Report

Trail Road Battery Energy Storage System (BESS) Geotechnical Investigation and Design

H375035-0000-2A0-066-0001

LICENSED PROFESSIONAL ENGINEER
2025-10-23
E. W. BEADLE
100199564
PROVINCE OF ONTARIO

2025-10-23	2	Approved for Use	T. Beadle	B. Kussmann	T. Beadle
2025-08-05	1	Approved for Use	T. Beadle	B. Kussmann	S. Chemanedji
2025-10-23	0	Approved for Use	T. Beadle	B. Kussmann	T. Beadle
DATE	REV.	STATUS	PREPARED BY	CHECKED BY	APPROVED BY
				Discipline Lead	Functional Manager

Table of Contents

List of Tables

List of Figure

List of Appendices

Exhibit A – Disclaimer (General)

IMPORTANT NOTICE TO READER

This report was prepared by Hatch Ltd. ("**Hatch**") for the sole and exclusive use of Brookfield Renewable (the "Principal") for the purpose of the Trail Road Battery Energy Storage System (BESS) project. This report must not be used by the Principal for any other purpose, or provided to, relied upon or used by any other person without Hatch's prior written consent.

This report contains the expression of the opinion of Hatch using its professional judgment and reasonable care based on information available and conditions existing at the time of preparation.

The use of, or reliance upon this report is subject to the following :

1. this report is to be read in the context of and subject to the terms of the relevant Purchase Order (PO) No. C157742 between Hatch and the Principal (the "**Hatch Agreement**"), including any methodologies, procedures, techniques, assumptions and other relevant terms or conditions specified in the Hatch Agreement.
2. this report is meant to be read as a whole, and sections of the report must not be read or relied upon out of context; and
3. unless expressly stated otherwise in this report, Hatch has not verified the accuracy, completeness or validity of any information provided to Hatch by or on behalf of the Principal and Hatch does not accept any liability in connection with such information.

1. Introduction

Hatch Ltd. (Hatch) has been retained by Brookfield BRP Canada Corporation (Brookfield) to provide geotechnical investigation services as part of the Trail Road Battery Energy Storage System (BESS) project (Project) under Purchase Order (PO) No. C157742.

The investigation was conducted in accordance with Project Addendum No. P-079707 Appendix I – Scope and Work Plan, dated October 9, 2024. A proposed geotechnical investigation document was prepared for the Trail Road BESS where geotechnical investigations were required and submitted to Brookfield for review and approval prior to initiation based on our understanding of the project scope. The investigation was carried out at locations selected by Hatch and approved by Brookfield at the project site.

The objective of the investigation was to characterize the soil, rock and groundwater conditions (where applicable) at the BESS site by advancing boreholes at select locations. This geotechnical investigation report presents the investigation methodology, records of boreholes, geotechnical field and laboratory test data completed to date and geotechnical analyses and recommendations for foundation design of the Trail Road BESS facility and ancillary structures, as well as general construction considerations. In addition, this report identifies and discusses potential geological and geotechnical hazards and their associated risks.

This report should be read in conjunction with the “Important Notice to Reader”. The reader’s attention is specifically drawn to this information, as it is essential for the proper use and interpretation of this report. If information or assumptions contained herein are incorrect, please inform Hatch so that we may amend our recommendations as appropriate.

2. Project and Site Description

The Trail Road BESS project is directly responding to the Independent Electricity System Operator’s (IESO) request to increase supply and capacity to meet Ontario’s growing electricity expenditure and demand by constructing an energy storage facility. The facility will increase renewable grid capacity and storage, enhance flexible grid operations and provide a low carbon initiative to avoid greenhouse gas emissions by reducing reliance on higher carbon intensive facilities. The BESS facility will ensure grid stability, lower system costs by increasing utilization of existing investments and enables residential, commercial and industrial development which will help the City of Ottawa grow.

Brookfield is proposing to develop approximately 8 acres of a 53-acre property at 4186 William McEwan Drive in Richmond, Ontario, approximately 23 km south of Ottawa. Hatch understands the Project will consist of about 244 battery energy storage “cabinets” in about 61 “modules”, a substation, access roads and associated electrical infrastructure.

A key plan outlining the site location is shown in Figure 1 following the text of this report.

3. Geotechnical Standards

The geotechnical investigation, soil descriptions and the graphical representations of the soil types are in general accordance with the American Society for Testing and Materials (ASTM) D2488-17. Geotechnical field, in-situ and laboratory testing was carried out in accordance with the relevant testing methods specified in the American Society for Testing and Materials (ASTM) Standards.

4. Investigation Procedures

4.1 Health and Safety Plan

Prior to initiating the field work at the site, Hatch prepared a site-specific Health and Safety Environment Plan (HSEP) for Hatch staff and subcontractor use. The HSEP addressed health and safety within the work area and established contingency plans for emergencies that may occur during the field work.

4.2 Utility Service Clearances

Underground public utility clearances were obtained through Ontario One Call prior to initiating the intrusive investigation. A private utility locator was also retained to confirm that the proposed borehole locations were clear of private underground utilities for boreholes located within private property.

4.3 Borehole Drilling, Sampling and In-Situ and Field Testing

The proposed borehole locations were selected by Hatch's geotechnical staff and approved by Brookfield prior to mobilization. Hatch located the boreholes in the field using measurements relative to existing site features and a hand-held Global Positioning System (GPS) device. Detailed below, the geotechnical investigation program consisted of the following:

- Standard Penetration Test (SPT) split-spoon sampling was carried out at eight (8) borehole locations (Boreholes TR24-1 to TR24-8);
- Two monitoring wells installed at select locations; and
- Electrical Resistivity Testing completed along two lines.

OGS Inc. (OGS) of Almonte, Ontario, supplied and operated a track-mounted drill rig to advance the SPT boreholes as detailed above and as shown on the Borehole Location Plan on Figure 1 following the text of this report.

4.4 Soil Sampling

The field work was observed by members of Hatch's engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling investigation and soil sampling, photographed and recorded field observations, in-situ testing operations, logged the boreholes, and examined the soil samples.

The SPT boreholes were advanced by hollow stem augers and soil samples were taken at 0.76-m intervals within the upper approximately 4.6 m, and at 1.5-m intervals below the 4.6 m depth using 50-mm diameter split-spoon samplers, in accordance with the SPT procedure (ASTM D1586-08a: Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of the Soil). The soil samples were described and logged in the field with respect to soil type/group and moisture content.

Bulk soil samples were collected in sealed 5-gallon buckets from auger cuttings at depths of approximately 0.3 m to 1.5 m below ground surface for thermal resistivity and California Bearing Ration (CBR) laboratory tests. Bulk samples on which moisture content and classification testing were performed were placed in sealed bags.

For geotechnical investigation purposes, the soil SPT samples were labelled and transported to Hatch's Niagara Falls geotechnical laboratory where the samples underwent further visual examination and laboratory testing. Bulk samples were shipped to Soil Engineering Testing, Inc., (SET) in Bloomington, Minnesota for the specified testing.

4.5 Field Electrical Resistivity Testing

Field electrical resistivity testing was completed at a total of two (2) locations. The resistivity testing was completed in accordance with ASTM method G57 "Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method" (equivalent to IEEE Std. 81). Electrode "A" spacings of 2, 5,10, 20, 50, 100, and 200 feet were used at the test locations. At each of the locations, measurements were taken to determine average soil resistivity along the test sections.

The equipment used to collect the data consisted of a resistivity meter, four metal electrodes and connecting wire. Co-linear arrays of four electrodes were placed in the ground for each measurement. Electrical current was input to the ground through the two outer electrodes of the array. The voltage drops produced by the resulting electrical field was measured across the two inner electrodes. The "A" spacing was increased with each measurement, expanding the array about a common center. Increasing the electrode separation increases the depth of exploration and indicates vertical variation in resistivity. The resistivity meter reported apparent resistivity; the conversion of electrical potential and inductance to apparent resistivity was not required.

4.6 As-Drilled Borehole Locations

The as-drilled borehole locations were surveyed using a hand-held GPS unit and the ground surface elevations were interpolated from site survey provided by Brookfield referenced to a High-Resolution Digital Elevation Model (HRDEM), dated January 2025. Borehole locations are shown on the Borehole Location Plan and referenced to NAD 83 MTM Zone 9. Elevations noted on the Record of Borehole sheets in Appendix A are referenced to Canadian Geodetic Vertical Datum 2013 (CGVD2013). A summary of the borehole locations and elevations are summarized in Table 4-1 below.

Table 4-1: As-Drilled Borehole Identification and Depth

Borehole Location	Borehole Type	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)	Monitoring Well Depth / Screened Interval (m)
TR24-1	SPT	5,008,429.08	363,344.02	95.34	9.52	9.52 / 6.48 – 9.52
TR24-2	SPT	5,008,470.26	363,389.47	95.93	6.60	-
TR24-3	SPT	5,008,541.17	363,519.64	95.86	6.60	-
TR24-4	SPT	5,008,544.22	363,632.97	95.48	6.40	-
TR24-5	SPT	5,008,332.21	363,480.73	95.14	6.45	-
TR24-6	SPT	5,008,455.88	363,597.80	95.57	7.05	7.05 / 5.53 – 7.05
TR24-7	SPT	5,008,651.30	363,710.91	95.74	2.10	-
TR24-8	SPT	5,008,730.81	363,894.84	96.04	2.10	-

The as-drilled borehole locations may differ slightly from the proposed borehole locations due to site access considerations.

5. Laboratory Testing

5.1 Geotechnical Laboratory Testing

The following geotechnical testing was carried out on selected soil samples:

- Moisture Content (ASTM D2216)
- Grain Size Distribution (ASTM D6913)
- Thermal Resistivity Test (ASTM D5334)
- California Bearing Ratio (ASTM D1883)
- Standard Proctor Density (ASTM D698)
- Soil pH tests in accordance (ASTM G51); and
- Soluble chloride and soluble sulfate of soils (ASTM D4327).

The geotechnical test results carried out on selected soil samples are shown on the Record of Borehole sheets presented in Appendix A. The results of the classification tests are presented in Appendix B.

A soil sample for thermal resistivity testing was collected at the location of Borehole TR24-1. The sample was transported to Soil Engineering Testing, Inc., (SET) in Bloomington, Minnesota for laboratory testing in accordance with ASTM D5334, “Standard Test Method for Determination of Thermal Conductivity of Soil and Soft Rock by Thermal Needle Probe Procedure”. Bulk samples were recompacted to 85 percent of the soils maximum dry density (MDD). California Bearing Ratio (CBR), Standard Proctor and grain size distribution testing were also conducted on the bulk sample. The test reports are presented in Appendix C.

6. Geotechnical Results

6.1 Regional Geology

As delineated in The Physiography of Southern Ontario[1], the Trail Road BESS site lies within the minor physiographic region known as the Edwardsburg Sand Plain, which lies within the major physiographic region of the Ottawa-St. Lawrence Lowland. The Edwardsburg Plain region is characterized by a slightly undulating sand plain that overlies boulder clay and bedrock. The sand is likely glaciofluvial in origin, deposited in the late stages of the Champlain Sea with a few morainic structures remaining.

The surficial geological mapping[2] produced by the Geological Survey of Canada (GSC) indicate that the study area is underlain by reworked glaciofluvial sands and silts overlying sandy silt to silty sand-textured till. The published drift thickness mapping (depth to bedrock) indicates that the bedrock surface is generally located at depths ranging from 15 to 25 m. The bedrock geology mapping[3] indicates that the bedrock at study area is limestone and dolomite of the Oxford Formation.

6.2 Subsurface Conditions

The detailed subsurface soil and rock conditions encountered in the boreholes advanced as part of the investigation and the results of the in-situ, field and laboratory testing are provided in the following appendices:

- Appendix A– Record of Boreholes
- Appendix B– Soil Classification Testing (Grain-Size Distribution)

---

[1] Chapman, L. J. and Putnam, D. F., 1984. *The Physiography of Southern Ontario*, Ontario Geological Survey. Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000. Ontario Ministry of Natural Resources.

[2] Ontario Geological Survey 2010. Surficial geology of Southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 128-REV

[3] Ontario Geological Survey 2011. 1:250 000 scale bedrock geology of Ontario; Ontario Geological Survey, Miscellaneous Release---Data 126-Revision 1.

- Appendix C– Advanced Laboratory Testing
- Appendix D– Chemical Testing
- Appendix E– Electrical Resistivity Testing.

Classification and identification of the soils are based on the American Society of Testing and Materials (ASTM) D2488-17 – Standard Practice for Description and Identification of Soils. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling, observations of drilling progress and results of SPTs. These boundaries, therefore, represent transitions between soil types/groups rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations.

A detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

6.2.1 Topsoil

Topsoil was encountered in all boreholes advanced at the site and is 100 mm to 300 mm thick. Materials identified as topsoil in this report were classified based on visual and textural evidence and no other testing for organic content or other nutrients was carried out. Localized zones of thicker or thinner surficial soil with variable organic content should be expected across the site depending on the agricultural use and topography.

6.2.2 Silty Sand to Sandy Silt

Silty sand to sandy silt was encountered below the topsoil in all boreholes advanced at the site. The silty sand to sandy silt extends to depths ranging from 6.2 m to 6.4 m below ground surface, where fully penetrated, in Boreholes TR24-1, TR24-4 and TR24-5. Boreholes TR24-1, TR24-4 and TR24-5 were terminated at the base of the silty sand to sandy silt after encountering split-spoon refusal on the inferred underlying bedrock. Boreholes TR24-2, TR24-3 and TR24-6 to TR24-8 were terminated within the silty sand to sandy silt deposit.

The measured SPT ‘N’ values within the silty sand to sandy silt range from 3 blows to 91 blows per 0.3 m of penetration, indicating a very loose to very dense compactness, however, were generally measured between 10 blows to 30 blows per 0.3 m of penetration, indicating a compact to dense compactness.

The results of grain-size distribution testing conducted on eight samples of the silty sand to sandy silt are shown in Appendix B.

The water content measured on samples of the silty sand to sandy silt range from 3 percent to 19 percent but generally range from 13 percent to 16 percent.

A laboratory compaction test was conducted on the bulk soil sample and the Standard Proctor testing indicated the maximum dry density was 18.2 kN/m^3 with a corresponding optimum moisture of 12.4 percent. The results of the standard Proctor tests are provided in Appendix C.

The bulk soil materials were also compacted to 95 percent of the maximum standard Proctor density at the optimum moisture content and subsequently soaked for 96 hours before California Bearing Ration (CBR) tests were performed. The test results indicated a CBR value of 5.7 percent. The results of the testing are provided in Appendix C.

Thermal resistivity testing was conducted on the bulk soil sample of the silty sand to sandy silt collected from about 0.3 m to 1.5 m below ground surface at Borehole TR24-1. The bulk soil materials were recompacted to 85 percent of the soils maximum dry density (MDD) and thermal dry-out curve populated based on the moisture content vs. the thermal resistivity measured with the needle probe. The results of the thermal resistivity testing are provided in Appendix C.

6.2.3 Sandy Silt with Gravel (Glacial Till)

A deposit of sandy silt with gravel appearing to be glacial till was encountered below the silty sand to sandy silty in Borehole TR24-1 at a depth of 6.2 m below ground surface. Borehole TR24-1 was terminated within the sandy silt with gravel till at a depth of 9.5 m below ground surface after encountering split-spoon refusal on inferred bedrock surface.

The measured SPT ‘N’ values within the sandy silt with gravel till range from 34 blows to 72 blows per 0.3 m of penetration, indicating a dense to very dense compactness.

The water content measured on samples of the silty sand range from 11 percent to 16 percent.

6.2.4 Groundwater Conditions

The groundwater level within the boreholes was monitored during advancement and in the open borehole upon completion. Monitoring wells were installed in Boreholes TR24-1 and TR24-6. Details of the monitoring well installation are shown on the Record of Borehole sheets in Appendix A.

The groundwater level measured manually in the monitoring wells ranged from 0.7 m to 2.1 m below ground surface in Borehole TR24-1 and from 1.1 m to 3.3 m below ground surface in Borehole TR24-6. Further details of the groundwater level monitoring events can be found on the Borehole Records in Appendix A.

The groundwater level at the site is expected to fluctuate seasonally in response to change in the precipitation and snow melt and is expected to be higher during the spring and during periods of precipitation.

6.3 Soil Chemical Testing

Chemical tests, consisting of soil pH, soluble chlorides and soluble sulfates, were performed on two samples collected at the Project site. The results of the chemical testing indicate that soil had a pH ranging from 7.33 to 7.36, resistivity ranging from 66 to 102 Ohm*m, and a soluble sulfate concentration ranging from 7 to 72 µg/g. The chemical test results are shown in Appendix D. A discussion of the results correlated to corrosion potential and sulphate attack on concrete is provided in Section 9.

7. Geotechnical Discussion and Design Considerations

This section of the report presents an interpretation of the factual geotechnical data to date and provides geotechnical design recommendations for the proposed Battery Energy Storage System (BESS) and associated structures. These discussions and recommendations are based on our understanding of the project and our interpretation of the factual data obtained from the December 2024 investigation.

This section of the report provides engineering information for the geotechnical design aspects of the project, based on our interpretation of the borehole data and on our understanding of the project requirements. The information in this portion of the report is provided for the guidance of the design engineers and professionals. Where comments are made on construction, they are provided only to highlight aspects of construction which could affect the design of the project. Contractors bidding on or undertaking any work at the site should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for construction and make their own interpretation of the factual data as it affects their proposed construction techniques, schedule, equipment capabilities, costs, sequencing, and the like. If the project is modified in concept, location or elevation, Hatch should be given the opportunity to confirm that the recommendations in this report are still valid.

This report addresses only the geotechnical (physical) aspects of the subsurface conditions at this Site. The geo-environmental (chemical) aspects, including the consequences of possible surface and/or subsurface contamination resulting from previous activities or uses of the Site and/or resulting from the introduction onto the site of materials from off-site sources, are outside of the terms of reference for this report.

Based on the results of this investigation, the subsurface soil conditions encountered at the Site are considered to generally be suitable for the proposed development, which is understood to comprise of BESS structures, a substation structure, access roads and associated electrical servicing.

7.1 Site Preparation

7.1.1 Subgrade Preparation

It is understood from drawings provided to Hatch that the BESS development will consist of a BESS area, a substation area with site servicing and access roads. However, a site grading plan was not provided. Therefore, it is assumed that minor cut and/or fill site grading operations (i.e., less than 1.5 m) will be required to establish subgrade levels and permit construction of the proposed development.

Any filling carried out at the Site in conjunction with grading (with the exception of future green spaces) should be carried out as engineered fill. Recommendations for the placement of engineered fill are outlined in Section 7.1.2 of this report. In general, the existing vegetation, surficial topsoil or other near-surface soils containing significant amounts of organic matter are not considered to be suitable for the subgrade support of engineered fill, foundations, slabs, pavements or other settlement sensitive structures. These materials, which are about 100 mm to 300 mm thick below existing ground surface, based on the boreholes advanced at the Site, should be completely stripped prior to placing any engineered fill or construction of foundations or exterior slab-on-grade(s).

Following the stripping of the surficial topsoil and/or soils containing significant amounts of organics and/or soft/disturbed, the exposed subgrade should be proof-rolled with suitable equipment, such as a heavy roller or partially loaded truck, in conjunction with inspection by qualified geotechnical personnel to confirm that the exposed soils are competent and have been adequately stripped of ponded water and all disturbed, loosened, softened, organic and other deleterious material. Remedial work (i.e., further sub-excavation and replacement) should be carried out on poorly performing areas identified during the proof-rolling activities, as directed by a geotechnical professional.

7.1.2 Engineered Fill Requirements

As described above, the anticipated site grading activities are expected to include both cutting and raising (filling) the original grade to meet the final design site grades.

In general, the existing native material is considered to be acceptable for reuse as engineered fill. In addition, the native materials to be used as engineered fill should be free of cobbles, boulders, topsoil, organic matter or other deleterious materials. All oversized cobbles (i.e., greater than 150 mm in size) and boulders, if present, should be removed from excavated material that will be used as engineered fill material. Based on the laboratory test results, the water content of soils present at the site are considered to be generally near or above their optimum water contents for compaction and, therefore, may require adjustment of the moisture content prior to placement. If excavated native materials will be used as engineered fill for grade raises on site, standard Proctor testing, including determination of the optimum water content of the material and gradation, should be carried out and approved by the geotechnical engineer prior to placement.

It should be noted that the native silty sand to sandy silt material at the site is susceptible to over-wetting and subsequent freezing during inclement weather. Therefore, it is recommended that site grading activities not be carried out during late fall, winter, early spring seasons or any periods of inclement weather conditions as this may cause delays in the construction activities.

If imported material is required for the engineered fill process, the material that is proposed for use as engineered fill should be approved by the geotechnical engineer, at its source, prior to importing the material to the site. In this regard, imported materials which meet the requirements for OPSS Select Subgrade Material (SSM) would be suitable for use as engineered fill. Suitable soils, free of topsoil, organic matter or other deleterious materials can be used as engineered fill provided that the water content of the soil at the time of placement does not vary by more than 2 percent above or below its optimum water content for compaction. Otherwise, the soils may require treatment (i.e., drying or wetting) prior to placement.

Following the inspection and approval of the subgrade as described previously in this report, engineered fill materials below foundation elements should be placed in maximum 300 mm thick loose lifts and uniformly compacted to 98 percent of the standard Proctor maximum dry density (SPMDD). Filling should continue until the design elevations are achieved. Full-time monitoring and in-situ density testing should be carried out during placement of engineered fill.

The final surface of the engineered fill should be protected, as necessary, from construction traffic and should be sloped to provide positive drainage for surface water during the construction period. If the engineered fill materials will be left exposed (i.e. uncovered) during periods of freezing weather, additional soil cover should be placed above final subgrade to provide some level of frost protection.

7.1.2.1 Fill Areas

It is understood from Drawing Nos. 7154024-200000-41-D52-0003 and 7154024-200000-41-D52-004, dated April 24, 2025, prepared by BBA and provided to Hatch by Brookfield that grade raises at the site could be up to 2.5 m in height with side slopes of 2 Horizontal to 1 Vertical (2H:1V). However, the drawings were provided for permitting purposes only and will be subject to change during subsequent design stages.

7.1.2.1.1 Global Slope Stability Analyses

Global stability analysis has been carried out using the commercially available program SLOPE/W (Version 5.13) produced by Geo-Slope International Ltd. employing the Morgenstern-Price method of analysis. For the analysis, the factor of safety of the potential failure surfaces was computed to establish the minimum factor of safety. For fill areas under static conditions, a target factor of safety of 1.5 was used according to the City of Ottawa Slope Stability Guidelines. This target factor of safety is considered appropriate for the soil conditions at the proposed fill areas considering the design and performance requirements and the available subsurface data.

Static global stability analyses were performed for the highest fill areas based on the provided drawings. The soil parameters used in the analysis, as given in the following table, were estimated from empirical correlations using the results of the in-situ Standard Penetration Tests (SPT) and geotechnical classification testing. The water level measured in the monitoring wells was measured at a depth as high as 0.7 m below ground surface, however, it is understood that a worst case groundwater level at ground surface has been requested to be used for analysis by the City of Ottawa.

Table 7-1: Slope Stability Parameters

Soil Type	Angle of Internal Friction (Deg)	Unit Weight (kN/m^3)	Undrained Shear Strength[1] (kPa)
New Granular Fill	35	22	-
Silty Sand to Sandy Silt	30	21	-

Notes: 1. Undrained shear strength not applicable to granular soils encountered at the site.

For conventional earth slopes at the side of the fill areas oriented at 2H:1V, the slopes have a factor of safety greater than 1.5 which were calculated using the Morgenstern-Price method of analysis. The stability analysis results are presented in Appendix F.

7.1.3 Excavations

Details of the excavations for BESS foundations, substation area and underground servicing for the proposed development are unknown at the time of this investigation; as such, for the purpose of this report, the maximum depth of the foundation footings was assumed to be up to about 3 m below the existing ground surface. Once detailed design is completed, review of the required excavations should be completed by this office for compliance with the recommendations contained herein.

The founding soils are anticipated to generally consist of the native silty sand to sandy silt. This material is considered to be suitable for supporting the BESS and substation foundations provided that the integrity of the base of the excavations is maintained in satisfactory condition during construction. Where softened or disturbed native soils or other deleterious materials are encountered at the base of excavations for settlement-sensitive foundations, these materials should be sub-excavated and replaced with compacted fills approved by the geotechnical engineer.

Care should be taken to direct surface water away from any open excavations and all temporary excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA) and Regulations for Construction Projects.

In general, the groundwater levels measured in the monitoring wells installed at the site ranged from about 0.7 m to 3.3 m below ground surface at the time of the monitoring events.

