# Geotechnical Investigation

## Slope Stability Assessment – Proposed Residential Development, Turner Street, Millbrook, ON

Veltri and Son Limited

7 March 2023

→ **The Power of Commitment**

# Contents



## Table Index



## Figure Index



## Appendices

# 1. Introduction

This report presents the results of a geotechnical investigation in response to Otonabee Region Conservation Authority (ORCA) comments related to the residential development proposed for property located at the north end of Turner Street in Millbrook, Ontario (herein referred to as "the Site"). The Site location is depicted on **Figure 1**. This geotechnical investigation addresses groundwater conditions and slope stability within the area of the proposed Stormwater Management Ponds (SWMP).

Since the original geotechnical and hydrogeological report was completed in 2020, the conceptual site layout including the SWMP locations have been updated. GHD was retained by Veltri and Son Limited (the Client) to complete this additional investigation. The work conducted for this investigation was carried out under the authorization of Mr. Frank Veltri, representing the Client, in accordance with our proposal dated July 12, 2022.

# 2. Purpose and Scope

The purpose of this geotechnical investigation was to define the subsurface soil and groundwater conditions at the proposed SWMP locations and complete a slope stability analysis of existing and proposed conditions. The information contained herein must in no way be construed as an opinion of this site's chemical, environmental, or hydrogeological status.

The following scope of work was performed in order to accomplish the foregoing purposes:

1. A site-specific health and safety plan (HASP) was prepared.
2. Underground services were cleared prior to advancing the boreholes.
3. The subsurface soil conditions were explored, logged, and sampled by advancing a total of three (3) boreholes to depths ranging from 6.2 to 6.6 metres below ground surface (mbgs).
4. Groundwater monitoring wells were installed in all three (3) boreholes. Groundwater level measurements were obtained from the monitoring wells immediately following their installation and on January 23, 2023.
5. Physical laboratory analysis of the encountered material was carried out including grain size analysis, hydrometer analysis and moisture content tests.
6. Geotechnical engineering analysis of acquired field and laboratory data have been compiled in this report outlining our findings, conclusions, and geotechnical engineering recommendations.

# 3. Field and Laboratory Procedures

The field investigation was conducted under the supervision of GHD staff on January 16$^{th}$ and 17$^{th}$, 2023. The work consisted of subsurface exploration by means of advancing and sampling a total of three (3) boreholes to depths ranging from 6.2 to 6.6 mbgs. The location of each borehole is illustrated on the attached **Borehole Location Plan and Cross-Section Locations (Figure 2)**.

A detailed log of each borehole was maintained, and representative samples of the materials encountered in the boreholes were collected. A detailed log of each borehole is presented in **Appendix A**.

The boreholes were advanced using a rubber-track mounted drill rig equipped with continuous flight, solid stem power augers. Representative, disturbed samples of the strata penetrated were obtained using a split-barrel, 50 mm outer-diameter (OD) sampler advanced by a 63.5 kg hammer dropping approximately 760 mm. The results of these standard penetration tests (SPTs) are reported as "N" values on the borehole logs at the corresponding depths.

Soil samples obtained from the boreholes were inspected in the field immediately upon retrieval for type, texture, and colour. All boreholes were backfilled following completion of the fieldwork. All samples were sealed in clean plastic containers and transported to the GHD laboratory for further visual-tactile examination, and to select appropriate samples for laboratory analysis.

Groundwater measurements and observations were obtained from the open boreholes during the drilling operations. Groundwater monitoring wells (50 mm diameter) were installed in all three (3) of the boreholes to depths of 5.6 to 6.0 mbgs with a sand pack around the screened interval and bentonite chips placed to seal above the screened interval. The monitoring wells were recorded and registered as wells with the Ministry of Environment, Conservation and Parks (MECP). Groundwater data is presented on individual borehole logs.

Physical laboratory testing was completed on the soil samples and consisted of moisture content tests on all samples recovered and gradation / hydrometer analyses on four (4) representative soil samples. The analytical results of the moisture content tests are plotted on the attached logs. The results of the gradation tests are incorporated into the borehole logs and are presented graphically in **Appendix B**.

UTM coordinates and ground surface elevations for each borehole location were surveyed using a GPS unit connected to the Real-Time Kinematic (RTK) network and is connected to the NAD 83 datum. Elevations hereafter contained in this report are for engineering analytical purposes only and must be verified prior to finalizing any design or contract parameters upon which they are based.

# 4. Subsurface Conditions

Details of the subsurface conditions encountered at the Site are graphically presented on the borehole logs (**Appendix A**). It should be noted that the boundaries between the strata have been inferred from the borehole observations and non-continuous samples. They generally represent a transition from one soil type to another and should not be inferred to represent an exact plane of geological change. Further, conditions may vary between and beyond the boreholes.

The boreholes generally encountered a surficial layer of organic topsoil over native soils consisting of silty sand underlain by clayey silt or sandy silt glacial till. Groundwater seepage and / or accumulation was observed in all of the boreholes during drilling operations at depths ranging from approximately 0.8 to 3.0 mbgs.

The following sections describe the major soil strata and subsurface conditions encountered during this investigation in more detail.

## 4.1 Topsoil

A layer of surficial topsoil was encountered in boreholes BH1-23 and BH3-23. The topsoil layer was approximately 25 mm and 100 mm thick in boreholes BH1-23 and BH3-23, respectively. This soil was observed to be in a damp, loose state, with a silty, highly organic content. As such, it is expected to be devoid of any structural engineering properties.

## 4.2 Silty Sand

A layer of silty sand was encountered at the surface in borehole BH2-23 and below the topsoil in boreholes BH1-23 and BH3-23. The silty sand layer extended to depths ranging from 0.2 to 2.3 mbgs. This soil was generally light brown in colour, generally consisted of silty sand containing trace amounts of gravel and clay, and existed in a generally moist in-situ condition. SPT N values obtained from within the silty sand layer varied from 1 blow / 300 mm to 20 blows / 300 mm, indicating a very loose to compact in-situ state of relative density.

Moisture content tests conducted on samples of the silty sand yielded values ranging from approximately 9 to 20 % moisture by weight. A grain size distribution analysis conducted on a representative sample of the silty sand suggested the following composition: 1 % gravel, 73 % sand, and 26 % silt and clay-sized particles.

## 4.3 Till

A layer of till was encountered in all of the boreholes and extended to the full depth of the investigation. The till was encountered beneath the silty sand layer in all of the boreholes. This soil was generally brown in colour, generally consisted of clayey silt or sandy silt and contained variable amounts of gravel, cobbles and boulders. SPT N values obtained from within the till layer varied from 4 blows / 300 mm to over 50 blows / 75 mm, indicating a loose to very dense in-situ state of relative density.

Moisture content tests conducted on samples of the till yielded values ranging from approximately 9 to 26 % moisture by weight. Grain size distribution analyses conducted on representative samples of the till suggested the following compositional ranges: 0 % gravel, 13 to 27 % sand, 53 to 66 % silt and 9% to 32% clay-sized particles.

## 4.4 Groundwater

Groundwater seepage was observed in all of the boreholes during drilling operations at depths ranging from approximately 0.8 to 3.0 mbgs. Groundwater measurements obtained from the monitoring wells immediately following their installation on January 16th and 17th, 2023 and on January 23rd, 2023 are provided in the following table:

*Table 1 Summary of Groundwater Levels and Elevations*

| Location | Ground Elevation (m)* | January 16/17, 2023 | | January 23, 2023 | |
|---|---|---|---|---|---|
| | | WL (mbgs) | GW Elev. (m) | WL (mbgs) | GW Elev. (m) |
| BH1-23 | 247.64 | 3.3 | 244.3 | 2.4 | 245.2 |
| BH2-23 | 244.72 | Dry | Dry | 2.3 | 242.4 |
| BH3-23 | 244.18 | 3.2 | 241.0 | 2.9 | 241.3 |

Note: *Ground elevations were surveyed using a GPS unit connected to the RTK network and is connected to the NAD 83 datum. Elevations are for engineering analytical purposes only. WL and GW denotes Water Level and Groundwater, respectively.

The groundwater flow direction was inferred to be in a south / southeast direction based upon the local topography. It should be noted that groundwater levels are transient and tend to fluctuate with the seasons, periods of precipitation and temperature.

# 5. Discussion and Recommendations

Supporting data upon which our recommendations are based have been presented in the foregoing sections of this report. The following recommendations are governed by the physical properties of the subsurface materials that were encountered at the site and assume that they are representative of the overall site conditions. It should be noted that these conclusions and recommendations are intended for use by the designers only. Contractors bidding on or undertaking any work at the Site should examine the factual results of the assessment, satisfy themselves as to the adequacy of the information for construction, and make their own interpretation of this factual data as it affects their proposed construction techniques, equipment capabilities, costs, sequencing, and the like. Comments, techniques, or recommendations pertaining to construction should not be construed as instructions to the contractor.

The boreholes generally encountered a surficial layer of organic topsoil, over native soils consisting of silty sand underlain by clayey silt or sandy silt glacial till. Groundwater seepage and / or accumulation was observed in all the boreholes during drilling operations at depths ranging from approximately 0.8 to 3.0 mbgs and is expected to have seasonal variations. Groundwater levels obtained on January 23rd, 2023 ranged from about 2.3 to 2.9 mbgs. Any groundwater intersected in the shallow till is anticipated to be of minimal volume.

Details regarding our conclusions and recommendations are outlined in the following sections.

## 5.1 Excavations and Dewatering

Excavations should be carried out to conform to the manner specified in Ontario Regulation 213/91 and the Occupational Health and Safety Act (OHSA) and Regulations for Construction Projects. All excavations above the water table not exceeding 1.2 m in depth may be constructed with unsupported slopes. The soils encountered during this investigation above the groundwater table are generally classed by OHSA as Type 3. As such, unsupported / unshored excavation walls in these soils must maintain a gradient of 1 horizontal to 1 vertical (1H:1V) or flatter, to the base of the excavation. The soils affected by groundwater seepage or disturbed by surficial water should be considered Type 4 soils, requiring unsupported / unshored walls of excavations to be sloped at 3H:1V or flatter to the base of the excavation.

Based on the groundwater and soil conditions observed, and the anticipated excavation depths for the proposed development, significant groundwater infiltration into open excavations is not expected. Seepage of groundwater within sandy seams or above the underlying, less-permeable dense to very dense till is considered likely and water levels are anticipated to be higher during seasonal wet periods. Groundwater or surficial water infiltration into open excavations is expected to be controlled by pumping from sump(s) to an acceptable outlet. However, should zones producing more significant groundwater infiltration be encountered, the use of filtered pumps, or other forms of groundwater control may be required.

## 5.2 Stormwater Management Pond

The native soils encountered at the proposed base of the SWMPs consisted of clayey silt till for the north pond (241.85 m obtained from the Conceptual Grading Plan (CGP-1) dated November 23, 2022) and very dense sandy silt till for the south pond (240.55 m obtained from CGP-1). Based on the grain size analysis and depositional environment of such, we assume that the till soils will have a hydraulic conductivity ranging from about $10^{-5}$ to $10^{-7}$ cm/sec (Freeze and Cherry, 1979) but may be more permeable in the presence of wet sand and / or gravel lenses commonly associated within till deposits.

Based on the soils observed, and the anticipated base elevations, it appears that construction of SWMPs in the currently proposed areas is feasible. In general, excavation of the soils for the SWMPs are expected to be straightforward, provided that appropriate measures are taken during construction to minimize any overland or near-surficial flow of water into the area. Groundwater seepage was encountered in all boreholes advanced within the proposed SWMPs at elevations ranging from 243.6 m to 242.4 m. Groundwater level measurements obtained on January 23rd, 2023 from the installed monitoring wells indicated groundwater at 245.2 m to 242.4 m in the north SWMP and 241.3 m in the south SWMP.

Groundwater and surficial water inflow into the open SWMP excavation is anticipated; however, the volume is expected to be controlled by pumping from within the excavation, along with further measures if required including up-gradient cutoff trenching with appropriate drainage outletting.

It is recommended that the SWMP subgrade surfaces be proof rolled, and a representative of GHD approve the subgrade prior to construction of the berms. Construction of the berms may utilize excess clayey silt till from the Site having a hydraulic conductivity of $10^{-5}$ cm/sec or lower. Such operations should place the till in lifts no thicker than 150 mm prior to compaction and compacted to at least 95% Standard Proctor Maximum Dry Density (SPMDD).

The native, undisturbed glacial till soils are expected to have a sufficiently low permeability where they could substitute for a liner. An inspection of the excavated and exposed SWMP surfaces should be performed at the time of construction, to assess whether any discrete or localized areas of increased hydraulic conductivity (such as sand and / or gravelly seams typically encountered within till soils) are present within the exposed soils, in which case such areas may be lined with a more suitable (i.e. less hydraulically conductive) material or an impermeable geosynthetic membrane.

The slope stability at the proposed SWMP locations was performed using the Morgenstern & Price Method and the module Slope/W of the computer software Geo-Studio, developed and distributed by Geo Slope International Ltd. The modelling was completed based on the existing and proposed grading along four (4) cross-section A-A' to D-D' provided in the CGP-1, dated November 23, 2022. The cross-section locations are illustrated in the **Borehole Location Plan and Cross-Section Locations (Figure 2)**. Each cross-section was analysed at its existing condition and at various locations along the proposed 100-year flood condition and proposed dry condition. Once the locations with the lowest Factor of Safety (FS) for the proposed conditions were determined for each cross section, they were modelled under seismic and rapid drawdown case scenarios. The conditions and scenarios analysed are listed below and the graphical outputs of the slope stability analyses are provided in **Appendix C**.

