Geotechnical Investigation

David Moubarak

Project Name:
Proposed Apartment Building
1494 Commissioners Road West
London, Ontario

Project Number:
LON-22006399-A0

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1. Introduction and Background

1.1 Introduction

EXP Services Inc. (EXP) was retained by David Moubarak (Client) to carry out a geotechnical investigation and slope stability assessment and prepare a report relating to the proposed development to be located at 1494 Commissioners Road West in London, Ontario, hereinafter referred to as the 'site'.

It is understood that the Client is proposing construct a four-storey apartment building containing ten (10) units with parking on the first level and a partial basement. It is anticipated that the development will be also contained paved access and parking and municipal servicing. The building location has not been finalized at the time of this report.

EXP previously completed a Slope Stability Assessment report in January 2015 and one (1) borehole was advanced as part of this investigation. The relevant factual information such as the soil and groundwater conditions encountered in the borehole advanced as part of the previous investigation have been included in the current report. The recommendations part of the slope assessment and erosion hazard limits have be revised in the current report to align with current practices.

Based on an interpretation of the factual test hole data and a review of soil and groundwater information from the test hole advanced at the site, EXP has provided geotechnical engineering guidelines to support the construction of the proposed apartment building, and an assessment of the stability of the slope to determine an erosion hazard limit (development setback).

The proposed development is within an area regulated by the Upper Thames Conservation Authority (UTRCA). As a result, consent from the Conservation Authority is required prior to construction of the proposed development.

1.2 Terms of Reference

The geotechnical investigation was generally completed in accordance with the scope of work outlined through EXP's proposal dated March 14, 2022. Authorization to proceed with this investigation was received from Mr. David Moubarak through email communications.

The purpose of the investigation was to examine the subsoil and groundwater conditions at the site by advancing a series of boreholes at the locations chosen by EXP and illustrated on the attached Site Plan (**Drawing 1**).

Based on an interpretation of the factual borehole data, and a review of soil and groundwater information from test holes advanced at the site, EXP Services Inc. has provided engineering guidelines for the geotechnical design and construction of the proposed development. More specifically, this report provides comments on site preparation, excavations, dewatering, foundations, slab-on-grade, basement construction, bedding and backfill, earthquake design considerations, pavement recommendations, preliminary LID comments, curbs and sidewalks, and erosion hazard limits.

This report is provided on the basis of the terms of reference presented above, and on the assumption that the design will be in accordance with applicable codes and standards. If there are any changes in the design features relevant to the geotechnical analyses, or if any questions arise concerning geotechnical aspects of the codes and standards, this office should be contacted to review the design.

The information in this report in no way reflects on the environmental aspects of the soil. Should specific information in this regard be needed, additional testing may be required.

Reference is made to **Appendix E** of this report, which contains further information necessary for the proper interpretation and use of this report.

2. Methodology

2.1 Field Work

The fieldwork was carried out on May 4th, 2022. In general, the geotechnical investigation consisted of the advancement of three (3) boreholes at the locations denoted on **Drawing 1** as BH101 to BH103, inclusive.

Previously, one (1) borehole was advanced in June of 2011 as part of the previous Slope Stability Assessment and is denoted as BH1 on **Drawing 1**.

Prior to the drilling, buried service clearances were obtained for the test hole locations by EXP.

The boreholes were completed by a specialist drilling subcontractor under the full-time supervision of EXP geotechnical staff. The boreholes were advanced utilizing a track-mounted drill rig equipped with continuous flight solid and hollow stem augers, soil sampling and soil testing equipment. In each borehole, disturbed soil samples were recovered at depth intervals of 0.75 m to 1.5 m using conventional split spoon sampling equipment and Standard Penetration Test (SPT) methods or auger samples.

During the drilling, the stratigraphy in the boreholes was examined and logged in the field by EXP geotechnical personnel.

Short-term groundwater levels within the open boreholes were observed. These observations pertaining to groundwater conditions at the test hole locations are recorded in the borehole logs found in **Appendix A**. Following the drilling, the boreholes were backfilled with the excavated materials and bentonite, to satisfy the requirements of O.Reg. 903.

Representative samples of the various soil strata encountered at the test locations were taken to our laboratory in London for further examination by a Geotechnical Engineer and laboratory classification testing. Laboratory testing for this investigation comprised routine moisture content determinations, with results presented on the borehole logs found in **Appendix A**.

Samples remaining after the classification testing will be stored for a period of three months following the issuance of report. After this time, they will be discarded unless prior arrangements have been made for longer storage.

Borehole locations were determined in the field in conjunction with information provided by the client.

In addition to the drilling, select slope profiles identified on Site were reviewed using the 'Slope Stability Rating Chart' (created by MNR), which summarizes the site observations and empirically scores various elements of the slope profile which contribute to slope stability, to provide an assessment of the potential for slope instabilities at the Site.

Four (4) rating charts were completed for the slope at the Site. The rating charts for the cross sections examined are provided in **Appendix C** for review and consideration. Based on the value recorded on the Slope Stability Rating Chart, the existing site slopes are considered to have a low potential for instability indicated by Slope Rating of 16 to 24. Slopes with a score equal to or less than 24 generally only require a site inspection and letter report, however, a detailed report including surveying and boreholes was completed.

2.2 Review of Topographic Data and Analysis

Topographic mapping of the Site was completed by MTE and provided to EXP for use in the slope assessment. The cross sections reviewed provide adequate representation of the various slope configurations across the Site. Using engineering judgement and technical experience, the various cross sections (which are considered to be representative of typical site conditions) have been reviewed. It should be noted that no significant changes to the slope profiles were noted relative to the site topography complied in 2012.

Examination of factors of safety using Morgenstern Price methods were carried out and analyzed by computer methods utilizing the Slope/W computer program. Using engineering judgement and technical experience, various cross sections (which are considered to be representative of the worst-case slope conditions near the proposed apartment building) have been reviewed. Soil strength parameters used in the analyses were based on our observations and experience with similar soil and groundwater conditions and are consistent with typical values in literature sources.

3. Site and Subsurface Conditions

3.1 Site Description

The Site is located 1494 Commissioners Road West in London, Ontario and is currently occupied by an existing residence, ancillary building and granular surfaced parking and access. The Site is bounded by Commissioners Road West to the north, residences to the west and a minor slope on the south and east.

In general, the slope is moderately vegetated with grass, shrubbery, and occasional trees. Based on the surveyed cross sections provided, the slope is approximately 3 to 5.5 m in height and has inclinations of approximately 2.1 horizontal to 1 vertical (2.1H:1V) to greater than 8.1H:1V. Localized steepened sections that have up to a 1.4H:1V inclination are present but generally located on the south slope. The green space on the east and south side of the Site is identified as the Warbler Woods Environmentally Sensitive Area (ESA) and contains a water course that is generally more than 15 from the base of the slope. No active erosion along the base of the slope was identified during the Site reconnaissance. The grading on the east side of the Site is generally much more gradual with minor steepened sections near the tablelands.

The following sections provide a summary of the soil conditions and groundwater conditions.

3.2 Soil Stratigraphy

The detailed stratigraphy encountered in the borehole is shown on the borehole log found in **Appendix A** and summarized in the following paragraphs. It must be noted that the boundaries of the soil indicated on the borehole log are inferred from non-continuous sampling and observations during drilling. These boundaries are intended to reflect transition zones for geotechnical design and should not be interpreted as exact planes of geological change

3.2.1 Topsoil

A layer of topsoil was encountered surfacing boreholes BH1, BH101 and BH102. The topsoil varied in thickness from approximately 150 to 300 mm.

3.2.2 Granular Fill

Borehole BH103 was surfaced with granular fill that was approximately 110 mm thick.

3.2.3 Fill

Beneath the topsoil and granular, fill was encountered at all borehole locations. The fill varied in composition from sand to silty sand. The fill was generally brown to black and contained trace to some organics. The fill was generally in a very loose to loose state based on SPT N-values of 1 to 8. The moisture content of the fill varied from 12 to 15 percent, indicating moist to very moist conditions. The fill extended to depths of 1.7 to 2.1 m bgs.

