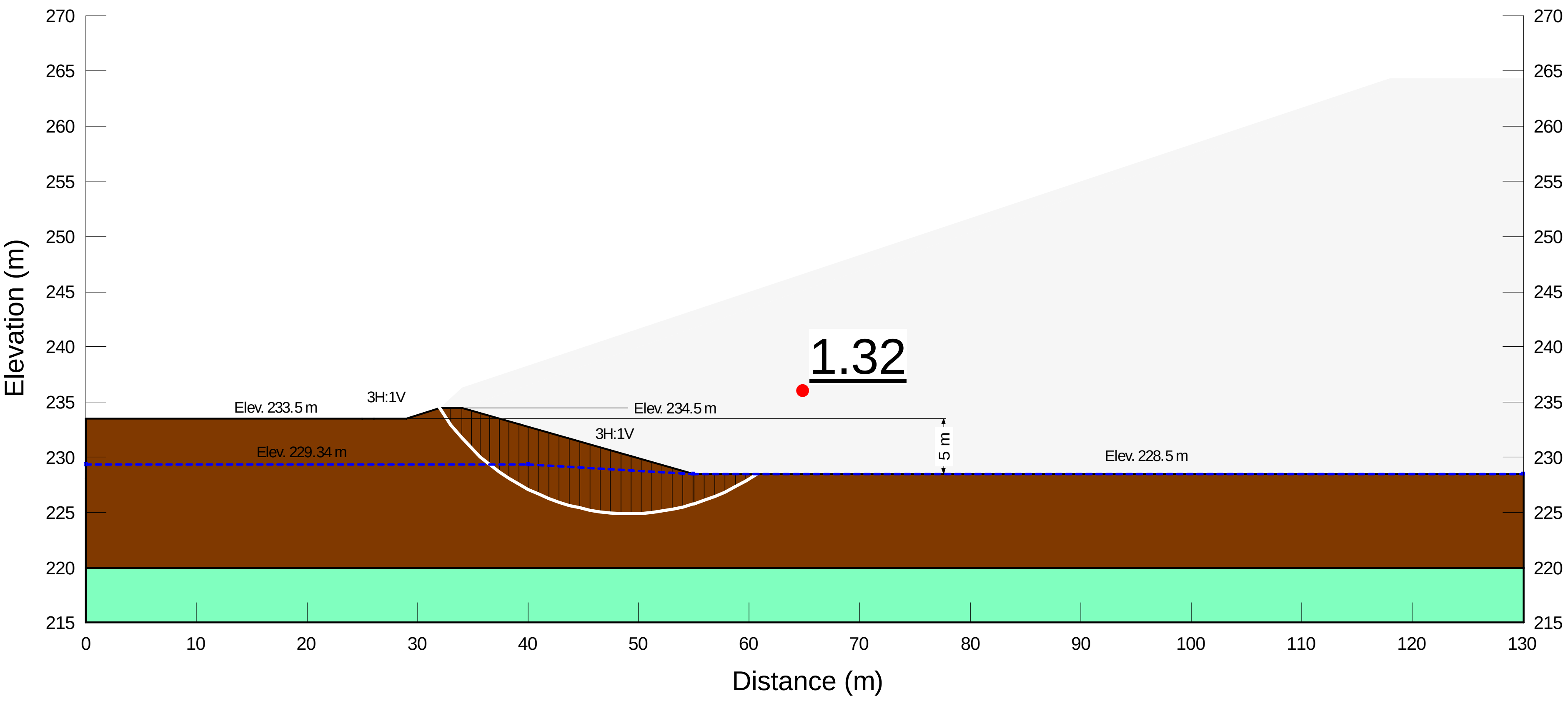


Cell 35: West Berm Cross-Section GW 229.34, Berm 234.5

Short Term - 4.5 m Excavation

2025-01-20 Figure 14 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1

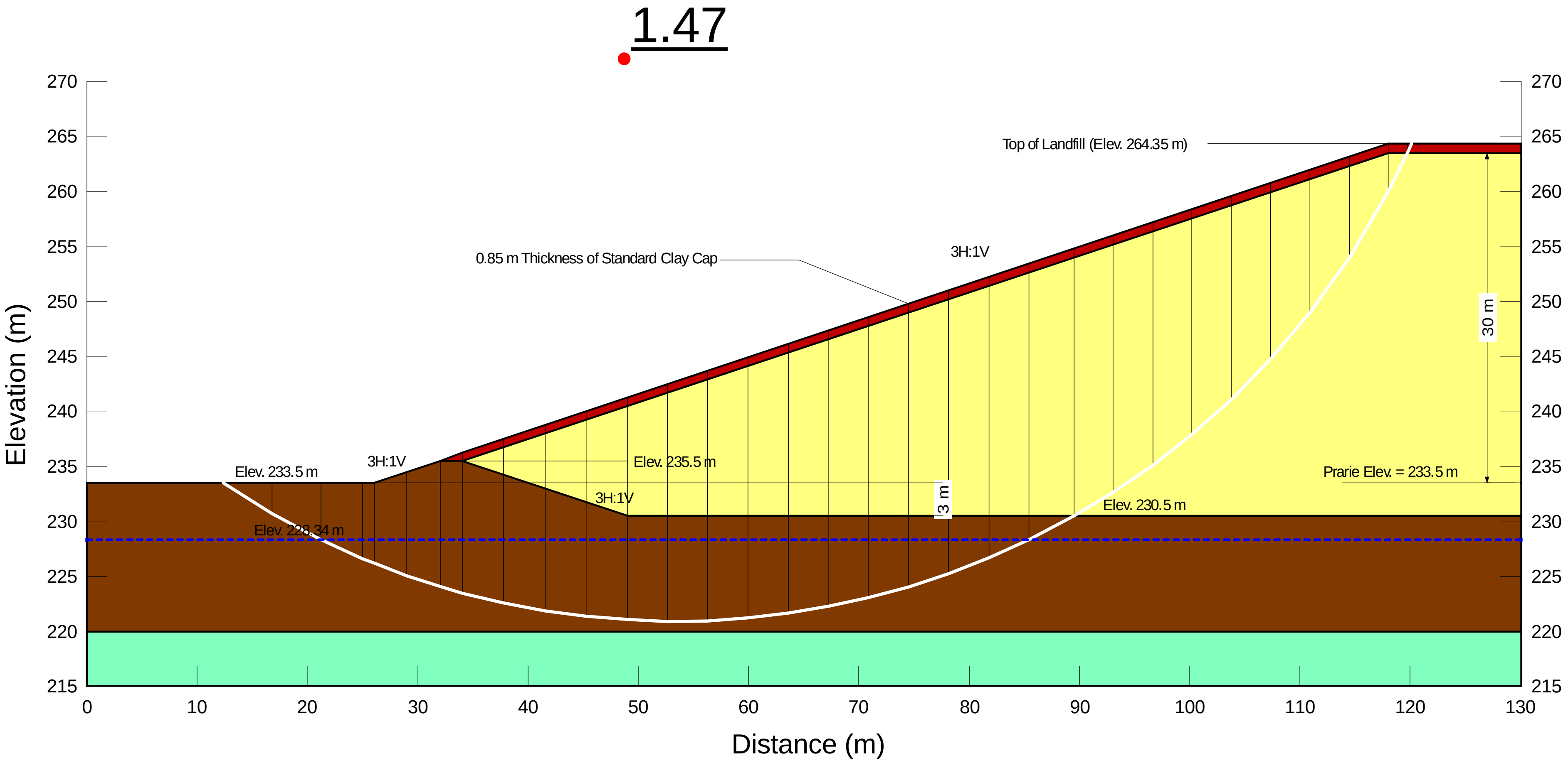


Cell 35: West Berm Cross-Section GW 229.34, Berm 234.5

Short Term - 5.0 m Excavation

2025-01-20 Figure 15 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟥	Clay Cap	Mohr-Coulomb	17.5	5	15	0	1
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1
🟨	Landfill Waste	Mohr-Coulomb	13.7	0	30	0	1

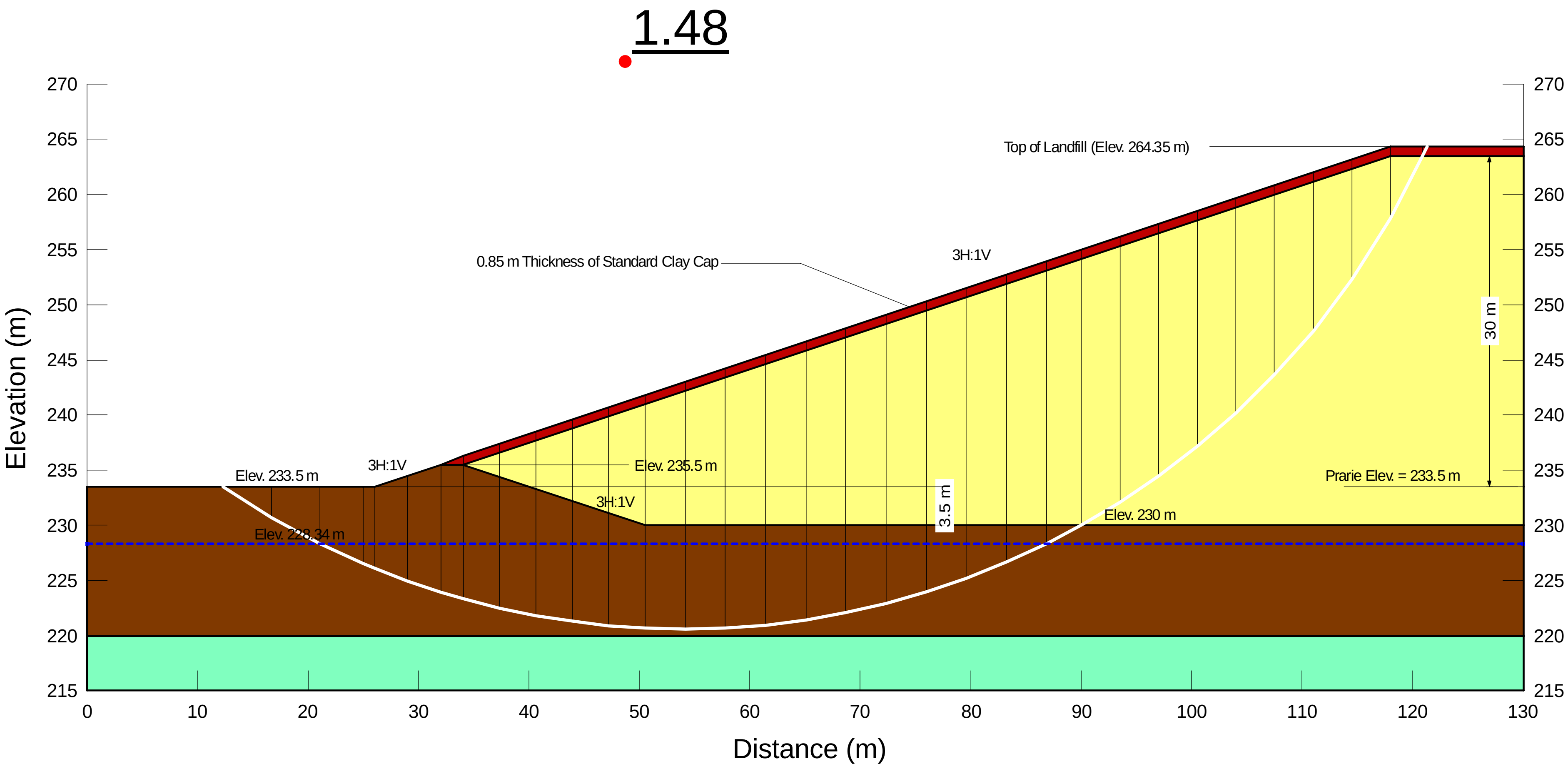


Cell 35: West Berm Cross-Section (Option 1)

Long Term - 3.0 m Excavation & 30 m Landfill

2024-12-12 Figure 16 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟥	Clay Cap	Mohr-Coulomb	17.5	5	15	0	1
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1
🟨	Landfill Waste	Mohr-Coulomb	13.7	0	30	0	1