The groundwater in the excavations within the native deposits above the groundwater table are likely to be handled by collection via properly constructed and filtered sumps, located within the excavations, and then pumping and discharging the water to a suitable discharge point. Where excavations will extend below the frost depth of 1.8 m below ground surface as discussed below, and below the highest groundwater level recorded within the monitoring wells of about 0.7 m below ground surface in the area of the proposed substation and BESS structures, some form of active groundwater control will be required to maintain the stability of the base and side slopes of the trench excavations, in addition to pumping from sumps. Consideration may also be given to reducing the length of open trench at one time, or the use of a tremie plug at the base of the excavation. Once the invert elevations for the structures are finalized, careful review of the borehole data should be carried out by the designers and the geotechnical engineer to determine the need for localized pro-active groundwater controls (which may need to take the form of installation of well points or a cut-off system) to help ensure the stability of slopes and bases of the proposed excavations.

All temporary excavations must be carried out in accordance with the requirements of the OHSA. The soil types, as defined in the OHSA, for overburden soils present at the proposed BESS development site are summarized below as an aid for design and are based on an assumed groundwater level at ground surface:

- Compact to dense silty sand to sandy silt below groundwater – Type 4 soil.

For open excavations, Type 4 soils must be sloped from the bottom of the excavation and may have a maximum allowable slope of 3H:1V. Depending upon the construction procedures adopted, the groundwater seepage conditions and weather conditions at the time of construction, some local flattening of the slopes of open cut excavations may be required, especially in looser/softer zones or where localized seepage is encountered. Further, layering of soils and the effectiveness of the Contractor’s dewatering systems could affect the OHSA classification and, therefore, the classification of soils for OHSA purposes must be made at the time the excavation is open and can be directly observed during construction.

Where the side slopes of excavations are required to be steepened to limit the extent of the excavation, then some form of trench support may be required. Some trench excavations could be carried out using a vertically-excavated, unsupported excavation (using a properly-engineered trench liner box for protection, certified by an experienced engineer); or by a supported (sheeted) excavation if conditions warrant so, such as in wet areas and/or in close proximity to adjacent underground services.

8. Structures

It is understood that Battery Energy Storage System (BESS) structures, or “cabinets”, are typically supported on deep foundation systems connected to a frame at the base of the structure. Typical deep foundation systems include drilled piers (caissons) or helical piers (ground screws). Based on the subsurface conditions encountered at the site, shallow foundations could also be considered for support of the BESS structures, substation and other ancillary structures including strip footings, spread footings or conventional slab-on-grade. Discussion of the shallow and deep foundation options that could be considered to support the BESS structures, substation and/or ancillary structures is provided in the following sections. Conceptual foundation details of the foundation options are provided in Appendix G.

8.1 Shallow Foundations

As noted in Section 6.2, the subsurface conditions in the area of the BESS structures and substation consist of topsoil overlying generally compact to dense silty sand to sandy silt to about 6.2 m below ground surface which is underlain by sandy silt with gravel (glacial till) and bedrock.

Based on the subsurface conditions encountered at the site, strip and/or spread footings may be used for the proposed BESS structures, substation and ancillary structures provided that the footings are founded on the soils at depths noted below and placed in accordance with the recommendations outlined in Section 7.1.

Based on the Ontario Provincial Standard Drawing (OPSD) 3090.010 entitled “Foundation Frost Penetration Depths for Southern Ontario”, the depth of frost penetration in the Ottawa area is approximately 1.8 m below ground surface. In order to provide adequate protection against frost damage, it is recommended that the shallow foundations be constructed a minimum of 1.8 m below finished ground surface.

For strip and/or spread footings, the following preliminary geotechnical axial resistances at Ultimate Limit States (ULS) and at Serviceability Limit States (SLS, for 25 mm of settlement) may be assumed for design purposes. At the time of this report, the dimensions of the footings for the proposed structures were not provided. Therefore, a footing width of 0.5 m with a length of 6 m has been assumed for strip footings. For spread footings, the dimensions have been assumed to be 1 m by 1 m in area at a minimum depth of 1.8 m below ground surface on compact to dense silty sand to sandy silt.

Table 8-1: Founding Elevations and Geotechnical Axial Resistances

Foundation Element	Maximum Founding Elevation (Depth Below Ground Surface) (m)	Relevant Boreholes	Founding Soil	Factored Geotechnical Resistance at ULS (kPa)	Factored Geotechnical Resistance at SLS (kPa)
BESS Structures	93.2 (1.8)	TR24-2 to TR24-6	Compact to Very Dense Silty Sand to Sandy Silt	200	-[1]
Substation	93.5 (1.8)	TR24-1	Compact to Very Dense Silty Sand Silty Sand to Sandy Silt	200	-[1]

Note: 1. ULS value will govern the design as the SLS value for 25 mm of settlement is higher than the ULS value.

The factored geotechnical axial resistance at ULS and geotechnical reaction at SLS are dependent on the foundation size, depth, configuration and applied loads. Geotechnical resistance/reaction should, therefore, be reviewed once more detailed design information (i.e., footing size and depth) becomes available. The geotechnical resistance/reaction are based on loading applied perpendicular to the base of the footings. Where applicable, inclination of the load should be taken into account.

Where spread footings are constructed at different elevations, the difference in elevation between the individual footings should not be greater than one half the clear distance between the footings. In addition, the lower footings should be constructed first so that if it is necessary to construct the lower footings at a greater depth than anticipated, the elevation of the upper footings can be adjusted accordingly. Stepped strip footings should be constructed in accordance with the Ontario Building Code (2024), Section 9.15.3.9.

The maximum total and differential settlements are expected to be less than 25 mm and 20 mm; respectively, for footings designed, constructed and inspected as outlined above.

All exterior footings, and interior footings in unheated areas, should be founded at a minimum depth of 1.8 m below finished grade level in order to provide adequate protection against frost penetration.

The native soils are susceptible to disturbance from construction activity, especially during wet or freezing weather. Care should be taken to preserve the integrity of the materials as bearing strata. It is essential that the founding surface for the footings be inspected by qualified geotechnical personnel prior to placing concrete. If the concrete for the footings cannot be placed immediately after excavation and inspection of the subgrade, it is recommended that a working mat of lean concrete be placed in the excavation to protect the integrity of the bearing stratum.

To avoid detrimental impacts from frost adhesion and heaving, the excavated areas behind any below grade foundation elements, such as the substation, should be backfilled with non-frost susceptible granular material conforming to the requirements for OPSS.MUNI 1010 Granular ‘B’ Type I material. In areas where asphalt/concrete pavement or other hard surfacing (flatwork) will abut the structure, differential frost heaving could occur between the granular fill immediately adjacent to the structure and the more frost susceptible native materials which exist beyond the wall backfill. To reduce the severity of this differential heaving, the backfill adjacent to the wall should be placed to form a frost taper. The frost taper should be brought up to asphalt/concrete subgrade level from 1.8 m below finished exterior grade at a slope of 3 horizontal to 1 vertical, or flatter, away from the wall. The backfill materials should be placed evenly in lifts not exceeding 200 mm loose thickness. The layers should be compacted to at least 98 percent of the materials standard Proctor maximum dry density (SPMDD). Light compaction equipment should be used immediately adjacent to the walls; otherwise, compaction stresses on the wall may be greater than that imposed by the backfill material. The upper 0.3 m of backfill should consist of clayey material (in landscape areas) to provide a relatively low-permeability cap and the exterior grade should also be shaped to slope away from the structure.

Resistance to lateral forces/sliding resistance between the concrete footings and the subgrade should be calculated in accordance with Section 6.10.4 of the Canadian Highway and Bridge Design Code (CHBDC). The unfactored coefficient of friction, tan δ, for the interface between the cast-in-place concrete footing and the properly prepared subgrade can be assumed to be 0.36.

8.2 Slab-On-Grade

Conventional slab-on-grade foundation construction could be considered for the proposed BESS structures (cabinets) at the site. The design of “raft” foundations is generally governed by settlement considerations rather than bearing capacity since the design bearing pressure is generally less than the allowable bearing capacity. Differential settlements may also occur along the length of the structure supported by a raft due to the variation in loading across the raft as well as potential variable soils at the base elevation, as such, reinforcing steel should be incorporated into the raft slab to help mitigate differential settlement.

The modulus of vertical subgrade reaction or soil “spring constant” is a concept used in structure engineering; however, it is not related to fundamental soil properties. The values of “spring constants” for raft design can only be evaluated following a detailed settlement analysis and should be considered approximate only. The moduli of subgrade reaction provided has been adjusted from that interpreted for a 0.3 m by 0.3 m square plate and a combined minimum base slab thickness of 600 mm has been used as an indicator of relative base slab stiffness and effective foundation width for calculation using spring constants. The design modulus of subgrade reaction is derived based on the assumption that the subgrade is not disturbed during construction, excavation subgrade is prepared according to recommendations in this report and adequate dewatering (if required) is undertaken to ensure an undisturbed subgrade.

For design of the raft foundation founded on the silty sand to sandy silt, a vertical moduli of subgrade reaction, k_s, of 10 MPa/m may be considered.

As noted previously, the modulus of subgrade reaction is not a fundamental nor intrinsic soil property and will vary depending on the rigidity of the slab, the thickness of the granular bedding, and the thickness, type and stiffness of the subgrade at the location/elevation of the raft slab-on-grade. Where the design is sensitive to the specific modulus value(s) and the design details of the proposed foundations for the raft is confirmed (including founding level and contact stresses at the underside of the foundation) a detailed settlement analysis will need to be carried out, from which values of modulus of subgrade reaction across the foundation can be estimated.

For predictable performance of the floor slab, the existing topsoil or organic soils, as well as any wet or disturbed material should be removed from within the proposed BESS slab-on-grade structure area. Provisions should be made for at least 150 mm of OPSS Granular ‘A’ to form the base for the floor slab.

Any bulk fill required to raise the grade to the underside of the Granular ‘A’ should consist of OPSS Granular ‘B’ Type II. The underslab fill should be placed in maximum 300 mm thick lifts and should be compacted to at least 98 percent of the materials standard Proctor maximum dry density (SPMDD) using suitable vibratory compaction equipment.

The raft foundations should be provided with a minimum 1.8 m of soil cover for frost protection as per OPSD 3090.101 (Frost Penetration Depths for Southern Ontario). This dimension should be measured perpendicular from the ground surface nearest to the outside toe of the footing.

Alternatively, rigid styrofoam insulation could be installed on the underside of the foundation to compensate for the lack of soil cover and provide protection from frost penetration. The insulation should cover the entire raft foundation area. As a guideline for design, 25 mm of rigid polystyrene foam insulation provides a 300 mm reduction in soil cover. For unheated structures, the insulation is typically placed below the foundation and extends outwards horizontally from the foundation. The horizontal distance from the foundation is dependent on the amount of soil cover provided. Hatch should be contacted for additional recommendations if rigid polystyrene foam insulation is used in lieu of soil cover. In addition, the bearing soil, backfill and fresh concrete should be protected from freezing during cold weather construction.

The type of insulation should be selected such that the bearing pressure on the insulation due to the raft load (including self-weight of the concrete and underslab fill) does not exceed about 35 percent of the insulation's quoted compressive strength due to the time dependent creep characteristics of this material.

8.3 Deep Foundations

8.3.1 Drilled Pier (Caisson) Foundations

Drilled pier foundations (caissons) can be considered for support of the proposed BESS, substation, and ancillary structures. The factored ULS bearing resistance values provided are based on a limit state resistance factor of 0.4. Based on the stratigraphic conditions, the recommended factored axial geotechnical resistance in compression at Ultimate Limit states (ULS) and the axial geotechnical resistance at Serviceability Limit States (SLS) for 600 mm diameter caissons founded in the compact to very dense silty sand to sandy silt, are provided in the table below. The bottom of the pile caps are assumed to be at approximately Elevation 93.3 m (1.8 m below ground surface, frost depth) and pile tip elevations extending to about Elevation 90.3 m (3 m long pile). Where the piles extend above ground surface to connect with the BESS support structure, the resistances provided below will also apply.

Table 8-2: Preliminary Geotechnical Axial Resistances for Caissons (Drilled Piers)

Recommended Minimum Caisson Founding Elevation (m) and Anticipated Founding Soils	Factored Geotechnical Axial Resistance at ULS (kN)	Geotechnical Resistance at SLS (kN)
90.3 (Pile Cap - Compact to Very Dense Silty Sand to Sandy Silt)	200	150
90.3 (No Pile Cap – Compact to Very Dense Silty Sand to Sandy Silt)	200	150

The installation of caissons likely will require a temporary liner to provide support to the surrounding soil, and the use of drilling slurry to minimize disturbance to the granular soil sidewalls and balance the groundwater head. Due to the anticipated water inflow, concrete must be placed in caissons using tremie techniques. That is, the concrete must be discharged at the base of the caisson excavations, and flow upward to the ground surface displacing the drilling fluid from the hole. The tremie discharge should be maintained a minimum of 1 m below the surface of the wet concrete during placement and as the temporary liner is withdrawn. The performance of caissons in compression will depend to a large degree upon the final cleaning and verification of the condition of the subgrade soils at the base of the circular pile. For the caissons acting in compression, the base of each caisson excavation must be cleaned to remove all loose cuttings to ensure that the concrete is in contact with the competent undisturbed base.

All caisson/pile caps should be founded at a minimum depth of 1.8 m or provided with an equivalent thickness of insulation below the cap for frost protection, in accordance with OPSD 3090.101 *(Foundation Frost Penetration Depths for Southern Ontario).* In addition, the bearing soil and fresh concrete should be protected from freezing during cold weather construction.

8.3.2 Helical (Screw) Piles

Typically, helical (screw) piles are considered a proprietary foundation system due to variability in the use of pile materials and installation methods. Therefore, the design guidelines provided in this memorandum are for planning and preliminary design purposes only and detailed design and verification of the installed capacity of helical piles is the responsibility of the proprietary foundation system designer/installer.

Helical piers would be augered into the ground and founded in the generally compact to dense silty sand to sandy silt material with the helices located below frost depth at a minimum. The helical pier would then be attached to the foundations using brackets. Pre-compression should be induced in the helical pier prior to transferring the foundation loads to minimize the amount of post-construction settlement.

Helical piers may be the preferred option for the Trail Road site to support the proposed development structures due to the following advantages:

- Minimal disturbance of saturated sands (groundwater table assumed to be at ground surface).
- Do not require temporary liners, placement steel reinforcing or tremie poured concrete.
- No vibration or excess soils to dispose.
- Adaptable to various subsurface conditions.
- Installation equipment requires minimal footprint and can be installed with portable equipment (if required); and
- Can be installed shallow or deep (2 m to 60 m).

The number, size and design of the helical piles should be determined and confirmed by the supplier.

The number and size of the helical piles will need to be determined based on the loading and configuration of the support system of the BESS ‘cabinet’ structures. The project geotechnical information and structural loading should be provided to a specialist design-build contractor to assess the feasibility of this foundation system and to determine probable helical pile installation depths and capacities.

For preliminary design purposes, the table below provides the factored helical pile capacities based on the helices found in the compact silty sand to sandy silt.

Table 8-3: Preliminary Factored Geotechnical Axial Resistances for Helical Piles

Anticipated Founding Stratum	Factored Geotechnical Axial Resistance at ULS (kN)	Geotechnical Resistance at SLS (kN)
Compact Silty Sand to Sandy Silt	270	200

It is recommended that a pile load test program be completed on site prior to completion of detailed design to verify or amend capacity of the helical piles if suggested by the specialist contractor.

The actual depth of each helical pile is determined on site based on depth, torque measurements and load support requirements. Full time inspection of the installation of the helical piles by a geotechnical professional is recommended to confirm that the subsurface conditions are consistent with the findings of the geotechnical investigation which the design was based on.

8.3.3 Pile Group Effects

Pile group effects associated with closely spaced piles are not anticipated to negatively impact the performance of potential pile foundations at this site based on the conceptual information for the BESS structures; however, the foundation plan for the substation has not been provided at the time of this report. The following items should be considered to ensure pile group effects are adequately evaluated.

Spacings between piles should be at least 3 times the pile diameter for the axial capacity to be valid. If this spacing is not maintained, the axial capacity of individual shafts should be reduced using group efficiency factors to account for group effects. Group efficiency factors depend on the pile spacing, pile diameter, and geometry of the pile group (number of rows and columns). Similarly, if the pile spacings are less than 6 times the diameter of the drilled shaft, then the lateral capacity of the individual shaft should be reduced using a P-multiplier to account for group action. The P-multiplier factor depends on the pile spacing, pile diameter, and a given pile's position (row and column) with respect to the group. Furthermore, the estimated settlement is for individual piles supporting structural loads; however, if the spacing is less than 6 times the diameter of the piles, the settlement may increase due to group effects. Group efficiency, P-multiplier factors, and group settlement can be provided upon request.

8.3.4 Additional Design and Construction Recommendations

Construction specifications for the drilled piles should include a concrete mix designed to limit bleeding. It is the contractor's responsibility to increase individual or group pile lengths and/or increase the number of piles to compensate for any soil disturbance created by the contractor's means and methods during construction.

To minimize disturbance of foundation soils, the contractor should drill piles using temporary casings where groundwater is present. After drilling, the casing should be extracted at a slow, uniform rate, with the pull in line with the center of the shaft. We recommend the contractor review this report and adjust drilled shaft installation means and methods accordingly.

A geotechnical professional or authorized representative should be on-site to observe drilled pile installation including drilling operations as well as concrete and reinforcing steel placement. The base of the drilled piles should be clean and free of debris or loose soil prior to pouring concrete or placing reinforcing steel. Concrete should be poured promptly after drilling to reduce exposing the subsoil to water or drying conditions. If foundation bearing soils are subjected to such conditions, the soils should be reevaluated before concrete is poured.

Free-fall concrete placement is not recommended unless approved by the structural engineer. The use of a bottom dump hopper or tremie pipe could be considered to prevent potential aggregate segregation or sidewall disturbance.

8.4 Lateral Earth Pressures

The parameters (unfactored) provided below may be used to calculate the lateral earth pressures acting on ancillary structures such as the substation systems for excavation support, if required:

Table 8-4: Lateral Earth Pressure Parameters

Soil Type	Angle of Internal Friction (Deg)	Unit Weight (kN/m^3)	Coefficients of Static Lateral Earth Pressure		
			At-Rest, K_o	Active, K_a	Passive, K_p
New Granular Fill	35	22	0.43	0.27	3.69
Silty Sand to Sandy Silt	30	21	0.50	0.33	3.00

The unit weight of water may be taken as 10 kN/m^3. If the structure allows for lateral yielding, active earth pressures may be used in the design of the structure(s). If the structure does not allow for lateral yielding, at-rest earth pressures should be assumed for design.

8.5 Installation of Underground Services

8.5.1 Temporary Excavations

The maximum depth of the underground services was assumed to be about 2 m below the existing ground surface. At this depth below existing ground surface, the founding soils for the proposed utilities are anticipated to be within the silty sand to sandy silt materials encountered across the site. These materials are considered to be suitable for supporting the underground services provided that the integrity of the base of the trench excavations is maintained during construction. Where softened or disturbed native soils or other deleterious materials are encountered at the base of the excavations for settlement-sensitive services, these materials should be subexcavated and replaced with compacted fills approved by a geotechnical engineer.

Care should be taken to direct surface water away from any open excavations and all temporary excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA) and Regulations for Construction Projects.

The groundwater level measured in the monitoring wells was measured at a minimum depth of 0.7 m below ground surface, however, as noted in previous sections, the groundwater level at the site should be assumed to be at ground surface. Therefore, it should be assumed that some form of active groundwater control will be required to maintain the stability of the base and side slopes of the trench excavations, in addition to pumping from sumps. Consideration should also be given to reducing the length of open trench at one time, or the use of a tremie plug at the base of the excavation. Once the invert elevations for the underground utilities are finalized, careful review of the borehole data should be carried out by the designers and the geotechnical engineer to determine the need for localized pro-active groundwater controls (which may need to take the form of installation of well points or a cut-off system) to help ensure the stability of slopes and base of the proposed excavations.

For excavations through the silty sand to sandy silt soils below the groundwater table, the side slopes should have a maximum allowable slope of 3H:1V. Where the side slopes of excavations are required to be steepened to limit the extent of the excavation, then some form of trench support will be required. Trench excavations could be carried out using a vertically excavated, unsupported excavation (using properly engineered trench liner box for protection, certified by an experienced engineer); or by supported (sheeted) excavation if conditions warrant so, such as in wet areas and/or in close proximity to adjacent underground services. It must be emphasized that a trench liner box provides protection for construction personnel but does not provide any lateral support for adjacent excavation walls, underground services or existing structures (if any). It is imperative that any underground services or existing structures adjacent to the trench excavations be accurately located prior to construction and adequate support provided where required. Steepened excavations should only be left open for as short duration as possible and completely backfilled at the end of each working day.

8.5.2 Pipe Bedding and Cover

The bedding for sewers and watermains should be compatible with the size, type and class of pipe and the surrounding subsoil and the requirements of the City of Ottawa. If granular bedding is deemed to be acceptable, then Ontario Provincial Standard Specifications (OPSS.MUNI 1010) Granular 'A' should be used from at least 150 mm below invert to springline. Clear stone should not be used as bedding material. From springline to 300 mm above obvert of the pipe, sand cover could be used. All bedding and cover material should be placed in 150 mm loose lifts and uniformly compacted to at least 100% of SPMDD. Where variable fill materials, softened or disturbed native soils or other deleterious materials are encountered at the base of excavations, these materials should be sub-excavated and replaced with compacted fills approved by the geotechnical engineer.

8.5.3 Trench Backfill

The excavated materials from the Site will consist predominantly of silty sand to sandy silt. Given the elevation of the water table at the site (assumed to be at/near ground surface), this material may be above the estimated optimum water content for compaction and will require drying in order to be reused as backfill, however, should not be used in settlement sensitive areas (i.e., under access roads, foundations, etc.). The soils optimum water content should be maintained during placement.

Care should be taken to maintain the water content of the soils close to/at the optimum water content for compaction during the construction operations, as difficulties with compaction and/or backfill performance would be anticipated with fine-grained soils where the water content is significantly above the optimum for compaction purposes. Soils that contain significant quantities of organics or debris are not suitable for use as trench backfill within settlement sensitive areas. In addition, any cobbles or boulders greater than 150 mm in size should be removed from the trench backfill materials. If there is a shortage of suitable in-situ material, an approved imported material such as Ontario Provincial Standard Specifications Select Subgrade Material (SSM) should be used for trench backfill. As noted above, the trench backfill materials are silty in nature and are susceptible to wetting/freezing temperatures. Backfilling during cold or wet weather is not recommended.

Trench backfill should be placed in maximum 300 mm loose lifts and uniformly compacted to at least 98% of the material's SPMDD. Soil that is frozen should not be used as backfill.

Normal post-construction settlement of the compacted trench backfill should be anticipated with the majority of such settlement taking place within about 12 months following the completion of trench backfilling operations. These settlements will be reflected at the ground surface and in gravel access road construction areas. This may be compensated for, where necessary, by placing additional granular material prior to placing the final granular lift. Post-construction settlement of the restored ground surface in off-road trench areas is also expected and should be topped-up and re-landscaped, as required.

It should be noted that in some cases, even though the compaction requirements have been met, the subgrade strength in the trench backfill areas may not be adequate to support heavy construction loading, especially during wet weather or where backfill materials wet of optimum have been placed. In any event, the subgrade should be proof-rolled and inspected by qualified geotechnical personnel prior to placing the Granular ‘B’ subbase and additional subbase material placed as required, being consistent with the prevailing weather conditions and anticipated use by construction traffic.

It is understood that the underground cables associated with the BESS structures will require specialized backfill requirements based on the results of the soils thermal resistivity testing provided in Appendix C. Therefore, cable sizing and backfill requirements should be selected by the appropriate civil designer and is beyond the scope of the geotechnical recommendations provided in this report.

8.6 Access Road Design

Provided that preparation of the site is completed in accordance with recommendations stated above, the following pavement structure should be suitable for the proposed access road construction.

- 250 mm Granular Base Course (GBC) consisting of OPSS.MUNI 1010 Granular ‘A’, compacted to 100 percent of SPMDD (ASTM D698).
- 300 mm minimum Select Granular Subbase Course (SGSB) consisting of OPSS.MUNI 1010 Granular ‘B’ (Type II), compacted to 98 percent of SPMDD.

The preliminary design should be reviewed and verified once the traffic volumes and vehicle types, including construction equipment, are confirmed prior to site development.

During construction, the lift thicknesses should be placed in lifts not exceeding 200 mm loose thickness and compacted, as noted above, within 2 percent of the optimum moisture content. If any import fill is required, quality control shall be carried out during the placement and compaction of the fill. The fill must be placed under the supervision of a qualified Geotechnical Engineer in loose lifts not exceeding 200 mm. Field density tests must be taken on each lift of fill. Records of the field density results should be maintained and added to the construction records.