3.2.4 Sand/Sandy Silt/Silty Sand

Beneath the fill and clayey silt till, a layer of sand/silty sand/sandy silt was encountered. The cohesionless soil was generally brown in colour, contained occasional sand layering, occasional silt layering, and clayey silt layering in BH101. The cohesionless material was generally in a loose to very dense state with SPT values ranging from 4 to 58 blows per 300 mm sample spoon penetration. The in-situ moisture content of the cohesionless material ranged

between 11 to 23 percent, indicating moist to wet conditions. A layer of sand and gravel was observed in BH102. The cohesionless soils extended to depths of approximately 3.2 to 7.1 m bgs and borehole BH103 was terminated in the silty sand at a depth of 6.6 m bgs.

3.2.5 Clayey Silt Till

A layer of clayey silt till was encountered in BH101 underlying the fill. The clayey silt till was brown in colour and contained trace sand and trace gravel. The till was very stiff with a SPT N value of 16 and was moist with in-situ moisture contents of 18 percent.

3.2.6 Silt/Silt Till

Underlying the sandy silt/silty sand/sand in all boreholes except BH103, silt/silt till was encountered. The silt/silt till generally contained trace to some clay, trace to some sand, trace gravel and occasional cobbles. The silt/silt till was generally in a dense to very dense state with SPT values ranging from 32 to more than 50 blows for less than 150 mm sample spoon penetration (refusal). The silt/silt till was generally in a moist to wet state with in-situ moisture contents of 6 to 21 percent. All boreholes except BH103 were terminated in the silt till.

3.3 Groundwater Conditions

Details of the groundwater conditions observed within the test holes are provided on the attached borehole logs. Upon completion of drilling, the open boreholes were examined for the presence of groundwater and groundwater seepage. Water was measured at depths of 6.6, 5.5 and 5.2 m bgs in Boreholes BH101, BH102 and BH103, respectively, upon the completion of drilling. Borehole BH1 was dry upon completion of drilling.

It is noted that insufficient time was available for the measurement of the depth to the stabilized groundwater table prior to backfilling the test hole.

It is also noted that the depth to the groundwater table may vary in response to climatic or seasonal conditions, and, as such, may differ at the time of construction, with higher levels in wet seasons. Capillary rise effects should also be anticipated in fine-grained soil deposits.

4. Geotechnical Discussion and Recommendations

It is understood that the Proposed Apartment Building will be four-stories and consist of ten (10) units with parking on the first level and a partial basement. It is anticipated that the development will be also contained paved access and parking and municipal servicing.

The property is located within Upper Thames Conservation Authority (UTRCA) regulated lands and will require approval from the conservation authority.

The following sections of this report provide geotechnical comments and recommendations regarding site preparation, excavations and dewatering, foundations, slab-on-grade and basement design, bedding and backfill, earthquake design considerations, pavement design and curbs and sidewalks.

4.1 Site Preparation

Prior to placement foundations and/or engineered fill, all surficial topsoil, vegetation and/or otherwise deleterious materials should be stripped. Thicker areas of topsoil may be anticipated in areas with trees and/or heavy vegetative cover. It is anticipated that the surficial topsoil may be stockpiled on site for possible reuse as landscaping fill.

It is understood that the existing structures on site will be demolished. The removal of the buildings should include all building debris, foundation walls, footings, and concrete floor slabs. The removal and disposal of the previously occupied buildings and associated fill must satisfy the local building standards, Ontario Building Code (OBC), Ministry of Labour (MOL) and the Ministry of Environment, Conservation and Parks (MECP) requirements. If any potable wells are present on site, they should be properly decommissioned by a licensed well contractor, in accordance with Ontario Regulation 903.Following the removal of the topsoil and unsuitable materials described above and prior to fill placement, the exposed subgrade should be inspected by a Geotechnical Engineer. Any loose or soft zones noted in the inspection should be over-excavated and replaced with approved fill.

It is recommended that construction traffic be minimized on the finished subgrade, and that the subgrade be sloped to promote surface drainage and runoff.

In the building areas where the grade will be raised, the fill material should comprise imported granular or approved onsite (excavated) material. The fill material should be inspected and approved by a Geotechnical Engineer and should be placed in maximum 300 mm (12 inch) thick lifts and uniformly compacted to 100 percent Standard Proctor Maximum Dry Density (SPMDD) within 3 percent of optimum moisture content. The geometric requirements for engineered fill are provided on **Drawing 6**.

The natural and inorganic fill materials on site would be suitable for reuse as engineered fill. The material should be examined and approved by a Geotechnical Engineer prior to reuse.

In areas along the proposed roadways, fill material used to raise grades may comprise of onsite excavated soils, or imported granular fill approved by an engineer. The fill should be placed in maximum 300 mm (12 inch) thick loose lifts and uniformly compacted to 95/98 percent SPMDD within 3 percent of optimum moisture content to provide adequate stability for the new pavements.

In situ compaction testing should be carried out during the fill placement to ensure that the specified compaction is being achieved.

If imported fill material is utilized at the site, verification of the suitability of the fill may be required from an environmental standpoint. Conventional geotechnical testing will not determine the suitability of the material in this regard. Analytical testing and environmental site assessment may be required at the source. This will best be assessed prior to the selection of the material source. A quality assurance program should be implemented to ensure that the fill material will comply with the current Ministry of Environment, Conservation and Parks (MECP) standards for placement and transportation. The disposal of excavated materials must also conform to the MECP Guidelines and requirements. EXP can be of assistance if an assessment of the materials is required.

4.2 Excavations & Groundwater Control

4.2.1 Excess Soil Management

Ontario Regulation 406/19 made under the Environmental Protection Act (November 28, 2019) was implemented on January 1, 2021. The new regulation dictates the testing protocol that is required for the management and disposal of Excess Soils. As set forth in the Regulation, specific analytical testing protocols will need to be implemented and followed based on the quality and quantity of soil to be managed. The quality of soils is assessed through an Assessment of Past Uses (APU) including the provision of an Ecolog ERIS data base report to determine if there are any Areas of Potential Environmental Concern (APEC). The parameters to be tested will be determined by the APU results.

The testing protocols are specific as to whether the soils are stockpiled or in-situ. In either scenario, the testing protocols are far more onerous than have been historically carried out as part of standard industry practices. These decisions should be factored in and accounted for prior to the initiation of the project-defined scope of work. EXP would be pleased to assist with the implementation of a soil management and testing program that would satisfy the requirements of Ontario Regulation 406/19.

Soil sampling requirements for noted APECs related to the new standard effective January 1, 2022 are provided below.

Table 1 – Ex-Situ (e.g., Stockpiles)

Soil Volume	Sampling Frequency
<130 m^3	Minimum of 3
>130 - 220 m^3	4
>220 - 5000 m^3	5-32*
>5000 m^3	N = 32 + (Volume – 5000) / 300

*refer to stockpile sampling frequency in O.Reg. 153/04 for specifics. Essentially, one sample for every 150 m^3 after 800 m^3

Table 2 – In Situ

Soil Volume	Sampling Frequency
<600 m^3	
>600 m^3 - 10,000 m^3	1 sample per every additional 200 m^3
>10,000 m^3 – 40,000 m^3	
>40,000 m^3	1 sample per every additional 2000 m^3

In addition to the above tables, one field duplicate should be submitted for approximately every 10 samples taken for quality control/quality assurance purposes.

In areas where no APECs have been identified, the sample frequency in the tables noted above do not need to be followed and sampling frequencies can be determined at the discretion of the QP.

Soil Analytical Testing Requirements:

- Samples to be tested for a minimum of Petroleum Hydrocarbons (PHCs) – Fractions F1-F4, Benzene, Toluene, Ethylbenzene & Xylenes (BTEX), Metals & Inorganics, including Electrical Conductivity (EC) and Sodium Absorption Ration (SAR).
- Any additional potential Contaminant of Concern identified in past uses report (comes into effect January 1, 2022)
- mSPLP Leachate testing (metals and VOCs) (not required for volumes under 350 m^3: between 350 m^3 and 600 m^3 (minimum of 3); greater than 600 m^3 (10 % of samples).