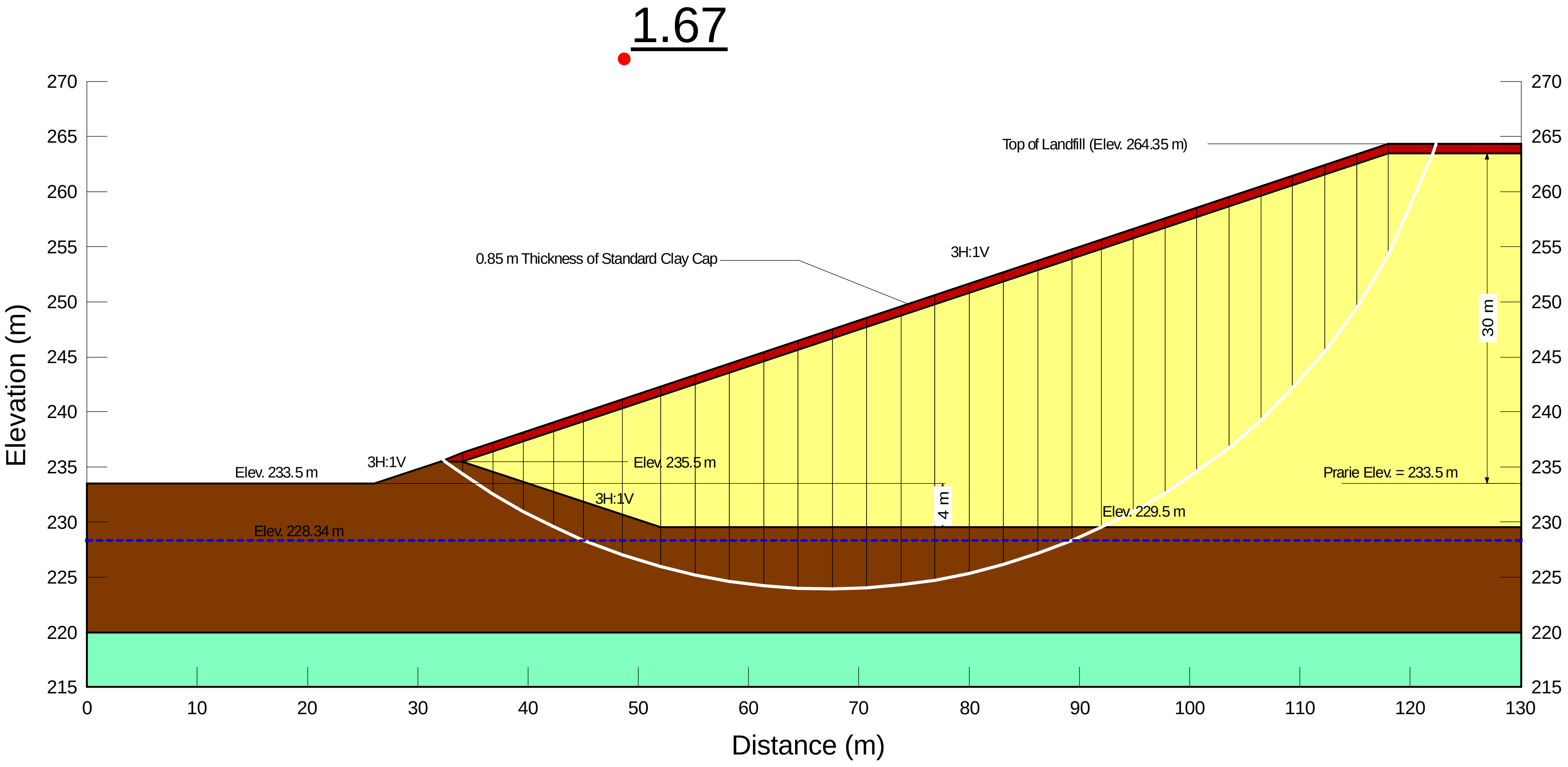


Cell 35: West Berm Cross-Section (Option 1)

Long Term - 3.5 m Excavation & 30 m Landfill

2024-12-12 Figure 17 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟥	Clay Cap	Mohr-Coulomb	17.5	5	15	0	1
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1
🟨	Landfill Waste	Mohr-Coulomb	13.7	0	30	0	1

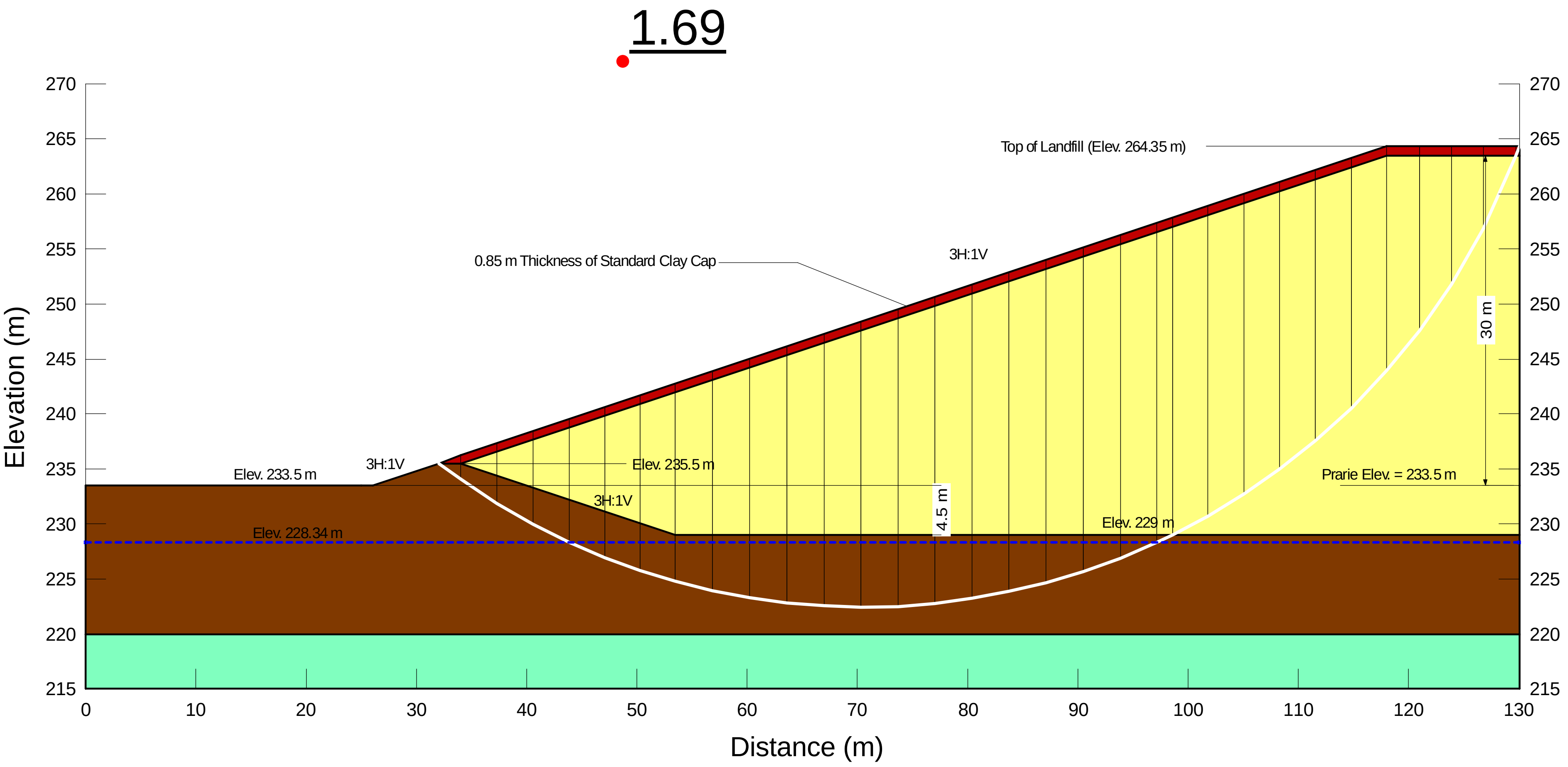


Cell 35: West Berm Cross-Section (Option 1)

Long Term - 4.0 m Excavation & 30 m Landfill

2024-12-12 Figure 18 1:570

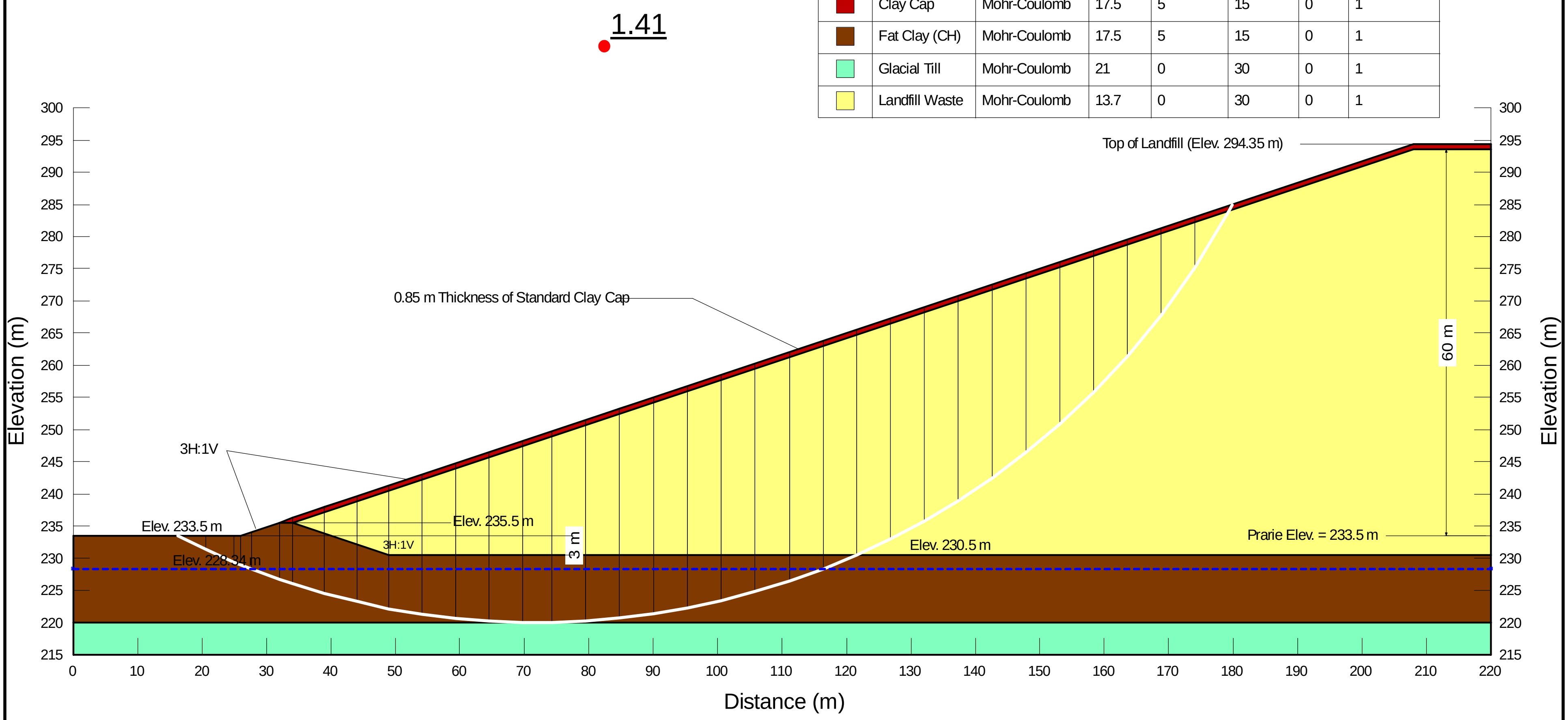
Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟥	Clay Cap	Mohr-Coulomb	17.5	5	15	0	1
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1
🟨	Landfill Waste	Mohr-Coulomb	13.7	0	30	0	1



Cell 35: West Berm Cross-Section (Option 1)

Long Term - 4.5 m Excavation & 30 m Landfill

2024-12-12 Figure 19 1:570



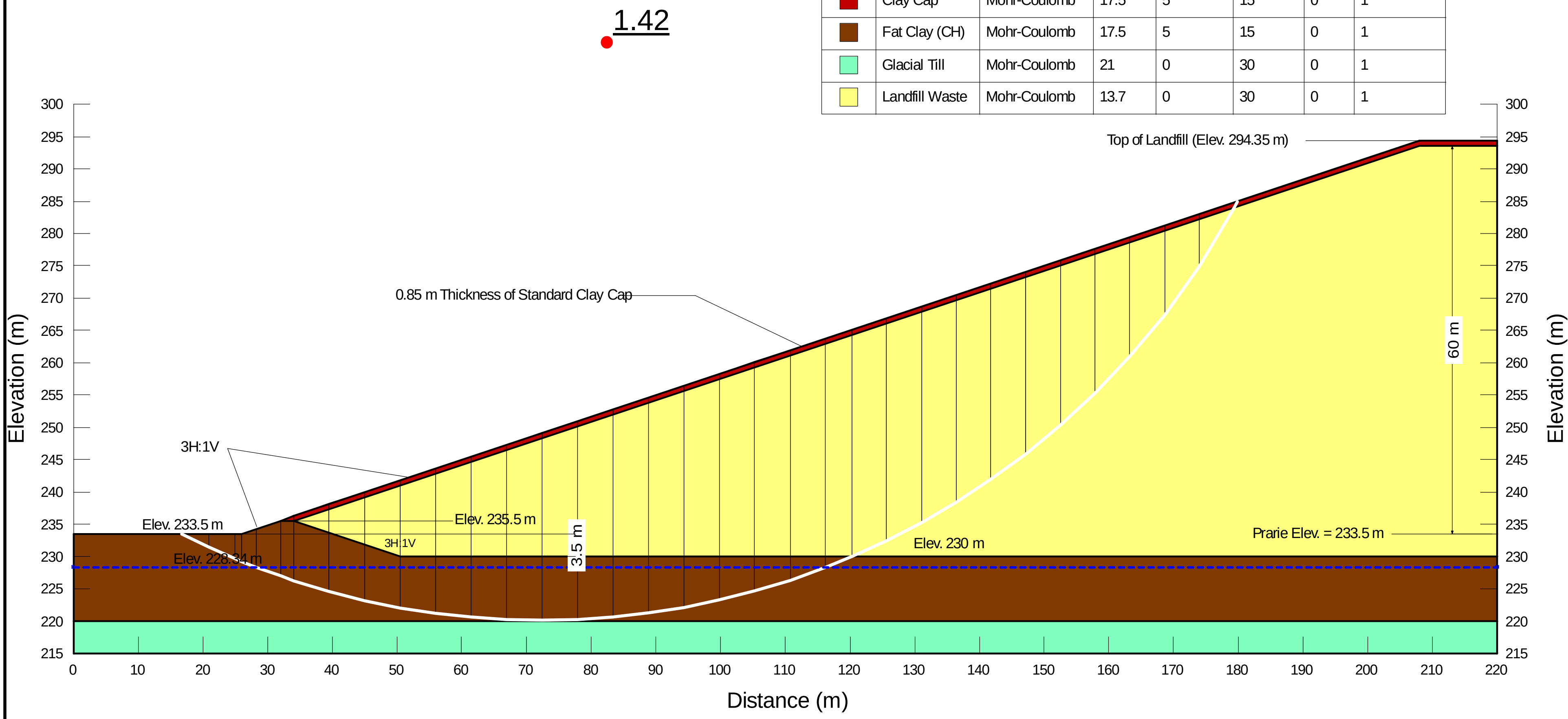
Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟥	Clay Cap	Mohr-Coulomb	17.5	5	15	0	1
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1
🟨	Landfill Waste	Mohr-Coulomb	13.7	0	30	0	1

Cell 35: West Berm Cross-Section (Option 2)