Surfaces of the roadways should be sloped at 2 percent or greater to promote runoff to designated surface drainage features and the subgrade should be crowned at the centreline and sloped at 3 percent minimum up to a maximum of 5 percent towards the roadway perimeter. The soils at the road subgrade level (directly beneath the topsoil), become unstable and soft when wet or at certain times of the year, particularly the spring thaw. It may be necessary if excessive rutting is noted at the subgrade of the access road to add a layer of geotextile reinforcing layer (e.g. Terrafix 300R or approved equivalent) above the subgrade. Adjacent sheets of geotextile should be overlapped a minimum 450 mm.

9. Corrosivity Analysis

Analytical laboratory testing to assess the corrosion potential of the site soils was completed on two selected soil samples from the site. The soil samples were submitted for chemical analysis of sulphate, chlorides, pH and electrical resistivity. The results of the chemical testing indicate that soils had a pH ranging from 7.33 to 7.36, resistivity ranging from 66 to 102 Ohm*m, and a soluble sulfate concentration ranging from 7 to 72 µg/g.

For potential sulphate attack on concrete, the results of the soil analyses were compared to Table 3 of the Canadian Standards Association (CSA) No. A23-1-09 document and the results indicate a low degree of exposure to sulphate attack.

The resistivity testing results indicate that the soils tested generally have a “very low” steel corrosiveness potential based on the Ministry of Transportation Gravity Pipe Design Guidelines, 2014, Table 3.2. We note that a limited number of tests were carried out across the site and that corrosiveness of the site soils may vary with depth and material types.

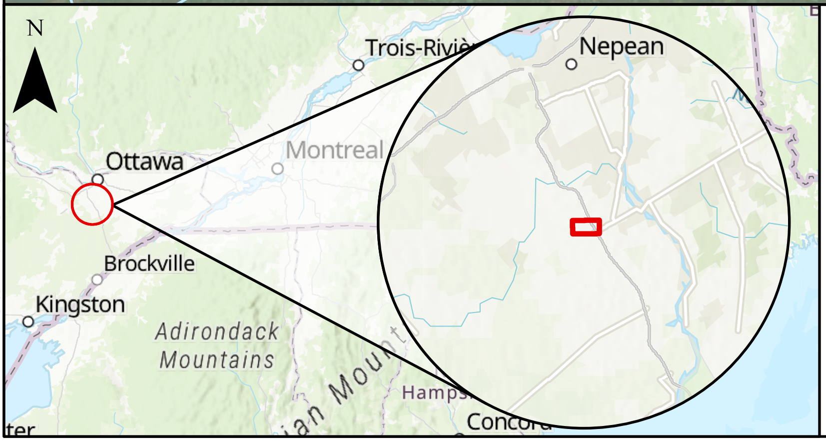
10. Seismic Classification for Seismic Response

Seismic hazard is defined in the 2024 Ontario Building Code (OBC, 2024) by uniform hazard spectra (UHS) at spectral coordinates of 0.2 second, 0.5 second, 1.0 second and 2.0 seconds and a probability of exceedance of 2 percent in 50 years. The OBC method uses a site classification system defined by the average soil/bedrock properties (e.g. shear wave velocity, Standard Penetration Test (SPT) resistance, undrained soil shear strength, etc.) in the 30 m below the foundation level. There are six site classes from A to F, decreasing in ground stiffness from A, hard rock, to E, soft soil; with site class F used to denote problematic soils (e.g. sites underlain by thick peat deposits and/or liquefiable soils). The site class is then used to obtain acceleration and velocity-based site coefficients Fa and Fv, respectively, used to modify the UHS to account for the effects of site-specific soil conditions in design.

Based on the results of the geotechnical investigation, a Site Class D is estimated for planning purposes. The specified site class is based on the SPT ‘N’ values measured during the geotechnical investigation. The site class could be further refined and confirmed with a non-intrusive site-specific seismic testing method such as the Multi-Channel Analysis of Surface Waves (MASW) test.

Figure 1:
Borehole Location Plan

World Topographic Map: Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, USFWS, NRCan, Parks Canada; World Imagery: Maxar; World Topographic Map: City of Ottawa, Province of Ontario, Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NPS, NRCan, Parks Canada; World Hillshade: Esri, USGS; World Hillshade: Esri, CGIAR, USGS



LEGEND

◐ Borehole

— Road

— Watercourse

Notes

1. Produced by Hatch, contains information under the Open Government License - Ontario
2. Spatial referencing: NAD 1983 MTM Zone 9

0 100 200 400 m

1:6,000

PROJECT: Trail Road BESS

FIGURE TITLE: Trail Road BESS: Borehole Location Plan

CLIENT: Brookfield BRP

DWG BY:	CHK BY:	FIG NO.:	REV NO.:	PROJ No.: H375035
J. SNELGROVE	T. BEADLE	1	1	HATCH
DATE: December 19, 2024	PAGE: 1 of 1			

Document Path: C:\Users\snel97010\Hatch E\MH375035 - Trailroad BESS Site Geotechnical Investi - Trailroad BESS Inc. - WIP Uncontrolled\GIS\APRX\BoreholeLocationPlans_Figures\BoreholeLocationPlans_Figures.aprx

Appendix A
Record of Boreholes

List of Abbreviations and Terms Used in the Borehole Reports

(Sheet 1)

General

Elevations
Elevations are referenced to datum indicated.

Depth
All depths are given in meters (feet) measured from the ground surface unless otherwise noted.

Sample Recovery
Indicates the length retained in millimeters (inches) in a split spoon sampler or percentage recovery of sample retained in the core barrel sampler.

Sample Number
Samples are numbered consecutively in the order in which they were obtained in the borehole.

Sampler Size
Dimension is in millimetres and refers to the outside diameter of the sampler.

Sample Type
The first letter describes the sampling method and the second, the shipping container.

Sampling Method

A – Split Tube
B – Thin Wall Tube
C – Piston Sampler
D – Core Barrel
E – Auger
F – Wash
G – Shovel Grab Sample
K – Slotted Sampler

Shipping Container

N – Insert (split spoon)
O – Tube
P – Water Content Tin
Q – Jar
R – Cloth Bag
S – Plastic Bag
U – Wooden Box
X – Plastic & PVC Sleeve (Sonic)
Y – Core Box
Z – Discarded

Abbreviations
N/A – Not applicable
N/E – Not encountered
N/O – Not observed

Soil

Soil Description, Label and Symbol
Soil description under the “Description” column conforms generally, but not rigorously , to the Unified Soils Classification System. For a given soil unit, defined by depth boundaries, the descriptive text constitutes the definitive soil unit description and takes precedence over both the brief label and the symbol used to graphically represent the soil unit.

Grain Size

Clay		<0.002 mm
Silt	0.002 –	0.075 mm
Sand	0.075 –	4.75 mm
Gravel	4.75 –	75 mm
Cobbles	75 –	300 mm
Boulder		>300 mm

Relative Quantities

Term	*Example*	*(%)*
Trace	Trace sand	1 – 10
Some	Some sand	10 – 20
With	With Sand	20 – 35
And	And sand	>35
Noun	Sand	>50

Standard Penetration Test (SPT)
The test is carried out in accordance with ASTM D-1586 and the ‘N’ value corresponds to the sum of the number of blows required by a 63.5-kg (140-lb) hammer, dropped 760 mm (30 in.), to drive a 50-mm (2-in.) diameter split tube sampler the second and third 150 mm (6 in.) of penetration.

Density (Granular Soils)

	N(SPT)
Very loose	0 – 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very dense	>50

Consistency (Cohesive Soils)

	N(SPT)
Very soft	<2
Soft	2 – 4
Firm	4 – 8
Stiff	8 – 15
Very stiff	15 – 30
Hard	>30

Plasticity/Compressibility

		Liquid Limit (%)
Low plasticity clays	Low compressibility silts	<30
Medium plasticity clays	Medium compressibility silts	30 – 50
High plasticity clays	High compressibility silts	>50

Dilatancy
None - No visible change.
Slow - Water appears slowly on surface of specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid - Water appears quickly on the surface of specimen during shaking and disappears quickly upon squeezing.

Sensitivity

Insensitive	<2
Low	2 – 4
Medium	4 – 8
High	8 – 16
Quick	>16

HATCH

List of Abbreviations and Terms Used in the Borehole Reports

(Sheet 2)

Rock

Core Recovery
Sum of lengths of rock core recovered from a core run, divided by the length of the core run and expressed as a percentage.

RQD (Rock Quality Designation)
Sum of lengths of hard, sound pieces of rock core equal to or greater than 100 mm from a core run, divided by the length of the core run and expressed as a percentage. Measured along centerline of core. Core fractured by drilling is considered intact. RQD normally quoted for N-size core.

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

Grain Size

Term	***Grain Size***
Very coarse-grained	>60 mm
Coarse-grained	2 mm - 60 mm
Medium-grained	60 µm - 2 mm
Fine-grained	2 µm - 60 µm
Very fine-grained	< 2 µm

Bedding

Term	***Bed Thickness***	
Very thickly bedded	>2 m	>6.50 ft
Thickly bedded	600 mm - 2 m	2.00 - 6.50 ft
Medium bedded	200 mm - 600 mm	0.65 - 2.00 ft
Thinly bedded	60 mm - 200 mm	0.20 - 0.65 ft
Very thinly bedded	20 mm - 60 mm	0.06 - 0.20 ft
Laminated	6 mm - 20 mm	0.02 - 0.06 ft
Thinly laminated	<6 mm	<0.02 ft

Discontinuity Frequency
Expressed as the number of discontinuities per metre or discontinuities per foot. Excludes drill-induced fractures and fragmented zones.

Discontinuity Spacing

Term	***Average Spacing***	
Extremely widely spaced	>6 m	>20.00 ft
Very widely spaced	2 m - 6 m	6.50 - 20.00 ft
Widely spaced	600 mm - 2 m	2.00 - 6.50 ft
Moderately spaced	200 mm - 600 mm	0.65 - 2.00 ft
Closely spaced	60 mm - 200 mm	0.20 - 0.65 ft
Very closely spaced	20 mm - 60 mm	0.06 - 0.20 ft
Extremely closely spaced	<20 mm	<0.06 ft

Note: Excludes drill-induced fractures and fragmented rock.

Broken Zone
Zone of full diameter core of very low RQD which may include some drill-induced fractures.

Fragmented Zone
Zone where core is less than full diameter and RQD = 0.

Strength

Term	***Description***	***Unconfined Compressive Strength***	
		(MPa)	***(psi)***
Extremely weak rock	Indented by thumbnail	0.25 – 1.0	36 – 145
Very weak	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife	1.0 – 5.0	145 – 725
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	725 – 3625
Medium strong rock	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer to facture it	25 – 50	3625 –7250
Strong rock	Specimen requires more than one blow of geological hammer to fracture it	50 – 100	7250 – 14500
Very strong rock	Specimen requires many blows of geological hammer to fracture it	100 – 250	14500 – 36250
Extremely strong rock	Specimen can only be chipped with geological hammer	>250	>36250

Weathering

Term	***Description***
Fresh	No Visible sign of rock material weathering
Faintly weathered	Discoloration on major discontinuity surfaces.
Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker than in its fresh condition.
Moderately weathered	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a continuous framework or as corestones.
Highly weathered	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones.
Completely weathered	All rock material is decomposed and/or disintegrated to a soil. The original mass structure is still largely intact.
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

HATCH

BASIS FOR SOIL DESCRIPTION

(Based on ASTM D 2488-17, with modifications)

UNIFIED CLASSIFICATION (in order of description)

Soil Name (BLOCK LETTERS);
Plasticity or grading characteristics for major components,
Plasticity or grading characteristics for secondary components,
Colour of soil,
Other minor components - name, plasticity or particle characteristics and colour,
Moisture conditions,
Consistency,
Structure, and
Additional observations such as ORIGIN or other significant features not relating to the composition, condition or structure of the soil.
The terms used in the unified classification are described below:

PARTICLE SIZE DISTRIBUTION

Clay	Silt	Sand			Gravel		Cobble	Boulder
		Fine	Medium	Coarse	Fine	Coarse		

0.002m 0.075m 0.425m 2.0mm 4.75mm 19mm 75mm 300mm

CLASSIFICATION OF SOILS

The Classification of soils is based on particle size distribution and plasticity, in general accordance with ASTM D 2488 - 17 Standard Practice for Description and Identification of Soils

SOIL NAME

The Soil Name is based on the grain size characteristics and plasticity. As most soils are a combination of a range of constituents, the primary soil is described and modified by minor components, as follows:

Coarse Grained Soil (<50% Clay and Silt content)		Fine Grained Soil (>50% Clay and Silt content)	
% Fines	**Modifier**	**% Fines**	**Modifier**
≤ 5%	Omit, or use “trace”	≤ 15%	Omit, or use “trace”
> 5% ≤ 15%	Describe as ‘with clay/silt’ as applicable	> 15% ≤ 30%	Describe as ‘with sand/gravel’ as applicable
> 15%	Prefix soil as ‘silty/clayey’ as applicable	> 30%	Prefix soil as ‘sandy/gravelly’ as applicable

PLASTICITY

Plasticity of clay and silt, both alone and in mixtures with coarser material, are described as:

Descriptive Term	Range of Liquid Limit	Field Guide to Plasticity
Of low plasticity	≤ 35%	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Of medium plasticity	> 35% ≤ 50 %	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
Of high plasticity	>50%	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

GRADING CHARACTERISTICS

For coarse grained soils only, grading is described as follows:

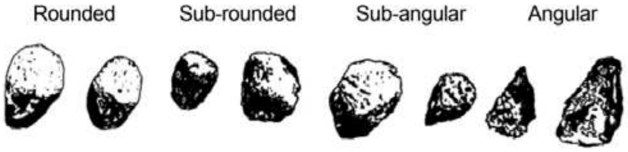
Descriptive Term	Characteristics
Well Graded	Having good representation of all particle sizes
Poorly Graded	With one or more intermediate sizes poorly represented
Gap Graded	With one or more intermediate sizes absent
Uniform	Essentially of one size

BASIS FOR SOIL DESCRIPTION

(Based on ASTM D 2488-17, with modifications)

PARTICLE SHAPE

The particle shape of equidimensional particles may be described as 'rounded', 'sub-rounded', 'sub-angular' or 'angular' as shown in the sketches overleaf. Two-dimensional particles with the third dimension small by comparison may be described as 'flaky' or 'platy'. One-dimensional particles with the other two dimensions small by comparison may be described as 'elongated'



COLOUR

The soil colour is described for soil in the 'moist' condition, using simple terms such as **'black', 'white', 'grey', 'brown', 'red', 'orange', 'yellow', 'green'** or **'blue'**. These may be modified as necessary by **'pale', 'dark'** or **'mottled'**. Borderline colours may be described as red-brown. Where a soil colour consists of a primary colour with a secondary mottling it should be described as: **(primary colour)** mottled **(secondary colour)**, eg. **grey** mottled **red-brown** clay.

MOISTURE CONDITION

Descriptive Term	General	Granular Soil	Cohesive Soil
Dry' (D)		Cohesionless and free running	Hard and friable or powdery, well dry of plastic limit
'Moist' (M)	Soil feels cool, darkened in colour	Particles tend to cohere	Soil may be moulded by hand
'Wet' (W)		Soil particles tend to cohere, free water forms when squeezed	Soil usually weakened and free water forms when handled

CONSISTENCY (Cohesive soils)

The consistency of cohesive soil is based on the undrained shear strength and is generally estimated, with or without the aid of a pocket penetrometer or shear vane test.

Descriptive Term	Undrained Shear Strength (kPa)	Field Guide to Consistency
'Very Soft' (VS)	≤ 12	Exudes between the fingers when squeezed in hand
'Soft' (S)	>12 ≤ 25	Can be moulded by light finger pressure
'Firm' (F)	>25 ≤ 50	Can be moulded by strong finger pressure
'Stiff' (St)	> 50 ≤ 100	Cannot be moulded by fingers
Very Stiff' (VSt)	>100 ≤ 200	Can be indented by thumb nail
'Hard' (H)	>200	Can be indented with difficulty by thumb nail

BASIS FOR SOIL DESCRIPTION

(Based on ASTM D 2488-17, with modifications)

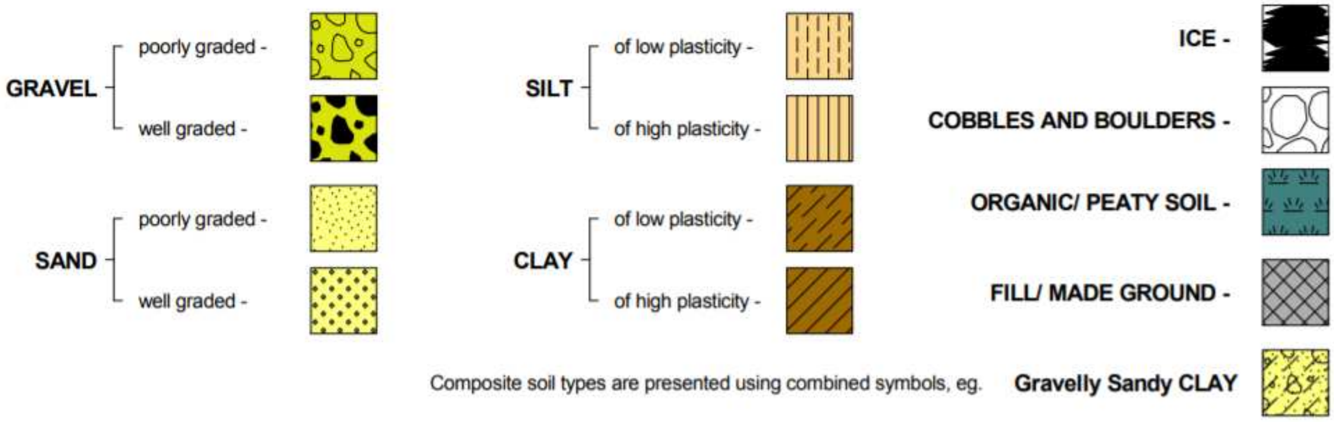
DENSITY (Granular soils)

The density of a non-cohesive soil is described via the Density Index (relative density), which is generally assessed using a penetration test and published correlations.

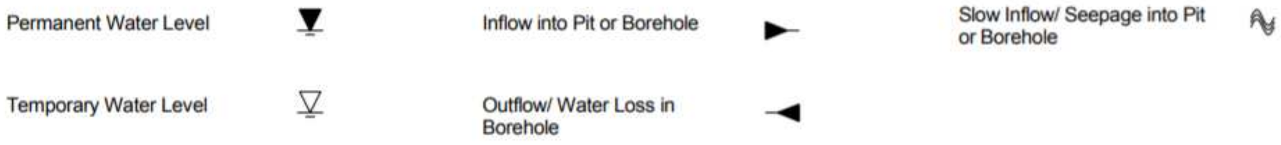
Descriptive Term	Density Index (%)	SPT N-Value	Scala blows per 100mm	CPT q_c (MPa)*
'Very Loose' (VL)	≤ 15	0-4	0-2	<5
‘Loose' (L)	>15 ≤ 35	4-10	2-6	5-10
‘Compact' (C)	>35 ≤ 65	10-30	6-16	10-15
‘Dense' (D)	>65 ≤ 85	30-50	16-26	15-20
‘Very Dense' (VD)	>85	>50	>26	>20

* At an effective overburden pressure of 100k

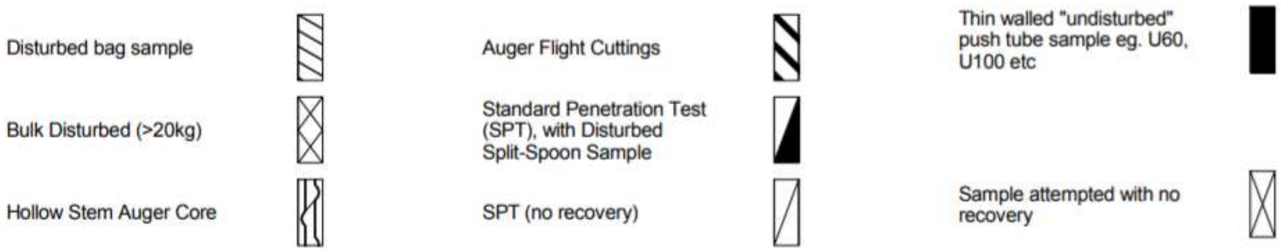
GRAPHIC SYMBOLS FOR SOILS



GROUNDWATER OBSERVATIONS



SAMPLE TYPES



HATCH

BASIS FOR ROCK DESCRIPTION

(Based on ISRM - Basic Geotechnical Description of Rock Masses, with modifications)

RUN AND RECOVERY

Every time the core barrel is lifted to recover a sample of the core one run is completed. The core recovery represents the ratio of core recovered to the length drilled for the corresponding core run and is expressed as a percentage. Intervals where no core is recovered are described as Core Loss and are denoted by CL.

ROCK QUALITY DESIGNATION (RQD)

Rock Quality Designation (RQD) is an index or measure of the quality of a rock mass. RQD is determined by the ratio of sound core recovered in pieces over 100mm to the length of the core run drilled. Mechanical breaks are discounted in the calculation. RQD is not determined for extremely to highly weathered rock.

The descriptive terms assigned to RQD are as follows:

RQD (%)	Rock Description
< 25	Very Poor
25 to 50	Poor
50 to 75	Fair
75 to 90	Good
90 to 100	Excellent

DEFECT SPACING

The defect spacing is a measure of the distance between natural discontinuities (drilling breaks are ignored), and is generally expressed in millimeters. The descriptive terms assigned to defect spacing are as follows:

Defect Spacing (mm)	Term
> 2,000	Extremely Wide
600 - 2,000	Very Wide
200 - 600	Wide
60 - 200	Moderately Wide
20 - 60	Moderately Narrow
6 - 20	Narrow
< 6	Very Narrow

DEFECT LOG

The defect log provides a graphical description of each defect in the recovered core sample observed during logging.

DEFECT DESCRIPTION AND COMMENTS

The defect description is an annotated description of rock defects including inclination/ dip, type, infill type and amount, apaerture, planarity, roughness and frequency of the defect. Other comments are also included under the defect description title.

The description format of an individual defect is as follows:

Inclination	*Type*	*Infill*	*Amount*	*Aperture*	*Planarity*	*Roughness*	*Frequency*
30°	J	Fe	Fi	Mw	Pl	Sm	C

Inclination

For specific defects, the inclination of each individual defect is noted in degrees and is measured perpendicular to the core axis. For example, in a vertically drilled borehole, an inclination of 0° corresponds to a horizontal defect and an inclination of 90°corresponds to a vertical defect.

Continue overleaf...

BASIS FOR ROCK DESCRIPTION

(Based on ISRM - Basic Geotechnical Description of Rock Masses, with modifications)

ROCK CLASSIFICATION (in order of description)

Rock Name (BLOCK LETTERS);
Grain Size,
Texture and Fabric,
Colour,
Other minor components - name, particle characteristics and colour,
Strength,
Weathering,
Structure of the rock,
Defects - type, orientation, sapcing, roughness, waviness and persistency, and
Additional rock mass observations noted from larger exposures.

WEATHERING

The Rock material weathering terms are deined in the Table below. The terms have been adopted from a combination of those used in AS1726-1981 and 1993.

Term	Symbol	Description
Residual Soil	RS	Soil developed on extremely weathered rock. The mass structure and substance fabric are no longer evident. There is a large change in volume but the soil has not been significantly transported.
Extremely Weathered Rock	XW	Rock substance affected by weathering to the extent that the rock exhibits soil properties, ie. it can be remoulded and classified in accordance with the Unified Soil Classification System.
Highly Weathered Rock	HW	Rock is weathered to such an extent that it shows considerable change in appearance and loss in strength. Chemical or physical decomposition of individual minerals are usually evident. The colour and strength of the original fresh rock is no longer recognisable.
Moderately Weathered Rock	MW	Rock is affected by weathering to the extent that staining extends throughout the whole of the rock substance and the original colour of the fresh rock is no longer recognisable. There is usually a significant loss in rock strength.
Slightly Weathered Rock	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh Rock	Fr	Rock shows no sign of decomposition or staining.

ROCK STRENGTH

The rock strength terms defined in AS1726-1993 and generally based on Point Load index testing. In weaker rocks Unconfined Compressive Strength testing may provide a better estimate for the rock strength. In the absence of either Point Load or Unconfined Compression Strength testing, the rock strength may be based on field estimates as discribed in the Table below.