Other components of the new regulation include:

- Development of an Excess Soil Waste Characterization Report
- Soil Destination Report
- Development and Implementation of a Tracking System.

4.2.2 Excavations

All work associated with design and construction relative to excavations must be carried out in accordance with Part III of Ontario Regulation 213/91 under the Occupational Health and Safety Act. Based on the results of the geotechnical investigation and in accordance with Section 226 of Ontario Regulation 213/91, the very loose fill and is classified as Type 4 Soils. The loose fill, loose to compact sandy silt/silty sand and clayey silt till are classified as Type 3 soils. The dense to very dense till and silty sand/sandy silt soils are classified as Type 2 soils

Where excavations extend into or through Type 4 soils, excavation side slopes must be cut back at a maximum inclination of about 3H:1V or flatter from the base of the excavation. Where excavations extend into or through Type 3 soils, excavation side slopes must be cut back at a maximum inclination of about 1H:1V or flatter from the base of the excavation. Temporary excavation sidewalls which extend through and terminate within Type 2 soil may be cut vertical in the bottom 1.2 m (4 ft.) and cut back at an inclination of 1 horizontal to 1 vertical above that level. Should groundwater egress loosen the side slopes, slopes of 3H:1V or flatter will be required.

Additionally, when excavating, care should be taken to not undermine or damage any existing buried utilities or structures. EXP can provide additional assistance in this regard, if necessary. Geotechnical inspection at the time of excavation can confirm the soil type present.

It should be noted that the presence of cobbles and boulders in natural glacial deposits may influence the progress of excavation and construction.

4.2.3 Excavation Support

The recommendations for side slopes given in the above section would apply to most of the conventional excavations expected for the proposed development. However, in areas adjacent to buried services that are located above the base of the excavations, side slopes may require support to prevent possible disturbance or distress to these structures. This concept also applies to connections to existing services. In granular soils above the groundwater and in cohesive natural soils, bracing will not normally be required if the structures are behind a 45-degree line drawn up from the toe of the excavation. In wet sandy or silty soils, the setback should be about 3H to 1V if bracing is to be avoided.

For support of excavations such as for any deep manholes or to minimize disturbance to surrounding lands, shoring such as sheeting or soldier piles and lagging can be considered. Alternatively, the option of a prefabricated trench box system may be available depending on the required depths. The prefabricated trench box system, if utilized, must be designed by a professional engineer to withstand the soil and hydrostatic loading. The design and use of the support system should conform to the requirements set out in the most recent version of the Occupational Health and Safety Act for Construction Projects and approved by the Ministry of Labour. Excavations should conform to the guidelines set out in the proceeding section and the Safety Act.

The shoring should also be designed in accordance with the guidelines set out in the Canadian Foundation Engineering Manual, 4th Edition. Soil-related parameters considered appropriate for a soldier pile and lagging system are shown below.

Where applicable, the lateral earth pressure acting on the excavation shoring walls may be calculated from the following equation:

$$P = K (\gamma h + q)$$

where, P = lateral earth pressure in kPa acting at depth h;

γ = natural unit weight, a value of 20.4 kN/m3 may be assumed;

h = depth of point of interest in m;

q = equivalent value of any surcharge on the ground surface in kPa.

The earth pressure coefficient (K) may be taken as 0.25 where small movements are acceptable and adjacent footing or movement sensitive services are not above a line extending at 45 degrees from the bottom edge of the excavation; 0.35 where utilities, roads, sidewalks must be protected from significant movement; and 0.45 where adjacent building footings or movement sensitive services (gas and water mains) are above a line of 60 degrees from the horizontal extending from the bottom edge of the excavation.

For long term design, a K at rest (K_o) of a minimum of 0.55 should be considered.

The above expression assumes that no hydrostatic pressure will be applied against the shoring system. It should be recognized that the final shoring design will be prepared by the shoring contractor. It is not possible to comment further on specific design details until this design is completed.

If the shoring is exposed to freezing temperatures, appropriate insulation may be provided to prevent outward movement.

The performance of the shoring must be checked through monitoring for lateral movement of the walls of the excavation to ensure that the shoring movements remain within design limits. The most effective method for monitoring the shoring movements can best be devised by this office when the shoring plans become available. The shoring designer should however assess the specific site requirements and submit the shoring plans to the engineer for review and comment.

4.2.4 Construction Dewatering

As stated in Section 3.3, groundwater was observed between 5.2 to 6.6 m below ground surface (bgs) in borehole BH101 through BH103 upon the completion of drilling and BH1 was dry upon completion of drilling. During drilling, the soils were noted to become wet at depth of 2.9 to 6.6 m bgs.

Based on the soil texture encountered during the investigation, minor to moderate groundwater infiltration should be anticipated within excavations to conventional depths. Any minor to moderate groundwater infiltration can likely be accommodated using conventional sump pumping techniques; however, due to sandy soil presence, it is recommended that the sump pits be lined with a suitable geotextile filter fabric and the pump inlet be set in a clear stone, which should fill the sump pit completely. The use of an unfiltered system will result in migration of sandy soil particles that will loosen the soil deposits. If groundwater infiltration persists, more extensive dewatering measures may be required. EXP would be pleased to provide further information in this regard, upon request.

The collected water should be discharged a sufficient distance away from the excavated area to prevent the discharge water from returning to the excavation. Sediment control measures should be provided at the discharge point of the dewatering system. Caution should also be taken to avoid any adverse impacts to the environment.

Although not anticipated for service excavations to conventional depths, it is important to mention that for any projects requiring positive groundwater control with a removal rate of 50,000 liters to less than 400,000 liters per day, an Environmental Activity and Sector Registry (EASR) will be required. Permit to Take Water (PTTW) applications are required for removal rates more than 400,000 L per day and will need to be approved by the MECP per Sections 34 and 98 of the Ontario Water Resources Act R.S.O. 1990 and the Water Taking and Transfer Regulation O. Reg. 387/04. It is noted that a standard geotechnical investigation will not determine all the groundwater parameters which may be required to support the application.

4.3 Building Foundations

4.3.1 Conventional Strip and Spread Footings

It is understood that the apartment building will be four-stories and contain 10 units and be constructed with parking on the first level and a partial basement. The proposed apartment building can be supported on conventional spread and strip footings founded below the topsoil and unsuitable soils on the natural competent subgrade soils, or engineered fill. The following section provides options for conventional foundations.

The following allowable bearing pressures (net stress increase) can be used on the natural, undisturbed compact to dense sandy silt/silty sand or till materials generally encountered below a depth of 2.1 m below ground surface (bgs):

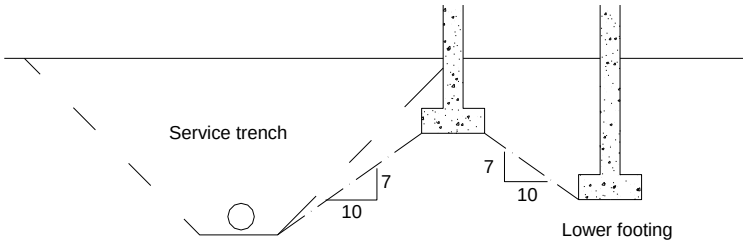
Bearing Resistance at Serviceability Limit States (SLS)	145 kPa (3,000 psf)
Factored Bearing Resistance at Ultimate Limit States (ULS)	215 kPa (4,500 psf)

It should be noted that competent soil was not encountered until a depth of approximately 3.5 m bgs in the area of borehole BH103. During inspection, recompaction of founding subgrade in conjunction with nominal concrete reinforcement in the footings may be recommended at the time of construction, if conditions warrant. It should also be noted that depths to competent soils may be significant deep in the area of the existing buildings on Site.