Long Term - 3.0 m Excavation & 60 m Landfill

2024-12-13 Figure 20 1:952

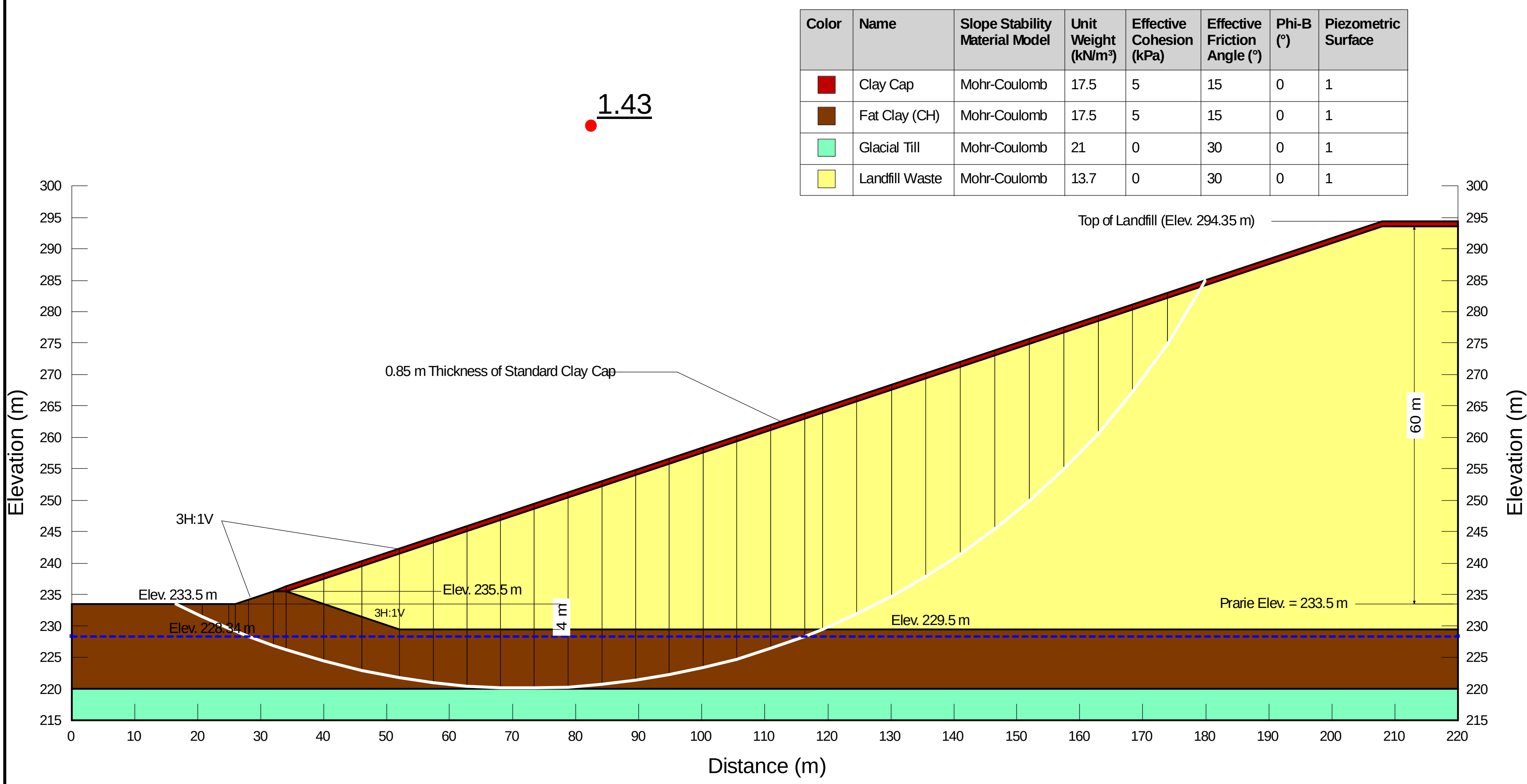
Color	Name	Slope Stability Material Model	Unit Weight (kN/m^3)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟥	Clay Cap	Mohr-Coulomb	17.5	5	15	0	1
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1
🟨	Landfill Waste	Mohr-Coulomb	13.7	0	30	0	1



Cell 35: West Berm Cross-Section (Option 2)

Long Term - 3.5 m Excavation & 60 m Landfill

2024-12-13 Figure 21 1:952

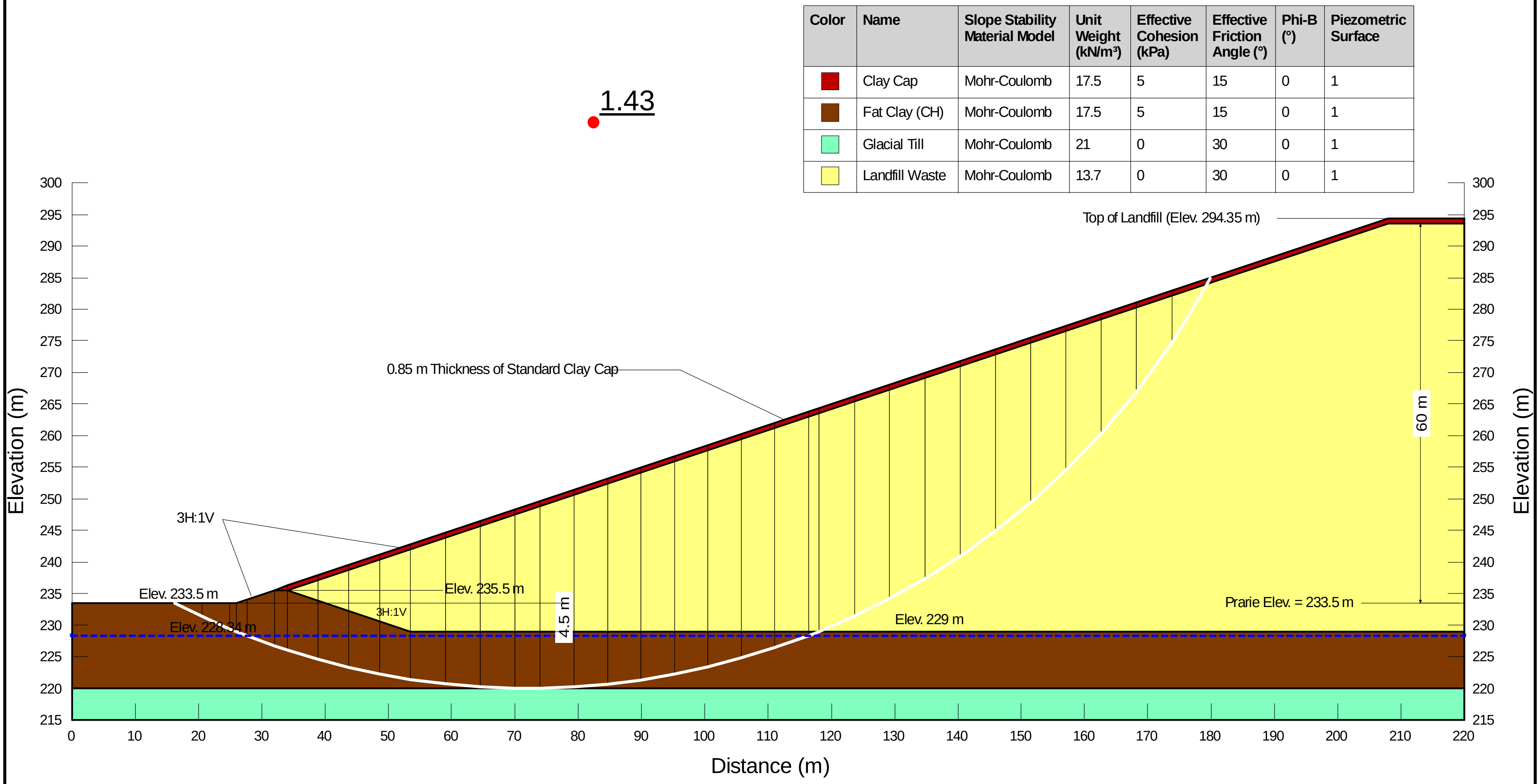


Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟥	Clay Cap	Mohr-Coulomb	17.5	5	15	0	1
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1
🟨	Landfill Waste	Mohr-Coulomb	13.7	0	30	0	1

Cell 35: West Berm Cross-Section (Option 2)

Long Term - 4.0 m Excavation & 60 m Landfill

2024-12-13 Figure 22 1:952



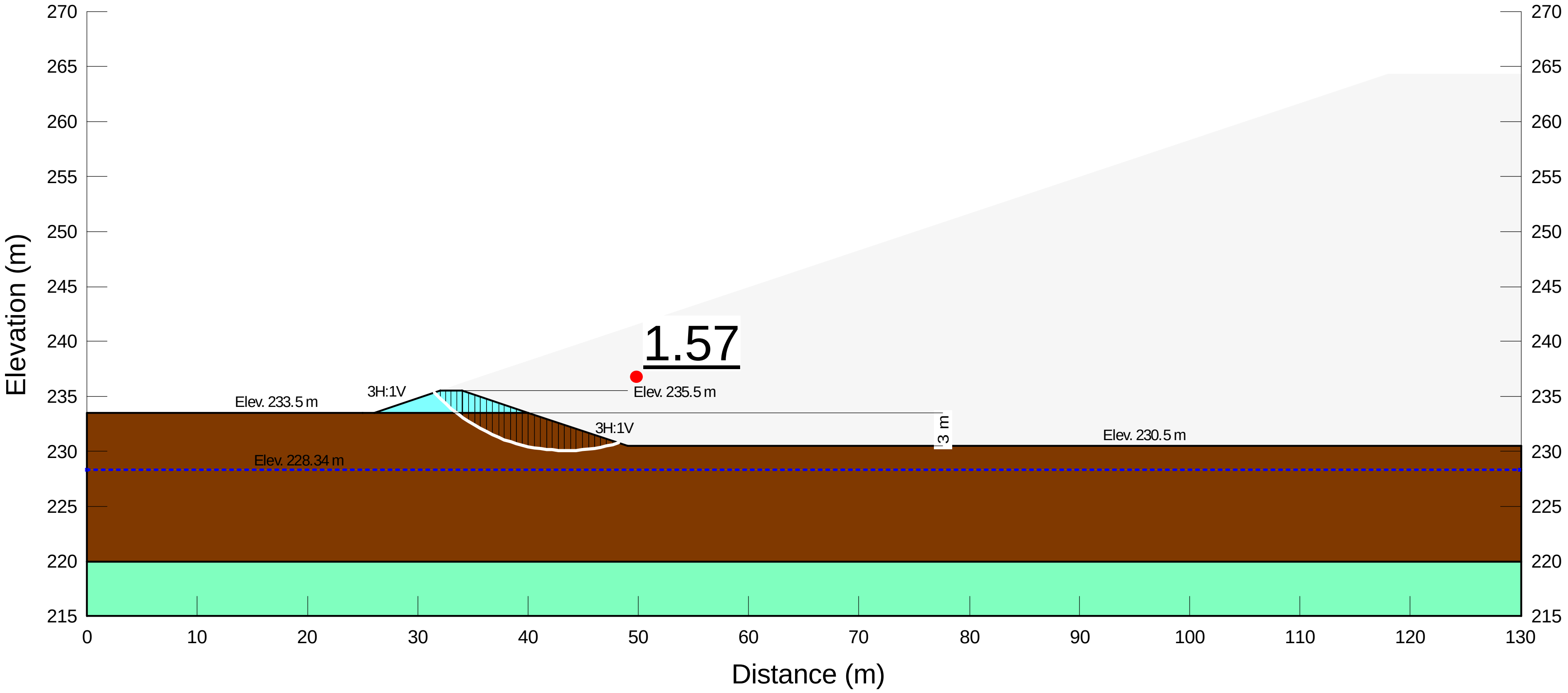
Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
🟥	Clay Cap	Mohr-Coulomb	17.5	5	15	0	1
🟫	Fat Clay (CH)	Mohr-Coulomb	17.5	5	15	0	1
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1
🟨	Landfill Waste	Mohr-Coulomb	13.7	0	30	0	1

Cell 35: West Berm Cross-Section (Option 2)

Long Term - 4.5 m Excavation & 60 m Landfill

2024-12-13 Figure 23 1:952

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface	B-bar	Add Weight
🟦	Berm	Mohr-Coulomb	17.5	5	15	0	1	0	Yes
🟫	Fat Clay - B-Bar	Mohr-Coulomb	17.5	5	15	0	1	0.6	No
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1	0	No