- Analysis 1 – Section A-A', Existing Condition [Appendix C.1];
- Analysis 2 – Section B-B', Existing Condition [Appendix C.2];
- Analysis 3 – Section C-C', Existing Condition [Appendix C.3];
- Analysis 4 – Section D-D', Existing Condition [Appendix C.4];
- Analysis 5 – Section A-A', Proposed Condition (100 Year Flood) [Appendix C.5];
- Analysis 6 – Section A-A', Proposed Condition (Dry) [Appendix C.6];
- Analysis 7 – Section A-A', Proposed Condition (Seismic) [Appendix C.7];
- Analysis 8 – Section A-A', Proposed Condition (Rapid Drawdown) [Appendix C.8];
- Analysis 9 – Section B-B', Proposed Condition (100 Year Flood) [Appendix C.9];
- Analysis 10 – Section B-B', Proposed Condition (Dry) [Appendix C.10];
- Analysis 11 – Section B-B', Proposed Condition (Seismic) [Appendix C.11];
- Analysis 12 – Section B-B', Proposed Condition (Rapid Drawdown) [Appendix C.12];
- Analysis 13 – Section C-C', Proposed Condition (100 Year Flood) [Appendix C.13];
- Analysis 14 – Section C-C', Proposed Condition (Dry) [Appendix C.14];
- Analysis 15 – Section C-C', Proposed Condition (Seismic) [Appendix C.15];
- Analysis 16 – Section C-C', Proposed Condition (Rapid Drawdown) [Appendix C.16];
- Analysis 17 – Section D-D', Proposed Condition (100 Year Flood) [Appendix C.17];
- Analysis 18 – Section D-D', Proposed Condition (Dry) [Appendix C.18];
- Analysis 19 – Section D-D', Proposed Condition (Seismic) [Appendix C.19]; and
- Analysis 20 – Section D-D', Proposed Condition (Rapid Drawdown) [Appendix C.20].

The material parameters assigned to each soil layer in the slope stability analyses are provided on the respective slope stability analyses illustrated with **Appendix C.1 to C.20** and are presented in **Table 2** below. The selected parameters are based on the field and laboratory testing performed on representative samples of the soils encountered, as well as published technical literature and our experience with similar materials.

***Table 2*** ***Soil Parameters for Analysis***

| Modelled Soil Profile | Unit Weight (kN/m$^2$) | Effective Friction Angle (Degrees) | Effective Cohesion (kPa) |
|---|---|---|---|
| Silty Sand | 20 | 30 | 0 |
| Clayey silt Till | 19 | 30 | 2 |
| Silty Sand Till | 20 | 34 | 0 |
| Engineered Fill – Excavated Native Soils | 20 | 29 | 1 |
| Infiltration Gallery Rock Fill | 21 | 36 | 0 |

The calculated minimum Factor of Safety (FoS) for each analysis is provided below in **Table 3**.

*Table 3 Summary of Cross-Sectional Minimum Factor of Safety*

| Conditions of Analysis | | Factor of Safety (FoS) |
|---|---|---|
| Section A-A' | Existing Condition | 4.2 |
| | Proposed Condition (100 Year Flood) | 2.3 to 2.9 |
| | Proposed Condition (Dry) | 2.2 to 3.0 |
| | Proposed Condition (Seismic) | 1.9 |
| | Proposed Condition (Rapid Drawdown) | 2.4 |
| Section B-B' | Existing Condition | 5.4 |
| | Proposed Condition (100 Year Flood) | 2.5 to 6.5 |
| | Proposed Condition (Dry) | 2.3 to 8.7 |
| | Proposed Condition (Seismic) | 2.0 |
| | Proposed Condition (Rapid Drawdown) | 2.3 |
| Section C-C' | Existing Condition | 5.6 |
| | Proposed Condition (100 Year Flood) | 1.9 to 2.8 |
| | Proposed Condition (Dry) | 2.3 to 3.1 |
| | Proposed Condition (Seismic) | 1.6 |
| | Proposed Condition (Rapid Drawdown) | 2.1 |
| Section D-D' | Existing Condition | 3.7 |
| | Proposed Condition (100 Year Flood) | 2.6 to 3.8 |
| | Proposed Condition (Dry) | 2.6 to 3.8 |
| | Proposed Condition (Seismic) | 2.0 |
| | Proposed Condition (Rapid Drawdown) | 2.6 |

A FoS for slope stability analysis can be defined as the ratio of the available shear strength to that of the applied stresses along a potential failure plane. A factor of safety of 1.0 or greater indicates stable conditions and a value of less than 1.0 represents unstable conditions. Typically, a target factor of safety between 1.3 and 1.5 is considered reasonable for natural slopes, under static conditions where the consequences of failure is property loss. For the purposes of this study, a minimum FoS of 1.3 was targeted for the seismic and rapid drawdown scenarios while a FoS of 1.5 was targeted for the remaining scenarios.

The analyses for the existing conditions yielded minimum FoS values ranging from 3.7 to 5.6, all of which are above the minimum FoS of 1.5. The stability analyses performed therefore suggested the existing condition is globally stable.

The analyses for the proposed conditions yielded minimum FoS values ranging from 1.9 to 8.7 for the north SWMP and FoS values ranging from 1.6 to 3.8 for the south SWMP, all of which are above the minimum FoS of 1.3 to 1.5. The stability analyses performed therefore suggest the proposed north SWMP and south SWMP designs are globally stable.

This stability analysis does not assess any instabilities resulting from the effects of surficial erosion or piping through the berm. It is GHD's understanding that various outlet pipes will be located within the berms of the pond. It is recommended that installation of these pipes within the berm take precautionary measures to reduce or eliminate the potential for water to be conducted through the sewer bedding and backfill materials, as this can be a cause of progressive erosion and piping if allowed to occur. Such measures can include (but not necessarily be limited to) use of an approved impermeable material to form trench plugs at appropriate locations within the utility trenching formed in the berm. At least two (2) such plugs should be constructed; one close to the up-gradient end of the berm trench, and one close to the down-gradient end of the berm trench. Slopes and berms of the SWMPs should be constructed to reduce or eliminate the effects of surficial erosion. Features to do so may include slope vegetation, installation of erosion or gabion mats, rip rap, and / or other acceptable stabilizing features.

It is recommended that GHD staff be onsite to observe the construction of the ponds including excavations, inspect subgrades as they are exposed, test berm and liner construction materials including gradation analysis, moisture contents, and compaction of each lift, and installation of the proposed utility pipe. The soils being considered for construction of the berm and / or liner must be inspected and approved by GHD at the time of construction, prior to being used.

It is recommended that the berm subgrade be stepped / benched down the existing sloped areas, with at least 2 percent backfall on the horizontal benching to reduce the potential for long-term shear effects at the native soil / berm interface, and to minimize any potential for long-term downhill creep.

It is recommended that a regular maintenance program for the SWMPs include monitoring for any potential slope erosion, degradation, piping, or otherwise undesirable structural conditions. Should such conditions become evident, immediate mitigative actions must be performed.

Based on the global stability analyses completed for the SWMPs, and incorporation of GHD’s recommendations including inspections and approval of all berm and liner materials during construction, it is GHD’s professional opinion that the proposed grading for the SWMPs is expected to be globally stable from a geotechnical perspective.

## 5.3 General Recommendations

### 5.3.1 Wells

Any decommissioning of wells on-site must be performed by an appropriately-licensed well contractor, in compliance with Ontario Regulation 903.

### 5.3.2 Test Pits During Tendering

It is strongly recommended that test pits be excavated at representative locations of this Site during the tendering phase, with mandatory attendance of interested contractors. This will allow them to make their own assessment of the groundwater and soil conditions at the Site and how these will affect their proposed construction methods, techniques and schedules.

### 5.3.3 Subsoil Sensitivity

Some of the native soils encountered are susceptible to strength loss if saturated or disturbed by construction traffic. Therefore, where the subgrade consists of approved soil, care must be taken to protect the exposed subgrade from excess moisture and from construction traffic.

### 5.3.4 Winter Construction

The subsoils encountered across the Site have a low to moderate frost-susceptibility and freezing conditions could cause soils to heave.

Due to the frost heave potential of the soils during winter, it is recommended that the trenches for exterior underground services be excavated with shallow transition slopes in order to minimize the abrupt change in density between the granular backfill, which is relatively non-frost susceptible, and the more frost-susceptible native soils.

### 5.3.5 Construction Monitoring

The foundation Engineered Fill placement must be closely monitored and inspected by qualified personnel to ensure consistency with the design parameters used for the stability analyses.

Qualified Geotechnical personnel should inspect and test all stages of the proposed development. Specifically, they should ensure that the materials and conditions comply with this geotechnical assessment report. In addition, qualified geotechnical personnel should provide material testing services prior to and during backfilling and grade raising operation. Should soil conditions be encountered that vary from those described in this report, our office should be informed immediately such that the proper measures are undertaken.

# 6. Limitations of the Investigation

This report is intended solely for Veltri and Son Limited and its designers and is prohibited for use by others without GHD's prior written consent. This report is considered GHD's professional work product and shall remain the sole property of GHD. Any unauthorized reuse, redistribution of or reliance on the report shall be at the Client and recipient's sole risk, without liability to GHD. No portion of this report may be used as a separate entity; it is to be read in its entirety and shall include all supporting drawings and appendices.

The recommendations made in this report are in accordance with our present understanding of the project, the current site use, ground surface elevation and conditions, and are based on the work scope approved by the Client and described in the report. The services were performed in a manner consistent with that level of care and skill ordinarily exercised by members of geotechnical engineering professions currently practicing under similar conditions in the same locality. No other representations, and no warranties or representations of any kind, either expressed or implied, are made. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties.

All details of design and construction are rarely known at the time of completion of a geotechnical study. The recommendations and comments made in the study report are based on our subsurface investigation and resulting understanding of the project, as defined at the time of the study. We should be retained to review our recommendations when the drawings and specifications are complete. Without this review, GHD will not be liable for any misunderstanding of our recommendations or their application and adaptation into the final design.

By issuing this report, GHD is the geotechnical engineer of record. It is recommended that GHD be retained during construction of all foundations and during earthwork operations to confirm the conditions of the subsoil are actually similar to those observed during our study. The intent of this requirement is to verify that conditions encountered during construction are consistent with the findings in the report and that inherent knowledge developed as part of our study is correctly carried forward to the construction phases.

It is important to emphasize that a soil investigation is, in fact, a random sampling of a site and the comments included in this report are based on the results obtained at the test locations only. The subsurface conditions confirmed at the test locations may vary at other locations. The subsurface conditions can also be significantly modified by the construction activities on site (e.g., excavation, dewatering and drainage, blasting, pile driving, etc.). These conditions can also be modified by exposure of soils or bedrock to humidity, dry periods or frost. Soil and groundwater conditions between and beyond the test locations may differ both horizontally and vertically from those encountered at the test locations and conditions may become apparent during construction which could not be detected or anticipated at the time of our investigation.

Should any conditions at the site be encountered which differ from those found at the test locations, we request that we be notified immediately in order to permit a reassessment of our recommendations. If changed conditions are identified during construction, no matter how minor, the recommendations in this report shall be considered invalid until sufficient review and written assessment of said conditions by GHD is completed.

All of Which is Respectfully Submitted,

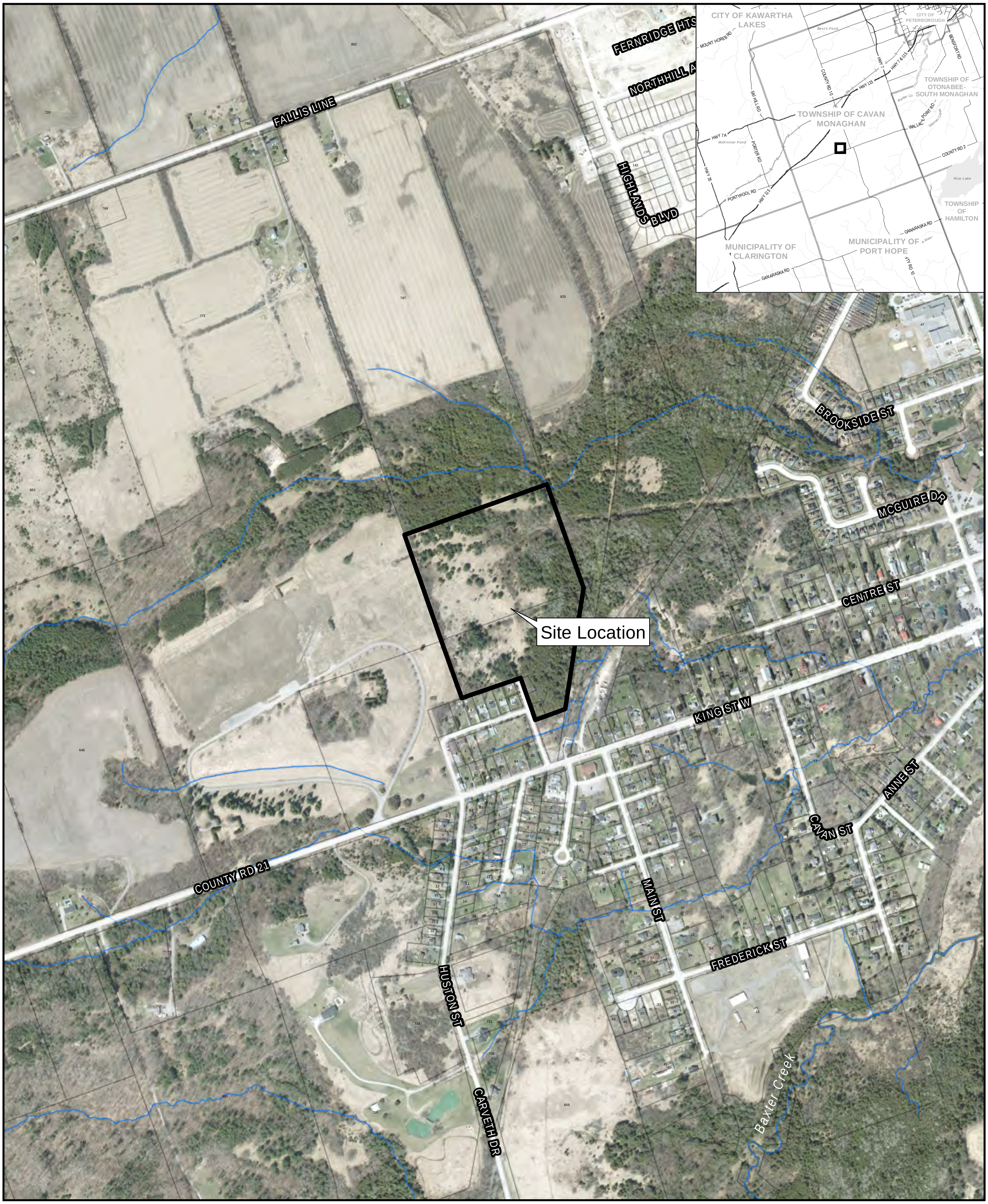
GHD

PROFESSIONAL GEOSCIENTIST
Mar. 7/23
LIMITED MEMBER
ROBERT W. NECK
2262
ONTARIO

LICENSED PROFESSIONAL ENGINEER
March 7, 2023
L. L. RAMOS
100209777
PROVINCE OF ONTARIO

Robert Neck, P.Geo.(Limited) Leandro Ramos, P.Eng.