If the grades are to be raised or restored, engineered fill can be used for foundation support. The geometric requirements for the fill placement are shown on **Drawing 6**, appended. The available SLS bearing capacity for the engineered fill is 145 kPa (3,000 psf). For footings placed on engineered fill, it is recommended that the strip footings be widened to 500 mm (20 inches) and contain nominal concrete reinforcing steel. Verification of the soil conditions and the extent of reinforcement are best determined by the Geotechnical Engineer at the time of excavation.

Foundations - General

Footings at different elevations should be located such that the higher footings are set below a line drawn up at 10 horizontal to 7 vertical from the near edge of the lower footing. This concept should also be applied to service excavation, etc. to ensure that undermining is not a problem.



FOOTINGS NEAR SERVICE TRENCHES OR AT DIFFERENT ELEVATIONS

Provided that the footing bases are not disturbed due to construction activity, precipitation, freezing and thawing action, etc., and the aforementioned bearing pressures are not exceeded, the total and differential settlements of footings designed in accordance with the recommendations of this report and with careful attention to construction detail are expected to be less than 25 mm and 20 mm (1 and ¾ inch) respectively.

All footings exposed to seasonal freezing conditions should be protected from frost action by at least 1.2 m (4 ft) of soil cover or equivalent insulation.

It should be noted that the recommended bearing capacities have been calculated by EXP from the borehole information for the design stage only. The investigation and comments are necessarily on-going as new information of underground conditions becomes available. For example, if more specific information becomes available with respect to conditions between boreholes when foundation construction is underway. The interpretation between the boreholes and the recommendations of this report must therefore be checked through field inspections provided by EXP to validate the information for use during the construction stage.

4.4 Slab-on-Grade Construction

Preparation of the subgrade should include the removal of all topsoil and/or deleterious material from the proposed building footprints. The entire floor slab area should then be thoroughly proof-rolled with a heavy roller and examined by a Geotechnical Engineer. Any excessively soft or loose areas should be sub-excavated and replaced with suitable compacted fill. Where the exposed subgrade requires reconstruction to achieve the design elevations, structural fill should be used. It is recommended that structural fill comprises granular material, such as OPSS Granular 'B', or approved alternative material. The fill should be placed in maximum 300 mm thick lifts and compacted to a minimum of 98 percent Standard Proctor Maximum Dry Density (SPMDD). For best compaction results, the *in situ* moisture content of the fill should be within about three percent of optimum, as determined by Standard Proctor density testing.

No special underfloor drains are required provided that the exterior grades are lower than the floor slab, and positively sloped away from the slab. It is recommended that an impermeable soil seal such as clay, asphalt or concrete be provided on the surface to minimize water infiltration from the exterior of the building. See **Drawing 7** for Drainage and Backfill recommendations for slab-on-grade construction.

A moisture barrier, consisting of a 200 mm (8 in.) thick, compacted layer of 19 mm (3/4 in.) clear stone, should be then placed between the prepared granular sub-base and the floor slab.

The installation and requirement of a vapor barrier under a concrete slab should conform to the flooring manufacturer's and designer's requirements. Moisture emission testing will be required to determine the concrete condition prior to flooring installation. In order to minimize the potential for excess moisture in the floor slab at the time of the flooring installation, a concrete mixture with a low water-to-cement ratio (i.e., 0.45 to 0.55) should be used. Chemical additives may be required at the time of placement to make the concrete workable, and should be used in place of additional water at the point of placement. Ongoing liaison from this office will be required.

For slab on grade design, the modulus of subgrade reaction (k) can be taken as 25 MPa/m for the compacted stone layer over the compacted granular subbase.

The water-to-cement ratio and slump of concrete utilized in the floor slabs should be strictly controlled to minimize shrinkage of the slabs. Adequate joints should be provided in the floor slab to further control cracking. During placement of concrete at the construction site, testing should be performed on the concrete.

4.5 Foundation Backfill

In general, the existing natural soils excavated from the foundation area should be suitable for re-use as foundation wall backfill outside of the free-draining zone if the work is carried out during relatively dry weather. The materials to be re-used should be within three percent of optimum moisture for best compaction results. Materials should be stockpiled per their composition; i.e. sandy soils should not be mixed with clayey soils.

If the weather conditions are very wet during construction, then imported granular material such as OPSS Granular 'B' should be used. Site review by the geotechnical consultant may be advised.

The backfill must be brought up evenly on both sides of walls not designed to resist lateral earth pressures.

During construction, the fill surface around the perimeter of structures should be sloped in such a way that the surface runoff water does not accumulate around the structure.

4.6 Site Servicing

The subgrade soils beneath the water and sewer pipes which are anticipated to service the site are generally expected to comprise silty sand/sandy silt, or till. For services constructed on the natural soils or engineered fill, the bedding should conform to OPS Standards. The bedding course may be thickened if portions of the subgrade become wet during excavation. Bedding aggregate should be placed around the pipe to at least 300 mm (12 inch) above the pipe and be compacted to a minimum 95 percent SPMDD.

Water and sewer lines installed outside of heated areas should be provided with a minimum 1.2 m (4 ft.) of soil cover for frost protection.

The bases of excavations which cut into and terminate in competent till or clayey silt are expected to remain stable for the short construction period. For bases terminated in the wet silty sand or sandy silt layers, localized improvement may be required. Base improvement may also be required if work is carried out in wet weather seasons. The extent of base improvement or stabilization is best determined in the field during construction, with consultation from a Geotechnical Engineer.

To minimize disturbance to the base, pipe laying should be carried out in short sections, with backfilling following closely after laying and no section of trench should be left open overnight.

The trenches above the specified pipe bedding should be backfilled with inorganic on-site soils placed in 300 mm thick lifts and uniformly compacted to at least 95% SPMDD. For trench backfill within 1 meter below the roadway subbase, the fill should be uniformly compacted to at least 98% SPMDD. A program of *in situ* density testing should be set up to ensure that satisfactory levels of compaction are achieved.

Requirements for backfill in service trenches, etc. should also have regard for OPS requirements. A summary of the general recommendations for trench backfill is presented on **Drawings 9** and **10**. A program of *in situ* density testing should be set up to ensure that satisfactory levels of compaction are achieved.

Based on the results of this investigation, the majority of the excavated sandy silt/silty sand and till material may be used for construction backfill provided that reasonable care is exercised in handling. In this regard, the material should be within 3 percent of the optimum moisture as determined in the Standard Proctor density test, and stockpiling of material for prolonged periods of time should be avoided. This is particularly important if construction is carried out in wet or otherwise adverse weather.

Soils excavated from below the stabilized groundwater table may be too wet for reuse as backfill unless adequate time is allowed for drying, or if the material is blended with approved dry fill; otherwise, it may be stockpiled onsite for reuse as landscape fill.

As noted previously, disposal of excavated materials off site should conform to current MECP guidelines.

4.7 Earthquake Design Considerations

The recommendations for the geotechnical aspects to determine the earthquake loading for design using the OBC 2012 are presented below.

The subsoil and groundwater information at this Site have been examined in relation to Section 4.1.8.4 of the OBC 2012. The subsoils at the Site generally consist of fill over silty sand/sandy silt over till deposits. It is anticipated that

the proposed structures will be founded on the natural compact silty sand/sandy silt or till deposits, below any loose or soft zones.

Table 4.1.8.4.A. Site Classification for Seismic Site Response in OBC 2012 indicates that to determine the site classification, the average properties in the top 30 m (below the lowest basement level) are to be used. The boreholes advanced at this Site were excavated to a maximum depth of 9.1 m below existing grade. Therefore, the Site Classification recommendation would be based on the available information as well as our interpretation of conditions below the boreholes based on our knowledge of the soil conditions in the area.

Based on the above assumptions, interpretations in combination with the known local geological conditions, the Site Class for the proposed development is "D" as per Table 4.1.8.4.A, Site Classification for Seismic Site Response, OBC 2012. Additional depth drilling may be advised to determine if the soil conditions below the current depth of exploration can support a higher Site Classification.