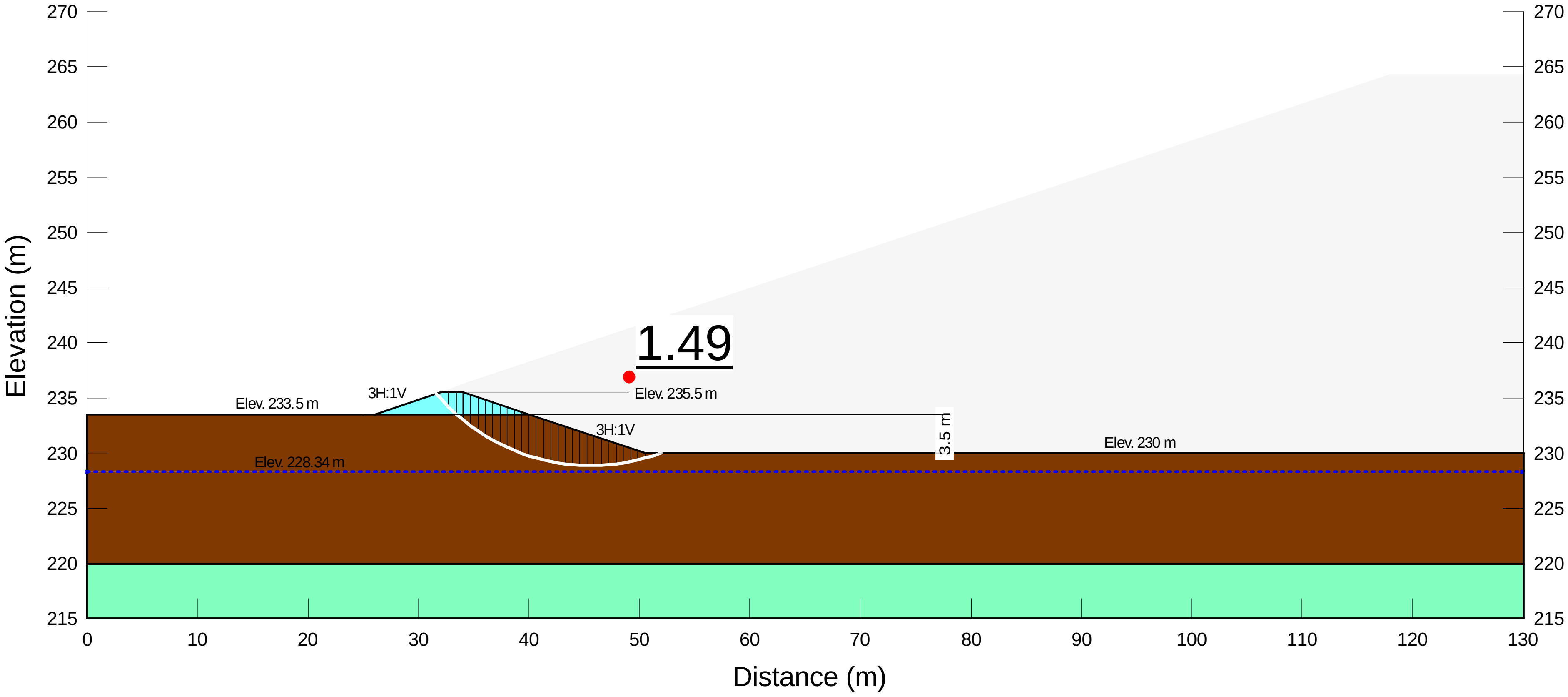


Cell 35: West Berm Cross-Section B-bar 0.6, Berm 235.5

Short Term - 3.0 m Excavation & B-bar Coefficient

2025-01-20 Figure 24 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface	B-bar	Add Weight
🟦	Berm	Mohr-Coulomb	17.5	5	15	0	1	0	Yes
🟫	Fat Clay - B-Bar	Mohr-Coulomb	17.5	5	15	0	1	0.6	No
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1	0	No

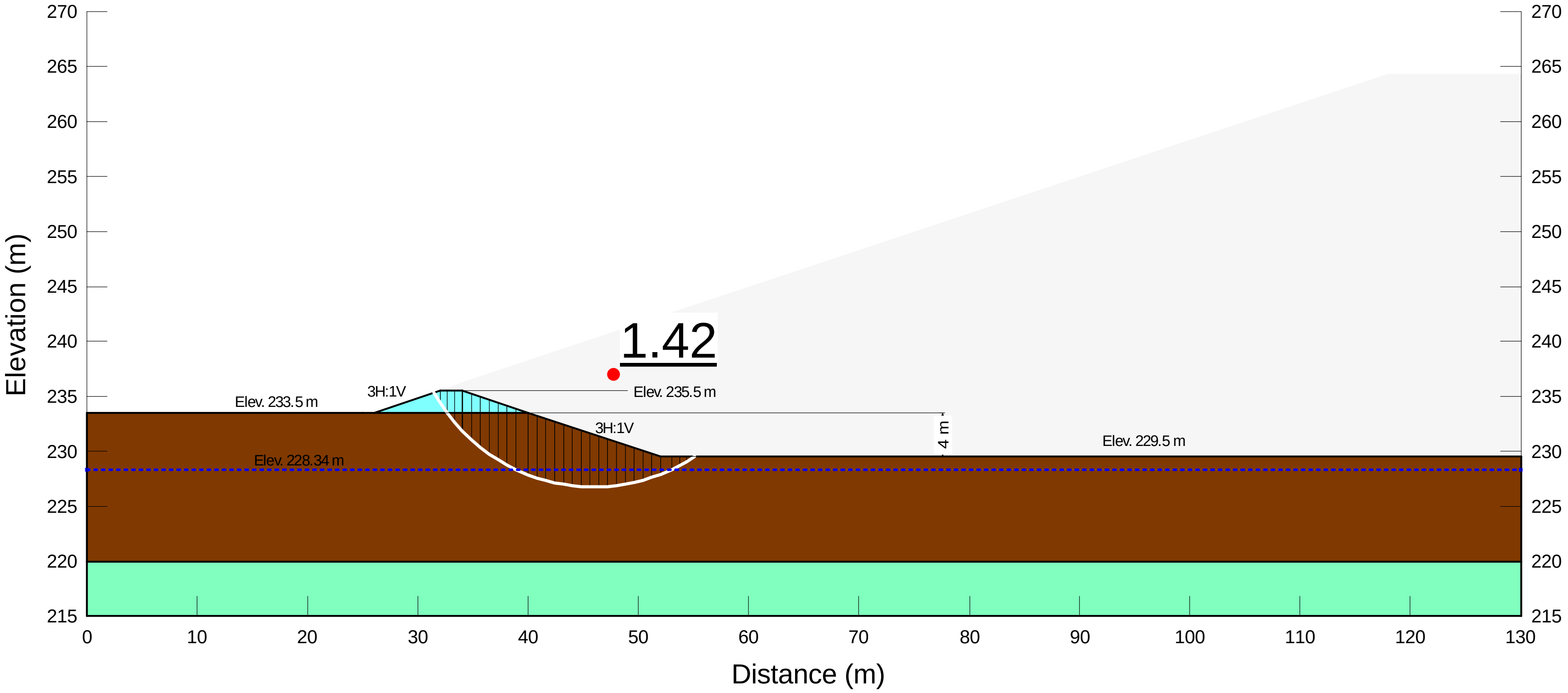


Cell 35: West Berm Cross-Section B-bar 0.6, Berm 235.5

Short Term - 3.5 m Excavation & B-bar Coefficient

2025-01-20 Figure 25 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface	B-bar	Add Weight
🟦	Berm	Mohr-Coulomb	17.5	5	15	0	1	0	Yes
🟫	Fat Clay - B-Bar	Mohr-Coulomb	17.5	5	15	0	1	0.6	No
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1	0	No

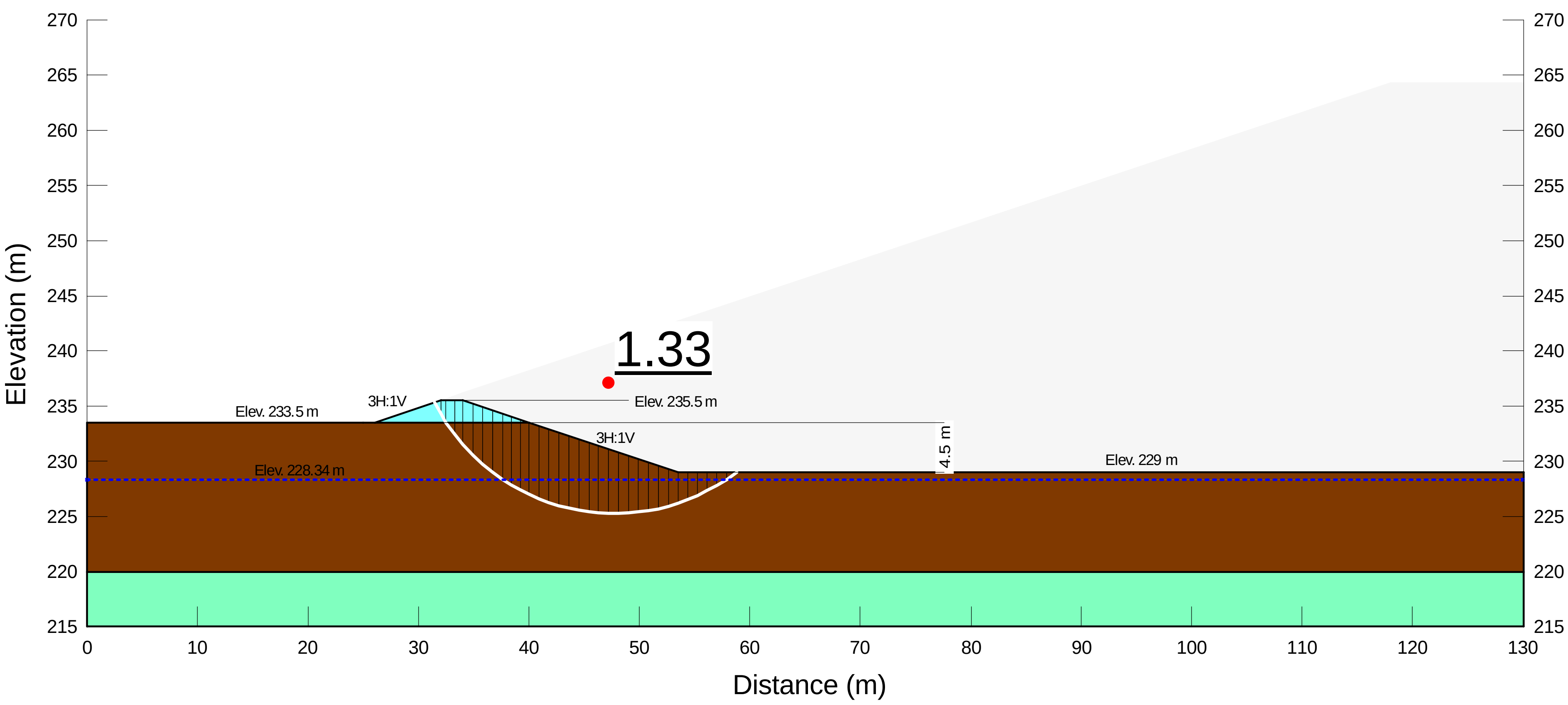


Cell 35: West Berm Cross-Section B-bar 0.6, Berm 235.5

Short Term - 4.0 m Excavation & B-bar Coefficient

2025-01-20 Figure 26 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface	B-bar	Add Weight
🟦	Berm	Mohr-Coulomb	17.5	5	15	0	1	0	Yes
🟫	Fat Clay - B-Bar	Mohr-Coulomb	17.5	5	15	0	1	0.6	No
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1	0	No

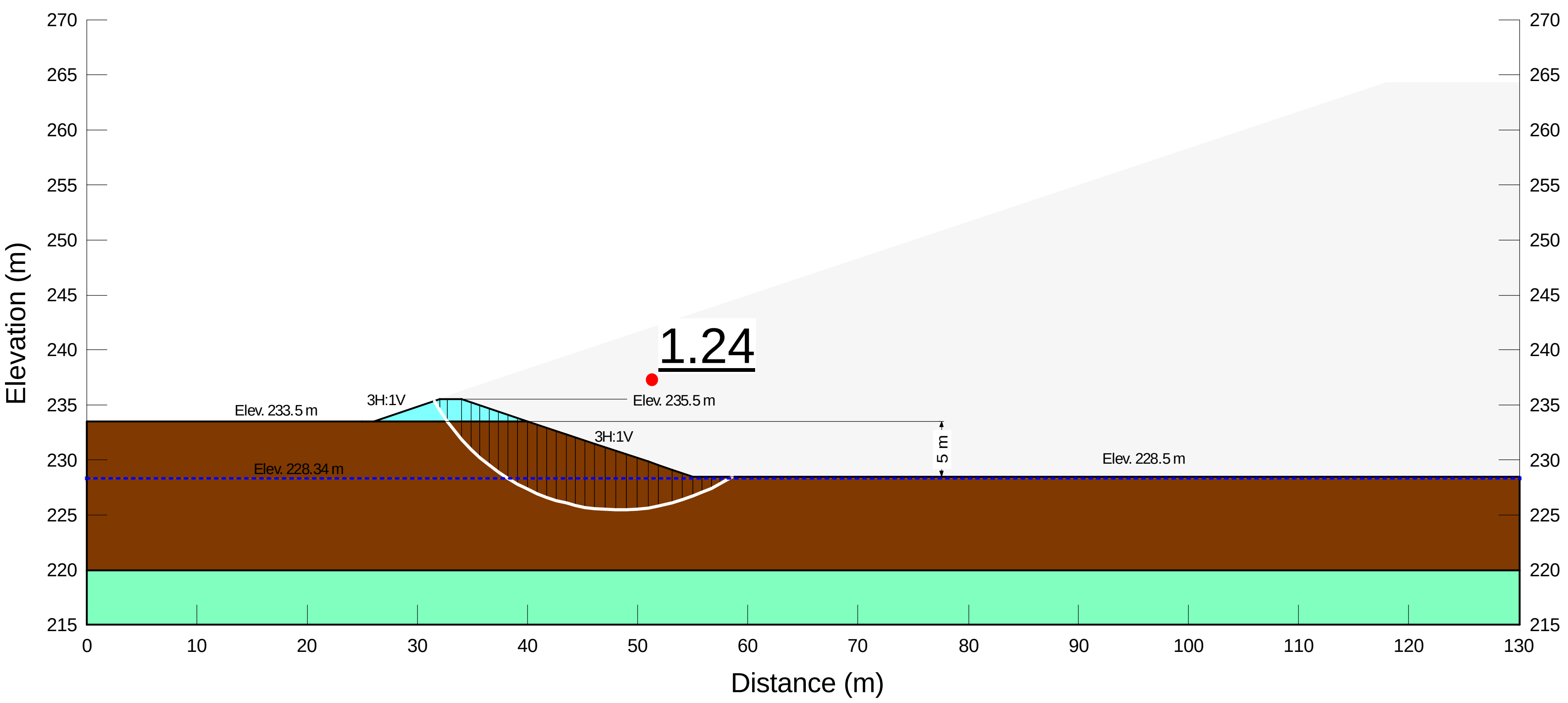


Cell 35: West Berm Cross-Section B-bar 0.6, Berm 235.5

Short Term - 4.5 m Excavation & B-bar Coefficient

2025-01-20 Figure 27 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface	B-bar	Add Weight
🟦	Berm	Mohr-Coulomb	17.5	5	15	0	1	0	Yes
🟫	Fat Clay - B-Bar	Mohr-Coulomb	17.5	5	15	0	1	0.6	No
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1	0	No