# Figures




1 cm = 100 meters

0 70 140 210 280

Metres

Map Projection: Transverse Mercator
Horizontal Datum: North American 1983
Grid: NAD 1983 UTM Zone 17N

N

Veltri and Son Limited
Turner Street, Millbrook, ON
Township of Cavan Monaghan
County of Peterborough

Slope Stability Assessment

# Site Location Plan

Project No. 12599716
Revision No.
Date Mar 3, 2023

Figure 1

Q:\GIS\PROJECTS\12599000s\12599716\Layouts\202303_SSA001\12599716_202303_SSA001_GIS001 - Site Location Plan.mxd
Print date: 03 Mar 2023 - 07:34

Data source: Image © County of Peterborough, 2018; Produced by GHD Limited under Licence with the Ontario Ministry of Natural Resources and Forestry© King's Printer for Ontario, 2023.


1 cm = 26 meters
0 10 20 30 40
Metres

Map Projection: Transverse Mercator
Horizontal Datum: North American 1983
Grid: NAD 1983 UTM Zone 17N

Veltri and Son Limited
Turner Street, Millbrook, ON
Township of Cavan Monaghan
County of Peterborough

Slope Stability Assessment

## Borehole Location Plan & Cross-Section Locations

Project No. 12599716
Revision No.
Date Mar 3, 2023

Figure 2

Q:\GIS\PROJECTS\12599000s\12599716\Layouts\202303_SSA001\12599716_202303_SSA001_GIS002 - Borehole Location Plan and Cross Section Locations.mxd
Print date: 03 Mar 2023 - 09:14

Data source: Image © County of Peterborough, 2018; Produced by GHD Limited under Licence with the Ontario Ministry of Natural Resources and Forestry© King's Printer for Ontario, 2023.

# Appendices

# Appendix A

## Borehole Logs

REFERENCE No.: 12599718

ENCLOSURE No.: A-1

**BOREHOLE No.: BH1-23**

**ELEVATION:** 247.64 m

# BOREHOLE REPORT



CLIENT: Veltri and Son Limited

PROJECT: Proposed Residential Development, Turner Street, Millbrook

LOCATION: Turner Street, Millbrook, Ontario

DESCRIBED BY: Riley Sanford    CHECKED BY: L. Ramos

DATE (START): 16 January 2023    DATE (FINISH): 16 January 2023

**LEGEND**

- SS - SPLIT SPOON
- ST - SHELBY TUBE
- RC - ROCK CORE
- ▼ - WATER LEVEL

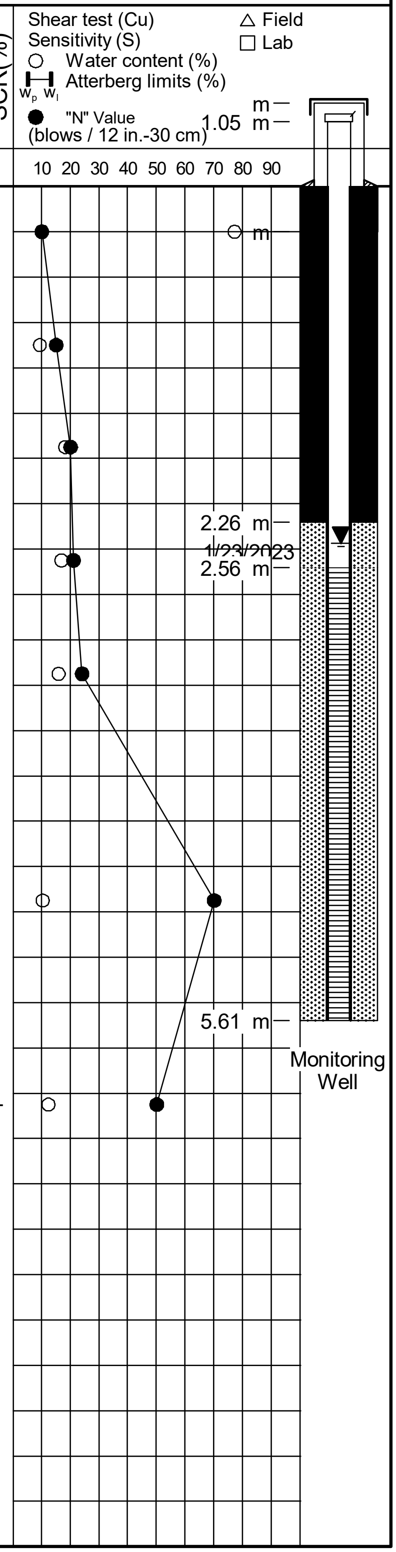
NORTHING: 4891962    EASTING: 703058

| Depth (m) | Elevation (m) | Description of Soil and Bedrock | Type and Number | Recovery/TCR(%) | Moisture Content (%) | Blows per 15cm/RQD(%) | 'N' Value/SCR(%) |
|---|---|---|---|---|---|---|---|
| 0.0 | 247.64 | GROUND SURFACE | | | | | |
| | 247.61 | **TOPSOIL** (25 mm) | | | | | |
| | | **NATIVE:** SILTY SAND, trace gravel, light brown, moist, compact | SS-1 | 4 | 77 | 3-5-5-13 | 10 |
| | | | SS-2 | 54 | 9 | 6-7-8-10 | 15 |
| | | | SS-3 | 50 | 18 | 13-10-10 | 20 |
| | 245.35 | CLAYEY SILT TILL, some sand, light brown, moist, compact | SS-4 | 75 | 17 | 5-9-12 | 21 |
| | | Red mottling, wet<br>**SS-5**<br>0% gravel, 13% sand, 66% silt, 21% clay | SS-5 | 83 | 16 | 5-11-13 | 24 |
| | | Moist, very dense | SS-6 | 83 | 10 | 16-20-50 | 70 |
| | 241.39 | Wet | SS-7 | 83 | 12 | 50 for 75mm | 50+ |

**END OF BOREHOLE at 6.2 mbgs**

**NOTES:**
- Borehole open upon completion
- Groundwater seepage first encountered at 3.0 mbgs
- mbgs denotes 'metres below ground surface'

**WATER LEVELS:**
- WL - 3.3 mbgs (Elev. 244.3m) on Jan. 16, 2023 (Upon Completion)
- WL - 2.4 mbgs (Elev. 245.2m) on Jan. 23, 2023



REFERENCE No.: 12599718

ENCLOSURE No.: A-2

GHD

**BOREHOLE No.:** BH2-23

**ELEVATION:** 244.72 m

# BOREHOLE REPORT

Page: 1 of 1

CLIENT: Veltri and Son Limited

PROJECT: Proposed Residential Development, Turner Street, Millbrook

LOCATION: Turner Street, Millbrook, Ontario

DESCRIBED BY: Riley Sanford    CHECKED BY: L. Ramos

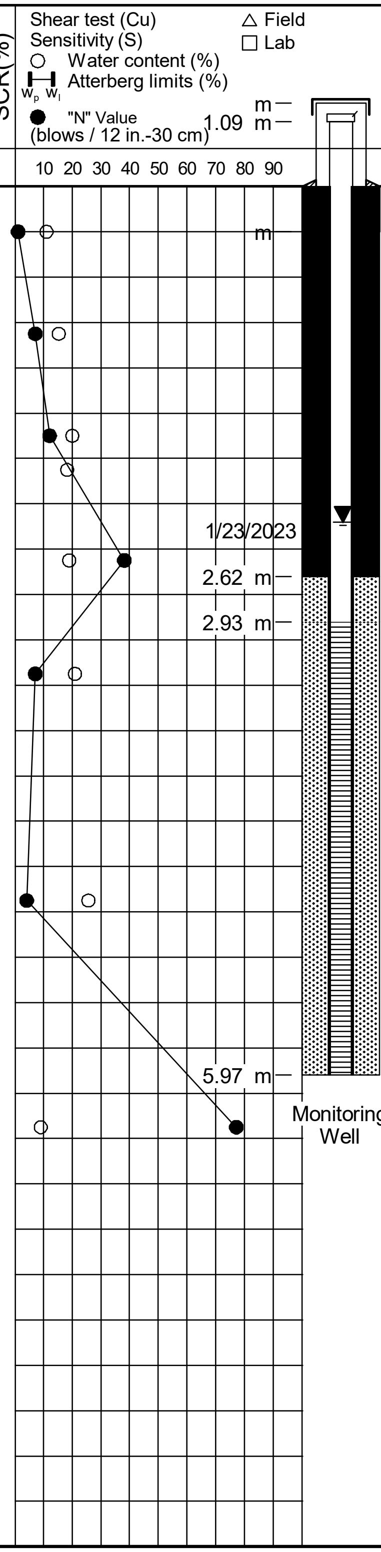
DATE (START): 16 January 2023    DATE (FINISH): 16 January 2023

**LEGEND**

- SS - SPLIT SPOON
- ST - SHELBY TUBE
- RC - ROCK CORE
- ▼ - WATER LEVEL

NORTHING: 4891961    EASTING: 703103

| Depth (Feet) | Depth (Metres) | Elevation (m) | Description of Soil and Bedrock | Type and Number | Recovery/ TCR(%) | Moisture Content (%) | Blows per 15cm/ RQD(%) | 'N' Value/ SCR(%) |
|---|---|---|---|---|---|---|---|---|
| 0 | | 244.72 | GROUND SURFACE | | | | | |
| 1 | | | **NATIVE:** SILTY SAND, red-brown, moist, very loose | SS-1 | 67 | 11 | 1-1-0-1 | 1 |
| 3 | 1.0 | | brown, loose<br>**SS-2**<br>1% gravel, 73% sand, 26% clay & silt | SS-2 | 58 | 15 | 2-2-5 | 7 |
| 5–6 | | | | SS-3A | 71 | 20 | 1-3-9 | 12 |
| 6 | | 242.89 | CLAYEY SILT TILL, some sand, brown, moist, compact | SS-3B | | 18 | -- | -- |
| 8 | | | **SS-4**<br>0% gravel, 15% sand, 53% silt, 32% clay<br>Wet, dense | SS-4 | 88 | 19 | 9-21-17 | 38 |
| 11 | | | Loose | SS-5 | 96 | 21 | 1-1-6 | 7 |
| 16 | | | | SS-6 | 100 | 26 | 0-1-3 | 4 |
| 21 | | | Moist, very dense | SS-7 | 83 | 9 | 18-34-43 | 77 |
| | | 238.17 | **END OF BOREHOLE at 6.6 mbgs** | | | | | |




**NOTES:**
- Borehole open and dry on completion
- Groundwater seepage first encountered at 2.3 mbgs
- mbgs denotes 'metres below ground surface'

**WATER LEVELS:**
- WL - Dry on Jan. 16, 2023 (Upon Completion)
- WL - 2.3 mbgs (Elev. 242.4 m) on Jan. 23, 2023

REFERENCE No.: 12599718 ENCLOSURE No.: A-3

# BOREHOLE REPORT

**BOREHOLE No.:** BH3-23

**ELEVATION:** 244.18 m

Page: 1 of 1

CLIENT: Veltri and Son Limited

PROJECT: Proposed Residential Development, Turner Street, Millbrook

LOCATION: Turner Street, Millbrook, Ontario

DESCRIBED BY: Riley Sanford CHECKED BY: L. Ramos

DATE (START): 17 January 2023 DATE (FINISH): 17 January 2023

**LEGEND**

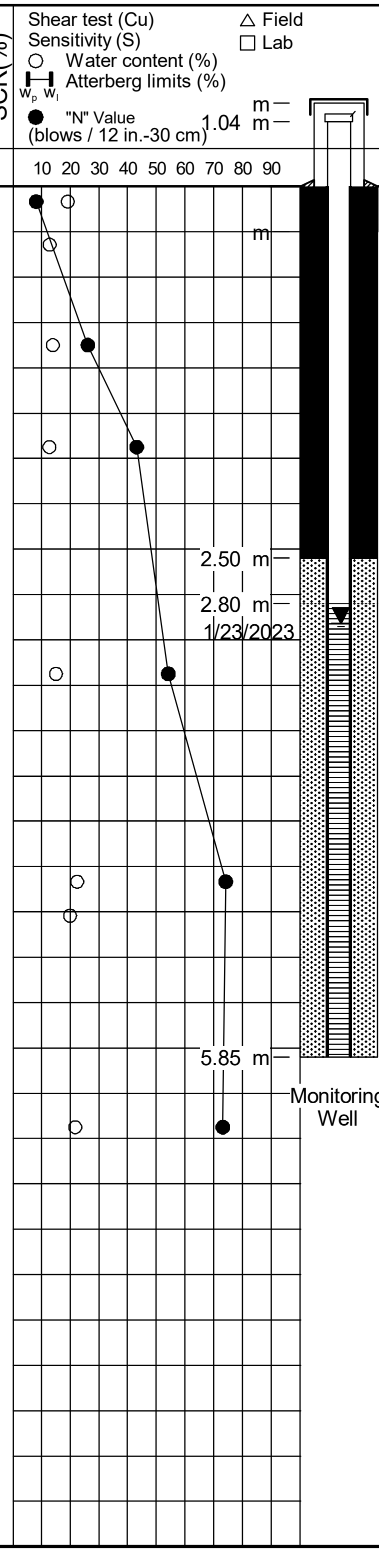
- SS - SPLIT SPOON
- ST - SHELBY TUBE
- RC - ROCK CORE
- ▼ - WATER LEVEL