4.8 Site Pavement Design

Areas to be paved should be stripped of all topsoil, organics and other obviously unsuitable material. The exposed subgrade must then be thoroughly proof-rolled. Any soft areas revealed by this or any other observations must be over-excavated and backfilled with approved material. All fill required to backfill service trenches or to raise the subgrade to design levels must conform to requirements outlined previously. Preferably, the natural inorganic excavated soils should be used to maintain uniform subgrade conditions, provided adequate compaction can be achieved.

Provided the preceding recommendations are followed, the pavement thickness design requirements given in the following table are recommended for the anticipated specified classification (local roads internal to the site) and anticipated subgrade conditions.

Table 3 – Recommended Pavement Structure Thicknesses

Pavement Layer	Compaction Requirements	Light Duty Pavement Structure (Cars Only)	Heavy Duty Pavement Structure (Cars and Trucks)
Asphaltic Concrete	92% MRD[1] or 97% BRD[1]	40 mm HL-3 50 mm HL-8	50 mm HL-3 60 mm HL-8
Granular 'A' (Base)	100% SPMDD[1]	150 mm	150 mm
Granular 'B' (Base)	100% SPMDD[1]	300 mm	450 mm

*Notes: 1) SPMDD denotes Standard Proctor Maximum Dry Density, MRD denotes Maximum Relative Density, BRD denotes Bulk Relative Density.
2) The subgrade must be compacted to 98% SPMDD.
3) The above recommendations are minimum requirements.

The recommended pavement structure provided in the above table is based on the existing subgrade soil properties determined from visual examination and textural classification of the soil samples. Consequently, the recommended pavement structures should be considered for preliminary design purposes only. Other granular configurations may also be possible provided the granular base equivalency (GBE) thickness is maintained. These recommendations on

thickness design are not intended to support heavy and concentrated construction traffic, particularly where only a portion of the pavement section is installed.

If construction is undertaken under adverse weather conditions (i.e., wet or freezing conditions) subgrade preparation and granular sub-base requirements should be reviewed by the Geotechnical Engineer. If the sub-base is set on wet or dilatant silty soils, a geotextile will be required. A woven type geotextile such as Terrafix 200W or equivalent would be suitable for this application.

If only a portion of the pavement will be in place during construction, the granular subbase may have to be thickened. This is best determined in the field during the site servicing stage of construction, prior to road construction.

Samples of both the Granular 'A' and Granular 'B' aggregate should be checked for conformance to OPSS 1010 prior to utilization on Site, and during construction. The Granular 'B' subbase and the Granular 'A' base courses must be compacted to 100 percent SPMDD.

The asphaltic concrete paving materials should conform to the requirements of OPSS MUNI 1150. The asphalt should be placed in accordance with OPSS 310 and compacted to at least 97 percent of the Marshall mix design bulk relative density (BRD) or 92% of maximum relative density (MRD). A tack coat should be applied between the surface and binder asphalt courses.

Good drainage provisions will optimize pavement performance. The finished pavement surface should be free of depressions and should be sloped (preferably at a minimum grade of two percent) to provide effective surface drainage toward catch basins. Surface water should not be allowed to pond adjacent to the outside edges of pavement areas. In low areas, sub-drains should be installed to intercept excess subsurface moisture and prevent subgrade softening, as shown on **Drawing 10**. This is particularly important in heavier traffic areas at the site entrances. The locations and extent of sub-drainage required within the paved areas should be reviewed by this office in conjunction with the proposed grading.

A program of *in situ* density testing must be carried out to verify that satisfactory levels of compaction are being achieved.

To minimize the effects of differential settlements of service trench fill, it is recommended that wherever practical, placement of binder asphalt be delayed for approximately six months after the granular sub-base is put down. The surface course asphalt should be delayed for a further one year. Prior to the surface asphalt being placed, it is recommended that a pavement evaluation be carried out on the base asphalt to identify repair areas or areas requiring remedial works prior to surface asphalt being placed.

4.9 Curbs and Sidewalks

It is recommended that the concrete for curb and gutter and sidewalks should be proportioned, mixed, placed, and cured in accordance with the requirements of OPSS MUNI 353, OPSS MUNI 1350 and City of London Standards.

During cold weather, the freshly placed concrete must be covered with insulating blankets to protect against freezing. Three cylinders from each day's pour should be taken for compressive strength testing. Air entrainment, temperature, and slump tests should be made from the same batch of concrete from which test cylinders are made.

The subgrade for the sidewalks should comprise undisturbed natural competent soil of well-compacted fill. A minimum 150 mm thick layer of compacted Granular 'A' type aggregate should be placed beneath the sidewalk slabs.

It is recommended that the Granular 'A' be compacted to a minimum 100 percent SPMDD, to provide adequate support for the concrete sidewalk. Construction traffic should be kept off the placed curbs and sidewalks as they are not designed to withstand heavy traffic load.

5. Slope Stability Assessment

5.1 General

A slope assessment was also conducted to determine a safe setback distance from the existing slope profiles in the area of the proposed apartment building using the survey data and topographic information provided by the MTE. It is understood that the building is proposed to contain one level of parking on the main level that will be located partially below ground surface.

The slope was evaluated generally using the method prescribed by Ministry of Natural Resources in the Technical Guide for Assessing the Erosion Hazard Limit for River and Stream Systems. The overall Erosion Hazard Limit (Development Setback) for the site slope is determined by evaluating the slope stability and considering toe erosion allowance and emergency access allowance recommendations.

A Slope Stability Rating Chart has been completed for Cross Section A-A through Cross Section D-D' and are attached in **Appendix C**. Based on slope rating scores of 16 to 24, the ratings suggest that a low potential of slope instability exists for all reviewed slope profiles.

To determine the erosion hazard limit (development setback) from the top of the slope, four (4) cross sections, designated as Cross-Section A-A' through Cross Section D-D', were drawn from the topographic data provided by the MTE. The locations of the cross-sections are shown on **Drawing 1** and the profiles are provided on **Drawing 2** through **5.** The cross-section locations reviewed provide adequate coverage of the various slope profiles across the Site including the worst-case-scenarios.

5.1 Existing Slopes on Site

The slope located of the south side of the Site is generally the steepest slope on Site and has an overall inclination of approximately 2.1 horizontal to 1 vertical (2.1H:1V) with steepened sections of 1.4H:1. The height of the slope on the south side of the Site is approximately 4.4 m and is vegetated with grass, shrubbery and occasional trees.

The slope located on the east side of the Site is generally slope at inclinations of 4.0H:1V to 6.3H:1V with very minor localized steepened sections, generally located near the table lands. The steepened sections near the table lands are anticipated to be composed of fill materials placed to create a level pad for the existing residence. The slope heights on the east side generally range from 2.0 m to 5.5 m and are generally vegetated with grass and mature trees.

A small water course is located in the base of the ravine but is generally located more than 15 m from the base of the slope. Photographs of the slopes are provided in **Appendix B**.

5.2 Erosion Hazard Limit

As defined by the MNR Technical Guide, based on the type of river and stream system landform (confined or unconfined) the following figure provides guidance on which factors (hazard allowances) should be used in defining the erosion hazard limits.