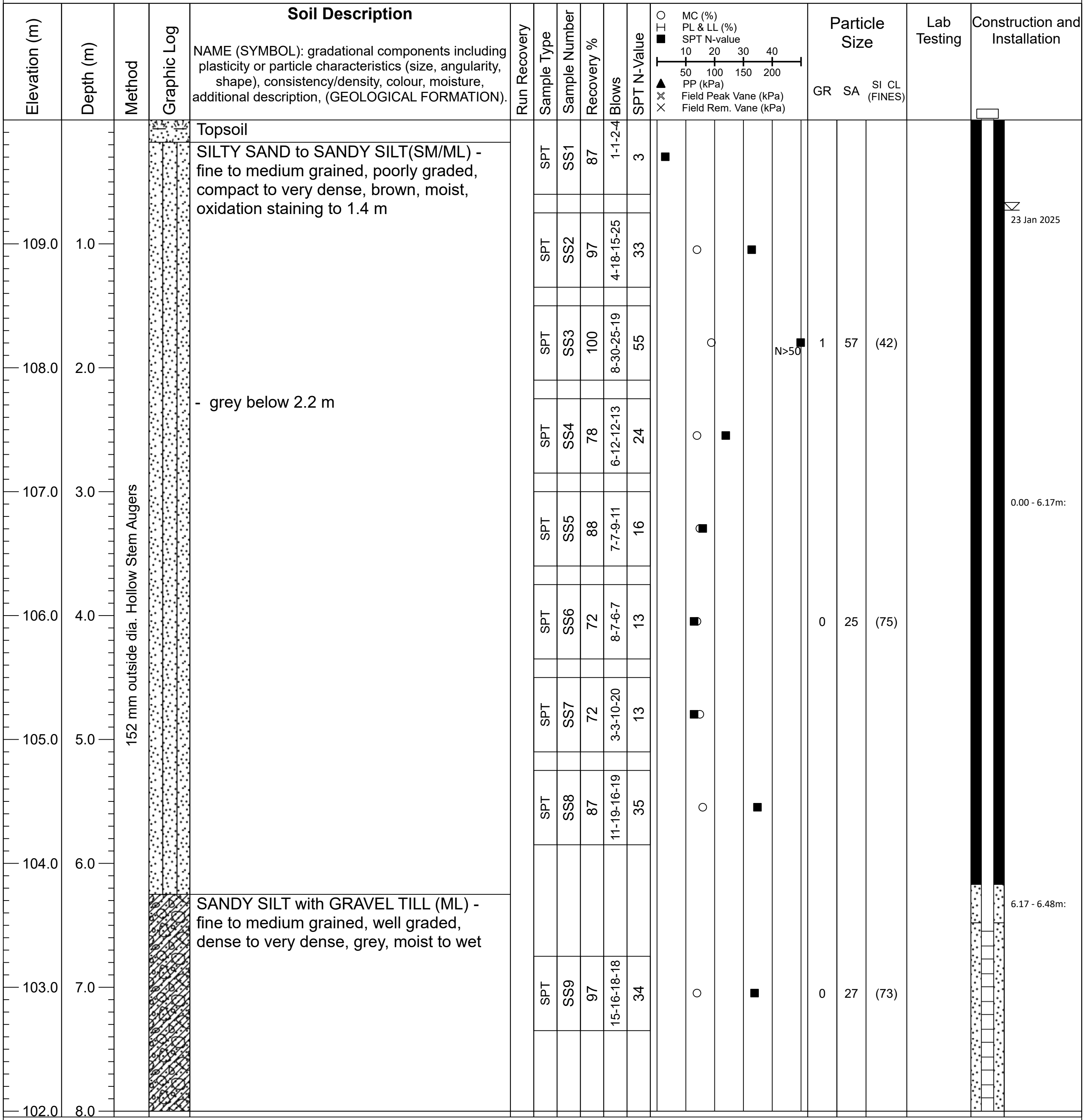
Term	Symbol	Point load index (MPa) Is_{50}	Unconfined Compression (MPa) UCS	Field guide to strength
Extremely Low	EL	≤ 0.03	≤ 0.7	Easily remoulded by hand to a material with soil properties.
Very Low	VL	> 0.03 ≤ 0.1	> 0.7 ≤ 2.4	Material crumbles under firm blows with sharp end of pick, can be peeled with knife, too hard to cut a triaxial sample by hand, pieces up to 30mm thick can be broken by finger pressure.
Low	L	> 0.1 ≤ 0.3	> 2.4 ≤ 7.0	Easily scored with a knife, indentations 1mm to 3mm show in the specimen with firm blows of the pick point, has dull sound under hammer. A piece of core 150mm long by 50mm diameter may be brocken by hand. Sharp edges of core may be friable and break during handling.
Medium	M	> 0.3 ≤ 1.0	> 7.0 ≤ 24	Readily scored with a knife, a piece of 150mm long by 50mm diameter can be broken by hand with difficulty.
High	H	> 1.0 ≤ 3.0	> 24 ≤ 70	A piece of core 150mm long by 50mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow, rock rings under hammer blows.
Very High	VH	> 3.0 ≤ 10	> 70 ≤ 240	Hand specimen break with pick after more than one blow, rock rings under hammer blows.
Extremely High	EH	> 10	> 240	Specimen requires many blows with geological pick to break through intact material, rock rings under hammer blows.

Continue overleaf...

BOREHOLE RECORD

TR24-1

Client:	Brookfield BRP	**Final Depth:**	9.52 m
Project:	Trail Road BESS	**Coord. System:**	NAD83 / MTM zone 9N
Project No:	H375035	**Location:**	
Vertical Datum:	CGVD2013	**Easting:**	363,344.02 m
Northing:	5,008,429.08 m	**Elevation:**	95.34 m
Contractor:	OGS	**Rig Type:**	CME 45 Trackmount
Bearing:		**Date Logged:**	Nov 28-Nov 29,2024
Logged by:	TV/DC	**Driller:**	Jamie
Hole Diam (mm):	152	**Inclination:**	90.00º
Date Checked:		**Reviewed by:**	TWB



Topsoil

SILTY SAND to SANDY SILT(SM/ML) - fine to medium grained, poorly graded, compact to very dense, brown, moist, oxidation staining to 1.4 m

- grey below 2.2 m

SANDY SILT with GRAVEL TILL (ML) - fine to medium grained, well graded, dense to very dense, grey, moist to wet

Sample Type	Sample Number	Recovery %	Blows	SPT N-Value	GR	SA	SI CL (FINES)
SPT	SS1	87	1-1-2-4	3			
SPT	SS2	97	4-18-15-25	33			
SPT	SS3	100	8-30-25-19	55	1	57	(42)
SPT	SS4	78	6-12-12-13	24			
SPT	SS5	88	7-7-9-11	16			
SPT	SS6	72	8-7-6-7	13	0	25	(75)
SPT	SS7	72	3-3-10-20	13			
SPT	SS8	87	11-19-16-19	35			
SPT	SS9	97	15-16-18-18	34	0	27	(73)

Notes:
1. Water level in open borehole measured at a depth of 2.5 m below ground surface upon completion of drilling.
2. Water level in open borehole measured at a depth of 2.0 m below ground surface on November 29, 2024.
3. Water level measurements in monitoring well:
January 23, 2025 - 0.7 m below ground surface, July 16, 2025 - 1.8 m below ground surface, September 11, 2025 - 2.1 m below ground surface

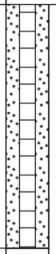
HATCH

BOREHOLE RECORD

TR24-1

Client:	Brookfield BRP	**Final Depth:**	9.52 m	**Easting:**	363,344.02 m
Project:	Trail Road BESS	**Coord. System:**	NAD83 / MTM zone 9N	**Northing:**	5,008,429.08 m
Project No:	H375035 **Location:**	**Vertical Datum:**	CGVD2013	**Elevation:**	95.34 m
Contractor:	OGS **Rig Type:** CME 45 Trackmount	**Bearing:**	**Date Logged:** Nov 28-Nov 29,2024	**Logged by:**	TV/DC
Driller:	Jamie **Hole Diam (mm):** 152	**Inclination:** 90.00º	**Date Checked:**	**Reviewed by:**	TWB

Elevation (m)	Depth (m)	Method	Graphic Log	**Soil Description** NAME (SYMBOL): gradational components including plasticity or particle characteristics (size, angularity, shape), consistency/density, colour, moisture, additional description, (GEOLOGICAL FORMATION).	Run Recovery	Sample Type	Sample Number	Recovery %	Blows	SPT N-Value	○ MC (%) ⊢ PL & LL (%) ■ SPT N-value 10 20 30 40 50 100 150 200 ▲ PP (kPa) ✖ Field Peak Vane (kPa) ✕ Field Rem. Vane (kPa)	Particle Size GR SA SI CL (FINES)	Lab Testing	Construction and Installation
		152 mm outside dia. Hollow Stem Augers		SANDY SILT with GRAVEL TILL (ML) - fine to medium grained, well graded, dense to very dense, grey, moist to wet		SPT	SS10	93	1-23-49-46	72	○ ■ N>50			6.48 - 9.52m:
						SPT	SS11		50/75 mm	R	■ N>50			
				9.52 m. END OF BOREHOLE Split-Spoon Refusal on inferred bedrock										



Elevation (m)	Depth (m)
101.0	9.0
100.0	10.0
99.0	11.0
98.0	12.0
97.0	13.0
96.0	14.0
95.0	15.0
94.0	16.0

Notes:
1. Water level in open borehole measured at a depth of 2.5 m below ground surface upon completion of drilling.
2. Water level in open borehole measured at a depth of 2.0 m below ground surface on November 29, 2024.
3. Water level measurements in monitoring well:
   January 23, 2025 - 0.7 m below ground surface, July 16 - 1.8 m below ground surface, September 11, 2025 - 2.1 m below ground surface

BOREHOLE RECORD

TR24-2

Client:	Brookfield BRP			**Final Depth:**	6.60 m	**Easting:**	363,389.47 m
Project:	Trail Road BESS			**Coord. System:**	NAD83 / MTM zone 9N	**Northing:**	5,008,470.26 m
Project No:	H375035	**Location:**		**Vertical Datum:**	CGVD2013	**Elevation:**	95.93 m
Contractor:	OGS	**Rig Type:**	CME 45 Trackmount	**Bearing:**		**Date Logged:** Nov 28,2024	**Logged by:** TV/DC
Driller:	Jamie	**Hole Diam (mm):**	152	**Inclination:**	90.00º	**Date Checked:**	**Reviewed by:** TWB

Soil Description

NAME (SYMBOL): gradational components including plasticity or particle characteristics (size, angularity, shape), consistency/density, colour, moisture, additional description, (GEOLOGICAL FORMATION).

Elevation (m)	Depth (m)	Method	Soil Description
		152 mm outside dia. Hollow Stem Augers	Topsoil
			SILTY SAND to SANDY SILT (SM/ML) - fine to medium grained, poorly graded, loose to dense, brown, moist, containing organics and rootlets to 0.7 m, oxidation staining to 0.7 m
109.0	1.0		
108.0	2.0		- grey below 2.2 m
107.0	3.0		
106.0	4.0		
105.0	5.0		
104.0	6.0		
			6.60 m. END OF BOREHOLE
103.0	7.0		
102.0	8.0		

Run Recovery	Sample Type	Sample Number	Recovery %	Blows	SPT N-Value
	SPT	SS1	77	1-2-2-5	4
	SPT	SS2	80	3-11-11-18	22
	SPT	SS3	83	5-21-16-26	37
	SPT	SS4	67	3-11-14-16	25
	SPT	SS5	67	5-15-13-12	28
	SPT	SS6	73	8-12-17-15	29
	SPT	SS7	83	9-13-13-11	26
	SPT	SS8	92	14-21-20-30	41

○ MC (%)
⊢ PL & LL (%)
■ SPT N-value
10 20 30 40
50 100 150 200
▲ PP (kPa)
✕ Field Peak Vane (kPa)
✕ Field Rem. Vane (kPa)

Particle Size: GR SA SI CL (FINES)

Lab Testing

Notes: 1. Water level in open borehole measured at a depth of 1.7 m below ground surface on Nov. 29, 2024

Sheet 1 of 1

Created using Hatch BH - Dynamic Soil Rock Log V2 on January 27 2025 03:24

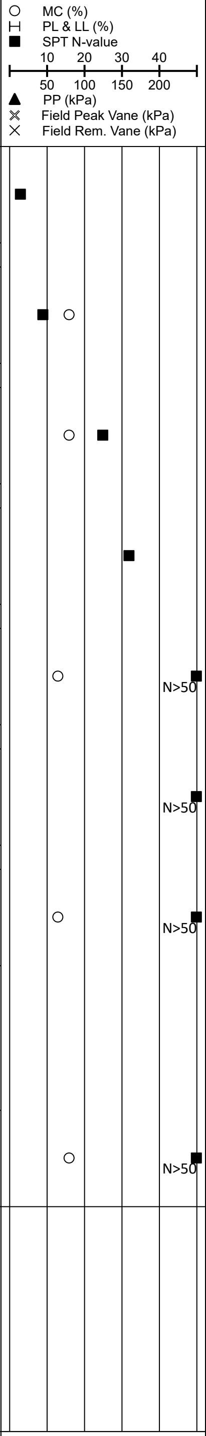
BOREHOLE RECORD

TR24-3

Client:	Brookfield BRP	**Final Depth:**	6.60 m	**Easting:**	363,519.64 m
Project:	Trail Road BESS	**Coord. System:**	NAD83 / MTM zone 9N	**Northing:**	5,008,541.17 m
Project No:	H375035 **Location:**	**Vertical Datum:**	CGVD2013	**Elevation:**	95.86 m
Contractor:	OGS **Rig Type:** CME 45 Trackmount	**Bearing:**	**Date Logged:** Nov 28,2024	**Logged by:**	TV/DC
Driller:	Jamie **Hole Diam (mm):** 152	**Inclination:**	90.00º **Date Checked:**	**Reviewed by:**	TWB

Elevation (m)	Depth (m)	Method	Soil Description NAME (SYMBOL): gradational components including plasticity or particle characteristics (size, angularity, shape), consistency/density, colour, moisture, additional description, (GEOLOGICAL FORMATION).
		152 mm outside dia. Hollow Stem Augers	Topsoil
			SILTY SAND to SANDY SILT (SM/ML) - fine to medium grained, poorly graded, very loose to very dense, brown, moist, containing organics and rootlets to 0.7 m, oxidation staining to 1.4 m
109.0	1.0		
108.0	2.0		
107.0	3.0		- grey below 3.0 m
106.0	4.0		
105.0	5.0		
104.0	6.0		
			6.60 m. END OF BOREHOLE
103.0	7.0		
102.0	8.0		

Run Recovery	Sample Type	Sample Number	Recovery %	Blows	SPT N-Value	GR	SA	SI CL (FINES)	Lab Testing
	SPT	SS1	62	1-1-2-3	3				
	SPT	SS2	92	3-4-5-4	9				
	SPT	SS3	80	9-12-13-15	25	0	48	(52)	
	SPT	SS4	83	8-16-16-27	32				
	SPT	SS5	83	18-27-38-50	65				
	SPT	SS6	88	15-18-35-48	53				
	SPT	SS7	83	23-36-50-30	86	0	56	(44)	
	SPT	SS8	93	9-35-42-50	77				



Notes: 1. Water level in open borehole measured at a depth of 5.0 m below ground surface upon completion of drilling.

Sheet 1 of 1

Created using Hatch BH - Dynamic Soil Rock Log V2 on January 27 2025 03:24

BOREHOLE RECORD

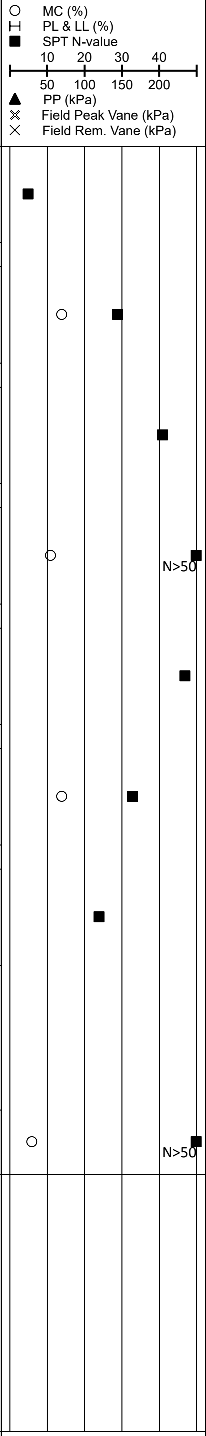
TR24-4

Client: Brookfield BRP		**Final Depth:** 6.40 m		**Easting:**	363,632.97 m
Project: Trail Road BESS		**Coord. System:** NAD83 / MTM zone 9N		**Northing:**	5,008,544.22 m
Project No: H375035	**Location:**	**Vertical Datum:** CGVD2013		**Elevation:**	95.48 m
Contractor: OGS	**Rig Type:** CME 45 Trackmount	**Bearing:**	**Date Logged:** Nov 30,2024	**Logged by:**	TV/DC
Driller: Jamie	**Hole Diam (mm):** 152	**Inclination:** 90.00º	**Date Checked:**	**Reviewed by:**	TWB

Method: 152 mm outside dia. Hollow Stem Augers

Elevation (m)	Depth (m)	Soil Description NAME (SYMBOL): gradational components including plasticity or particle characteristics (size, angularity, shape), consistency/density, colour, moisture, additional description, (GEOLOGICAL FORMATION).
		Topsoil
		SILTY SAND to SANDY SILT (SM/ML) - fine to medium grained, poorly graded, loose to very dense, brown, moist, containing organics and rootlets to 0.7 m, oxidation staining to 0.7 m
109.0	1.0	
		- grey below 1.4 m
108.0	2.0	
107.0	3.0	
106.0	4.0	
105.0	5.0	
		- trace gravel, transition to glacial till below 5.6 m
104.0	6.0	
		6.40 m. END OF BOREHOLE Split-Spoon Refusal on inferred bedrock
103.0	7.0	
102.0	8.0	

Run Recovery	Sample Type	Sample Number	Recovery %	Blows	SPT N-Value
	SPT	SS1	75	1-2-3-3	5
	SPT	SS2	80	6-13-16-27	29
	SPT	SS3	87	4-16-25-30	41
	SPT	SS4	72	16-30-30-29	60
	SPT	SS5	83	8-25-22-35	47
	SPT	SS6	93	11-13-20-22	33
	SPT	SS7	80	18-11-13-18	24
	SPT	SS8	88	14-22-50/100 mm	R



Particle Size			Lab Testing
GR	SA	SI CL (FINES)	

Notes:
1. Water level in open borehole measured at a depth of 5.5 m below ground surface upon completion of drilling

Sheet 1 of 1

Created using Hatch BH - Dynamic Soil Rock Log V2 on January 27 2025 03:24

BOREHOLE RECORD

TR24-5

Client: Brookfield BRP
Project: Trail Road BESS
Project No: H375035 **Location:**
Contractor: OGS **Rig Type:** CME 45 Trackmount
Driller: Jamie **Hole Diam (mm):** 152
Final Depth: 6.45 m
Coord. System: NAD83 / MTM zone 9N
Vertical Datum: CGVD2013
Bearing: **Date Logged:** Nov 17-Nov 29,2024
Inclination: 90.00º **Date Checked:**
Easting: 363,480.73 m
Northing: 5,008,332.21 m
Elevation: 95.14 m
Logged by: TV/DC
Reviewed by: TWB

Method: 152 mm outside dia. Hollow Stem Augers

Soil Description

NAME (SYMBOL): gradational components including plasticity or particle characteristics (size, angularity, shape), consistency/density, colour, moisture, additional description, (GEOLOGICAL FORMATION).

Topsoil

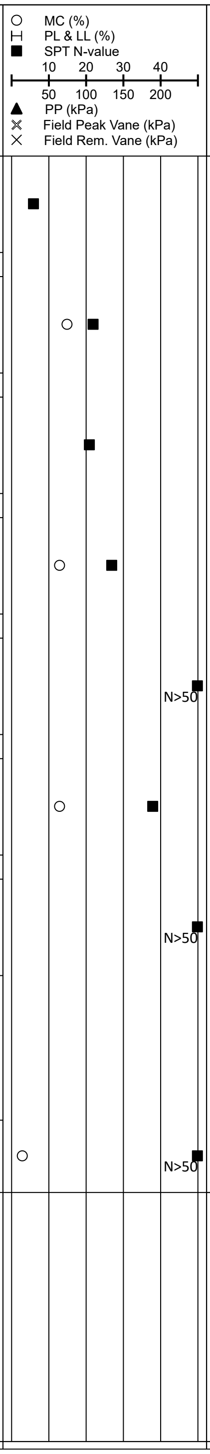
SILTY SAND to SANDY SILT (SM/ML) - fine to medium grained, poorly graded, loose to very dense, brown, moist, containing organics and rootlets to 0.7 m, oxidation staining to 1.4 m

- grey below 2.2 m
- trace gravel below 5.6 m

6.45 m.
END OF BOREHOLE
Split-Spoon Refusal on inferred bedrock

Elevation (m)	Depth (m)
109.0	1.0
108.0	2.0
107.0	3.0
106.0	4.0
105.0	5.0
104.0	6.0
103.0	7.0
102.0	8.0

Run Recovery	Sample Type	Sample Number	Recovery %	Blows	SPT N-Value	GR	SA	SI CL (FINES)	Lab Testing
	SPT	SS1	70	1-2-4-6	6				
	SPT	SS2	83	3-10-12-15	22				
	SPT	SS3	67	4-11-10-12	21				
	SPT	SS4	80	4-12-15-19	27	0	49	(51)	
	SPT	SS5	97	7-24-38-49	62				
	SPT	SS6	97	12-15-23-27	38				
	SPT	SS7	100	20-37-50-40	87				
	SPT	SS8	73	19-50-41-50/0 mm	91				



Notes:
1. Water level in open borehole measured at a depth of 4.5 m below ground surface upon completion of drilling.

Created using Hatch BH - Dynamic Soil Rock Log V2 on January 27 2025 03:24

HATCH

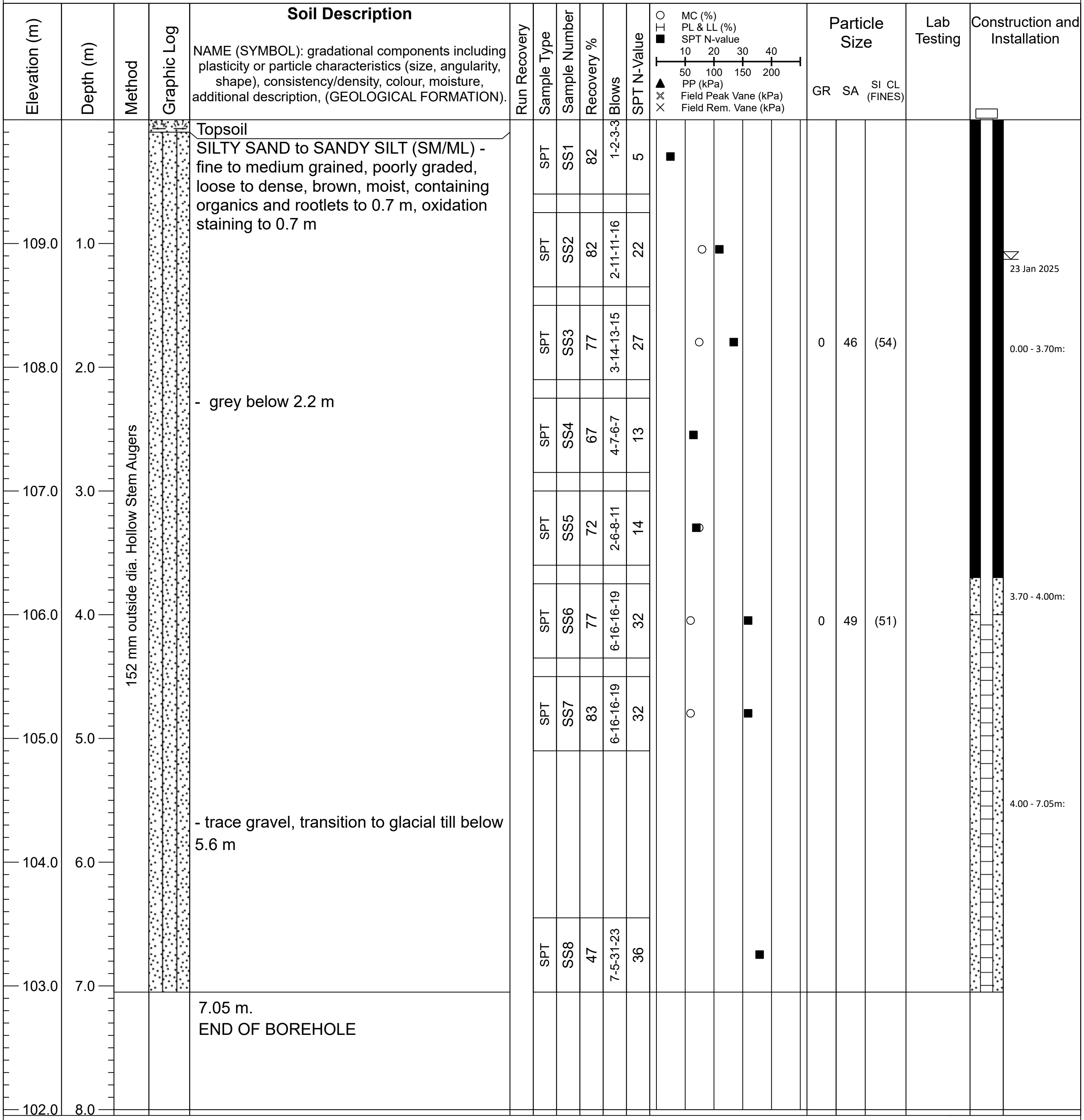
BOREHOLE RECORD

TR24-6

Client: Brookfield BRP
Project: Trail Road BESS
Project No: H375035 **Location:**
Contractor: OGS **Rig Type:** CME 45 Trackmount
Driller: Jami **Hole Diam (mm):** 152

Final Depth: 7.05 m
Coord. System: NAD83 / MTM zone 9N
Vertical Datum: CGVD2013
Bearing: **Date Logged:** Nov 29,2024
Inclination: 90.00º **Date Checked:**

Easting: 363,597.80 m
Northing: 5,008,455.88 m
Elevation: 95.57 m
Logged by: TV/DC
Reviewed by: TWB



Soil Description

NAME (SYMBOL): gradational components including plasticity or particle characteristics (size, angularity, shape), consistency/density, colour, moisture, additional description, (GEOLOGICAL FORMATION).