NORTHING: 4891657 EASTING: 703098

| Depth (m) | Elevation (m) | DESCRIPTION OF SOIL AND BEDROCK | Type and Number | Recovery/ TCR(%) | Moisture Content (%) | Blows per 15cm/ RQD(%) | 'N' Value/ SCR(%) |
|---|---|---|---|---|---|---|---|
| 0 | 244.18 | GROUND SURFACE | | | | | |
| | 244.07 | **TOPSOIL** (100 mm) | SS-1A | 33 | 19 | 1-3-5-5 | 8 |
| | 243.97 | **NATIVE:** SILTY SAND, trace gravel, brown, moist, compact | SS-1B | | 13 | -- | -- |
| | | SANDY SILT TILL, trace clay, trace gravel, brown, moist, compact. Wet | SS-2 | 58 | 14 | 12-11-15-14 | 26 |
| | | Moist, dense to very dense | SS-3 | 79 | 13 | 9-18-25 | 43 |
| | | Wet | SS-4 | 83 | 15 | 20-27-27 | 54 |
| | | - Approx. 200mm wet sand seam at 4.6 mbgs | SS-5A | 83 | 22 | 25-37-37 | 74 |
| | | | SS-5B | | 20 | -- | -- |
| | | **SS-6** 0% gravel, 27% sand, 64% silt, 9% clay | SS-6 | 58 | 22 | 12-23-50 | 73 |
| 6.6 | 237.62 | **END OF BOREHOLE at 6.6 mbgs** | | | | | |

**NOTES:**
- Borehole open on completion
- Groundwater seepage first encountered at 0.8 mbgs
- mbgs denotes 'metres below ground surface'

**WATER LEVELS:**
- WL - 3.2 mbgs (Elev. 241.0 m) on Jan. 16, 2023 (Upon Completion)
- WL - 2.9 mbgs (Elev. 241.3 m) on Jan. 23, 2023



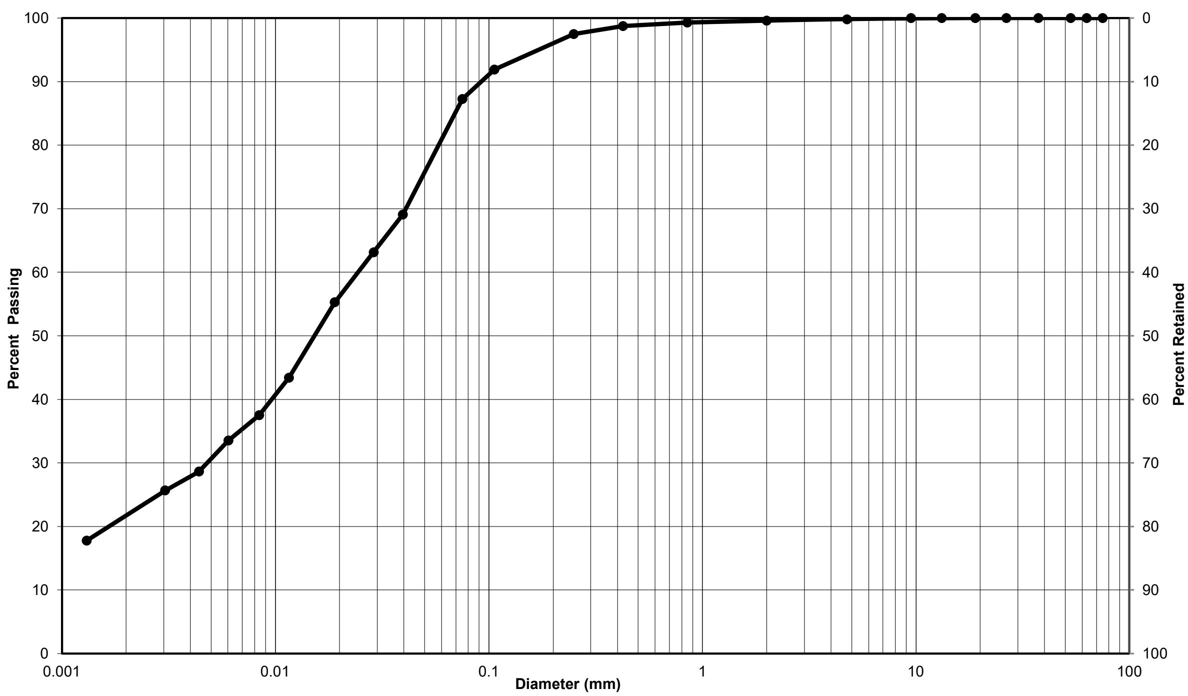
# Appendix B

## Geotechnical Laboratory Results

**Particle-Size Analysis of Soils**
**MTO LS-702 (Geotechnical)**

| | | | |
|---|---|---|---|
| **Client:** | Veltri and Son Limited | **Lab No.:** | SS-23-03 |
| **Project/Site:** | Geotech Investigation, Turner Street, Millbrook | **Project No.:** | 12599716 |

| | | | |
|---|---|---|---|
| Borehole No.: | BH1-23 | Sample No.: | SS5 |
| Depth: | 3.0-3.5m | Enclosure: | B-1 |




| Clay & Silt | Sand | | | Gravel | |
|---|---|---|---|---|---|
| | Fine | Medium | Coarse | Fine | Coarse |
| Particle-Size Limits as per USCS (ASTM D-2487) | | | | | |

| Soil Description | Gravel (%) | Sand (%) | Clay & Silt (%) |
|---|---|---|---|
| Silt with clay and few sand | 0 | 13 | 87 |
| Silt-size particles (%) : | 66 | | |
| Clay-size particles (%) (<0.002 mm): | 21 | | |

Additional laboratory reporting information available upon request.

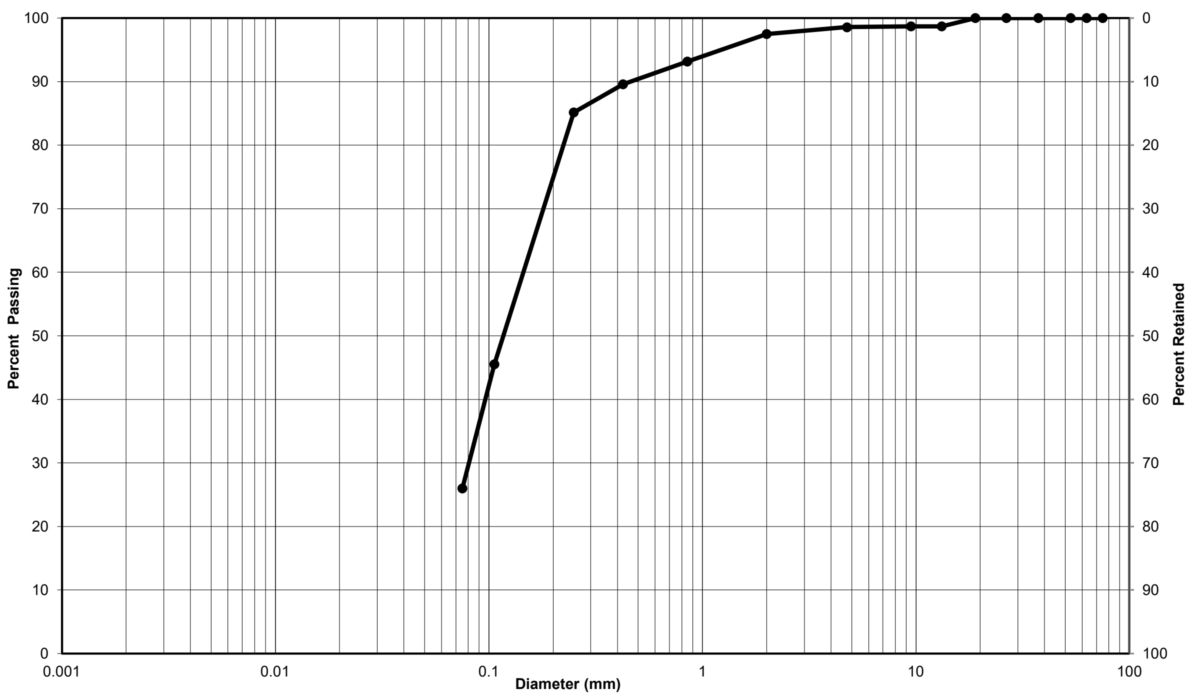
**Remarks:**

| | | | |
|---|---|---|---|
| **Performed by:** | Josh Sullivan | **Date:** | February 2, 2023 |
| **Verified by:** | Joe Sullivan | **Date:** | February 2, 2023 |
| **Laboratory Location:** | GHD Limited - 347 Pido Road, Unit 29, Peterborough, ON | | |

# Particle-Size Analysis of Soils
# MTO LS-702 (Geotechnical)

| | | | |
|---|---|---|---|
| **Client:** | Veltri and Son Limited | **Lab No.:** | SS-23-03 |
| **Project/Site:** | Geotech Investigation, Turner Street, Millbrook | **Project No.:** | 12599716 |

| | | | |
|---|---|---|---|
| Borehole No.: | BH2-23 | Sample No.: | SS2 |
| Depth: | 0.8-1.2m | Enclosure: | B2 |




| Clay & Silt | Sand | | | Gravel | |
|---|---|---|---|---|---|
| | Fine | Medium | Coarse | Fine | Coarse |
| Particle-Size Limits as per USCS (ASTM D-2487) | | | | | |

| Soil Description | Gravel (%) | Sand (%) | Clay & Silt (%) |
|---|---|---|---|
| Silty sand, trace gravel | 1 | 73 | 26 |

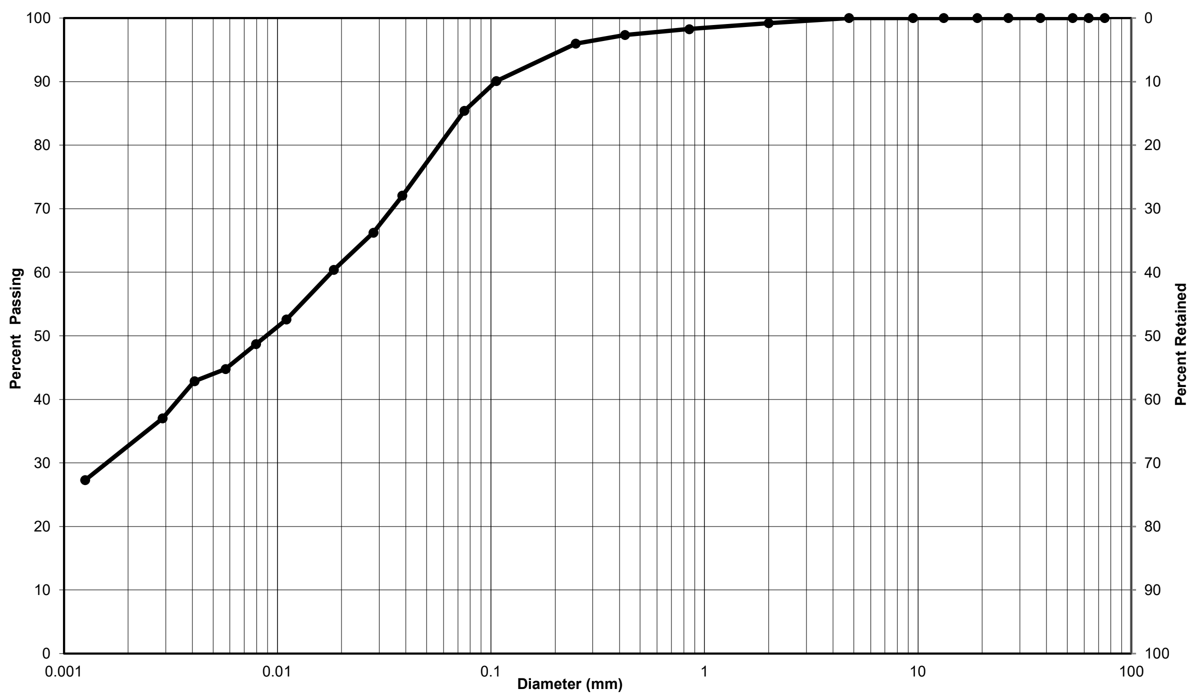
Additional laboratory reporting information available upon request.

**Remarks:**

| | | | |
|---|---|---|---|
| **Performed by:** | Josh Sullivan | **Date:** | February 2, 2023 |
| **Verified by:** | Joe Sullivan | **Date:** | February 2, 2023 |
| **Laboratory Location:** | GHD Limited - 347 Pido Road, Unit 29, Peterborough, ON | | |

**Particle-Size Analysis of Soils**
**MTO LS-702 (Geotechnical)**

| | | | |
|---|---|---|---|
| **Client:** | Veltri and Son Limited | **Lab No.:** | SS-23-03 |
| **Project/Site:** | Geotech Investigation, Turner Street, Millbrook | **Project No.:** | 12599716 |
| Borehole No.: | BH2-23 | Sample No.: | SS4 |
| Depth: | 2.3-2.7m | Enclosure: | B3 |




| Clay & Silt | Sand | | | Gravel | |
|---|---|---|---|---|---|
| | Fine | Medium | Coarse | Fine | Coarse |
| Particle-Size Limits as per USCS (ASTM D-2487) | | | | | |

| Soil Description | Gravel (%) | Sand (%) | Clay & Silt (%) |
|---|---|---|---|
| Clayey silt and few sand | 0 | 15 | 85 |
| Silt-size particles (%) : | 53 | | |
| Clay-size particles (%) (<0.002 mm): | 32 | | |

Additional laboratory reporting information available upon request.