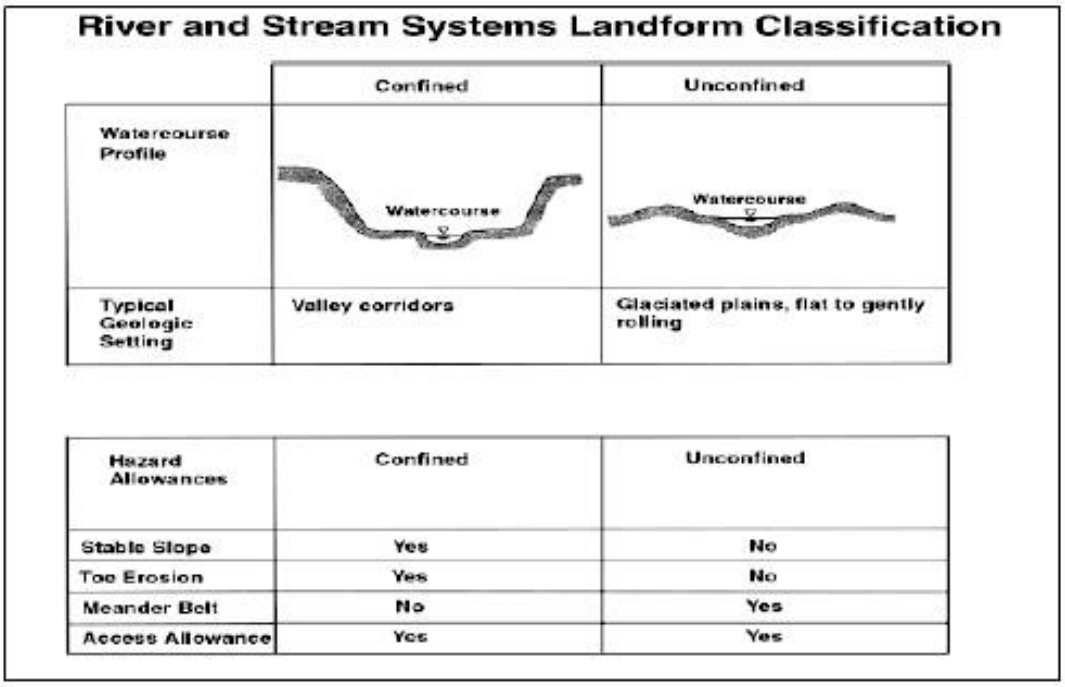


Figure obtained from page 35 of MNR Technical Guide – River and Stream Systems: Erosion Hazard Limit

As defined by the MNR Technical Guide, confined river and stream systems are ones in which the physical presence of a valley corridor containing a river or stream channel, which may or may not contain flowing water, is visibly discernable from the surrounding landscape by either field investigations, aerial photography and or map interpretation. The Erosion Hazard Limit for a confined system consists of the following hazard allowances:

- Toe Erosion Allowance
- Stable Slope Allowance
- Access Allowance

The slope and water course on the south side of the Site is considered to be a confined system. The grade on the east side of the Site is generally a very shallow gradient that does not exhibit discernable valley walls from the surrounding landscape. EXP believes that this portion of the slope on the east side could be classified as an unconfined system due to the gradual gradient and minimal risk associated with slope stability, in which case a meander belt allowance may be more applicable to the given conditions. However, the UTRCA advised that the entire Site should be classified as a confined system.

Ultimately, the Erosion Hazard Limit generally defines the development limit for the Site. Additional setbacks may also be required based on local Municipal and Conservation Authority requirements.

The top of the existing slope and toe of the existing slope were determined from the topographic mapping provided by MTE and observations made on Site. The top and toe of the slope were generally determined to be located where the slope inclination transitions to less than 4.0H:1V.

The setback distance from the slope crest varies slightly along the slope, based on the overall slope height and inclination. Four (4) cross sections (Cross Sections A-A' through D-D') have been shown on **Drawing 1** along the existing slope and were used for establishing the location of the Erosion Hazard Limit. Additionally, the extrapolated location of the Erosion Hazard Limit, top of existing slope, top of stable slope, toe erosion allowance and toe of slope are also provided on **Drawing 1** and on cross sectional **Drawings 2** through **Drawing 5**.

5.3 Toe Erosion Allowance

An unnamed water course is present in the base of the ravine located on the east and south side of the Site. The water course was observed to be located more than 11 m from the toe of the slope at all cross-section locations reviewed. Minor erosion was observed at the banks of the water course; however, no active toe erosion was observed along the toe of the slope.

Considering the nature of the soils at the base of the slope, expected to comprise dense sandy or dense to very dense silt till, a conservative toe erosion allowance of 5 m was applied from the edge of the water course in accordance with Table 3 in the MNR technical guide. It should be noted that since the toe of the slope is located more than 5 m from the toe of the slope, no toe erosion allowance is applied to the overall setback. Consideration was also given to toe erosion during flood conditions; however, the toe is generally well vegetated with grass, shrubbery and mature trees and are considered to provide adequate toe protection during the short-term flood conditions.

5.4 Stable Slope Geometry

The stability of the existing slope was investigated for a number of different Factors of Safety (FOS). The various types of failures resulting include shallow, moderate depth and deep rotational failures, occasionally through the entire height of the slope. The analyses were undertaken by computer methods utilizing the Slope/W computer program for select slope profiles.

The deterministic analyses were undertaken by computer methods utilizing the Slope/W computer program for select slope profile. The soil parameters used were conservative to build in an added safety factor for the analyses.

The soil conditions at the site are anticipated to generally consist of a fill over silt/sandy silt overlying till based on the boreholes advanced at the Site. The water level used in the slope model was conservatively estimated from observations recorded on the borehole logs. The influence of potential building loads was also considered in the analyses.

Based on correspondence with the UTRCA, it is understood that flood mapping of the area has not been completed, however, a very conservative regulatory flood elevation of 250.0 m asl was provided by the UTRCA for use in the slope stability analyses. Regulatory flood conditions were also considered in the slope analyses completed and results are provided in the table above.

The following table summarizes the parameters for the predominant soils which were used in EXP's evaluation of the stable slope configuration:

Table 4 – Existing Slope Soil Parameters

Soil Type	Density (kN/m^3)	Cohesion (kPa)	Angle of Internal Friction ( )
Fill	18.0	0	27
Loose Sandy Silt	18.5	0	30
Compact to Dense Silty Sand	18.5	0	32
Silt Till	21.5	2	33
Clayey Silt Till	21.5	5	31

Minimum factors of safety are provided in the report "Geotechnical Principles for Stable Slopes" prepared for the Ministry of Natural Resources, for active land-use (Section 4.3.3.1 in the MNR Technical Guide).

In order to determine a stable slope, a minimum factor of safety of 1.40 was used during the computerized for long term stable slope analyses. The following table from the MNR Technical Guide provides guidance on how to select a minimum factor of safety based on the intended land use above or below the slope.

Table 5 – Design Minimum Factor of Safety

Table 4.3

	LAND-USES	DESIGN MINIMUM FACTOR OF SAFETY
A	**PASSIVE**; no buildings near slope; farm field, bush, forest, timberland, woods, wasteland, badlands, tundra	1.10
B	**LIGHT**; no habitable structures near slope; recreational parks, golf courses, buried small utilities, tile beds, barns, garages, swimming pools, sheds, satellite dishes, dog houses	1.20 to 1.30
C	**ACTIVE**; habitable or occupied structures near slope; residential, commercial, and industrial buildings, retaining walls, storage/warehousing of non-hazardous substances	1.30 to 1.50
D	**INFRASTRUCTURE and PUBLIC USE**; public use structures or buildings (i.e., hospitals, schools, stadiums), cemeteries, bridges, high voltage power transmission lines, towers, storage/warehousing of hazardous materials, waste management areas	1.40 to 1.50

Table obtained from page 60 of MNR Technical Guide – River and Stream Systems: Erosion Hazard Limit

The cross sections were assessed and provides adequate coverage of the slope around the proposed development. The cross-section locations are shown on **Drawing 1** with the profile provided on **Drawing 2** through **Drawing 5**. Cross

Section A-A' and Cross Section C-C' were assessed using Slope/W as these sections represent the worst-case scenarios for the east and south slopes on Site. Summarized results of the slope stability analyses are provided in the following table for post development condition:

Table 6 - Summary of Pertinent Slope Stability Analyses

Cross Section Condition	Description of Failure Mode	Computed Factor of Safety
Slope Section, A-A'	Shallow Depth Failure	2.12
Slope Section, A-A'	Moderate Depth Failure	2.49
Slope Section, A-A'	Deep Rotational Failure	2.71
Slope Section, A-A' Flood Conditions	Minimum FOS	2.06
Slope Section, C-C'	Shallow Depth Failure	1.36
Slope Section, C-C'	Moderate Depth Failure	1.30
Slope Section, C-C'	Deep Rotational Failure	1.55
Slope Section, C-C' Flood Conditions	Minimum FOS	1.21

Based on the soil conditions encountered during the field investigation and based on the results of the computerized slope stability analysis a stable slope line of 2.1H:1V has been applied and should be considered suitable for the long-term stability of the slope based on the results of the current geotechnical study. The stable slope line should be applied from the toe of the slope where the slope is steeper than 2.1H:1V (Cross Sections C-C' and D-D'). The slopes located on the east side of the Site are overall much flatter than the computed stable slope and do not require a stable slope setback. These existing sections (Cross Section A-A' and B-B') are considered stable in the existing condition based on the analyses.