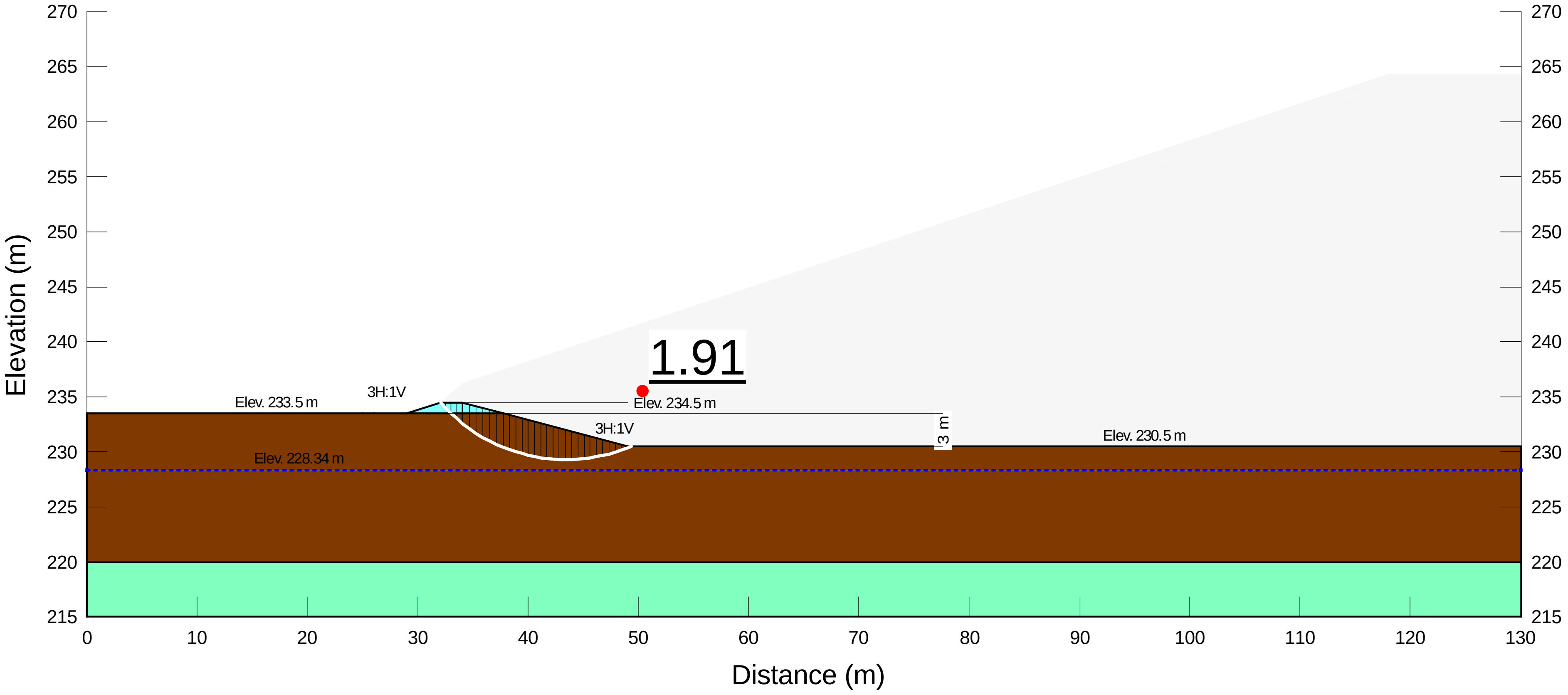


Cell 35: West Berm Cross-Section B-bar 0.6, Berm 235.5

Short Term - 5.0 m Excavation & B-bar Coefficient

2025-01-20 Figure 28 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface	B-bar	Add Weight
🟦	Berm	Mohr-Coulomb	17.5	5	15	0	1	0	Yes
🟫	Fat Clay B-Bar	Mohr-Coulomb	17.5	5	15	0	1	0.6	No
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1	0	No

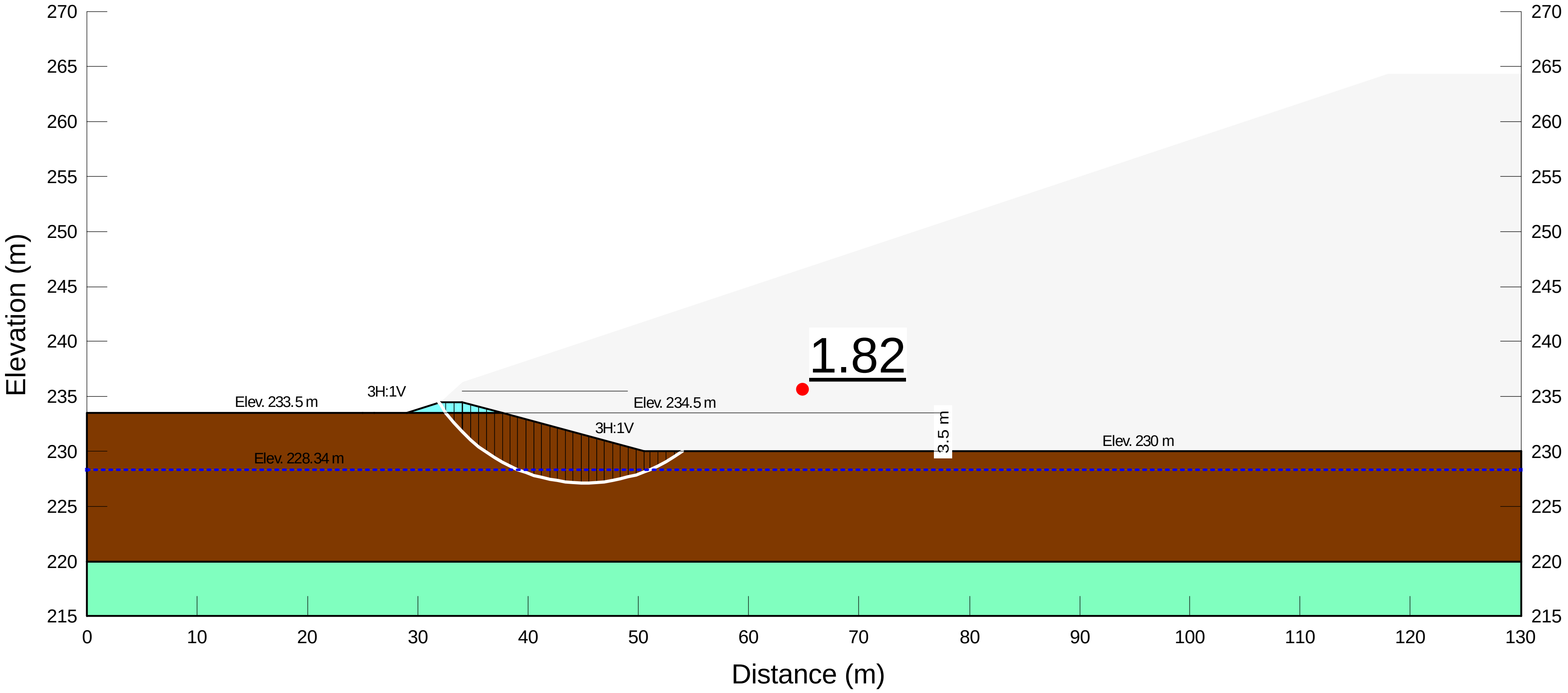


Cell 35: West Berm Cross-Section B-bar 0.6, Berm 234.5

Short Term - 3.0 m Excavation & B-bar Coefficient

2025-01-20 Figure 29 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface	B-bar	Add Weight
🟦	Berm	Mohr-Coulomb	17.5	5	15	0	1	0	Yes
🟫	Fat Clay B-Bar	Mohr-Coulomb	17.5	5	15	0	1	0.6	No
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1	0	No

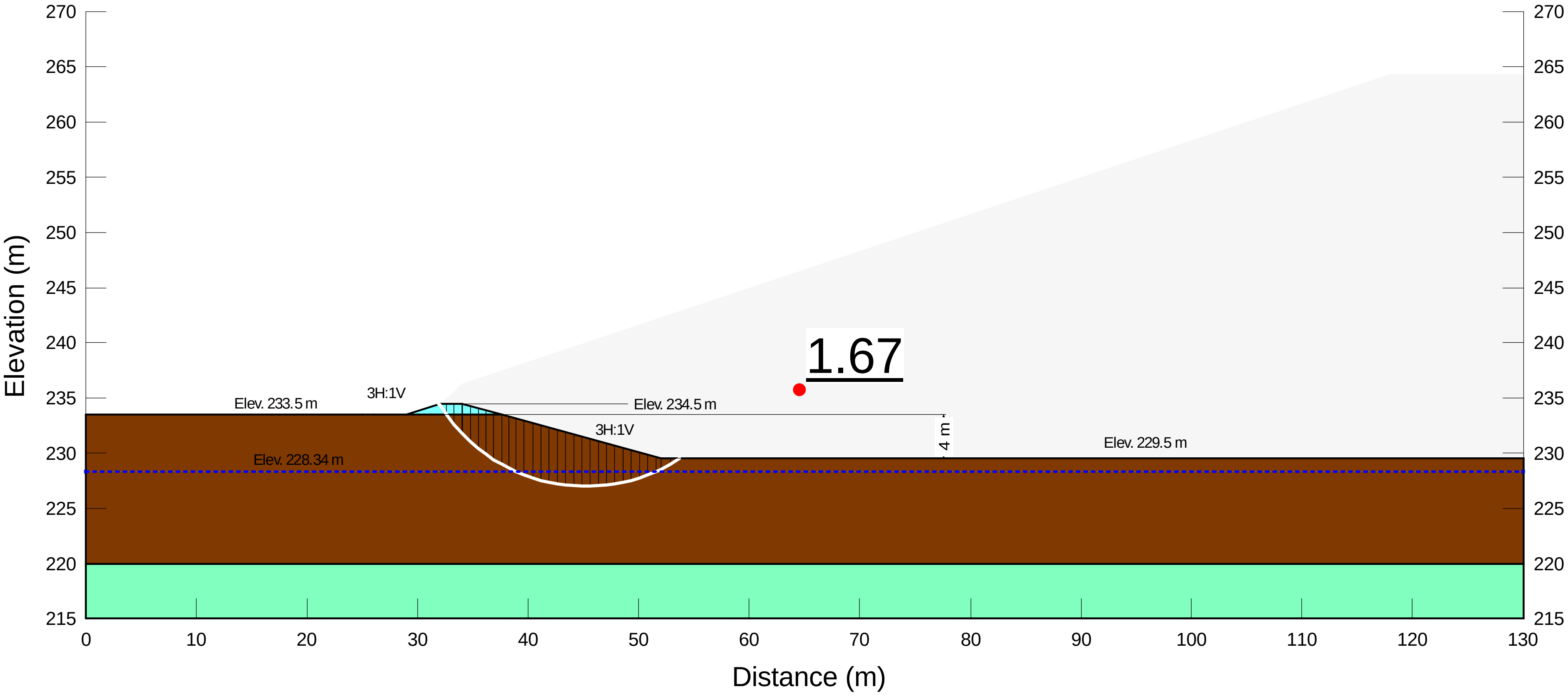


Cell 35: West Berm Cross-Section B-bar 0.6, Berm 234.5

Short Term - 3.5 m Excavation & B-bar Coefficient

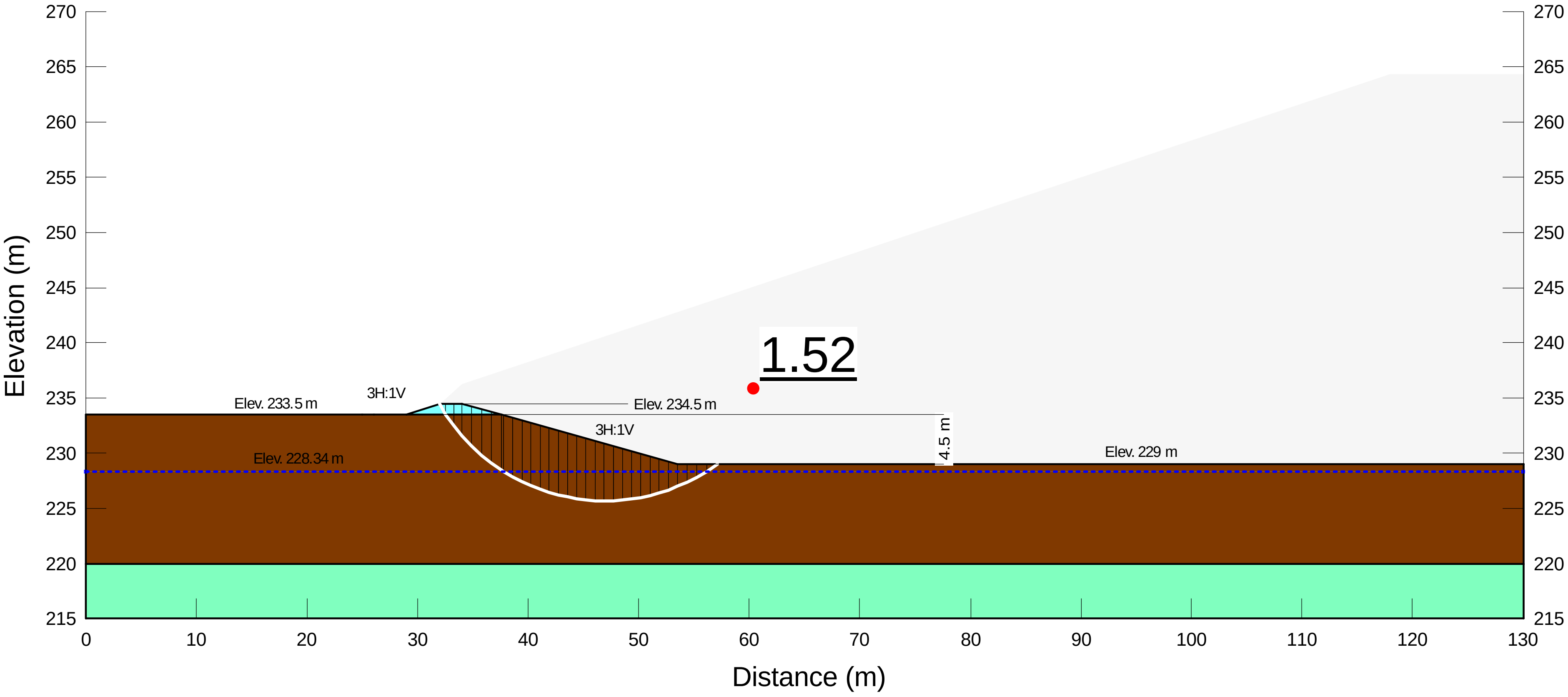
2025-01-20 Figure 30 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface	B-bar	Add Weight
🟦	Berm	Mohr-Coulomb	17.5	5	15	0	1	0	Yes
🟫	Fat Clay B-Bar	Mohr-Coulomb	17.5	5	15	0	1	0.6	No
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1	0	No