Topsoil

SILTY SAND to SANDY SILT (SM/ML) - fine to medium grained, poorly graded, loose to dense, brown, moist, containing organics and rootlets to 0.7 m, oxidation staining to 0.7 m

- grey below 2.2 m

- trace gravel, transition to glacial till below 5.6 m

7.05 m.
END OF BOREHOLE

Sample Type	Sample Number	Recovery %	Blows	SPT N-Value	GR	SA	SI CL (FINES)
SPT	SS1	82	1-2-3-3	5			
SPT	SS2	82	2-11-11-16	22			
SPT	SS3	77	3-14-13-15	27	0	46	(54)
SPT	SS4	67	4-7-6-7	13			
SPT	SS5	72	2-6-8-11	14			
SPT	SS6	77	6-16-16-19	32	0	49	(51)
SPT	SS7	83	6-16-16-19	32			
SPT	SS8	47	7-5-31-23	36			

Notes: 1. Water level in open borehole measured at a depth of 4.8 m below ground surface upon completion of drilling.
2. Water level measurements in monitoring well:
January 23, 2025 - 1.1 m below ground surface, July 16 - 1.9 m below ground surface, September 11, 2025 - 3.3 m below ground surface

Created using Hatch BH - Dynamic Soil Rock Log V2 on January 27 2025 03:24

HATCH

BOREHOLE RECORD

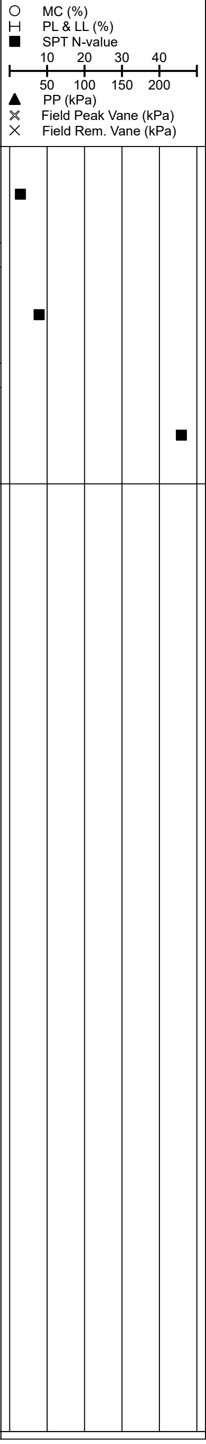
TR24-7

Client: Brookfield BRP		**Final Depth:** 2.10 m		**Easting:**	363,710.91 m
Project: Trail Road BESS		**Coord. System:** NAD83 / MTM zone 9N		**Northing:**	5,008,651.30 m
Project No: H375035	**Location:**	**Vertical Datum:** CGVD2013		**Elevation:**	95.74 m
Contractor: OGS	**Rig Type:** CME 45 Trackmount	**Bearing:**	**Date Logged:** Nov 28,2024	**Logged by:**	TV/DC
Driller: Jamie	**Hole Diam (mm):** 152	**Inclination:** 90.00º	**Date Checked:**	**Reviewed by:**	TWB

Elevation (m)	Depth (m)	Method	Soil Description NAME (SYMBOL): gradational components including plasticity or particle characteristics (size, angularity, shape), consistency/density, colour, moisture, additional description, (GEOLOGICAL FORMATION).
		152 mm outside dia. Hollow Stem Augers	Topsoil
			SILTY SAND (SM) - fine to medium grained, poorly graded, very loose to dense, brown, moist, containing organics and rootlets to 0.7 m, oxidation staining to 1.4 m
			2.10 m. END OF BOREHOLE

Elevation (m)	Depth (m)
109.0	1.0
108.0	2.0
107.0	3.0
106.0	4.0
105.0	5.0
104.0	6.0
103.0	7.0
102.0	8.0

Run Recovery	Sample Type	Sample Number	Recovery %	Blows	SPT N-Value
	SPT	SS1	70	1-1-2-2	3
	SPT	SS2	100	3-4-4-7	8
	SPT	SS3	90	10-21-25-18	46



Particle Size			Lab Testing
GR	SA	SI CL (FINES)	

Notes: 1. Borehole dry upon completion of drilling.

Sheet 1 of 1

HATCH

BOREHOLE RECORD

TR24-8

Client: Brookfield BRP		**Final Depth:** 2.10 m		**Easting:**	363,894.84 m
Project: Trail Road BESS		**Coord. System:** NAD83 / MTM zone 9N		**Northing:**	5,008,730.81 m
Project No: H375035	**Location:**	**Vertical Datum:** CGVD2013		**Elevation:**	96.04 m
Contractor: OGS	**Rig Type:** CME 45 Trackmount	**Bearing:**	**Date Logged:** Nov 28,2024	**Logged by:**	TV/DC
Driller: Jamie	**Hole Diam (mm):** 152	**Inclination:** 90.00º	**Date Checked:**	**Reviewed by:**	TWB

Elevation (m)	Depth (m)	Method	Graphic Log	**Soil Description** NAME (SYMBOL): gradational components including plasticity or particle characteristics (size, angularity, shape), consistency/density, colour, moisture, additional description, (GEOLOGICAL FORMATION).	Run Recovery	Sample Type	Sample Number	Recovery %	Blows	SPT N-Value	○ MC (%) ⊢ PL & LL (%) ■ SPT N-value 10 20 30 40 50 100 150 200 ▲ PP (kPa) ✕ Field Peak Vane (kPa) ✕ Field Rem. Vane (kPa)	Particle Size GR	SA	SI CL (FINES)	Lab Testing
		152 mm outside dia. Hollow Stem Augers		Topsoil											
				SILTY SAND (SM) - fine to medium grained, poorly graded, very loose to dense, brown, moist, containing organics and rootlets to 0.7 m, oxidation staining to 1.4 m		SPT	SS1	90	1-1-2-5	3	■				
109.0	1.0					SPT	SS2	97	6-6-11-17	17	■				
						SPT	SS3	97	13-20-29-31	49	■				
108.0	2.0														
				2.10 m. END OF BOREHOLE											
107.0	3.0														
106.0	4.0														
105.0	5.0														
104.0	6.0														
103.0	7.0														
102.0	8.0														

Notes:
1. Borehole dry upon completion of drilling.

Created using Hatch BH - Dynamic Soil Rock Log V2 on January 27 2025 03:24

Appendix B
Geotechnical Laboratory Testing

Test for Determination of Particle Size Analysis of Soils

HATCH
Geotechnical Laboratory

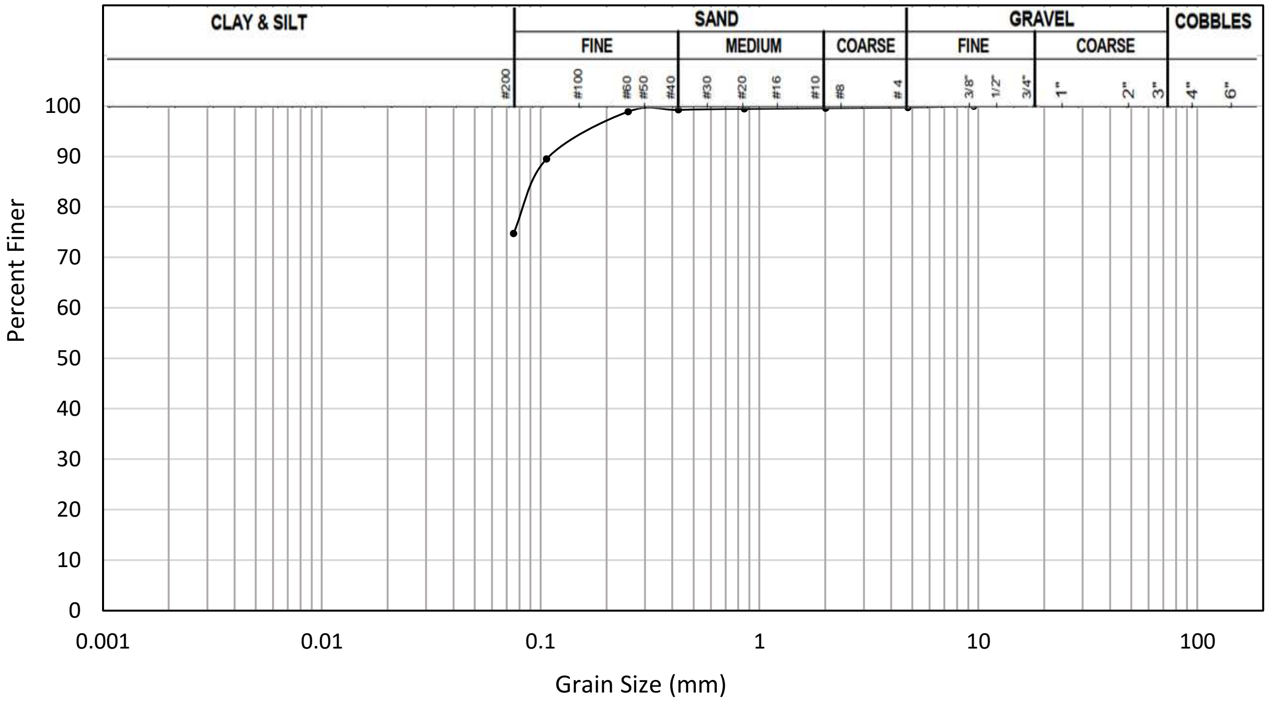
MTO LS-702

Date: January 22.2025
Project Number: H/375035
Project: **Trailroads BESS**

Brrokfield BRP
Brookfield Place, Suite 100, 181 Bay St. Toronto ON. M5J 2T3
Attn: Ted Beadle

Sample	SS6	**Depth**	12.5 - 14.5 ft
Source	TR24-1		

Sieve (mm)	% Passing	Sieve (mm)	% Passing	Size (mm)	% Passing
75	100.0	4.75	99.7		
63	100.0	2	99.6		
53	100.0	0.850	99.5		
37.5	100.0	0.425	99.3		
26.5	100.0	0.250	98.9		
19	100.0	0.106	89.5		
13.2	100.0	0.075	74.7		
9.5	100.0				



Comments: Whole sample, tested as received.

Reported By: D. Cuellar, Technician **Date:** January 22.2025
Reviewed By: R.Serluca, Lab Manager **Date:** January 23.2025

Notice: The test data given herein pertain to the sample provide, and may not be applicable to other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

Test for Determination of Particle Size Analysis of Soils

HATCH
Geotechnical Laboratory

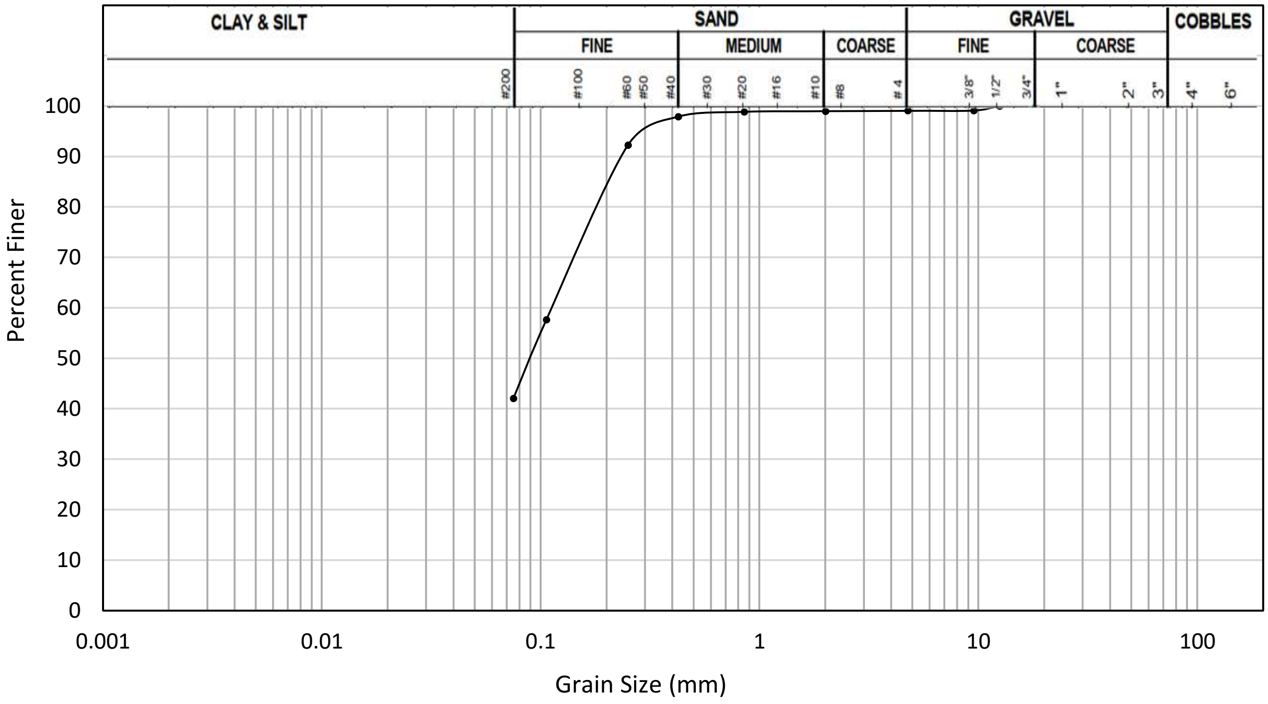
MTO LS-702

Date: January 22.2025
Project Number: H/375035
Project: **Trailroads BESS**

Brrokfield BRP
Brookfield Place, Suite 100, 181 Bay St. Toronto ON. M5J 2T3
Attn: Ted Beadle

Sample	SS3	**Depth**	5.0 - 7.0 ft
Source	TR24-1		

Sieve (mm)	% Passing	Sieve (mm)	% Passing	Size (mm)	% Passing
75	100.0	4.75	99.1		
63	100.0	2	99.0		
53	100.0	0.850	98.9		
37.5	100.0	0.425	97.9		
26.5	100.0	0.250	92.2		
19	100.0	0.106	57.7		
13.2	100.0	0.075	42.1		
9.5	99.1				



Comments: Whole sample, tested as received.

Reported By: D. Cuellar, Technician **Date:** January 22.2025
Reviewed By: R.Serluca, Lab Manager **Date:** January 23.2025

Test for Determination of Particle Size Analysis of Soils

Geotechnical Laboratory

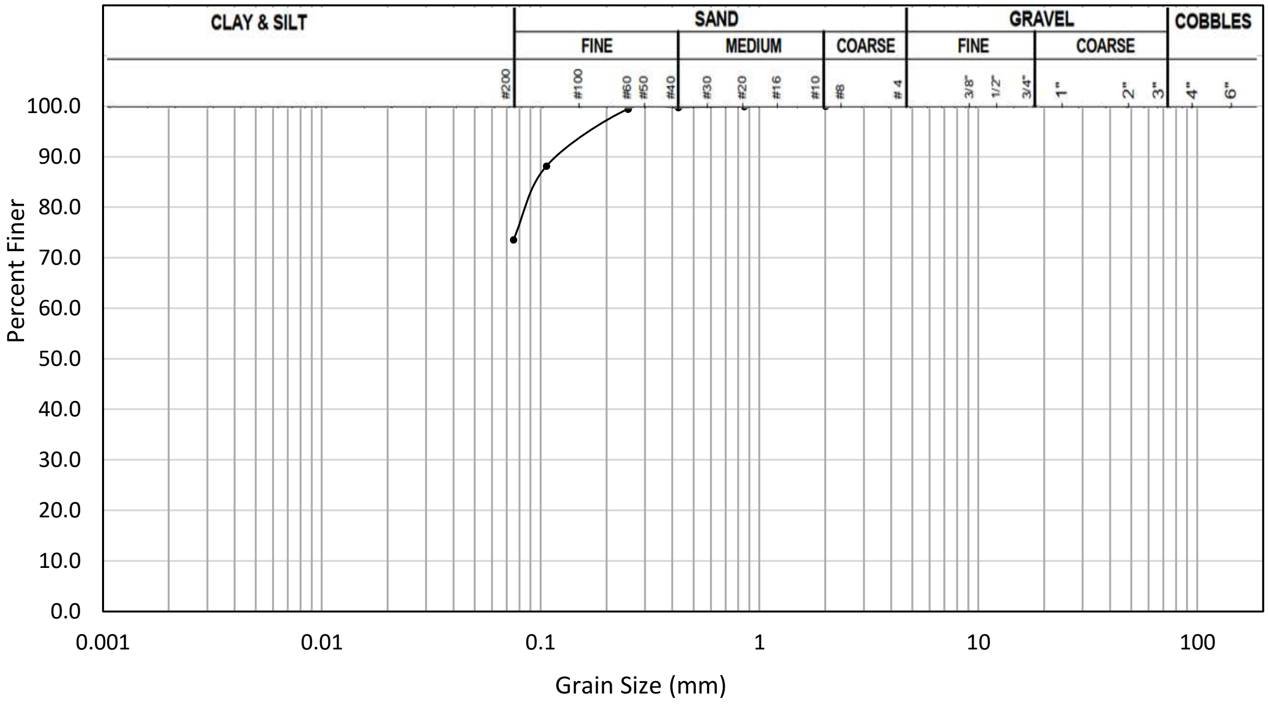
MTO LS-702

Date: January 22.2025
Project Number: H/375035
Project: **Trailroads BESS**

Brrokfield BRP
Brookfield Place, Suite 100, 181 Bay St. Toronto ON. M5J 2T3
Attn: Ted Beadle

Sample	SS9	**Depth**	22.0 - 24.0 ft
Source	TR24-1		

Sieve (mm)	% Passing	Sieve (mm)	% Passing	Size (mm)	% Passing
75	100.0	4.75	100.0		
63	100.0	2	100.0		
53	100.0	0.850	99.9		
37.5	100.0	0.425	99.7		
26.5	100.0	0.250	99.4		
19	100.0	0.106	88.2		
13.2	100.0	0.075	73.6		
9.5	100.0				



Comments: Whole sample, tested as received.

Reported By: D. Cuellar, Technician **Date:** January 22.2025
Reviewed By: R.Serluca, Lab Manager **Date:** January 23.2025

Notice: The test data given herein pertain to the sample provide, and may not be applicable to other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

Test for Determination of Particle Size Analysis of Soils

HATCH
Geotechnical Laboratory

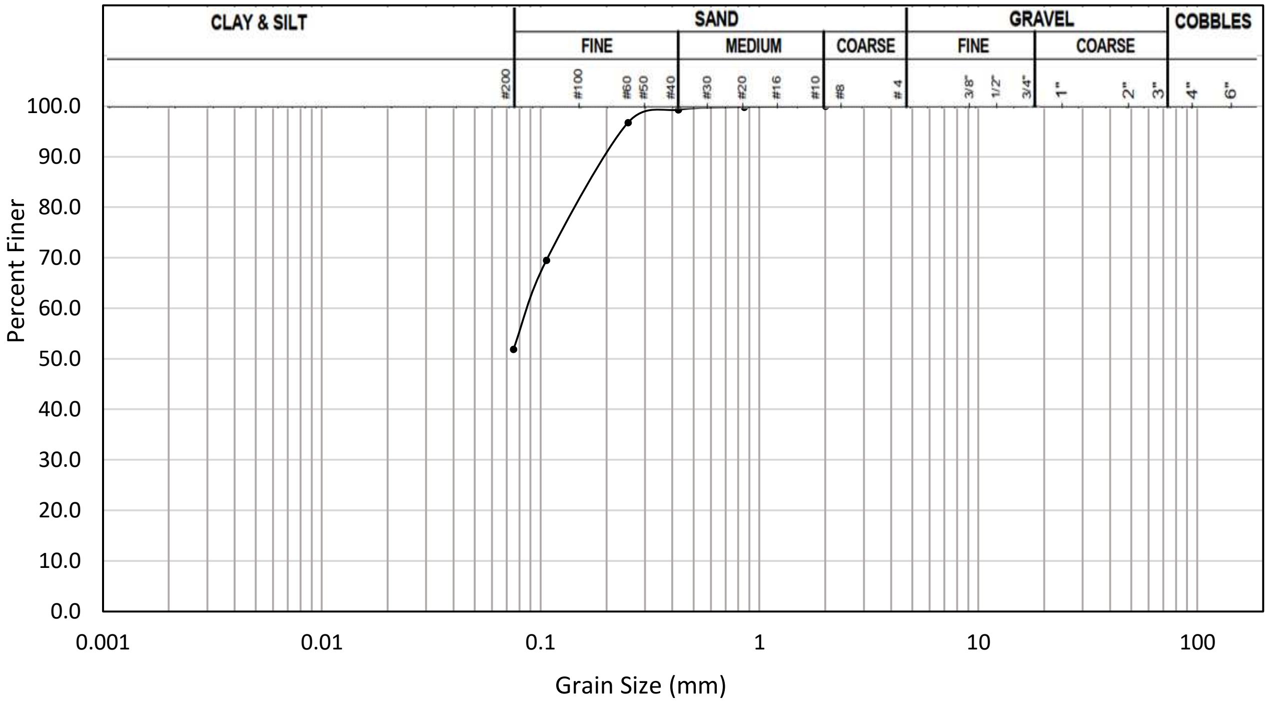
MTO LS-702

Date: January 22.2025
Project Number: H/375035
Project: **Trailroads BESS**

Brrokfield BRP
Brookfield Place, Suite 100, 181 Bay St. Toronto ON. M5J 2T3
Attn: Ted Beadle

Sample	SS3	**Depth**	5.0 - 7.0 ft
Source	TR24-3		

Sieve (mm)	% Passing	Sieve (mm)	% Passing	Size (mm)	% Passing
75	100.0	4.75	100.0		
63	100.0	2	100.0		
53	100.0	0.850	99.8		
37.5	100.0	0.425	99.3		
26.5	100.0	0.250	96.7		
19	100.0	0.106	69.5		
13.2	100.0	0.075	51.9		
9.5	100.0				



Comments: Whole sample, tested as received.