In addition to the stable slope geometry, an erosion access allowance should also be applied. This is described in the following section.

5.5 Erosion Access Allowance

The Erosion Access Allowance is required in order to provide emergency access to erosion prone areas, construction access for regular maintenance and access to the slope in the event of an erosion event of failure and provide protection against unforeseen or predicted external conditions as specified in Section 3.4 of the MNR Technical Guide.

The slope on the east side of the Site generally has a very shallow overall inclination (>4.0H:1V) and the height of the slope height is generally less than 5.5 m. From a geotechnical standpoint, an erosion access allowance of 4.0 m would be sufficient. Given that the slope inclination is generally less than 4.0H:1V, the slope will remain accessible for maintenance and emergencies with the reduced emergency access and the risk of slope failure is considerably less. An Erosion Access Allowance of 4.0 m still generally satisfies the intent of the erosion access allowance in this area. Select photographs of the east slope are provided below and in **Appendix B.**

The slope on the south side of the Site is generally steeper with overall inclinations of 2.1H:1V. In this area, it is recommended that an emergency access allowance of 6 m be applied form the top of the stable slope.

Photo 1 – East Side Gradual Slope Profile

Photo 2 – East Side Slope From Top of the Slope

5.6 Erosion Hazard Limit

The Erosion Hazard Limit is defined by the sum of the Stable Safe Slope Line plus the Toe Erosion Component plus the Erosion Access Allowance. The table below summarizes the three (3) components to the Recommended Development Limit Setback.

Table 7 – Erosion Hazard Limit Components

Cross Section	Toe Erosion Allowance (m)*	Stable Slope Allowance (From Top of Slope) (m)	Emergency Access Allowance (m)	Erosion Hazard Limit (From Top of Slope) (m)
A-A'	5.0	0.0	4.0	4.0
B-B'	5.0	0.0	4.0	4.0
C-C'	5.0	3.3	6.0	9.3
D-D'	5.0	3.6	6.0	9.6

*Toe erosion applied from the edge of the water course.

The Stable Slope Setback and Erosion Hazard Limit are shown on **Drawings 1**. Any proposed structures as part of the development should not encroach on the Erosion Hazard Limit.

5.7 UTRCA Generic Regulation

In 2006, Ontario Regulation 178/06 came into effect in the Upper Thames Conservation Authority (UTRCA) watershed, which locally implements the Generic Regulation (Development, Interference with Wetlands and Alterations to Shoreline and Watercourses). This regulation replaces the former Fill, Construction and Alteration to Waterways regulations, and is intended to ensure public safety, prevent property damage and social disruption, due to natural hazards such as flooding and erosion. Ontario Regulation 178/06 is implemented by the local Conservation Authority, by means of permit issuance for works in or near watercourses, valleys, wetlands, or shorelines, when required.

Property owners must obtain permission from the UTRCA before beginning any development, site alteration, construction, or placement of fill within the regulated area. Permits are also required for any wetland interference, or for altering, straightening, diverting or interfering in any way with the existing channel of a creek, stream or river. Proposed development within the study area will be subject to the above referenced Regulation. Consultation with the local Conservation Authority for review of site-specific development plans is recommended in this regard.

5.8 General Comments for Site Works

It is imperative that future changes to the development footprint not occur within the Erosion Hazard Limit identified at the Site. To this end, the following comments are provided, and measures are recommended.

- The site should be graded such that surface water is directed away from the slope. No water from the table land should be out-letted down the slope.
- Where possible, uncontrolled surface water flows over the face of the slope should be minimized, to reduce the risk of surface erosion. Erosion control measures may be required during construction, to reduce the risk of surface water flows from washing out non-vegetated surfaces.

- Indiscriminate stockpiling of fill or construction materials near the crest of the slope should be avoided. In the event that stockpiling of material is proposed in the vicinity of the slope crest, a review by the Geotechnical consultant is required.
- Any buildings and permanent structures associated with the proposed site development must be located outside of the Erosion Hazard Limit, which is identified on the Site Plan. The Cross Section drawing helps identify the location of this line.
- Water from downspouts and perimeter weeping tile etc. must also be collected in a controlled manner and re-directed away from the slope.
- Existing vegetation on the slope should be maintained. Any bare spots should be re-vegetated.
- A regular maintenance program should be implemented such as tree preservation, grading, and drainage control.
- Final design drawings including building locations, services etc. should be reviewed by a geotechnical consultant to ensure that the Erosion Hazard Limit is properly interpreted. Geotechnical inspection and testing is recommended during construction to confirm that all recommendations set out will be followed.

6. General Comments

The information presented in this report is based on a limited investigation designed to provide information to support an assessment of the current geotechnical conditions within the subject property. The conclusions and recommendations presented in this report reflect site conditions existing at the time of the investigation. Consequently, during the future development of the property, conditions not observed during this investigation may become apparent. Should this occur, EXP Services Inc. should be contacted to assess the situation, and the need for additional testing and reporting. EXP has qualified personnel to provide assistance in regards to any future geotechnical and environmental issues related to this property.

Our undertaking at EXP, therefore, is to perform our work within limits prescribed by our clients, with the usual thoroughness and competence of the engineering profession.

The comments given in this report are intended only for the guidance of design engineers. The number of test holes required to determine the localized underground conditions between test holes affecting construction costs, techniques, sequencing, equipment, scheduling, etc. would be much greater than has been carried out for design purposes. Contractors bidding on or undertaking the works should in this light, decide on their own investigations, as well as their own interpretations of the factual borehole results, so that they may draw their own conclusions as to how the subsurface conditions may affect them.