Cell 35: West Berm Cross-Section B-bar 0.6, Berm 234.5		
Short Term - 4.0 m Excavation & B-bar Coefficient		
2025-01-20	Figure 31	1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface	B-bar	Add Weight
🟦	Berm	Mohr-Coulomb	17.5	5	15	0	1	0	Yes
🟫	Fat Clay B-Bar	Mohr-Coulomb	17.5	5	15	0	1	0.6	No
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1	0	No

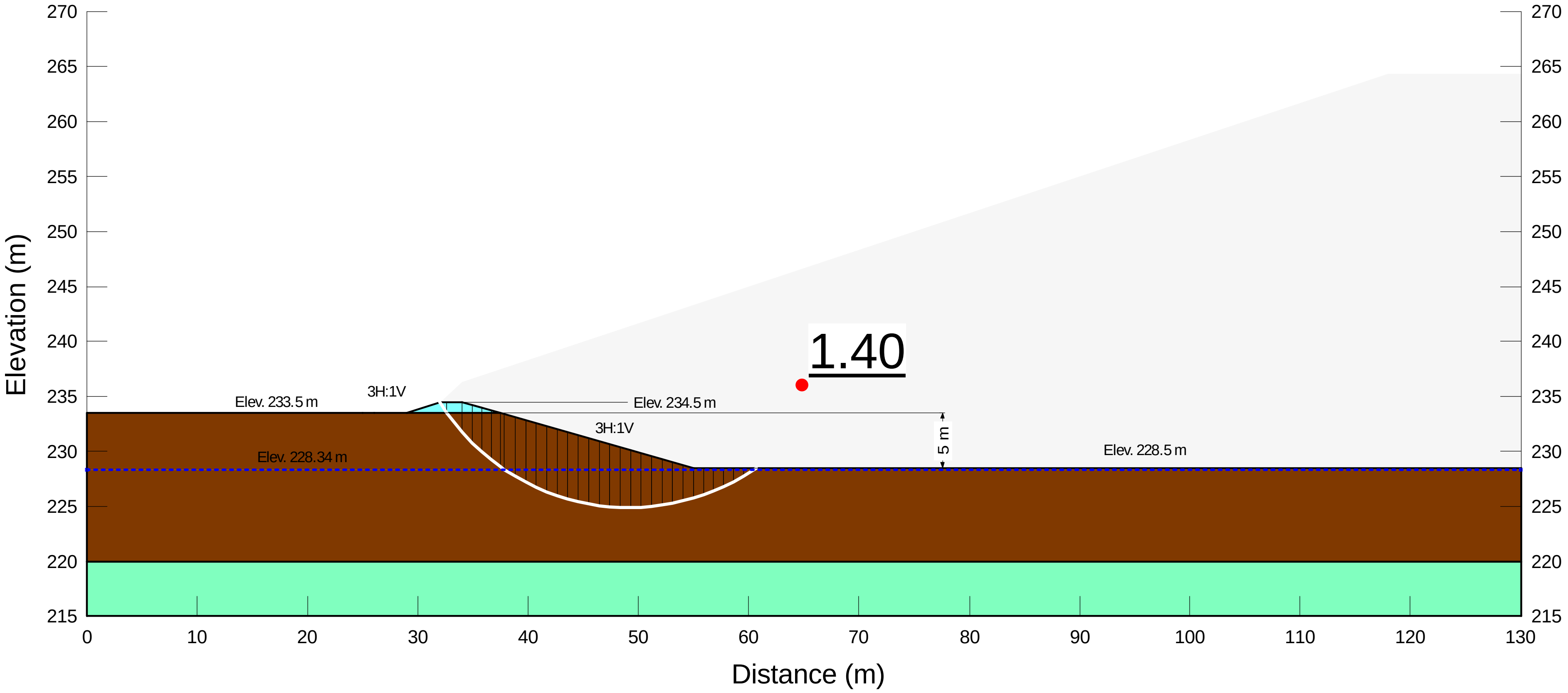


Cell 35: West Berm Cross-Section B-bar 0.6, Berm 234.5

Short Term - 4.5 m Excavation & B-bar Coefficient

2025-01-20 Figure 32 1:570

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface	B-bar	Add Weight
🟦	Berm	Mohr-Coulomb	17.5	5	15	0	1	0	Yes
🟫	Fat Clay B-Bar	Mohr-Coulomb	17.5	5	15	0	1	0.6	No
🟩	Glacial Till	Mohr-Coulomb	21	0	30	0	1	0	No



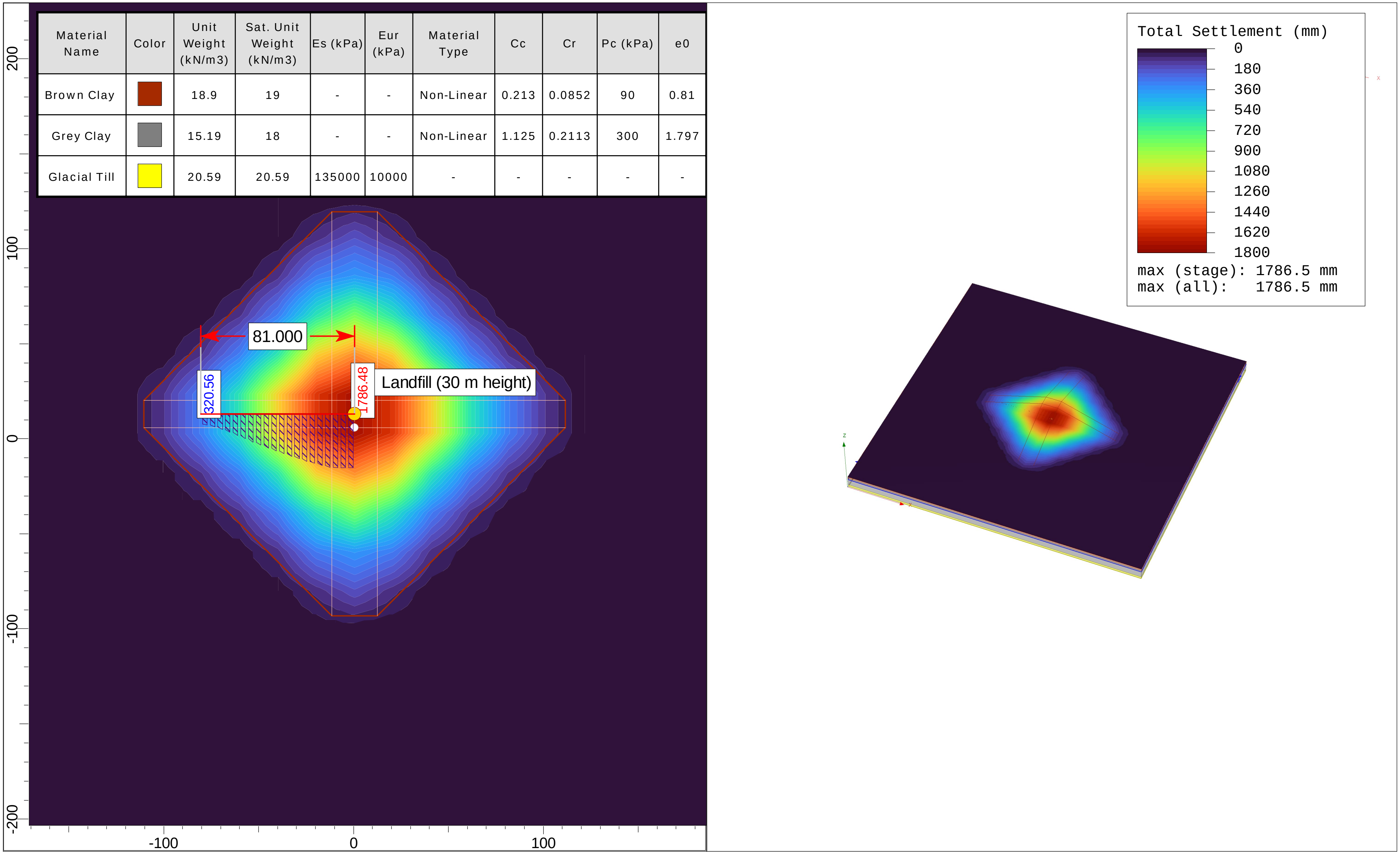
Cell 35: West Berm Cross-Section B-bar 0.6, Berm 234.5

Short Term - 5.0 m Excavation & B-bar Coefficient

2025-01-20 Figure 33 1:570

Appendix F

Settlement Design Outputs



Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Es (kPa)	Eur (kPa)	Material Type	Cc	Cr	Pc (kPa)	e0
Brown Clay	🟫	18.9	19	-	-	Non-Linear	0.213	0.0852	90	0.81
Grey Clay	◼	15.19	18	-	-	Non-Linear	1.125	0.2113	300	1.797
Glacial Till	🟨	20.59	20.59	135000	10000	-	-	-	-	-

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SETTLE3 5.022

Project
Brady Road Resource Management Facility - Area B

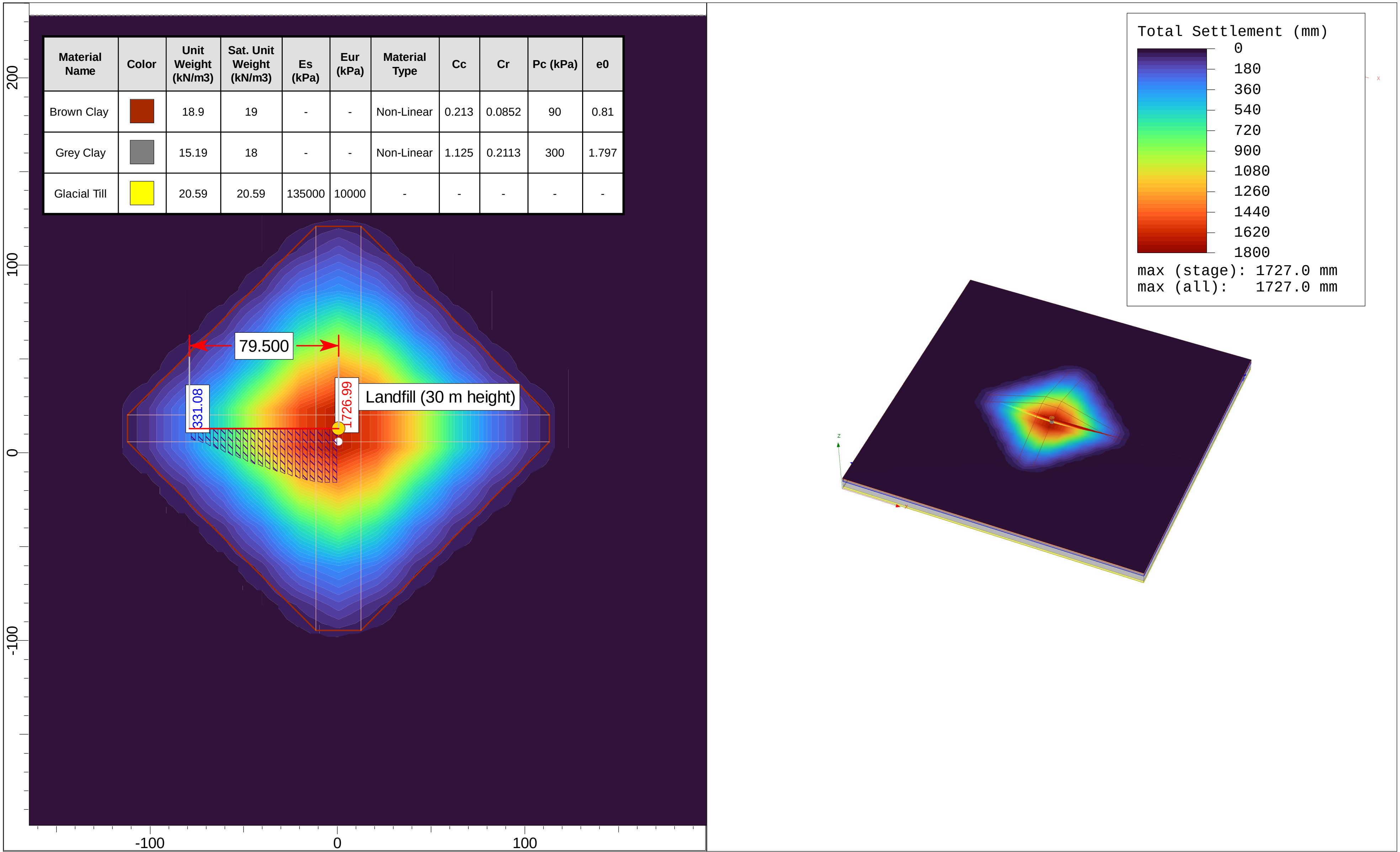
Analysis Description
Option 1 (3.0 m Excavation Depth): Consolidation Analysis for Clay