Reported By: D. Cuellar, Technician **Date:** January 22.2025
Reviewed By: R.Serluca, Lab Manager **Date:** January 23.2025

Test for Determination of Particle Size Analysis of Soils

HATCH
Geotechnical Laboratory

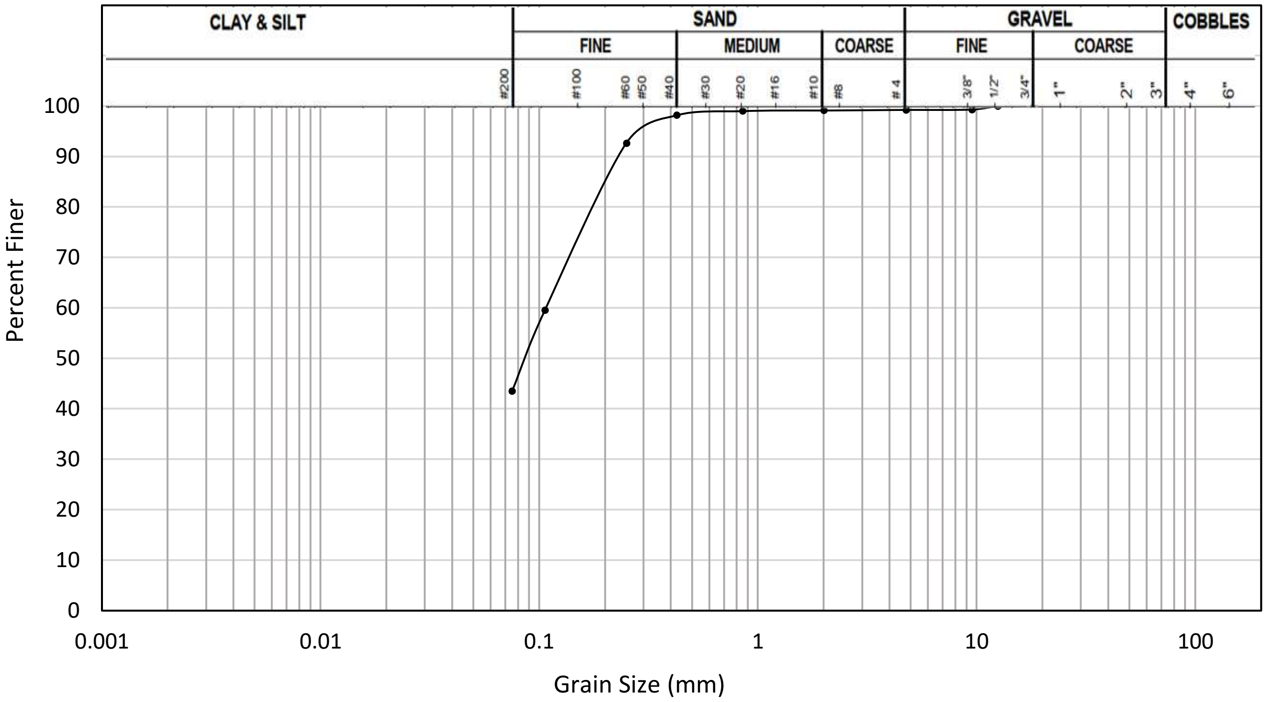
MTO LS-702

Date: January 22.2025
Project Number: H/375035
Project: **Trailroads BESS**

Brrokfield BRP
Brookfield Place, Suite 100, 181 Bay St. Toronto ON. M5J 2T3
Attn: Ted Beadle

Sample	SS7	**Depth**	15.0 - 17.0 ft
Source	TR24-3		

Sieve (mm)	% Passing	Sieve (mm)	% Passing	Size (mm)	% Passing
75	100.0	4.75	99.2		
63	100.0	2	99.1		
53	100.0	0.850	99.0		
37.5	100.0	0.425	98.2		
26.5	100.0	0.250	92.6		
19	100.0	0.106	59.6		
13.2	100.0	0.075	43.5		
9.5	99.3				



Comments: Whole sample, tested as received.

Reported By: D. Cuellar, Technician **Date:** January 22.2025
Reviewed By: R.Serluca, Lab Manager **Date:** January 23.2025

Test for Determination of Particle Size Analysis of Soils

HATCH
Geotechnical Laboratory

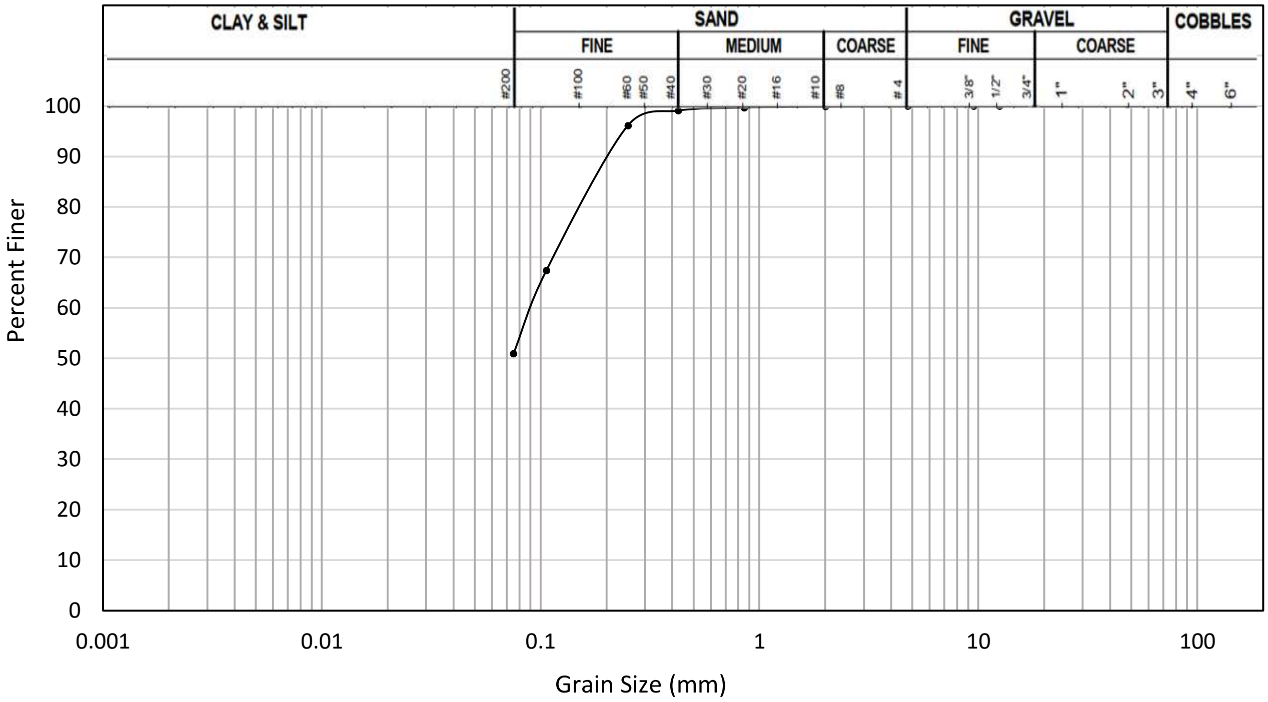
MTO LS-702

Date: January 22.2025
Project Number: H/375035
Project: **Trailroads BESS**

Brrokfield BRP
Brookfield Place, Suite 100, 181 Bay St. Toronto ON. M5J 2T3
Attn: Ted Beadle

Sample	SS4	**Depth**	7.5 - 9.5 ft
Source	TR24-5		

Sieve (mm)	% Passing	Sieve (mm)	% Passing	Size (mm)	% Passing
75	100.0	4.75	100.0		
63	100.0	2	99.9		
53	100.0	0.850	99.7		
37.5	100.0	0.425	99.1		
26.5	100.0	0.250	96.1		
19	100.0	0.106	67.4		
13.2	100.0	0.075	50.9		
9.5	100.0				



Comments: Whole sample, tested as received.

Reported By: D. Cuellar, Technician **Date:** January 22.2025
Reviewed By: R.Serluca, Lab Manager **Date:** January 23.2025

Test for Determination of Particle Size Analysis of Soils

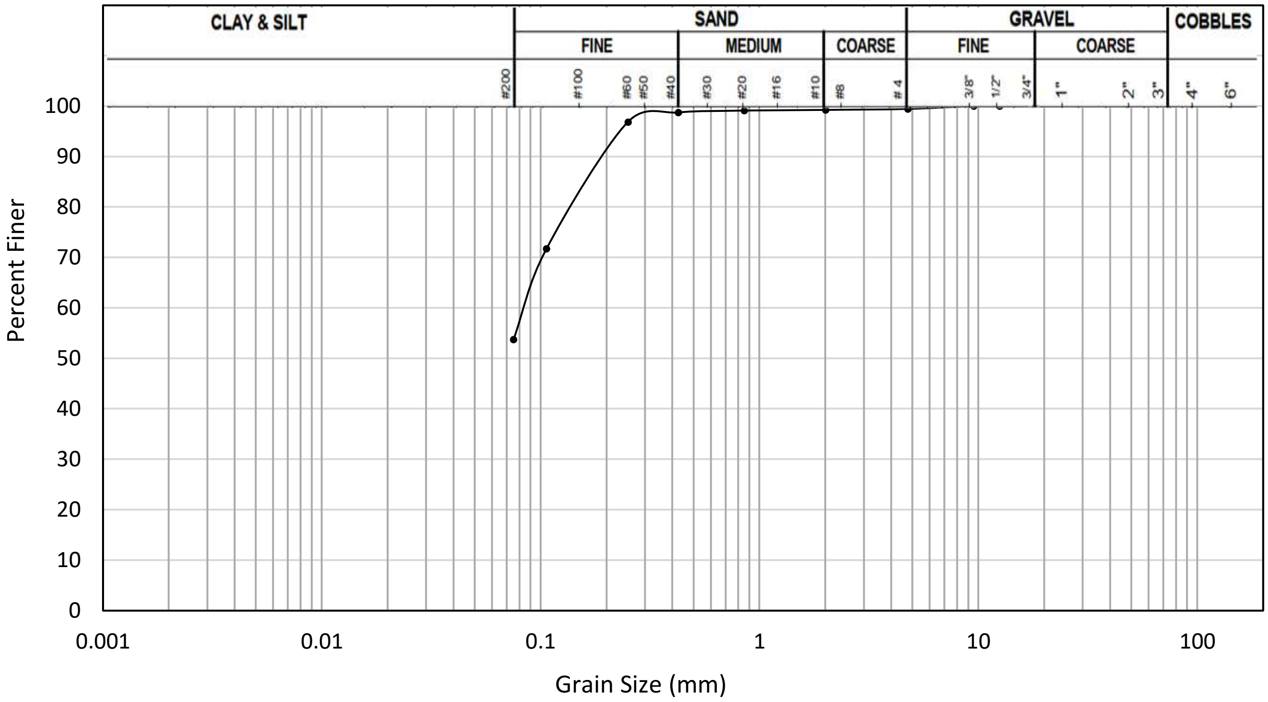
HATCH
Geotechnical Laboratory

MTO LS-702

Date:	January 22.2025	**Brrokfield BRP**
Project Number:	H/375035	Brookfield Place, Suite 100, 181 Bay St. Toronto ON. M5J 2T3
Project:	**Trailroads BESS**	**Attn:** Ted Beadle

Sample	SS3	**Depth**	5.0 - 7.0 ft
Source	TR24-6		

Sieve (mm)	% Passing	Sieve (mm)	% Passing	Size (mm)	% Passing
75	100.0	4.75	99.4		
63	100.0	2	99.2		
53	100.0	0.850	99.1		
37.5	100.0	0.425	98.7		
26.5	100.0	0.250	96.8		
19	100.0	0.106	71.7		
13.2	100.0	0.075	53.7		
9.5	100.0				



Comments: Whole sample, tested as received.

Reported By: D. Cuellar, Technician **Date:** January 22.2025

Reviewed By: R.Serluca, Lab Manager **Date:** January 23.2025

Test for Determination of Particle Size Analysis of Soils

HATCH
Geotechnical Laboratory

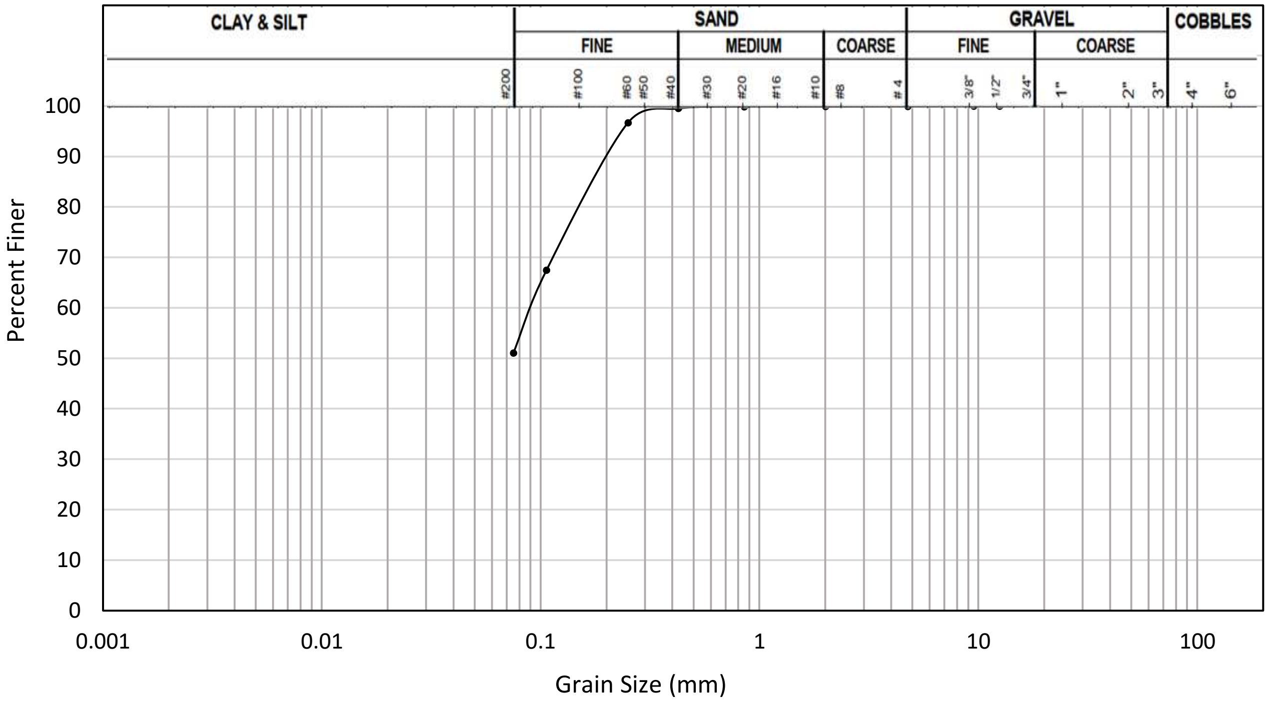
MTO LS-702

Date: January 22.2025
Project Number: H/375035
Project: **Trailroads BESS**

Brrokfield BRP
Brookfield Place, Suite 100, 181 Bay St. Toronto ON. M5J 2T3
Attn: Ted Beadle

Sample	SS6	**Depth**	12.5 - 14.5 ft
Source	TR24-6		

Sieve (mm)	% Passing	Sieve (mm)	% Passing	Size (mm)	% Passing
75	100.0	4.75	99.9		
63	100.0	2	99.9		
53	100.0	0.850	99.9		
37.5	100.0	0.425	99.5		
26.5	100.0	0.250	96.7		
19	100.0	0.106	67.4		
13.2	100.0	0.075	51.1		
9.5	100.0				



Comments: Whole sample, tested as received.

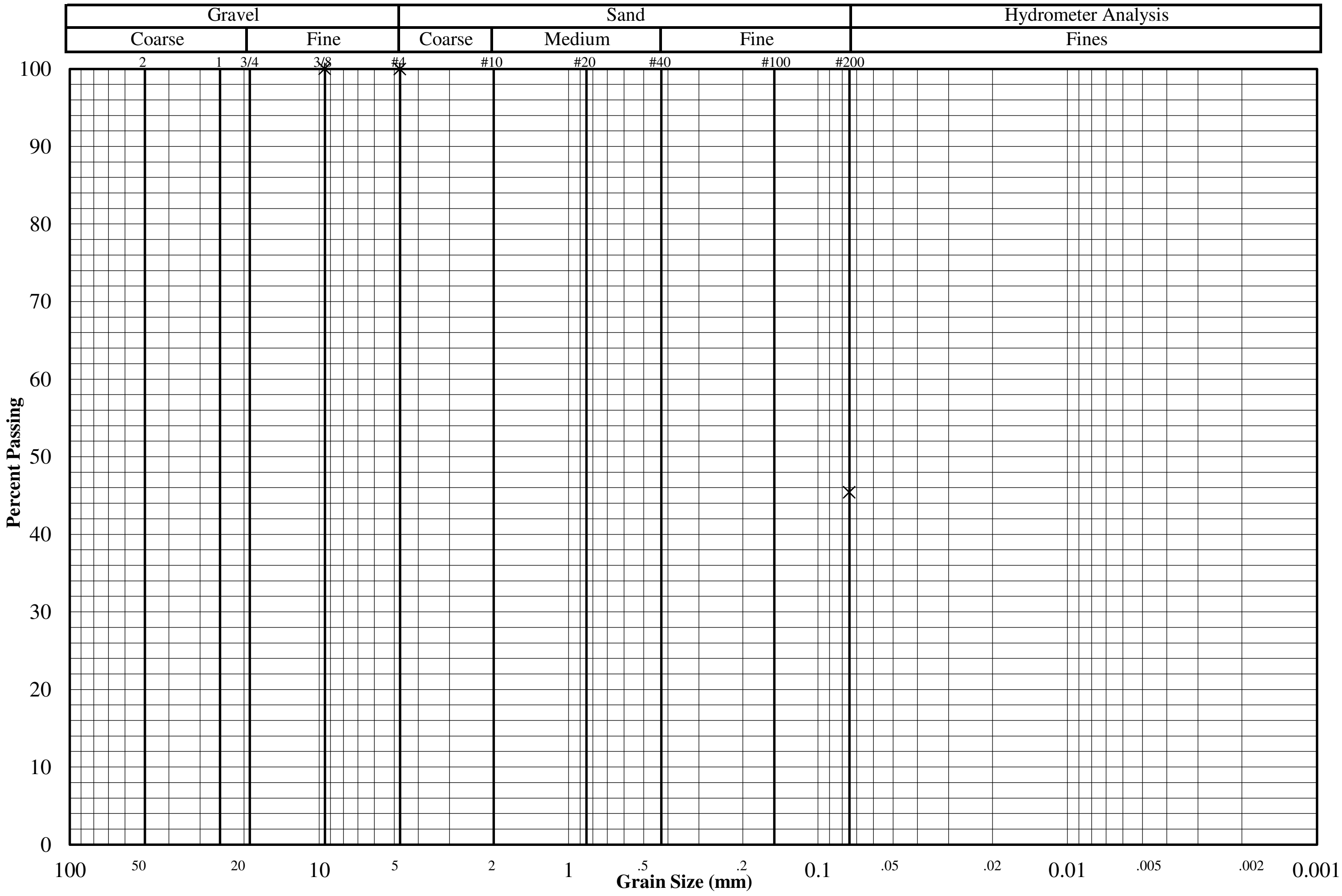
Reported By: D. Cuellar, Technician **Date:** January 22.2025
Reviewed By: R.Serluca, Lab Manager **Date:** January 23.2025

Grain Size Distribution ASTM D1140

Job No. : **15594**

Project:	H/375035/999-0101	Test Date:	1/7/25
Reported To:	Hatch	Report Date:	1/13/25

	Location / Boring No.	Sample No.	Depth (ft)	Sample Type	Soil Classification
∗	TR24-1		1-5	Bulk	Silty Sand (SM)
●					
◇					



Additional Results	∗	●	◇
Liquid Limit			
Plastic Limit			
Plasticity Index ASTM:D4318			
Water Content ASTM:D2216			
Dry Density (pcf) ASTM:D7263			
Specific Gravity ASTM:D854			
Porosity			
Organic Content ASTM:D2974			
pH ASTM:D4972 Method B			

Percent Passing

	∗	●	◇
Mass (g)	25226.0		
2"			
1.5"			
1"			
3/4"			
3/8"	100.0		
#4	100.0		
#10			
#20			
#40			
#100			
#200	45.4		

	∗	●	◇
D_{60}			
D_{30}			
D_{10}			
C_U			
C_C			

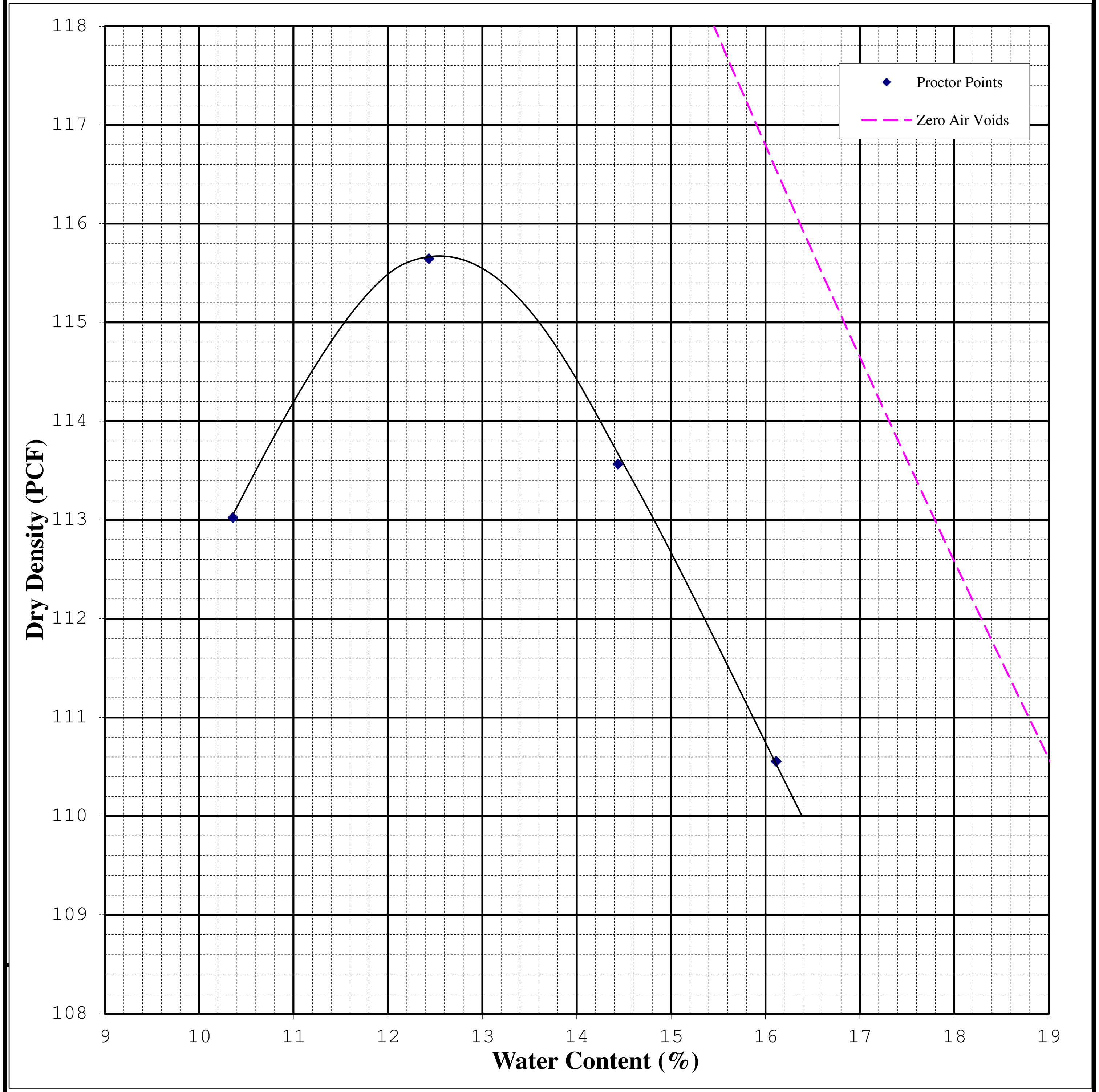
Remarks:

(* = assumed)

Appendix C
Advanced Geotechnical Laboratory

Moisture Density Curve ASTM: D698, Method B

Project: **H/375035/999-0101** Date: **1/13/25**
Client: **Hatch** Job No. **15594**
Boring No. **TR24-1** Sample: Depth(ft): **1-5** Location:
Soil Type: **Silty Sand (SM)**
As Received W.C. (%): **18.8** ◆ LL: △ PL: PI: Specific Gravity: **2.67** ◆ *Assumed △
Maximum Dry Density (pcf): **115.7** Opt. Water Content (%): **12.5**



9530 James Ave South

SOIL ENGINEERING TESTING, INC.