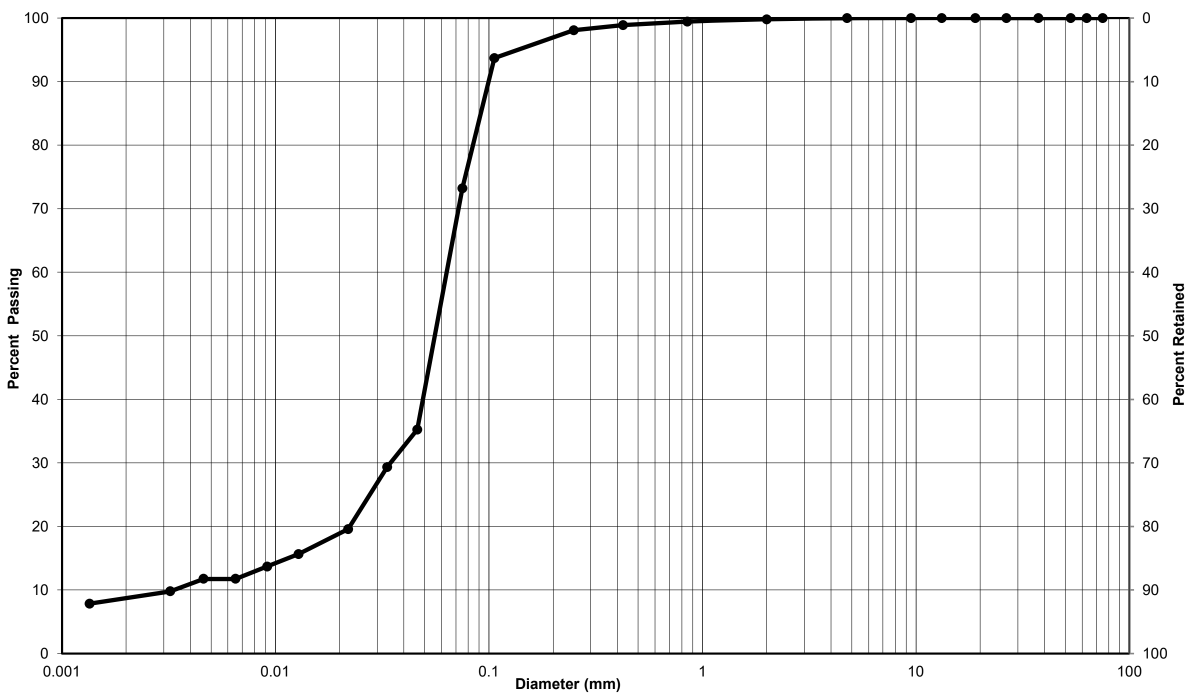
**Remarks:**

| | | | |
|---|---|---|---|
| **Performed by:** | Josh Sullivan | **Date:** | February 2, 2023 |
| **Verified by:** | Joe Sullivan | **Date:** | February 2, 2023 |

**Laboratory Location:** GHD Limited - 347 Pido Road, Unit 29, Peterborough, ON

## Particle-Size Analysis of Soils
## MTO LS-702 (Geotechnical)

| | | | |
|---|---|---|---|
| **Client:** | Veltri and Son Limited | **Lab No.:** | SS-23-03 |
| **Project/Site:** | Geotech Investigation, Turner Street, Millbrook | **Project No.:** | 12599716 |
| Borehole No.: | BH3-23 | Sample No.: | SS6 |
| Depth: | 6.1-6.5m | Enclosure: | B4 |




| Clay & Silt | Sand | | | Gravel | |
|---|---|---|---|---|---|
| | Fine | Medium | Coarse | Fine | Coarse |
| Particle-Size Limits as per USCS (ASTM D-2487) | | | | | |

| Soil Description | Gravel (%) | Sand (%) | Clay & Silt (%) |
|---|---|---|---|
| Silt with sand and few clay | 0 | 27 | 73 |
| Silt-size particles (%) : | 64 | | |
| Clay-size particles (%) (<0.002 mm): | 9 | | |

Additional laboratory reporting information available upon request.

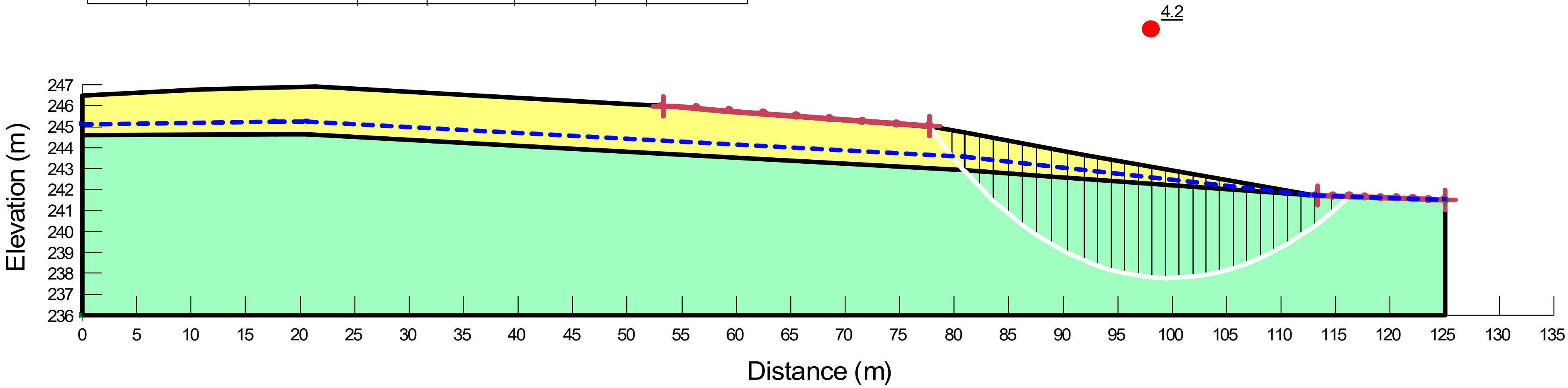
**Remarks:**

| | | | |
|---|---|---|---|
| **Performed by:** | Josh Sullivan | **Date:** | February 2, 2023 |
| **Verified by:** | Joe Sullivan | **Date:** | February 2, 2023 |
| **Laboratory Location:** | GHD Limited - 347 Pido Road, Unit 29, Peterborough, ON | | |

# Appendix C

## Slope Stability Assessment Models

| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| (green) | Clayey Silt Till | Mohr-Coulomb | 19 | 2 | 30 | 0 | 1 |
| (yellow) | Silty Sand | Mohr-Coulomb | 20 | 0 | 30 | 0 | 1 |




**Scale:**
As Shown Above
2x Vertical Exaggeration

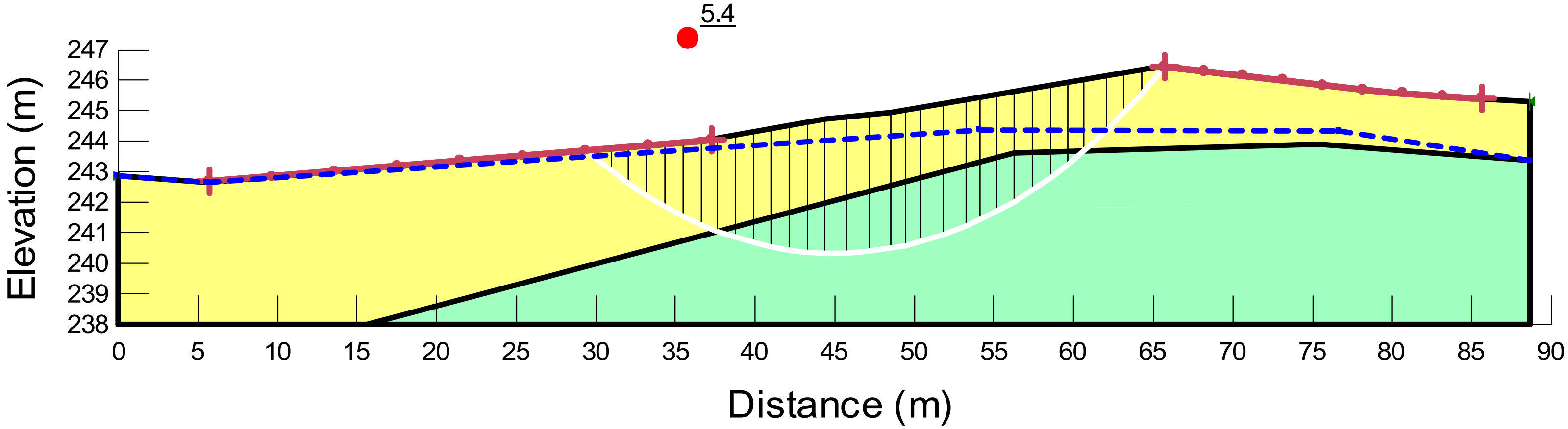
Veltri and Son Limited
Proposed Residential Development, Turner Street, Millbrook
Slope Stability Assessment

SLOPE STABILITY MODEL - CROSS SECTION A-A' - EXISTING CONDITION

12599716
Feb. 2023

C.1

| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| | Clayey Silt Till | Mohr-Coulomb | 19 | 2 | 30 | 0 | 1 |
| | Silty Sand | Mohr-Coulomb | 20 | 0 | 30 | 0 | 1 |




**Scale:**
As Shown Above
2x Vertical Exaggeration

GHD

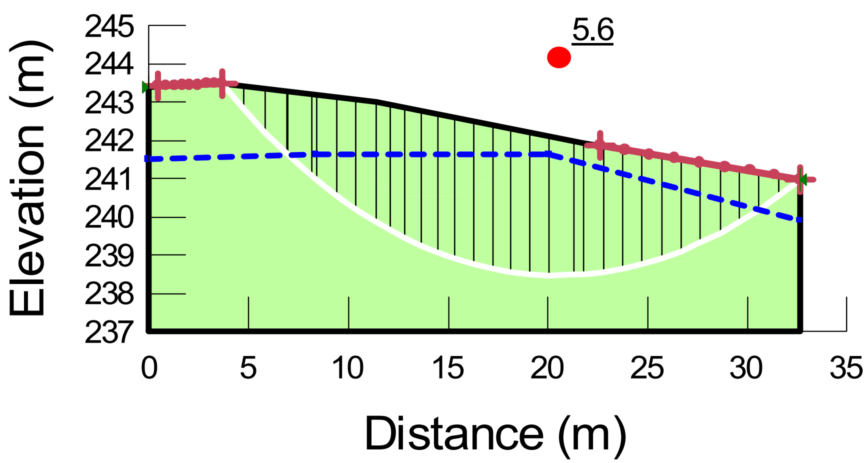
Veltri and Son Limited
Proposed Residential Development, Turner Street, Millbrook
Slope Stability Assessment

SLOPE STABILITY MODEL - CROSS SECTION B-B' - EXISTING CONDITION

12599716
Feb. 2023

C.2

| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| | Sandy Silt Till | Mohr-Coulomb | 20 | 0 | 34 | 0 | 1 |



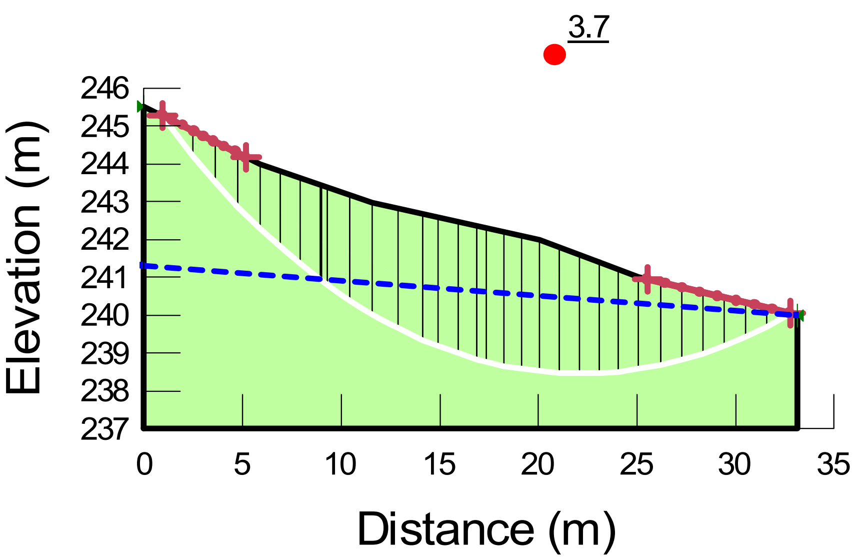

**Scale:**
As Shown Above
2x Vertical Exaggeration

Veltri and Son Limited
Proposed Residential Development, Turner Street, Millbrook
Slope Stability Assessment

SLOPE STABILITY MODEL - CROSS SECTION C-C' - EXISTING CONDITION

12599716
Feb. 2023

| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| | Sandy Silt Till | Mohr-Coulomb | 20 | 0 | 34 | 0 | 1 |



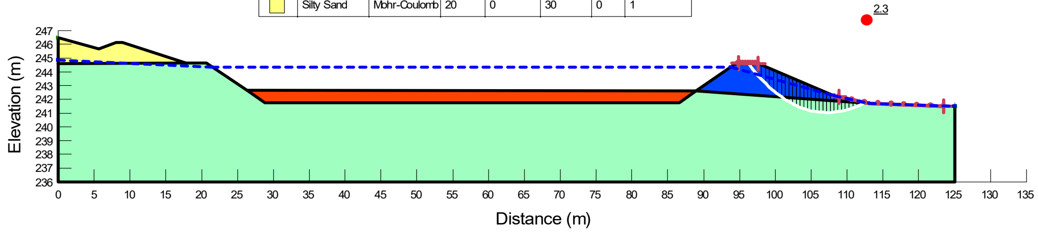

**Scale:**
As Shown Above
2x Vertical Exaggeration

Veltri and Son Limited
Proposed Residential Development, Turner Street, Millbrook
Slope Stability Assessment

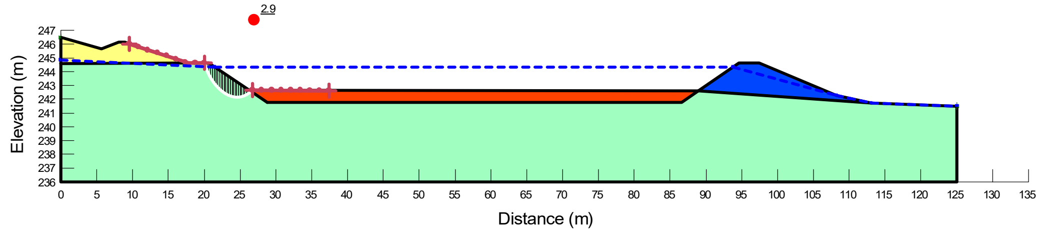
SLOPE STABILITY MODEL - CROSS SECTION D-D' - EXISTING CONDITION

12599716
Feb. 2023

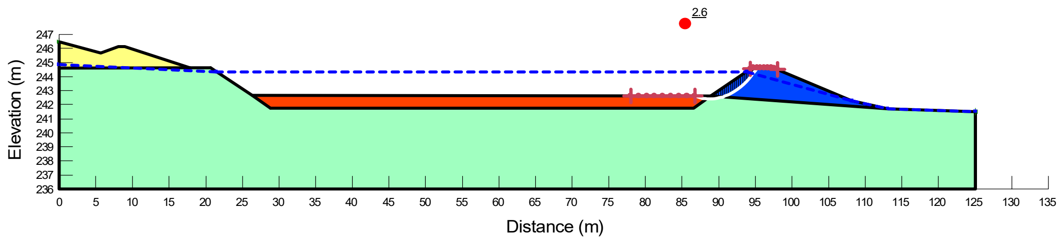
| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| | Clayey Silt Till | Mohr-Coulomb | 19 | 2 | 30 | 0 | 1 |
| | Engineered Fill | Mohr-Coulomb | 20 | 1 | 29 | 0 | 1 |
| | Rock Fill | Mohr-Coulomb | 21 | 0 | 36 | 0 | 1 |
| | Silty Sand | Mohr-Coulomb | 20 | 0 | 30 | 0 | 1 |




| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| | Clayey Silt Till | Mohr-Coulomb | 19 | 2 | 30 | 0 | 1 |
| | Engineered Fill | Mohr-Coulomb | 20 | 1 | 29 | 0 | 1 |
| | Rock Fill | Mohr-Coulomb | 21 | 0 | 36 | 0 | 1 |
| | Silty Sand | Mohr-Coulomb | 20 | 0 | 30 | 0 | 1 |




| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| | Clayey Silt Till | Mohr-Coulomb | 19 | 2 | 30 | 0 | 1 |
| | Engineered Fill | Mohr-Coulomb | 20 | 1 | 29 | 0 | 1 |
| | Rock Fill | Mohr-Coulomb | 21 | 0 | 36 | 0 | 1 |
| | Silty Sand | Mohr-Coulomb | 20 | 0 | 30 | 0 | 1 |