Drawn By
Camilo Olivar

Company
AECOM

Date
2024-12-18

Figure
Figure 34



Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Es (kPa)	Eur (kPa)	Material Type	Cc	Cr	Pc (kPa)	e0
Brown Clay	🟫	18.9	19	-	-	Non-Linear	0.213	0.0852	90	0.81
Grey Clay	⬛	15.19	18	-	-	Non-Linear	1.125	0.2113	300	1.797
Glacial Till	🟨	20.59	20.59	135000	10000	-	-	-	-	-

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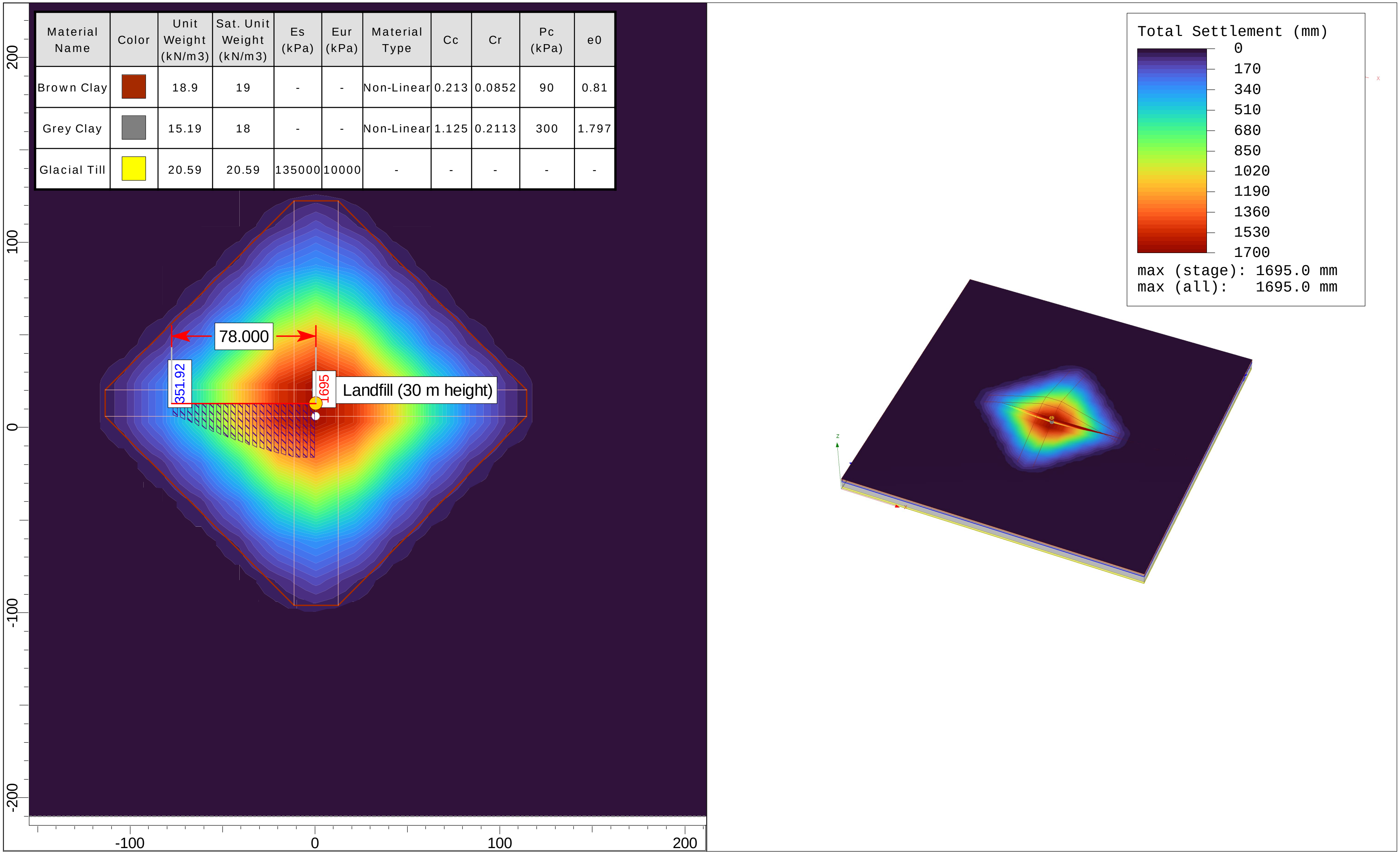
SETTLE3 5.022

Project	Brady Road Resource Management Facility - Area B
Analysis Description	Option 1 (3.5 m Excavation Depth): Consolidation Analysis for Clay
Drawn By	Camilo Olivar
Company	AECOM
Date	2024-12-18
Figure	Figure 35



Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Es (kPa)	Eur (kPa)	Material Type	Cc	Cr	Pc (kPa)	e0
Brown Clay	🟫	18.9	19	-	-	Non-Linear	0.213	0.0852	90	0.81
Grey Clay	◼	15.19	18	-	-	Non-Linear	1.125	0.2113	300	1.797
Glacial Till	🟨	20.59	20.59	135000	10000	-	-	-	-	-

Project	Brady Road Resource Management Facility - Area B		
Analysis Description	Option 1 (4.0 m Excavation Depth): Consolidation Analysis for Clay		
Drawn By	Camilo Olivar	Company	AECOM
Date	2024-12-18	Figure	Figure 36

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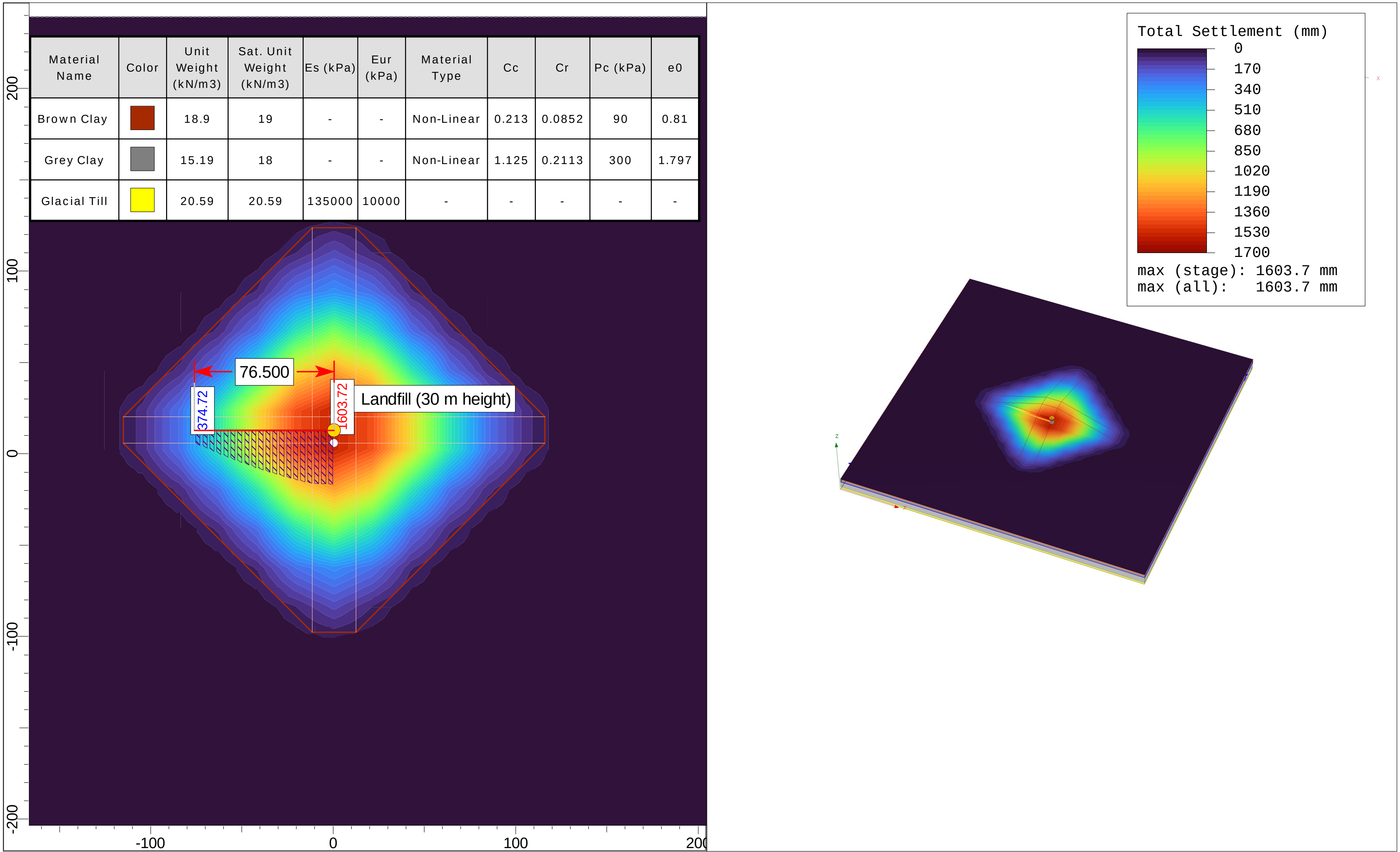

Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Es (kPa)	Eur (kPa)	Material Type	Cc	Cr	Pc (kPa)	e0
Brown Clay	🟫	18.9	19	-	-	Non-Linear	0.213	0.0852	90	0.81
Grey Clay	◼	15.19	18	-	-	Non-Linear	1.125	0.2113	300	1.797
Glacial Till	🟨	20.59	20.59	135000	10000	-	-	-	-	-

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SETTLE3 5.022

Project
Brady Road Resource Management Facility - Area B

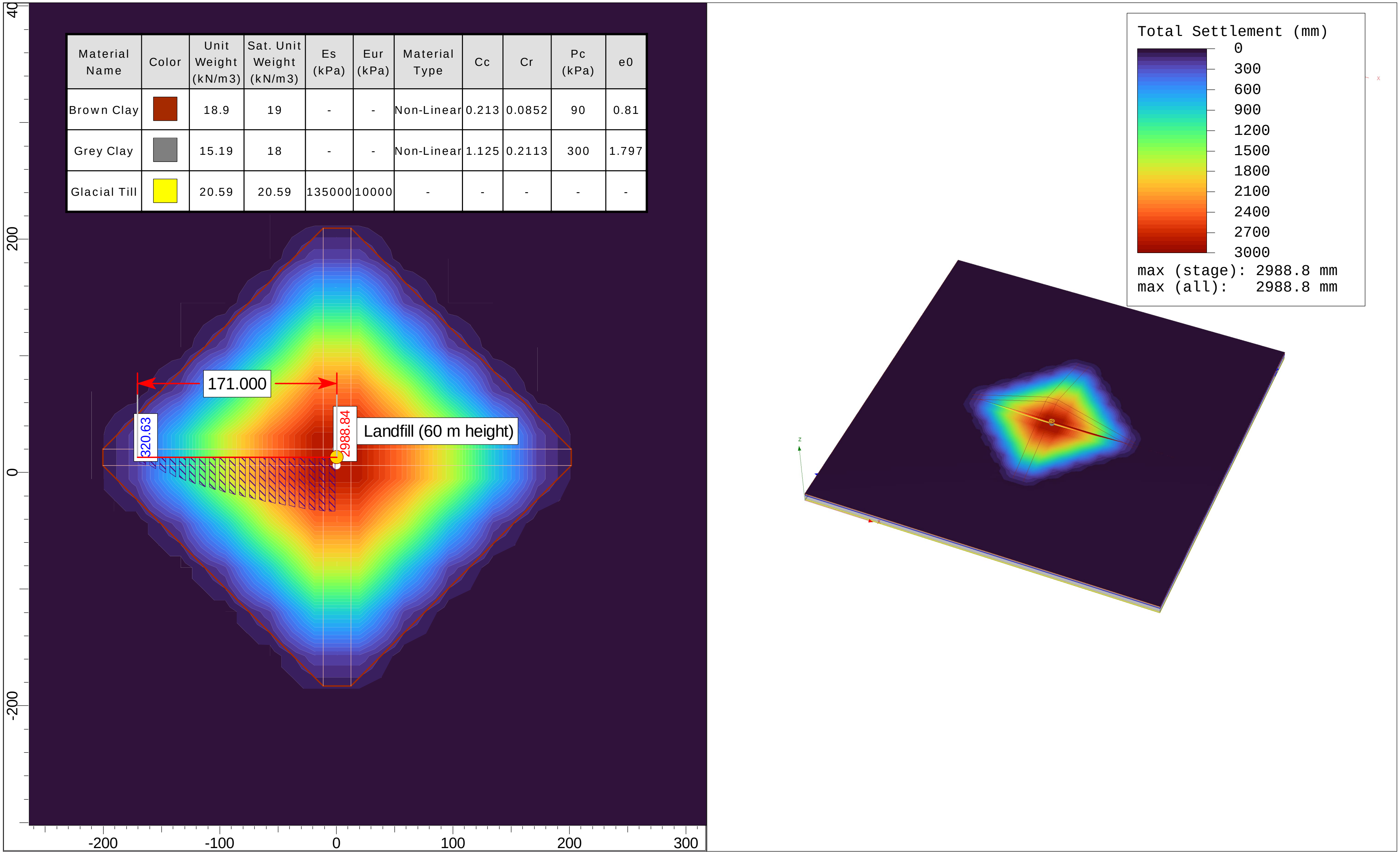
Analysis Description
Option 1 (4.5 m Excavation Depth): Consolidation Analysis for Clay

Drawn By
Camilo Olivar

Company
AECOM

Date
2024-12-18

Figure
Figure 37



Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Es (kPa)	Eur (kPa)	Material Type	Cc	Cr	Pc (kPa)	e0
Brown Clay	🟫	18.9	19	-	-	Non-Linear	0.213	0.0852	90	0.81
Grey Clay	◼	15.19	18	-	-	Non-Linear	1.125	0.2113	300	1.797
Glacial Till	🟨	20.59	20.59	135000	10000	-	-	-	-	-