Bloomington, MN 55431

SET-R18a

California Bearing Ratio ASTM:D1883

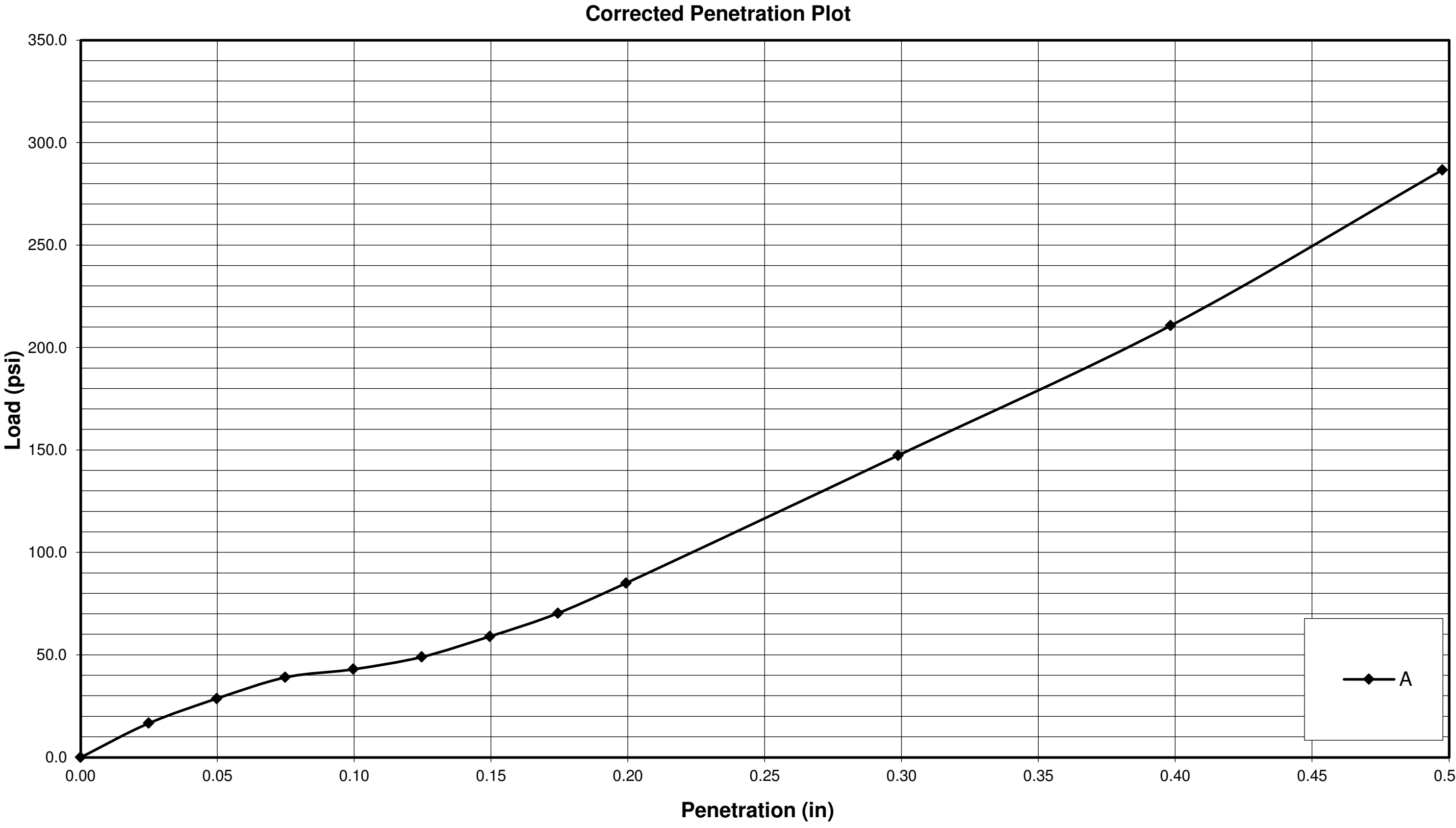
Project:	H/375035/999-0101	Job:	**15594**
Client:	Hatch	Date:	1/21/25

Boring #:	TR24-1			Procedural Method:
Sample:				Specimens compacted to approximately 95% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft):	1-5			
Type:	Bulk			
Classification:	Silty Sand (SM)			

Laboratory Moisture-Density Values				Index Properties	
Method:	ASTM:D698 Method B			LL:	Gs:
Maximum Dry Density (PCF):	115.7			PL:	Organic Content:
Optimum Water Content:	12.5%			PI:	pH:

Initial Molding Conditions			
Specimen	A		
Compaction Hammer:	5 lb		
Number of Layers:	3		
Blows per Layer:	NA		
Initial Moisture Content:	12.5%		
Initial Dry Density (PCF)	109.7		
Relative Compaction	94.8%		
Soaking Phase			
Days Soaked	4		
Surcharge (psf)	50		
Total Swell (%)	0.4%		
Penetration Phase			
Surcharge (psf)	50		
Corrected CBR Values			
at 0.1 inch (%)	4.3%		
at 0.2 inch (%)	**5.7%**		
Moisture Content After Penetration			
Top 1" of Specimen:	16.3%		
Average of specimen:	16.3%		

Stress vs. Penetration Graph



Thermal Resistivity Report ASTM D:5334

Project: **H/375035/999-0101**

Job #: **15594**

Client: **Hatch**

Date: **1/22/25**

					Proctor Values		Initial Conditions			Dry
Boring	Specimen Type	Depth (ft)	Type	Classification	Maximum Dry Density (PCF)	Optimum Moisture (%)	Dry Density (PCF)	WC (%)	Thermal Resistivity (ºC-cm/W)	Thermal Resistivity (ºC-cm/W)
TR24-1	**Reconstituted**	**1-5**	**Bulk**	**Silty Sand (SM)**	**115.7**	**12.5%**	**98.3**	**18.9%**	**62**	**222**
	Specimens reconstituted to approximately 85% of maximum standard proctor density near the greater of the as received or optimum moisture content.									

9530 James Ave South

SOIL
ENGINEERING
TESTING, INC.

Bloomington, MN 55431

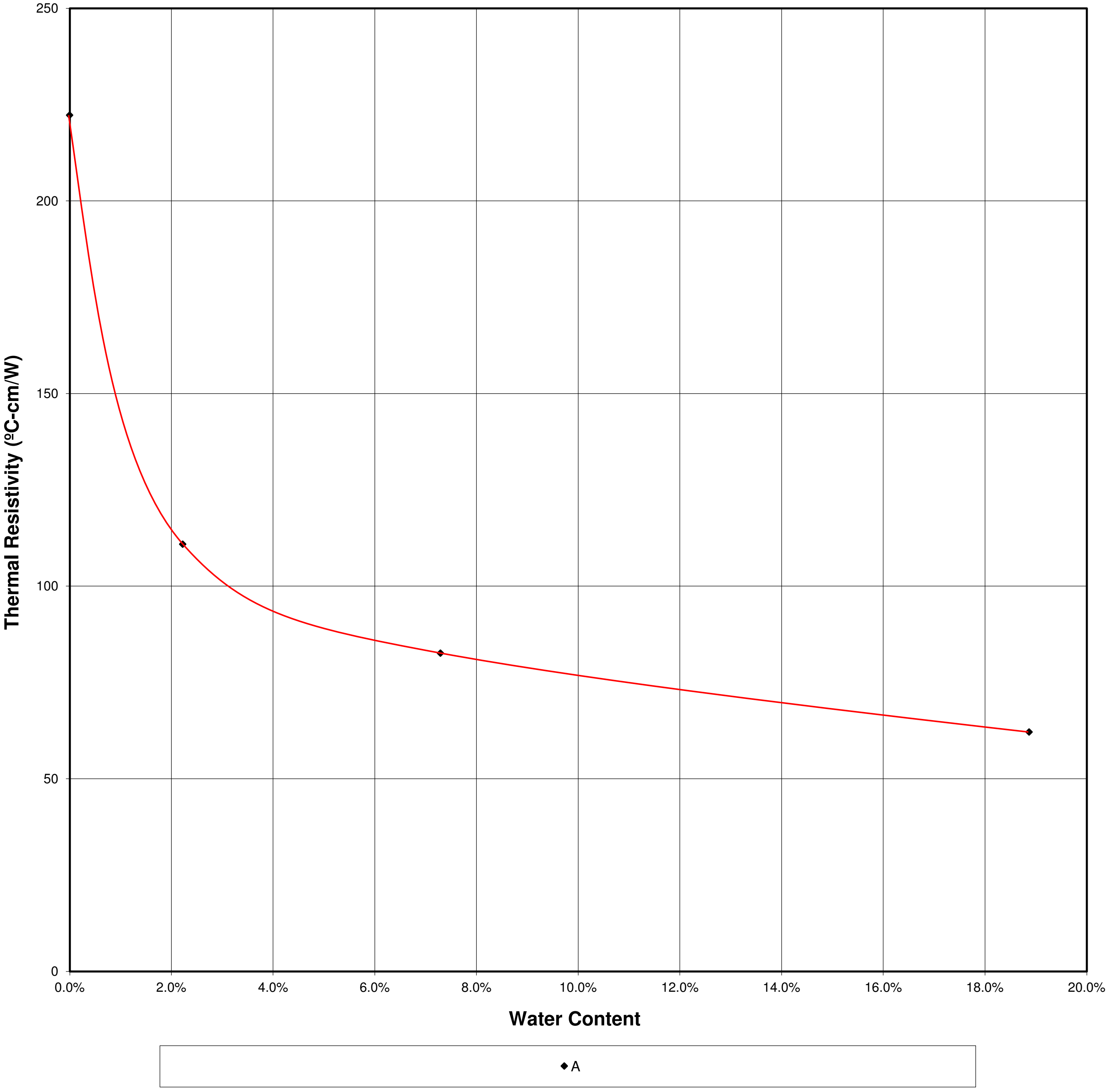
http://www.soilengineeringtesting.com

Thermal Resistivity Report ASTM D:5334

Project:	H/375035/999-0101	Job:	15594
Client:	Hatch	Date:	1/22/25

	Boring	Depth (ft)
Specimen A:	TR24-1	1-5

Thermal Dryout Curves (Water Content vs. Resistivity)



Appendix D
Chemical Testing

PARACEL LABORATORIES LTD.
TRUSTED. RESPONSIVE. RELIABLE.

351 Nash Road North, unit 9B
Hamilton, ON L8H 7P4
1-800-749-1947
www.paracellabs.com

Certificate of Analysis

Hatch Ltd.
4342 Queen Street, Suite 300
Niagara Falls, ON L2E 7J7
Attn: Ted Beadle

Report Date: 24-Dec-2024
Order Date: 18-Dec-2024

Client PO:
Project: H/375035 / H/375142
Custody: 145330

Order #: 2451324

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

Paracel ID	Client ID
2451324-01	TR24-1-C1
2451324-02	TR24-6-C1
2451324-03	FY24-1-C1
2451324-04	FY24-5-C1

Approved By:

Alex Enfield, MSc
Lab Manager

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	23-Dec-24	23-Dec-24
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	19-Dec-24	20-Dec-24
Resistivity	EPA 120.1 - probe, water extraction	23-Dec-24	24-Dec-24
Solids, %	CWS Tier 1 - Gravimetric	19-Dec-24	20-Dec-24

Certificate of Analysis

Report Date: 24-Dec-2024

Client: **Hatch Ltd.**

Order Date: 18-Dec-2024

Client PO:

Project Description: H/375035 / H/375142

Client ID:		TR24-1-C1	TR24-6-C1	FY24-1-C1	FY24-5-C1	-	-
Sample Date:		18-Dec-24 11:00	18-Dec-24 11:00	18-Dec-24 11:30	18-Dec-24 11:30		
Sample ID:		2451324-01	2451324-02	2451324-03	2451324-04		
Matrix:		Soil	Soil	Soil	Soil		
	MDL/Units						
Physical Characteristics							
% Solids	0.1 % by Wt.	88.3	87.5	73.9	72.3	-	-
General Inorganics							
pH	0.05 pH Units	7.36	7.33	7.16	7.10	-	-
Resistivity	0.10 Ohm.m	65.5	102	175	106	-	-
Anions							
Chloride	5 ug/g	<5	<5	<5	<5	-	-
Sulphate	5 ug/g	72	7	10	6	-	-

Method Quality Control: Blank

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

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g	ND			NC	20	
Sulphate	63.6	5	ug/g	72.4			13.0	20	
General Inorganics									
pH	7.12	0.05	pH Units	7.11			0.1	10	
Resistivity	77.5	0.10	Ohm.m	75.9			2.0	20	
Physical Characteristics									
% Solids	80.8	0.1	% by Wt.	81.5			0.9	25	

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	10.8	5	ug/g	ND	105	80-120			
Sulphate	16.9	5	ug/g	7.24	97.0	80-120			

Qualifier Notes:

Sample Data Revisions:

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable

ND: Not Detected

MDL: Method Detection Limit

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

%REC: Percent recovery.

RPD: Relative percent difference.

NC: Not Calculated

Soil results are reported on a dry weight basis unlesss otherwise noted.

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

PARACEL
LABORATORIES LTD.

Paracel ID: 2451324

Paracel Order Number
(Lab Use Only)

Chain of Custody
(Lab Use Only)
№ 145330

Client Name: Hatch
Contact Name: Ted Beadle
Address: 4342 Queen St.
Niagara Falls, ON
Telephone: 647-523-5446

Project Ref: H/375035 / H/375142
Quote #:
PO #:
E-mail: ted.beadle@hatch.com

Page 1 of 1

Turnaround Time
☐ 1 day ☐ 3 day
☐ 2 day ☑ Regular
Date Required:

☐ REG 153/04 ☐ REG 406/19
☐ Table 1 ☐ Res/Park ☐ Med/Fine
☐ Table 2 ☐ Ind/Comm ☐ Coarse
☐ Table 3 ☐ Agri/Other
☐ Table ___
For RSC: ☐ Yes ☐ No

Other Regulation
☐ REG 558 ☐ PWQO
☐ CCME ☐ MISA
☐ SU - Sani ☐ SU-Storm
Mun: ___
☐ Other

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

Required Analysis

	Sample ID/Location Name	Matrix	Air Volume	# of Containers	Sample Taken		PHCs F1-F4+BTEX	VOCs	PAHs	Metals by ICP	Hg	CrVI	B (HWS)	Corrosivity Package				
					Date	Time												
1	TR24-1-C1	Soil		1	Dec.18/24	11:00								X				
2	TR24-6-C1	Soil		1	Dec.18/24	11:00								X				
3	FY24-1-C1	Soil		1	Dec.18/24	11:30								X				
4	FY24-5-C1	Soil		1	Dec.18/24	11:30								X				
5																		
6																		
7																		
8																		
9																		
10																		

Comments:

Method of Delivery: WALK IN

Relinquished By (Sign):	Received at Depot: B. Barton (Niagara)	Received at Lab: Km	Verified By: Km
Relinquished By (Print):	Date/Time: Dec 18/24 @ 1:50 pm	Date/Time: 12/19/24 1030	Date/Time: 12/19/24 1035
Date/Time:	Temperature: 2° °C	Temperature: 6.9 °C	pH Verified: ☐ By: NA.

Appendix E
Electrical Resistivity Testing

Project Report

January 31, 2025

Brookfield Renewable

Distribution

Ted Beadle
Racheal Seymour

Electrical Resistivity Field Testing

Table of Contents

List of Figures

List of Table

1. Introduction

This report presents the results of the Vertical Electric Resistivity Testing survey carried out by Hatch on November 30, 2024, at the Trail Road Battery Energy Storage System (BESS) site in Richmond, Ontario. The objective of the survey was to conduct soil electrical resistivity testing using the 4-electrode Wenner method at the site.

2. Methodology

The Wenner 4-electrode method is also known as a Vertical Electric Resistivity Sounding (VES). This method is described by ASTM G57-06 and ANSI/IEEE Standard 81-1983 standards. To determine the soils resistivity, four evenly spaced steel electrodes are inserted into the soil in a straight line and a DC or AC test current is applied to the outer two electrodes. The associated potential difference, V, is measured between the inner pair of potential electrodes. The effective resistance, R, of subsurface material is measured and converted to units of Ohms using Ohms' law, R=V/I. The influence of each specific electrode spacing between electrodes is then converted to the soils apparent resistivity using the geometrical correction factor $p,\Omega\bullet m = 2\pi aR$ where 'a' is the electrode spacing in metres. The apparent resistivity is then reported in units of ohm-metres (Ω•m).

The test is carried out by keeping the test instrument at a central location, while the a-spacing between the current electrodes A and B (C1 and C2) and potential electrodes M and N (P1 and P2) is increased outwards from the central location in steps in order to achieve greater depth penetration (see Figure 1 below). The survey depth increases with increasing electrode separation to yield a vertical electrical sounding of the subsurface. This approach highlights changes in vertical stratification in electrical properties of the ground. Where possible, the test array is then rotated 90 degrees creating two orthogonal spreads about a common midpoint to investigate the possibility of planar anisotropy in the ground where space permits.

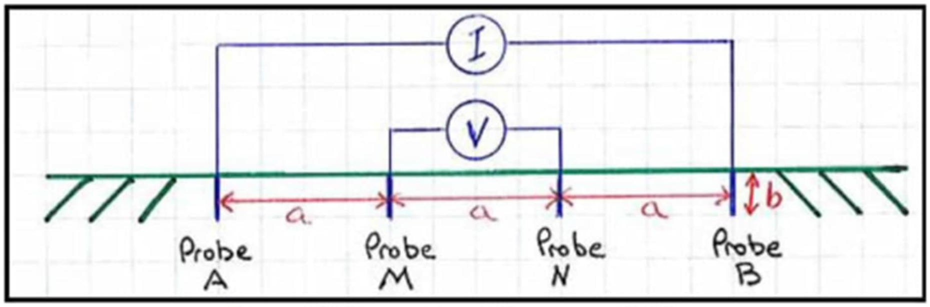


Figure 1: Typical Wenner Array Configuration

The data was acquired with the following standards as guidelines.

- ASTM Standard G 57, 2006, “Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method,” ASTM International, West Conshohocken, PA.
- ANSI/IEEE Standard 81, 1983, “Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System,” The Institute of Electrical and Electronics Engineers, Inc., New York, NY, USA.

3. Field Work

Data was collected from two VES lines at the site, Lines A and B shown in Figure 2 below. The VES data was acquired with a Syscal R1 Plus soil resistivity meter using the 4-electrode Wenner survey. Electrode ‘a’-spacings of 0.61, 1.5, 3.0, 6.1, 15.2, 30.5, and 36.6 metres were employed for Line A, and 0.61, 1.5, 3.0, 6.1, 15.2, 30.5, and 61.0 m for Line B.

Cold, windy and cloudy conditions persisted throughout the duration of the field testing. Temperature ranged from -2 to 2 degrees Celsius.

The ground surface in the Trail Road BESS site consists of an organic layer composed of fallen leaves, and soil conditions were moist at the time of testing. Terrain was generally flat.

Figure 2 displays a general project location map indicating the VES test locations.

Figure 2: Site Map Showing VES Test Location (Red Line)

Table 1 shows the NAD 83 MTM Zone 9 coordinates for each VES line. Table 2 and 3 show the measurements taken on site and Figures 3 and 4 present the graphical results of the VES data.

Table 1: Coordinates of VES Lines

Line	Location of Point	Easting (m)	Northing (m)	Approximate Elevation (m)
A	North End	363,628.54	5,008,468.72	95.86
	Mid-Point	363,608.99	5,008,520.00	95.86
	South End	363,589.44	5,008,571.28	95.57
B	West End	363,333.17	5,008,481.67	95.34
	Mid-point	363,416.66	5,008,519.03	95.93
	East End	363,500.15	5,008,556.39	95.86

Table 2: Measured Data of VES Line A

Electrode Spacing, a (m)	Pin Depth, d (m)	Voltage (mV)	Current (mA)	Resistance (Ω)	Apparent Resistivity (Ω-m)
0.61	0.06	3,270.45	52.43	62.38	238.80
1.50	0.15	3,116.09	175.06	17.80	170.36
3.00	0.15	1,133.02	156.63	7.23	138.46
6.10	0.15	863.75	207.07	4.17	159.69
15.20	0.15	481.45	152.83	3.15	301.50
30.50	0.2	456.92	165.93	2.75	527.10
36.60	0.2	713.72	268.64	2.66	610.26

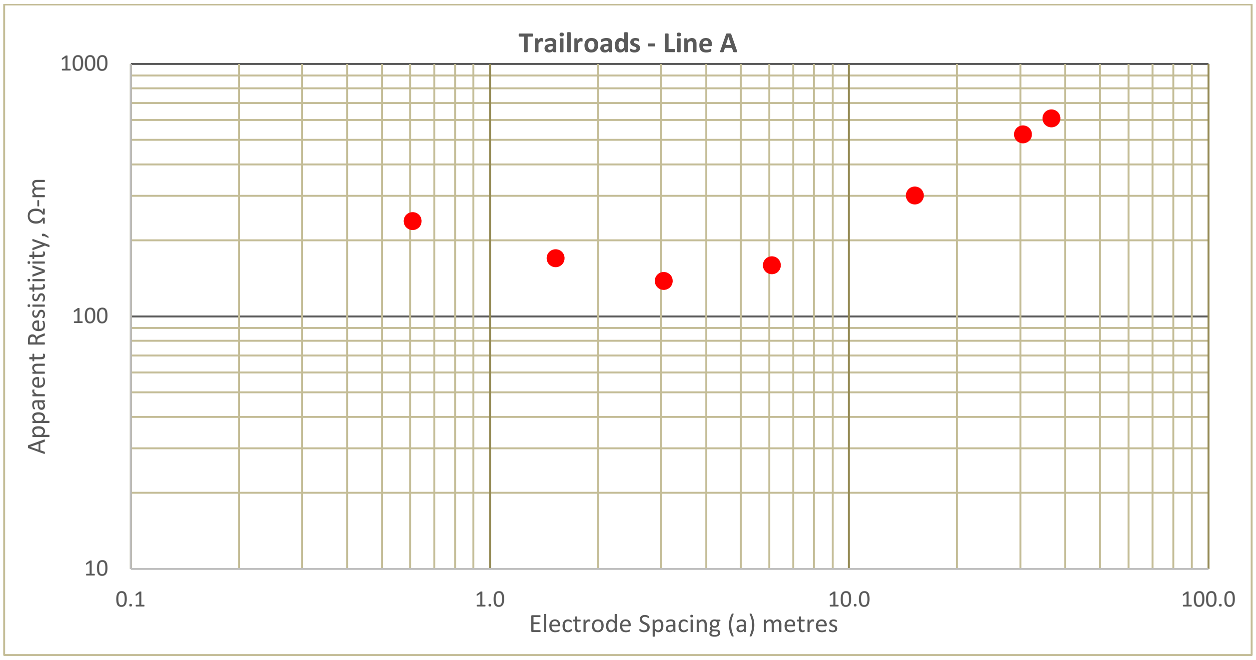


Figure 3: Graphical Presentation of Measured VES Data Line A

Table 3: Measured Data of VES Line B

Electrode Spacing, a (m)	Pin Depth, d (m)	Voltage (mV)	Current (mA)	Resistance (Ω)	Apparent Resistivity (Ω-m)
0.61	0.06	3,331.26	25.22	132.09	505.67
1.50	0.15	3,276.67	59.93	54.67	523.28
3.00	0.15	1,098.27	106.84	10.28	196.77
6.10	0.15	542.51	123.68	4.39	167.92
15.20	0.15	250.45	74.62	3.36	321.23
30.50	0.20	253.48	92.10	2.75	526.82
61.00	0.20	418.74	175.41	2.39	914.49

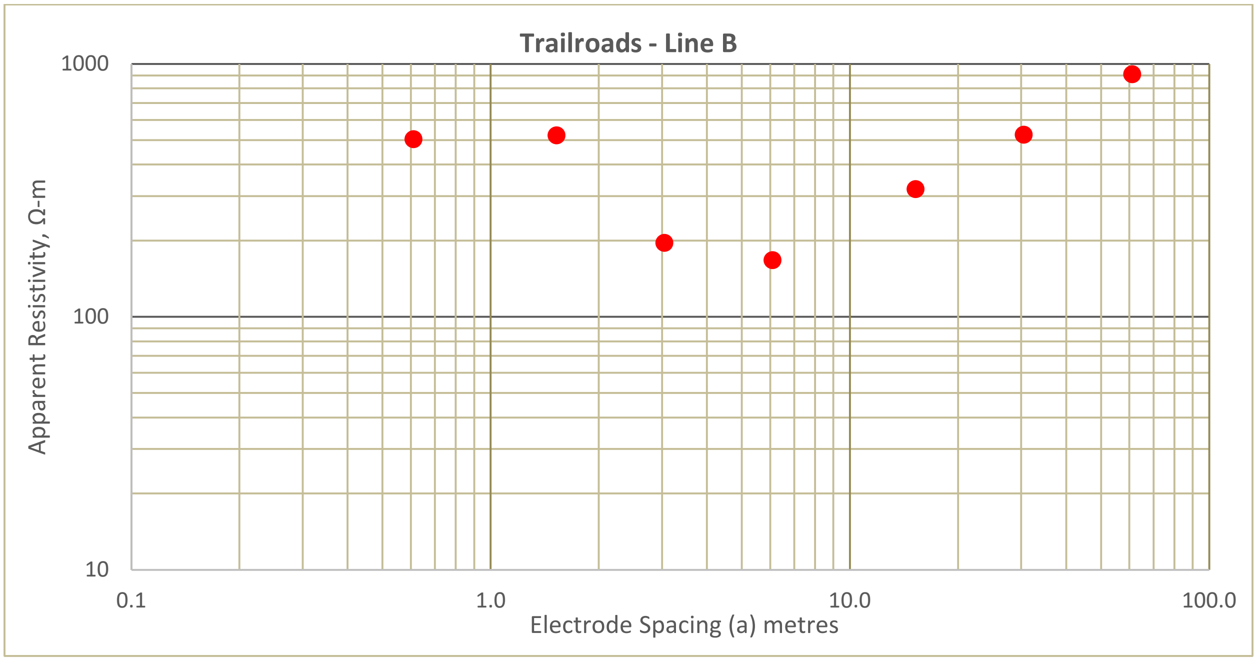


Figure 4: Graphical Presentation of Measured VES Data Line B

4. Limitations of Use

The resistivity testing method presented in this report is based on the use of geophysical surveying techniques. As with any geophysical method, values presented in this report should be confirmed by intrusive methods (boreholes, test pits, etc.).