**Scale:**
As Shown Above
2x Vertical Exaggeration

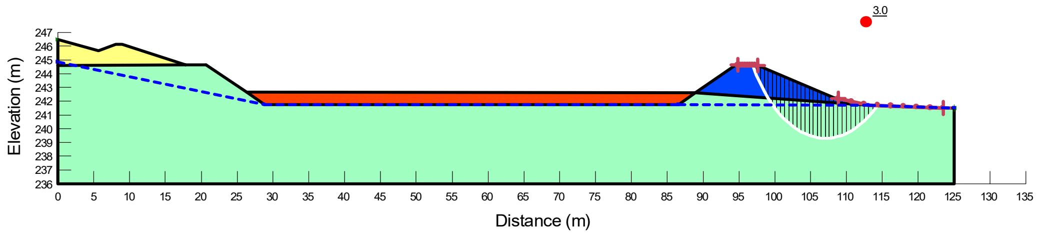
Veltri and Son Limited
Proposed Residential Development, Turner Street, Millbrook
Slope Stability Assessment

SLOPE STABILITY MODEL - CROSS SECTION A-A' - PROPOSED CONDITION, 100 YR FLOOD

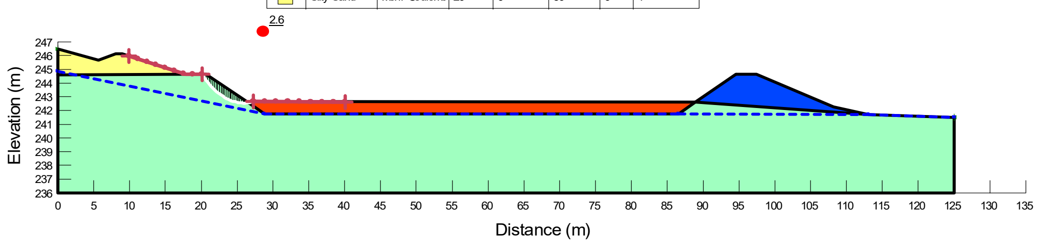
12599716
Feb. 2023

C.5

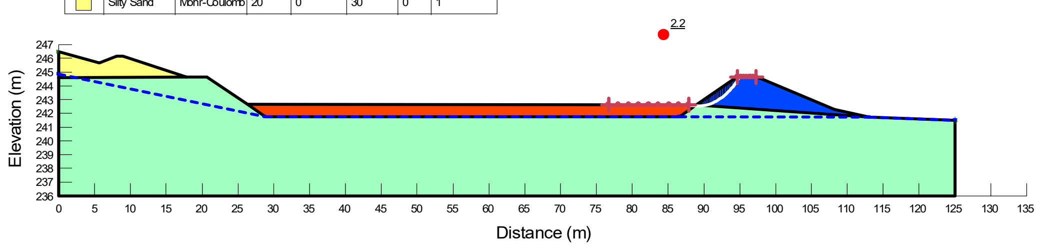
| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| | Clayey Silt Till | Mohr-Coulomb | 19 | 2 | 30 | 0 | 1 |
| | Engineered Fill | Mohr-Coulomb | 20 | 1 | 29 | 0 | 1 |
| | Rock Fill | Mohr-Coulomb | 21 | 0 | 36 | 0 | 1 |
| | Silty Sand | Mohr-Coulomb | 20 | 0 | 30 | 0 | 1 |




| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| | Clayey Silt Till | Mohr-Coulomb | 19 | 2 | 30 | 0 | 1 |
| | Engineered Fill | Mohr-Coulomb | 20 | 1 | 29 | 0 | 1 |
| | Rock Fill | Mohr-Coulomb | 21 | 0 | 36 | 0 | 1 |
| | Silty Sand | Mohr-Coulomb | 20 | 0 | 30 | 0 | 1 |




| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| | Clayey Silt Till | Mohr-Coulomb | 19 | 2 | 30 | 0 | 1 |
| | Engineered Fill | Mohr-Coulomb | 20 | 1 | 29 | 0 | 1 |
| | Rock Fill | Mohr-Coulomb | 21 | 0 | 36 | 0 | 1 |
| | Silty Sand | Mohr-Coulomb | 20 | 0 | 30 | 0 | 1 |




**Scale:**
As Shown Above
2x Vertical Exaggeration

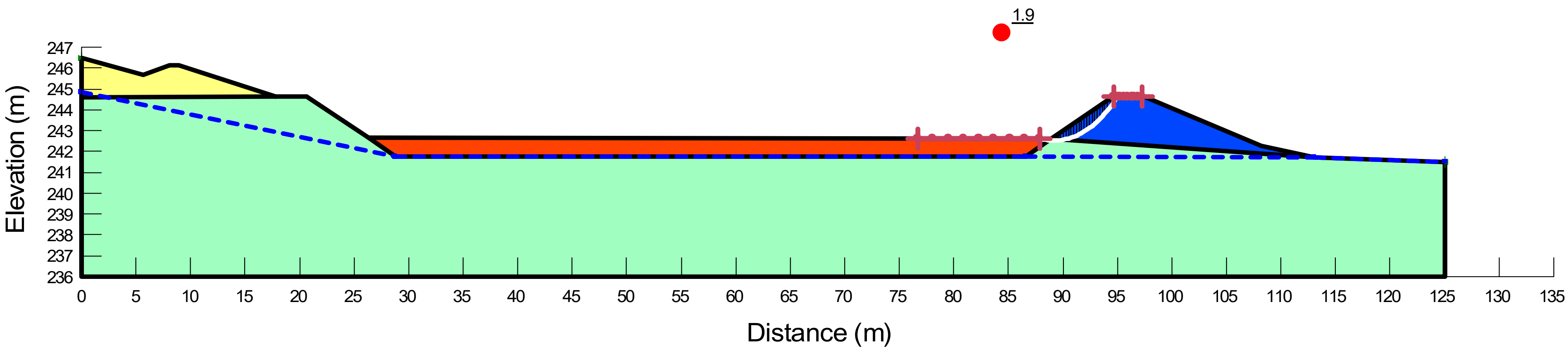
Veltri and Son Limited
Proposed Residential Development, Turner Street, Millbrook
Slope Stability Assessment

SLOPE STABILITY MODEL - CROSS SECTION A-A' - PROPOSED CONDITION, DRY

12599716
Feb. 2023

C.6

| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| (light green) | Clayey Silt Till | Mohr-Coulomb | 19 | 2 | 30 | 0 | 1 |
| (blue) | Engineered Fill | Mohr-Coulomb | 20 | 1 | 29 | 0 | 1 |
| (red-orange) | Rock Fill | Mohr-Coulomb | 21 | 0 | 36 | 0 | 1 |
| (yellow) | Silty Sand | Mohr-Coulomb | 20 | 0 | 30 | 0 | 1 |




**Scale:**
As Shown Above
2x Vertical Exaggeration

GHD

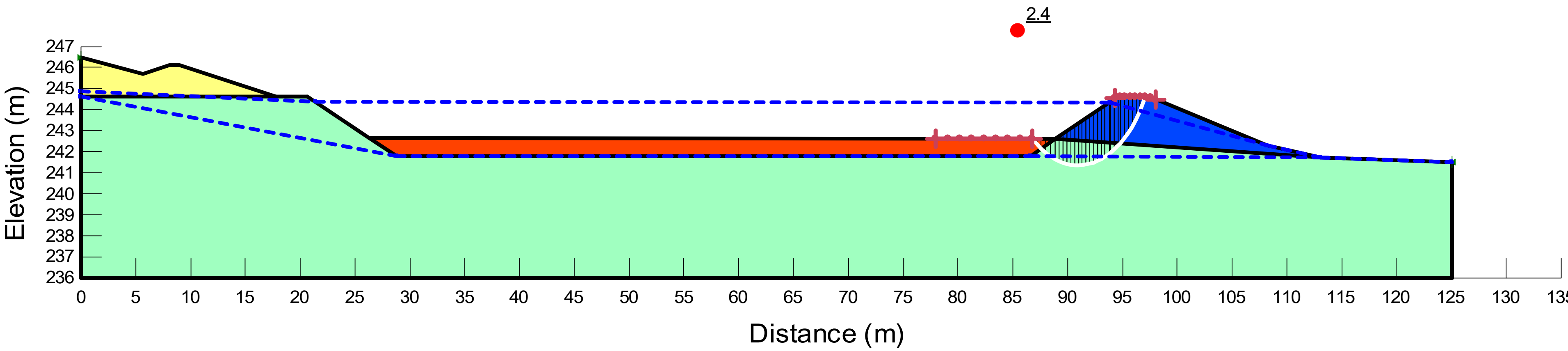
Veltri and Son Limited
Proposed Residential Development, Turner Street, Millbrook
Slope Stability Assessment

SLOPE STABILITY MODEL - CROSS SECTION A-A' - PROPOSED CONDITION, SEISMIC

12599716
Feb. 2023

C.7

| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Cohesion R (kPa) | Phi R (°) | Piezometric Line | Piezometric Line After Drawdown |
|---|---|---|---|---|---|---|---|---|---|---|
| | Clayey Silt Till | Mohr-Coulomb | 19 | 2 | 30 | 0 | 20 | 0 | 1 | 2 |
| | Engineered Fill | Mohr-Coulomb | 20 | 1 | 29 | 0 | 20 | 0 | 1 | 2 |
| | Rock Fill | Mohr-Coulomb | 21 | 0 | 36 | 0 | 0 | 0 | 1 | 2 |
| | Silty Sand | Mohr-Coulomb | 20 | 0 | 30 | 0 | 0 | 0 | 1 | 2 |




**Scale:**
As Shown Above
2x Vertical Exaggeration

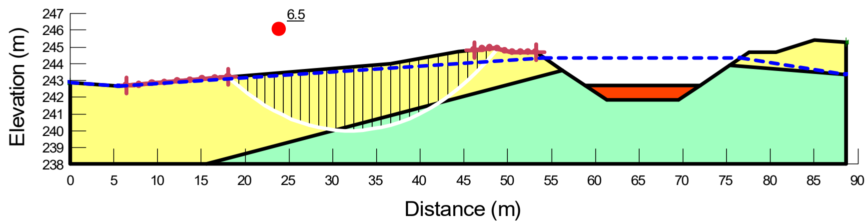
Veltri and Son Limited
Proposed Residential Development, Turner Street, Millbrook
Slope Stability Assessment

SLOPE STABILITY MODEL - CROSS SECTION A-A' - PROPOSED CONDITION, RAPID DRAWDOWN

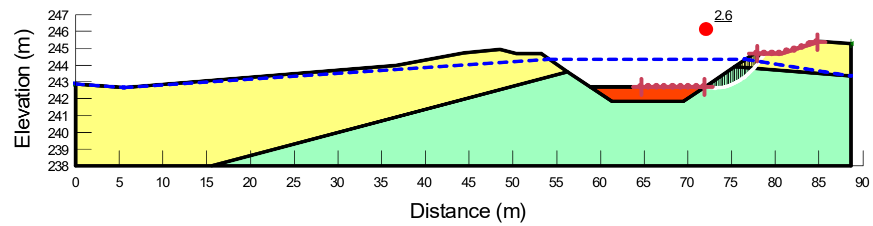
12599716
Feb. 2023

C.8

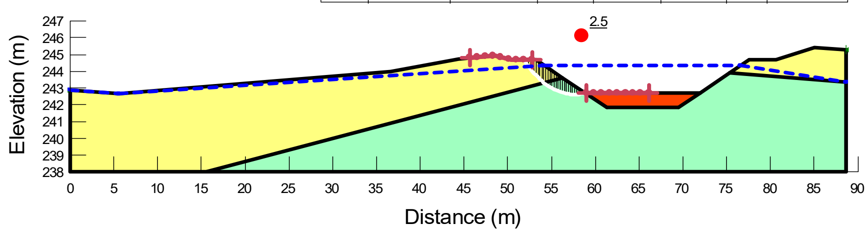
| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| (green) | Clayey Silt Till | Mohr-Coulomb | 19 | 2 | 30 | 0 | 1 |
| (red) | Rock Fill | Mohr-Coulomb | 21 | 0 | 36 | 0 | 1 |
| (yellow) | Silty Sand | Mohr-Coulomb | 20 | 0 | 30 | 0 | 1 |




| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| (green) | Clayey Silt Till | Mohr-Coulomb | 19 | 2 | 30 | 0 | 1 |
| (red) | Rock Fill | Mohr-Coulomb | 21 | 0 | 36 | 0 | 1 |
| (yellow) | Silty Sand | Mohr-Coulomb | 20 | 0 | 30 | 0 | 1 |




| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| (green) | Clayey Silt Till | Mohr-Coulomb | 19 | 2 | 30 | 0 | 1 |
| (red) | Rock Fill | Mohr-Coulomb | 21 | 0 | 36 | 0 | 1 |
| (yellow) | Silty Sand | Mohr-Coulomb | 20 | 0 | 30 | 0 | 1 |