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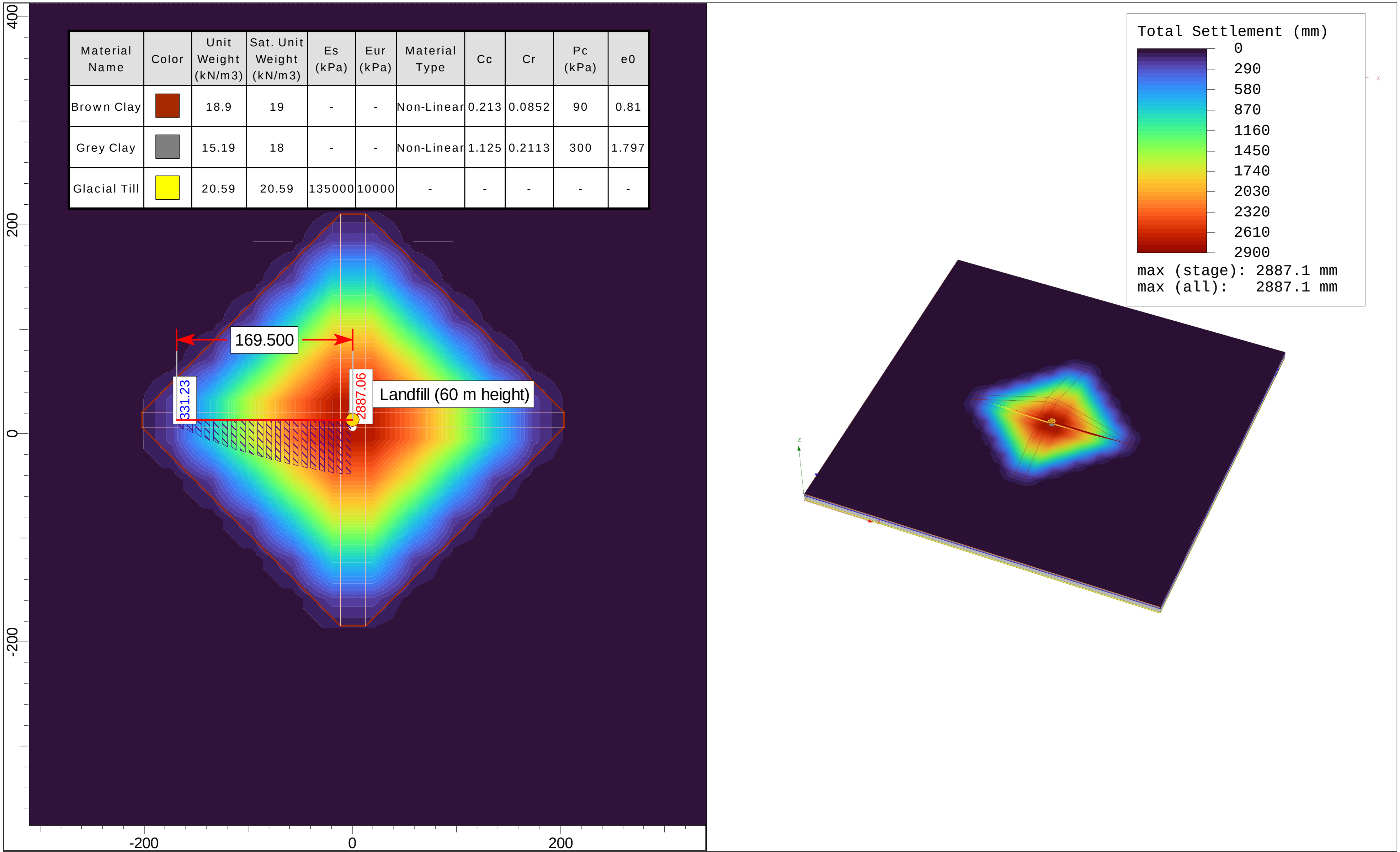
Project	Brady Road Resource Management Facility - Area B
Analysis Description	Option 2 (3.0 m Excavation Depth): Consolidation Analysis for Clay

Drawn By	Camilo Olivar	Company	AECOM
Date	2024-12-18	Figure	Figure 38



Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Es (kPa)	Eur (kPa)	Material Type	Cc	Cr	Pc (kPa)	e0
Brown Clay	🟫	18.9	19	-	-	Non-Linear	0.213	0.0852	90	0.81
Grey Clay	■	15.19	18	-	-	Non-Linear	1.125	0.2113	300	1.797
Glacial Till	🟨	20.59	20.59	135000	10000	-	-	-	-	-

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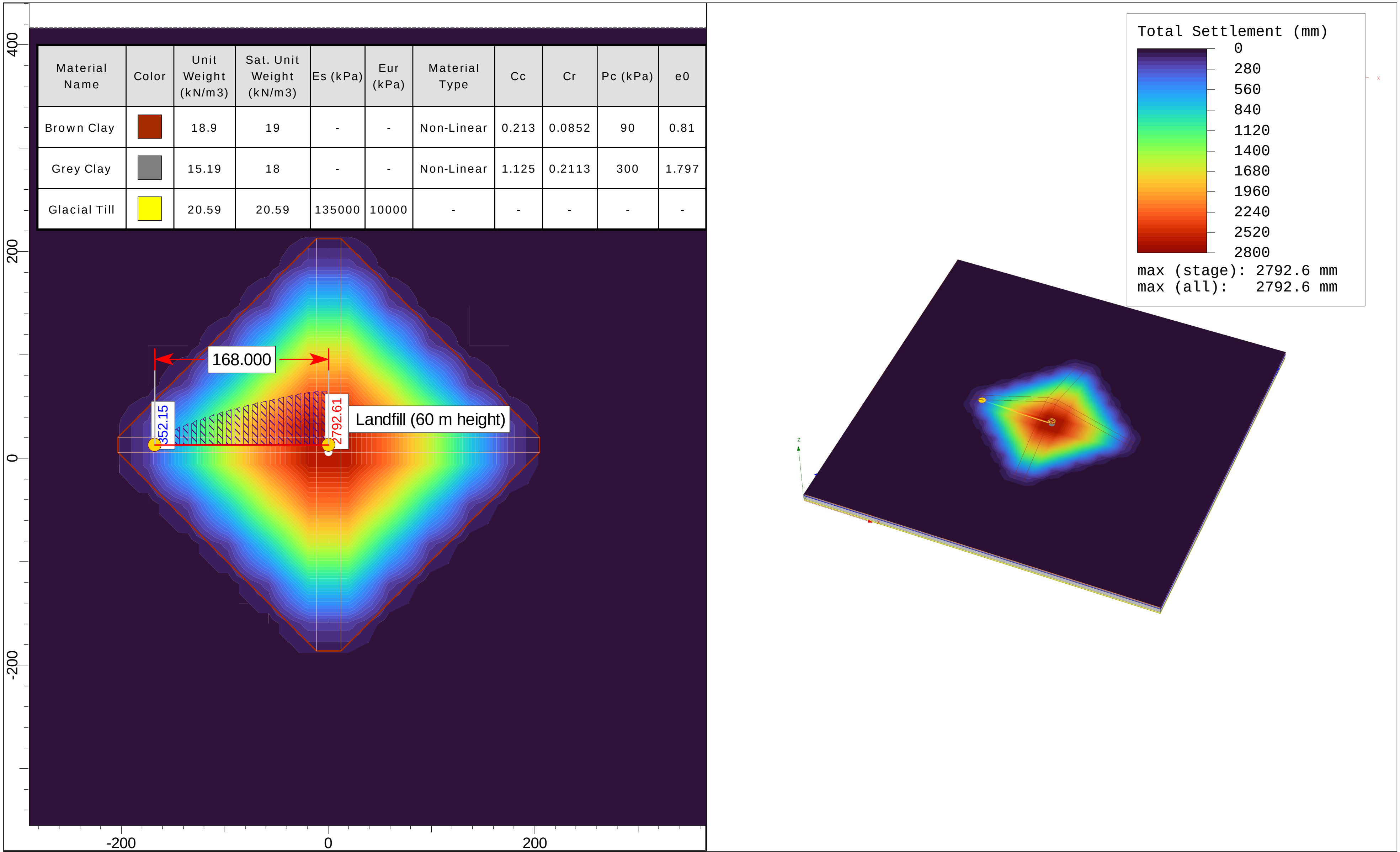
SETTLE3 5.022

Project	Brady Road Resource Management Facility - Area B
Analysis Description	Option 2 (3.5 m Excavation Depth): Consolidation Analysis for Clay

Drawn By	Camilo Olivar	Company	AECOM
Date	2024-12-18	Figure	Figure 39



Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Es (kPa)	Eur (kPa)	Material Type	Cc	Cr	Pc (kPa)	e0
Brown Clay	🟫	18.9	19	-	-	Non-Linear	0.213	0.0852	90	0.81
Grey Clay	⬜	15.19	18	-	-	Non-Linear	1.125	0.2113	300	1.797
Glacial Till	🟨	20.59	20.59	135000	10000	-	-	-	-	-

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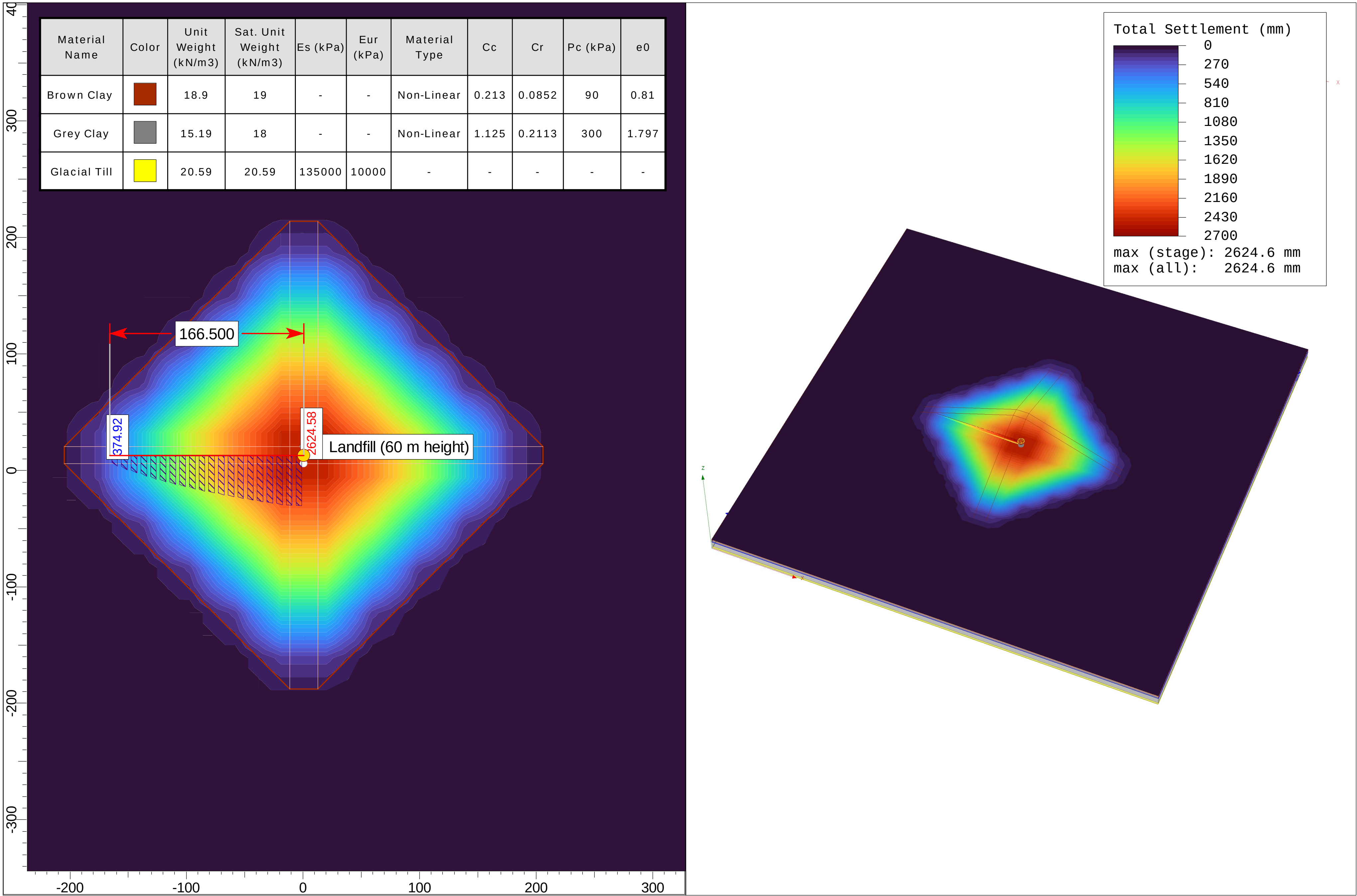
Project	Brady Road Resource Management Facility - Area B
Analysis Description	Option 2 (4.0 m Excavation Depth): Consolidation Analysis for Clay

Drawn By	Camilo Olivar	Company	AECOM
Date	2024-12-18	Figure	Figure 40



Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Es (kPa)	Eur (kPa)	Material Type	Cc	Cr	Pc (kPa)	e0
Brown Clay	🟫	18.9	19	-	-	Non-Linear	0.213	0.0852	90	0.81
Grey Clay	⬛	15.19	18	-	-	Non-Linear	1.125	0.2113	300	1.797
Glacial Till	🟨	20.59	20.59	135000	10000	-	-	-	-	-

Project
Brady Road Resource Management Facility - Area B

Analysis Description
Option 2 (4.5 m Excavation Depth): Consolidation Analysis for Clay

Drawn By	Camilo Olivar	Company	AECOM
Date	2024-12-18	Figure	Figure 41

SETTLE3 5.022