This geophysical survey was carried out in a manner consistent with the level of care and skill normally exercised by other members of the engineering and science professions currently practising under similar conditions, subject to the time limits and financial and physical constraints applicable to the services provided. This is a factual report, therefore, no warranty is either expressed, implied, or made as to the conclusions, advice, and recommendations offered.

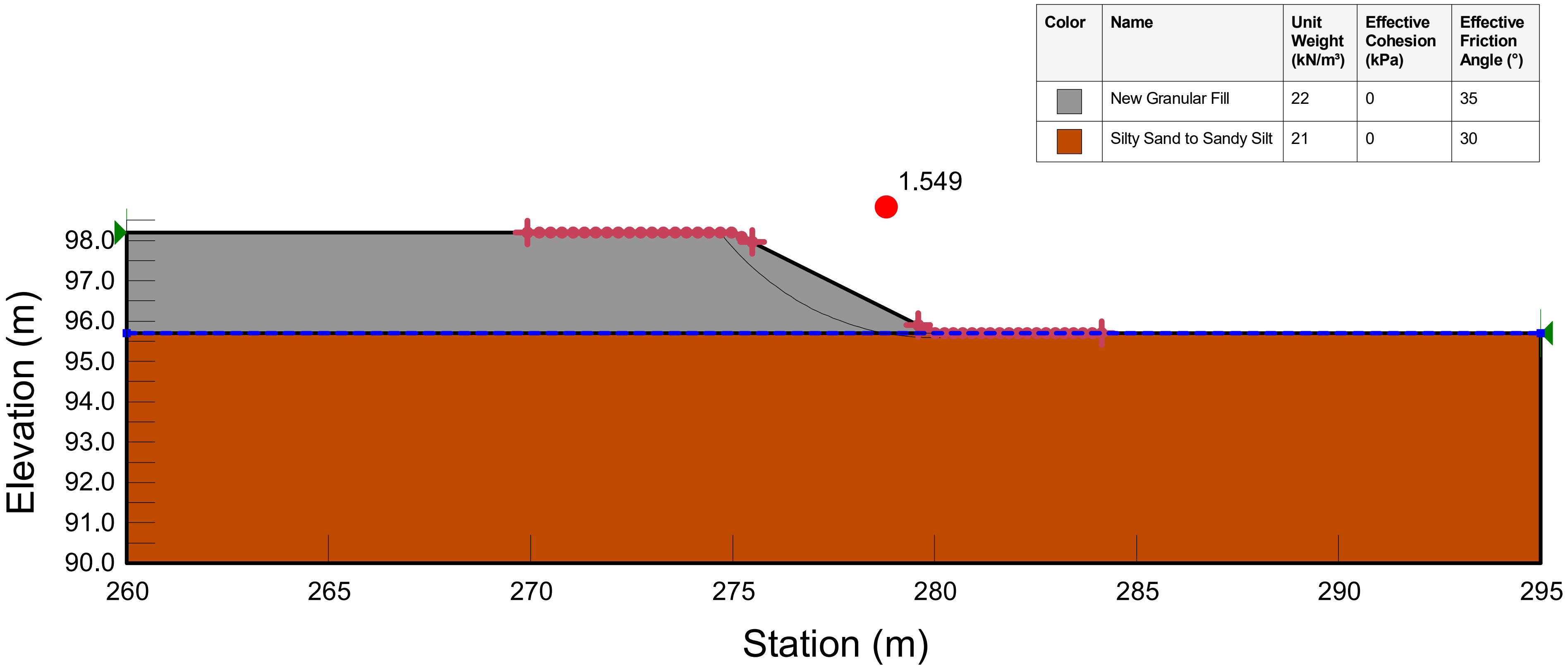
Any use of the information within this report made by a third party, or any reliance on, or decisions to be made based on it, are the sole responsibility of such third parties. Hatch accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

5. Closure

We trust that this technical memorandum meets your needs at the present time. If you have any questions or require clarification, please contact the undersigned at your convenience.

Ralph Serluca, C. Tech
Civil Technologist

Appendix F
Slope Stability Analysis

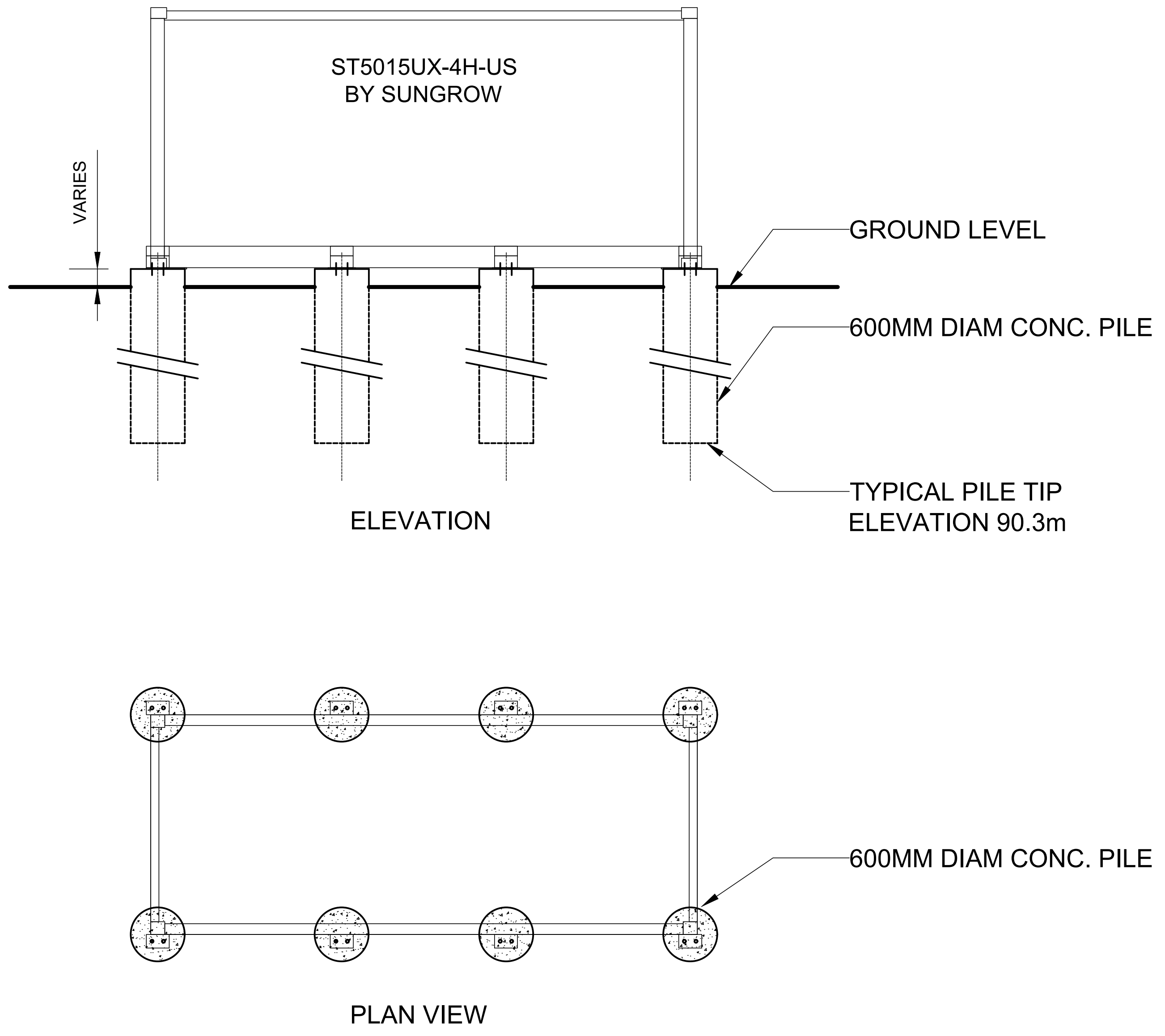


Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
▨	New Granular Fill	22	0	35
🟧	Silty Sand to Sandy Silt	21	0	30

Appendix G
Conceptual Foundation Drawings

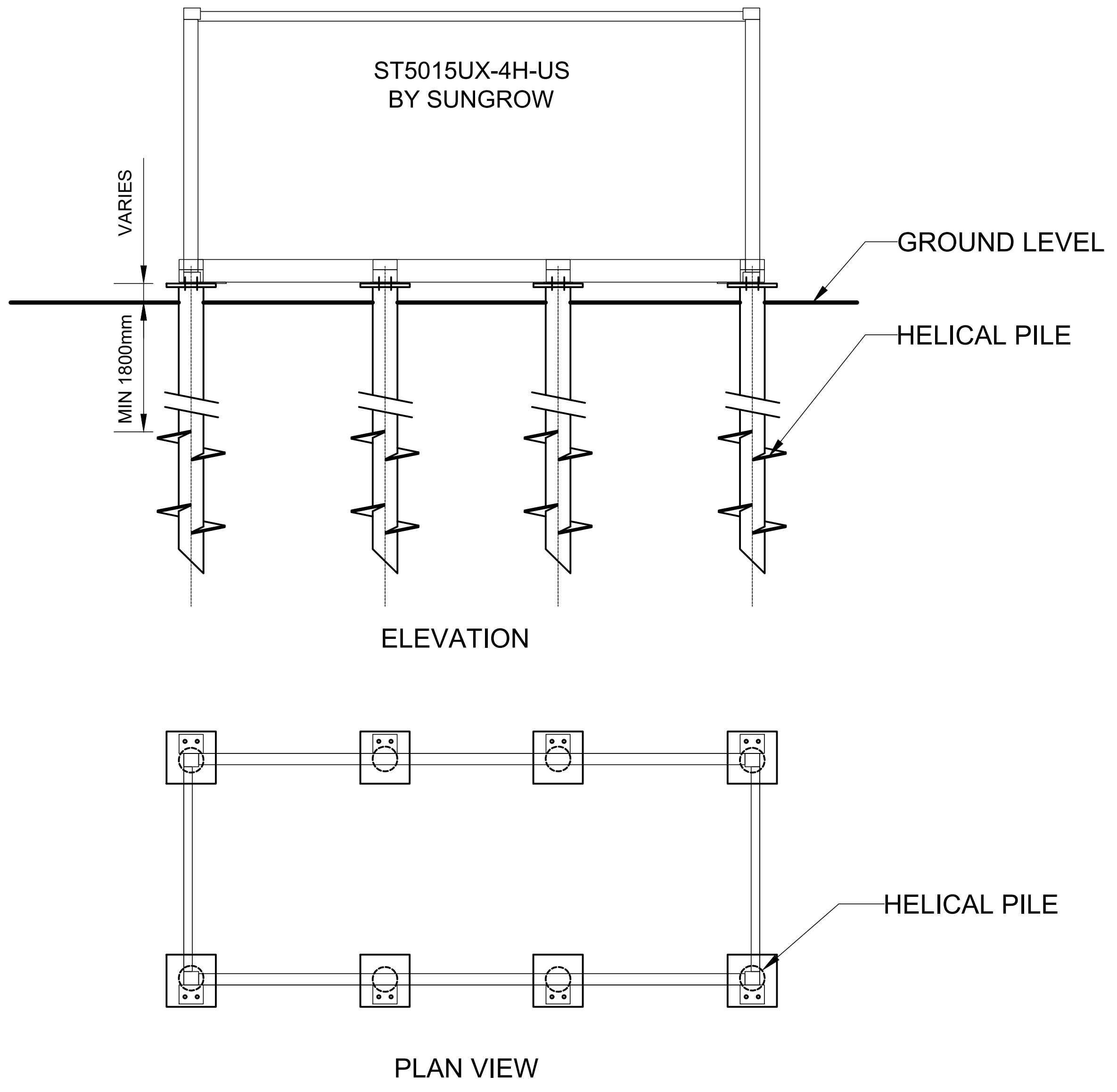
DWG. No.

GENERAL NOTES
1. THIS SKETCH PRESENTS VARIOUS TYPES OF FOUNDATIONS TO BE USED FOR THE TRAIL ROAD BESS PROJECT AND IS BASED ON THE GEOTECHNICAL REPORT H375035-0000-2A0-066-0001 (REVISION 2025-04-11) . REFER TO GEOTECHNICAL REPORT FOR FURTHER FOUNDATION DETAILS.
2. DUE TO THE VARYING DEPTH OF BEDROCK ON THE SITE, CONTRACTOR TO SELECT THE MOST OPTIMAL OPTION BASED ON THE ACTUAL SOIL CONDITIONS.
3. CONTRACTOR IS RESPONSIBLE FOR DETAIL DESIGN OF ALL FOUNDATIONS TO BE CONSTRUCTED BY THEM.
4. FOR DEAD LOADS AND MANUFACTURER REQUIREMENTS FOR FOUNDATION DESIGN REFER TO THE DOCUMENT "DW_20241019_ST5015UX-4H-US_STRUCTURE DRAWING AND THE FOUNDATION DIAGRAM_V5".



TYPE 1:
CONCRETE CAISSON PILE

NOTES:
1. PILE TIP ELEVATION TO BE DETERMINED ACCORDING TO SUBSURFACE CONDITIONS ENCOUNTERED BY THE CONSTRUCTION CONTRACTOR. SEE GEOTECHNICAL REPORT.
2. THE USE OF TEMPORARY CAISSON LINERS TO BE DETERMINED BY CONSTRUCTION CONTRACTOR.
3. A FACTORED PILE RESISTANCE OF 200 KN AT ULTIMATE LIMIT STATES (ULS) AND 150 KN AT SERVICEABILITY LIMITS STATES CAN BE USED FOR DESIGN.



TYPE 2:
HELICAL PILE

NOTES:
1. PILE TIP ELEVATION TO BE DETERMINED ACCORDING TO SUBSURFACE CONDITIONS ENCOUNTERED BY THE CONSTRUCTION CONTRACTOR.
2. HELICAL PILE GEOTECHNICAL RESISTANCE TO BE DETERMINED BY PROPRIETARY DESIGNER.
3. A FACTORED PILE RESISTANCE OF 270 KN AT ULTIMATE LIMIT STATES (ULS) AND 200 KN AT SERVICEABILITY LIMITS STATES WITH THE TIP HELIX INSTALLED IN THE COMPACT SILTY SAND TO SANDY SILT CAN BE USED FOR DESIGN PURPOSES.

NOT FOR CONSTRUCTION

HATCH

TRAIL ROAD BESS
DEEP FOUNDATION

DRAWING No.	DRAWING TITLE
Ref No	-

REFERENCE DRAWINGS

No.	DESCRIPTION	BY	CHK'D	DATE
A	ISSUED FOR INFORMATION	MB	AK	2025/07/18

REVISIONS

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON		–	
DESIGNER			
CHECKER			
DESIGN COORD.			
RESP. ENG.			
LEAD DISC. ENG.			
ENG. MANAGER			
PROJ. MANAGER			

DRAWING APPROVAL STATUS:

SCALE
N.T.S.
OR AS NOTED

DWG. No.

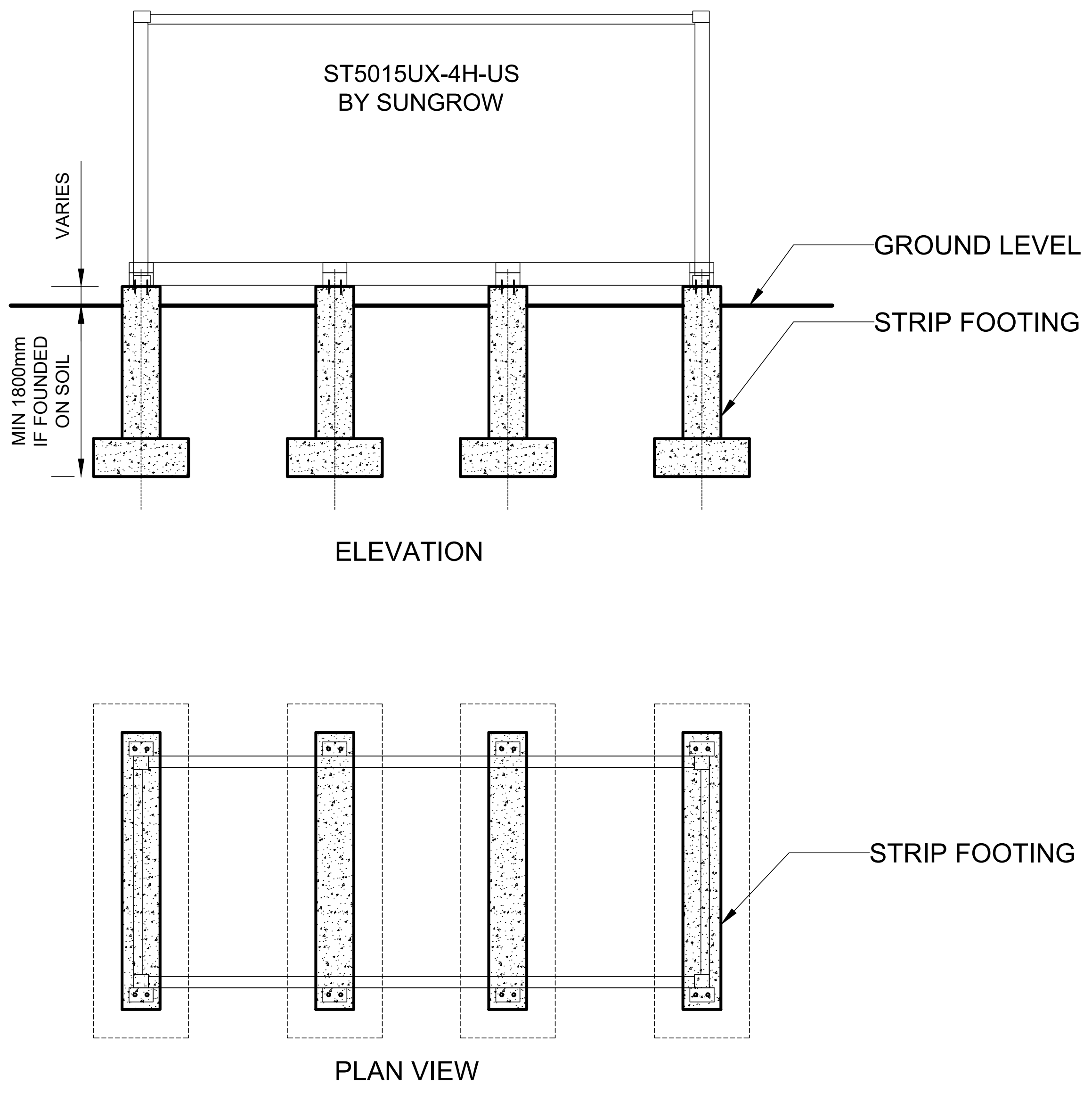
REV
0

SHEET SIZE: A2

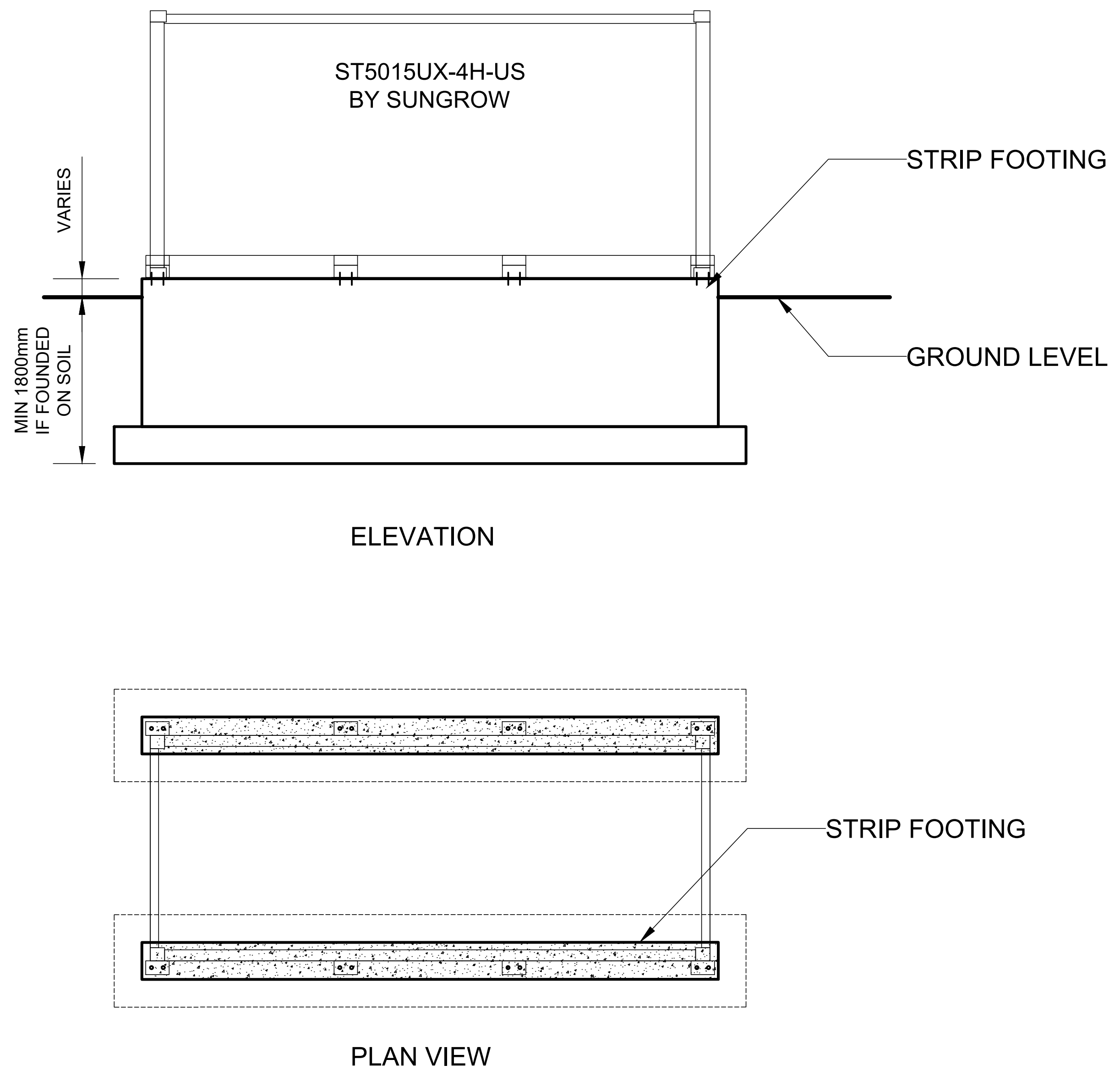
DWG. No.

GENERAL NOTES

1. THIS SKETCH PRESENTS VARIOUS TYPES OF FOUNDATIONS TO BE USED FOR THE TRAIL ROAD BESS PROJECT AND IS BASED ON THE GEOTECHNICAL REPORT H375035-0000-2A0-066-0001 (REVISION 2025-04-11) . REFER TO GEOTECHNICAL REPORT FOR FURTHER FOUNDATION DETAILS.
2. DUE TO THE VARYING DEPTH OF BEDROCK ON THE SITE, CONTRACTOR TO SELECT THE MOST OPTIMAL OPTION BASED ON THE ACTUAL SOIL CONDITIONS.
3. CONTRACTOR IS RESPONSIBLE FOR DETAIL DESIGN OF ALL FOUNDATIONS TO BE CONSTRUCTED BY THEM.
4. FOR DEAD LOADS AND MANUFACTURER REQUIREMENTS FOR FOUNDATION DESIGN REFER TO THE DOCUMENT "DW_20241019_ST5015UX-4H-US_STRUCTURE DRAWING AND THE FOUNDATION DIAGRAM_V5".



TYPE 3:
CONCRETE STRIP FOOTING
ACROSS THE LENGTH



TYPE 4:
CONCRETE STRIP FOOTING
ALONG THE LENGTH

NOT FOR CONSTRUCTION

HATCH

TRAIL ROAD BESS
SHALLOW FOUNDATION

REFERENCE DRAWINGS

DRAWING No.	**DRAWING TITLE**
Ref No	-

REVISIONS

No.	**DESCRIPTION**	**BY**	**CHK'D**	**DATE**
A	ISSUED FOR INFORMATION	MB	AK	2025/07/18

DRAWING APPROVAL STATUS:

ROLE	**NAME**	**SIGNATURE**	**DATE**
DRAFTSPERSON		–	
DESIGNER			
CHECKER			
DESIGN COORD.			
RESP. ENG.			
LEAD DISC. ENG.			
ENG. MANAGER			
PROJ. MANAGER			

SCALE N.T.S. **OR AS NOTED**

DWG. No.

REV 0

SHEET SIZE: A2