**Scale:**
As Shown Above
2x Vertical Exaggeration

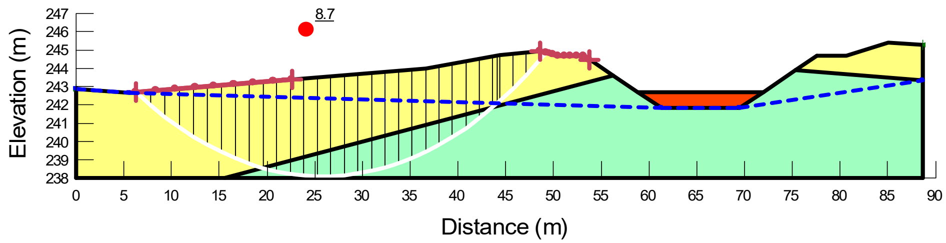
GHD

Veltri and Son Limited
Proposed Residential Development, Turner Street, Millbrook
Slope Stability Assessment

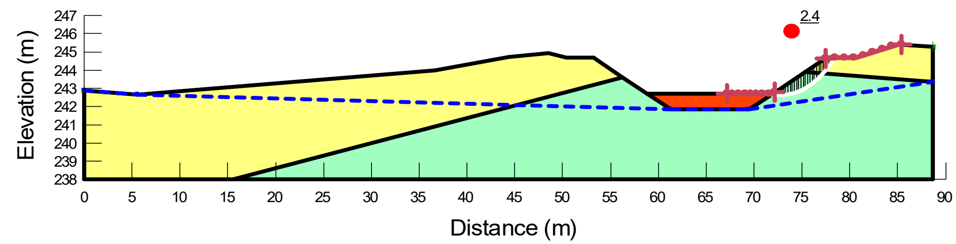
SLOPE STABILITY MODEL - CROSS SECTION B-B' - PROPOSED CONDITION, 100 YR FLOOD

12599716
Feb. 2023

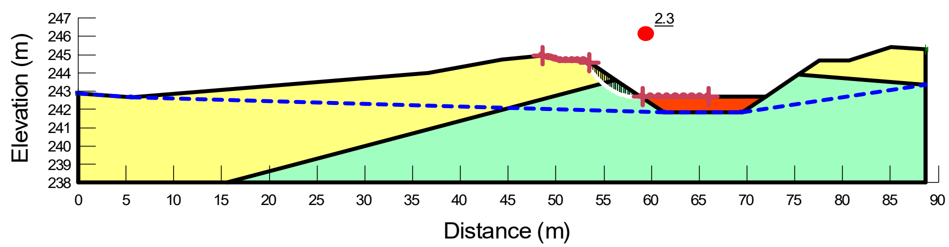
| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| | Clayey Silt Till | Mohr-Coulomb | 19 | 2 | 30 | 0 | 1 |
| | Rock Fill | Mohr-Coulomb | 21 | 0 | 36 | 0 | 1 |
| | Silty Sand | Mohr-Coulomb | 20 | 0 | 30 | 0 | 1 |




| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| | Clayey Silt Till | Mohr-Coulomb | 19 | 2 | 30 | 0 | 1 |
| | Rock Fill | Mohr-Coulomb | 21 | 0 | 36 | 0 | 1 |
| | Silty Sand | Mohr-Coulomb | 20 | 0 | 30 | 0 | 1 |




| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| | Clayey Silt Till | Mohr-Coulomb | 19 | 2 | 30 | 0 | 1 |
| | Rock Fill | Mohr-Coulomb | 21 | 0 | 36 | 0 | 1 |
| | Silty Sand | Mohr-Coulomb | 20 | 0 | 30 | 0 | 1 |



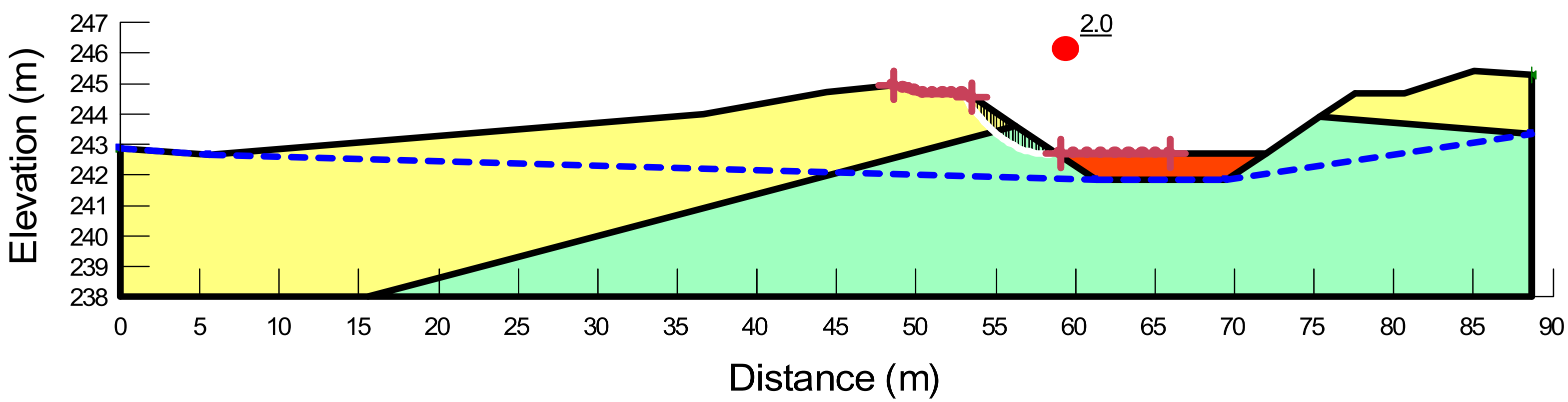

**Scale:**
As Shown Above
2x Vertical Exaggeration

Veltri and Son Limited
Proposed Residential Development, Turner Street, Millbrook
Slope Stability Assessment

SLOPE STABILITY MODEL - CROSS SECTION B-B' - PROPOSED CONDITION, DRY

12599716
Feb. 2023

| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| | Clayey Silt Till | Mohr-Coulomb | 19 | 2 | 30 | 0 | 1 |
| | Rock Fill | Mohr-Coulomb | 21 | 0 | 36 | 0 | 1 |
| | Silty Sand | Mohr-Coulomb | 20 | 0 | 30 | 0 | 1 |




**Scale:**
As Shown Above
2x Vertical Exaggeration

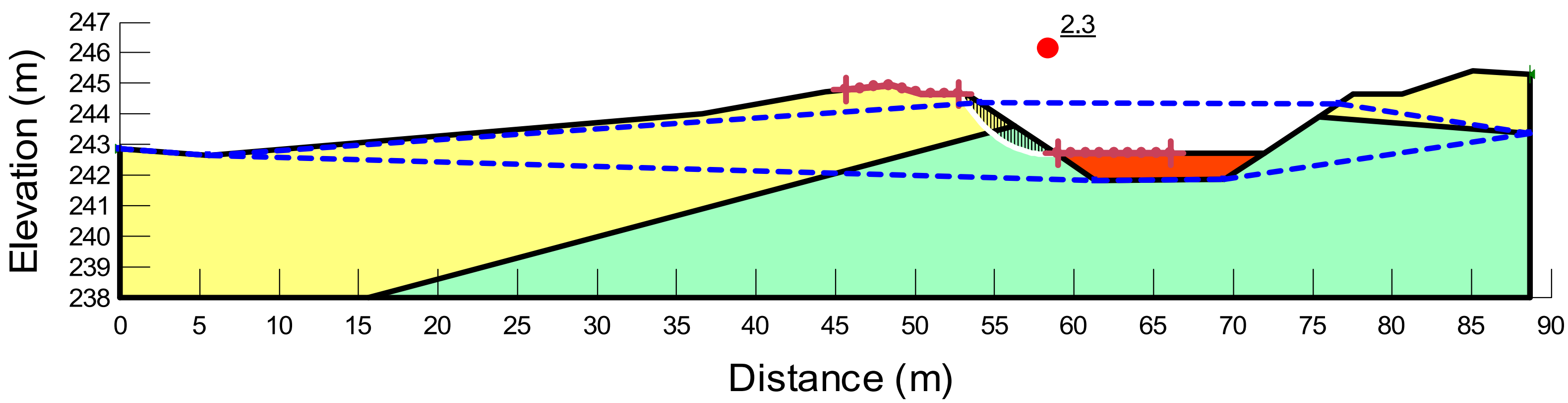
Veltri and Son Limited
Proposed Residential Development, Turner Street, Millbrook
Slope Stability Assessment

SLOPE STABILITY MODEL - CROSS SECTION B-B' - PROPOSED CONDITION, SEISMIC

12599716
Feb. 2023

C.11

| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Cohesion R (kPa) | Phi R (°) | Piezometric Line | Piezometric Line After Drawdown |
|---|---|---|---|---|---|---|---|---|---|---|
| | Clayey Silt Till | Mohr-Coulomb | 19 | 2 | 30 | 0 | 20 | 0 | 1 | 2 |
| | Rock Fill | Mohr-Coulomb | 21 | 0 | 36 | 0 | 0 | 0 | 1 | 2 |
| | Silty Sand | Mohr-Coulomb | 20 | 0 | 30 | 0 | 0 | 0 | 1 | 2 |




**Scale:**
As Shown Above
2x Vertical Exaggeration

GHD

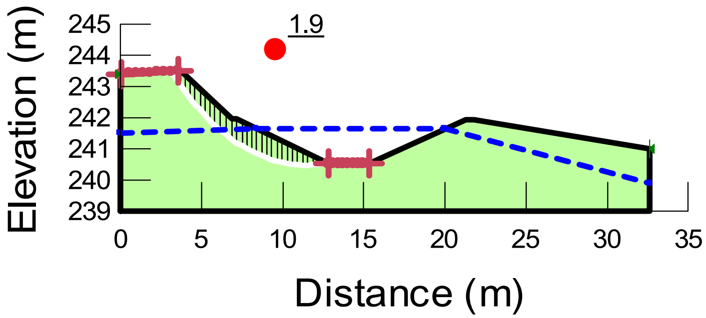
Veltri and Son Limited
Proposed Residential Development, Turner Street, Millbrook
Slope Stability Assessment

SLOPE STABILITY MODEL - CROSS SECTION B-B' - PROPOSED CONDITION, RAPID DRAWDOWN

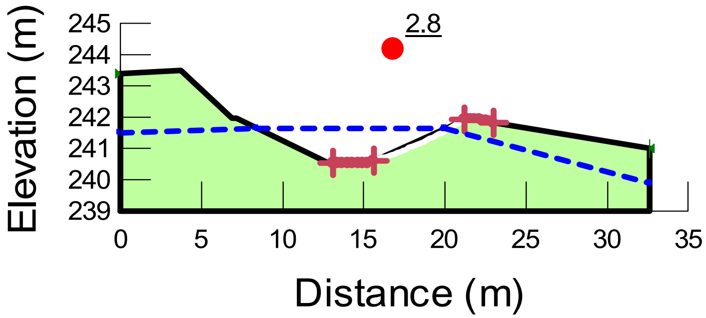
12599716
Feb. 2023

C.12

| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| | Sandy Silt Tilll | Mohr-Coulomb | 20 | 0 | 34 | 0 | 1 |




| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| | Sandy Silt Tilll | Mohr-Coulomb | 20 | 0 | 34 | 0 | 1 |



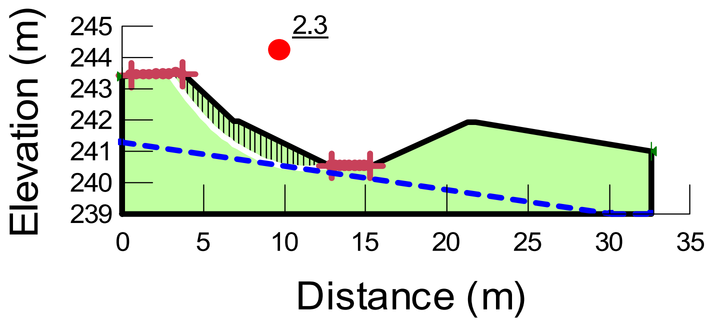

**Scale:**
As Shown Above
2x Vertical Exaggeration

Veltri and Son Limited
Proposed Residential Development, Turner Street, Millbrook
Slope Stability Assessment

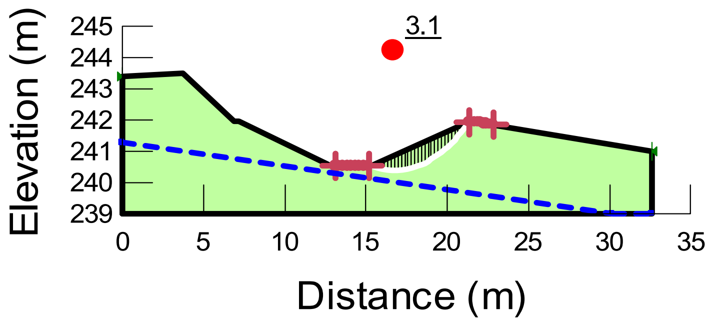
12599716
Feb. 2023

SLOPE STABILITY MODEL - CROSS SECTION C-C' - PROPOSED CONDITION, 100 YR FLOOD

| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| | Sandy Silt Till | Mohr-Coulomb | 20 | 0 | 34 | 0 | 1 |




| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| | Sandy Silt Till | Mohr-Coulomb | 20 | 0 | 34 | 0 | 1 |




**Scale:**
As Shown Above
2x Vertical Exaggeration

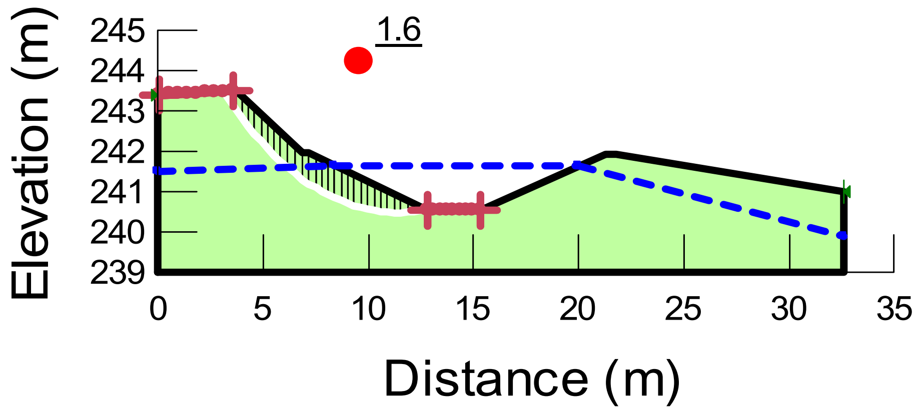
GHD

Veltri and Son Limited
Proposed Residential Development, Turner Street, Millbrook
Slope Stability Assessment

SLOPE STABILITY MODEL - CROSS SECTION C-C' - PROPOSED CONDITION, DRY

12599716
Feb. 2023

| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| | Sandy Silt Tilll | Mohr-Coulomb | 20 | 0 | 34 | 0 | 1 |



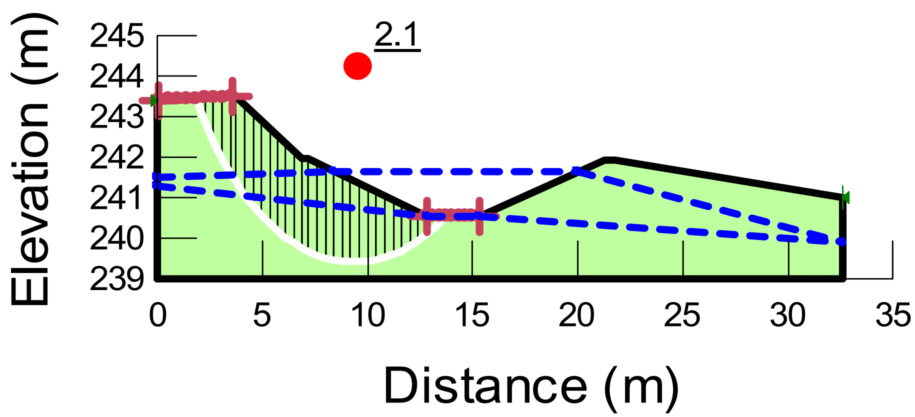

Scale:
As Shown Above
2x Vertical Exaggeration

Veltri and Son Limited
Proposed Residential Development, Turner Street, Millbrook
Slope Stability Assessment

SLOPE STABILITY MODEL - CROSS SECTION C-C' - PROPOSED CONDITION, SEISMIC

12599716
Feb. 2023

| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Cohesion R (kPa) | Phi R(°) | Piezometric Line | Piezometric Line After Drawdown |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sandy Silt Tilll | Mohr-Coulomb | 20 | 0 | 34 | 0 | 15 | 10 | 1 | 2 |




**Scale:**
As Shown Above
2x Vertical Exaggeration

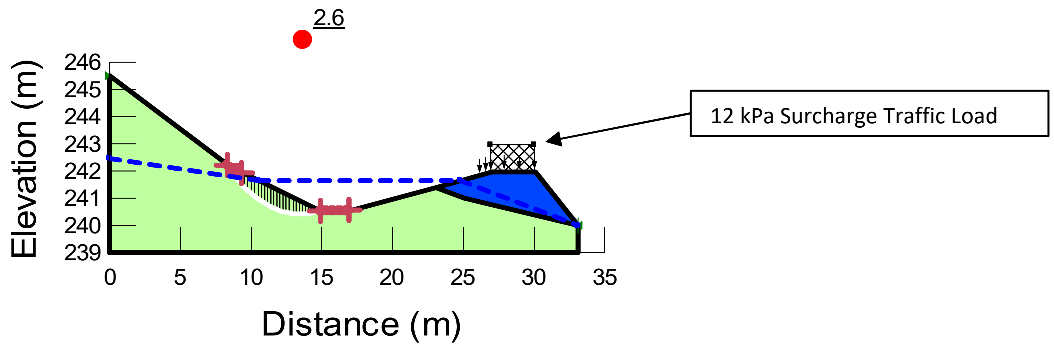
Veltri and Son Limited
Proposed Residential Development, Turner Street, Millbrook
Slope Stability Assessment

SLOPE STABILITY MODEL - CROSS SECTION C-C' - PROPOSED CONDITION, RAPID DRAWDOWN

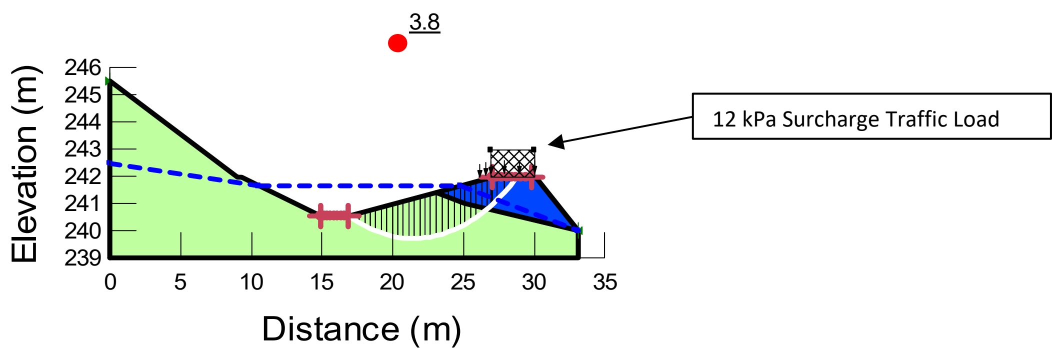
12599716
Feb. 2023

C.16

| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| Blue | Engineered Fill | Mohr-Coulomb | 20 | 1 | 29 | 0 | 1 |
| Light green | Sandy Silt Tilll | Mohr-Coulomb | 20 | 0 | 34 | 0 | 1 |




| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| Blue | Engineered Fill | Mohr-Coulomb | 20 | 1 | 29 | 0 | 1 |
| Light green | Sandy Silt Tilll | Mohr-Coulomb | 20 | 0 | 34 | 0 | 1 |



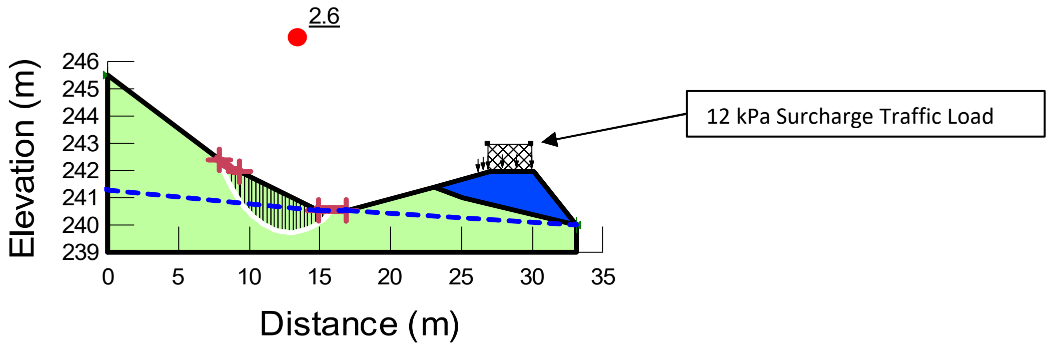

**Scale:**
As Shown Above
2x Vertical Exaggeration

Veltri and Son Limited
Proposed Residential Development, Turner Street, Millbrook
Slope Stability Assessment

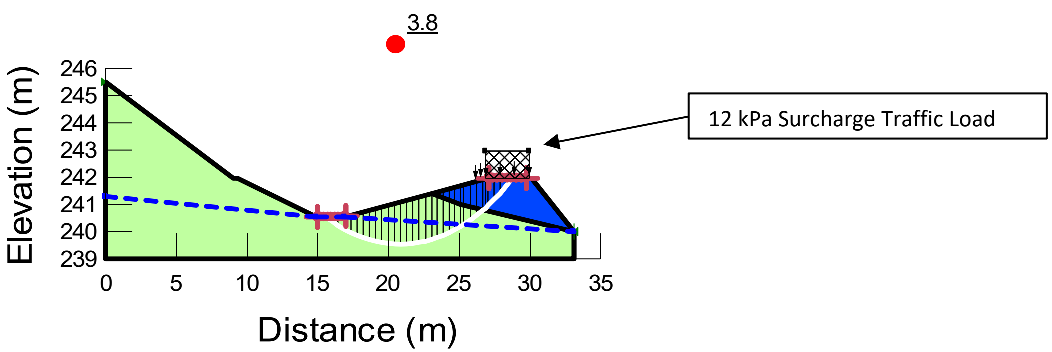
SLOPE STABILITY MODEL - CROSS SECTION D-D' - PROPOSED CONDITION, 100 YR FLOOD

12599716
Feb. 2023

| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| | Engineered Fill | Mohr-Coulomb | 20 | 1 | 29 | 0 | 1 |
| | Sandy Silt Tilll | Mohr-Coulomb | 20 | 0 | 34 | 0 | 1 |




| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| | Engineered Fill | Mohr-Coulomb | 20 | 1 | 29 | 0 | 1 |
| | Sandy Silt Tilll | Mohr-Coulomb | 20 | 0 | 34 | 0 | 1 |



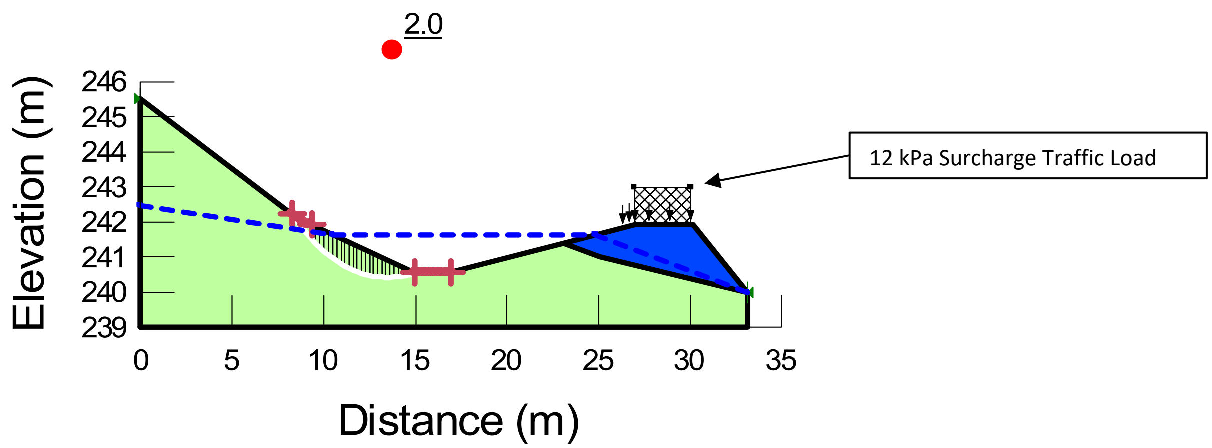

**Scale:**
As Shown Above
2x Vertical Exaggeration

Veltri and Son Limited
Proposed Residential Development, Turner Street, Millbrook
Slope Stability Assessment

SLOPE STABILITY MODEL - CROSS SECTION D-D' - PROPOSED CONDITION, DRY

12599716
Feb. 2023

| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Piezometric Line |
|---|---|---|---|---|---|---|---|
| | Engineered Fill | Mohr-Coulomb | 20 | 1 | 29 | 0 | 1 |
| | Sandy Silt Tilll | Mohr-Coulomb | 20 | 0 | 34 | 0 | 1 |



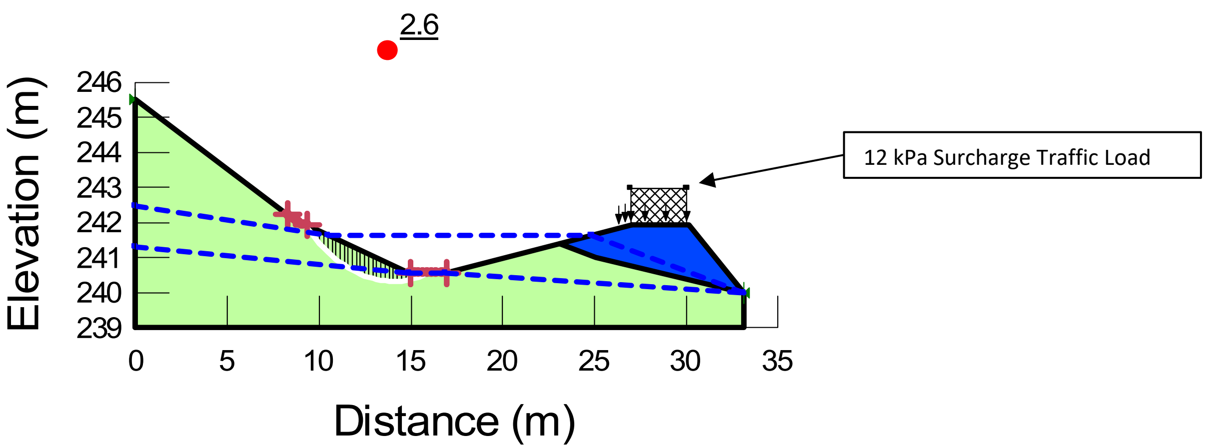

**Scale:**
As Shown Above
2x Vertical Exaggeration

Veltri and Son Limited
Proposed Residential Development, Turner Street, Millbrook
Slope Stability Assessment

SLOPE STABILITY MODEL - CROSS SECTION D-D' - PROPOSED CONDITION, SEISMIC

12599716
Feb. 2023

| Color | Name | Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Phi-B (°) | Cohesion R (kPa) | Phi R (°) | Piezometric Line | Piezometric Line After Drawdown |
|---|---|---|---|---|---|---|---|---|---|---|
| | Engineered Fill | Mohr-Coulomb | 20 | 1 | 29 | 0 | 20 | 0 | 1 | 2 |
| | Sandy Silt Tilll | Mohr-Coulomb | 20 | 0 | 34 | 0 | 15 | 10 | 1 | 2 |




**Scale:**
As Shown Above
2x Vertical Exaggeration

GHD

Veltri and Son Limited
Proposed Residential Development, Turner Street, Millbrook
Slope Stability Assessment

SLOPE STABILITY MODEL - CROSS SECTION D-D' - PROPOSED CONDITION, RAPID DRAWDOWN

12599716
Feb. 2023