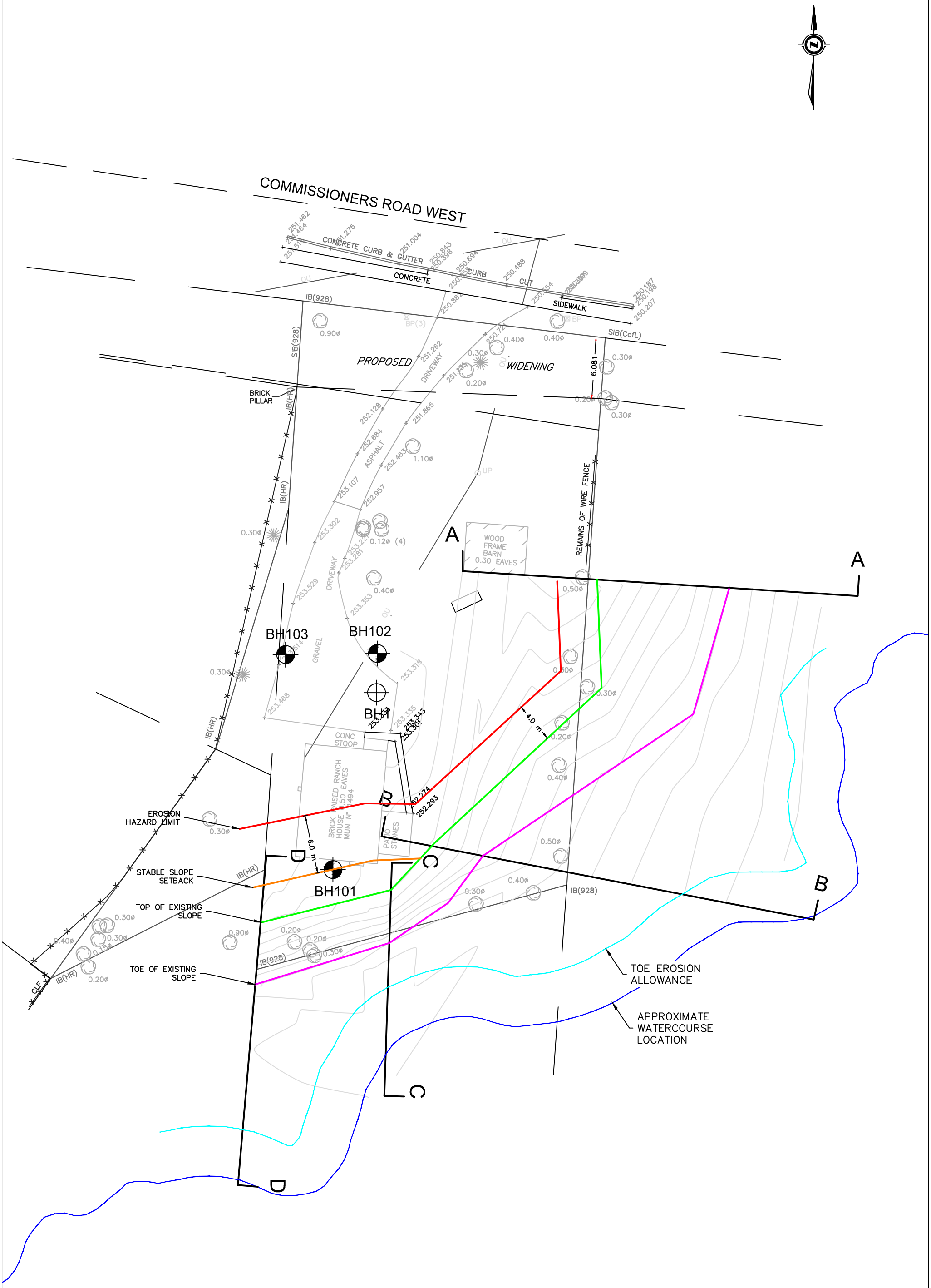
EXP Services Inc. should be retained for a general review of the final design and specifications to verify that this report has been properly interpreted and implemented. If not afforded the privilege of making this review, EXP Services Inc. will assume no responsibility for interpretation of the recommendations in this report.

This report was prepared for the exclusive use of **David Moubarak** and may not be reproduced in whole or in part, without the prior written consent of EXP, or used or relied upon in whole or in part by other parties for any purposes whatsoever. Any use which a third party makes of this report, or any part thereof, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. EXP Services Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

We trust this report is satisfactory for your purposes. Should you have any questions, please do not hesitate to contact this office.

Drawings

15701 Robin’s Hill Road | London, Ontario | Canada
t: +1.519.963.3000 | f: +1.519.963.1152 | exp.com



-LEGEND-

BH103	Approximate Borehole Location (EXP 2022)
BH1	Approximate Borehole Location (EXP 2011)
	Bottom of Existing Slope
	Top of Existing Slope
	Stable Slope Setback
	Erosion Hazard Limit

-NOTES-

1. The site plan was reproducted from a drawing provided by MTE and should be read in conjunction with EXP Geotechnical Report LON-22006399-A0

Geotechnical Investigation

Proposed Apartment Building

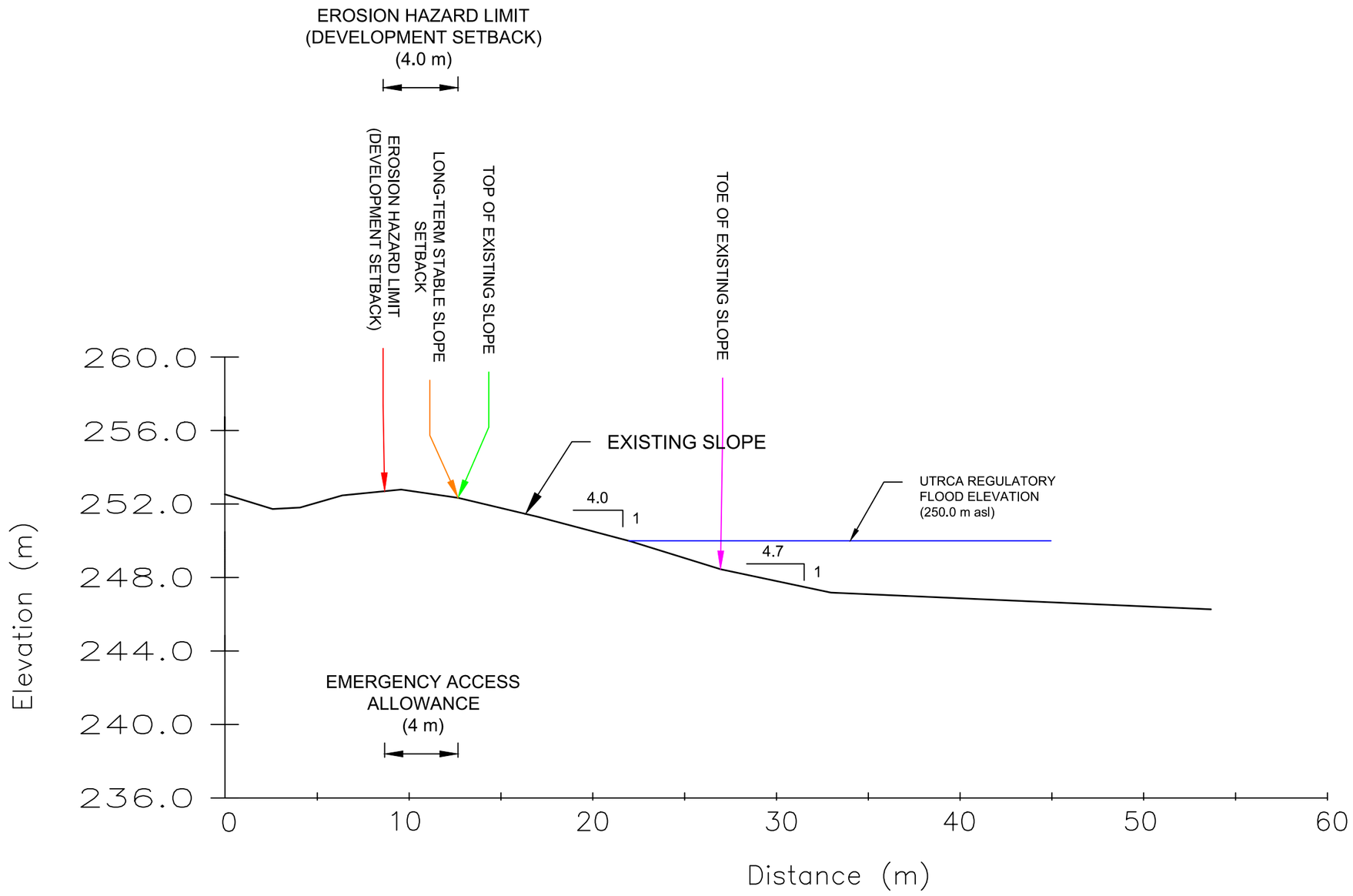
1494 Commissioners Road West ,
London, Ontario

CLIENT	David Moubarak
TITLE	Site Plan
DRAWN BY:	M.B.
REVIEWED BY:	A.S.
DATE	OCTOBER 2022

EXP Services Inc.
15701 Robin's Hill Road
London, ON, N5V 0A5

SCALE	PROJECT NO.	DWG.
NTS	LON-22006399-A0	1

CROSS SECTION A-A'



-NOTES-

1. The cross section diagram should be read in conjunction with EXP Geotechnical Report LON-22006399-A0.

2. Refer to Drawing 1 for cross section location.

Geotechnical Investigation

Proposed Apartment Building

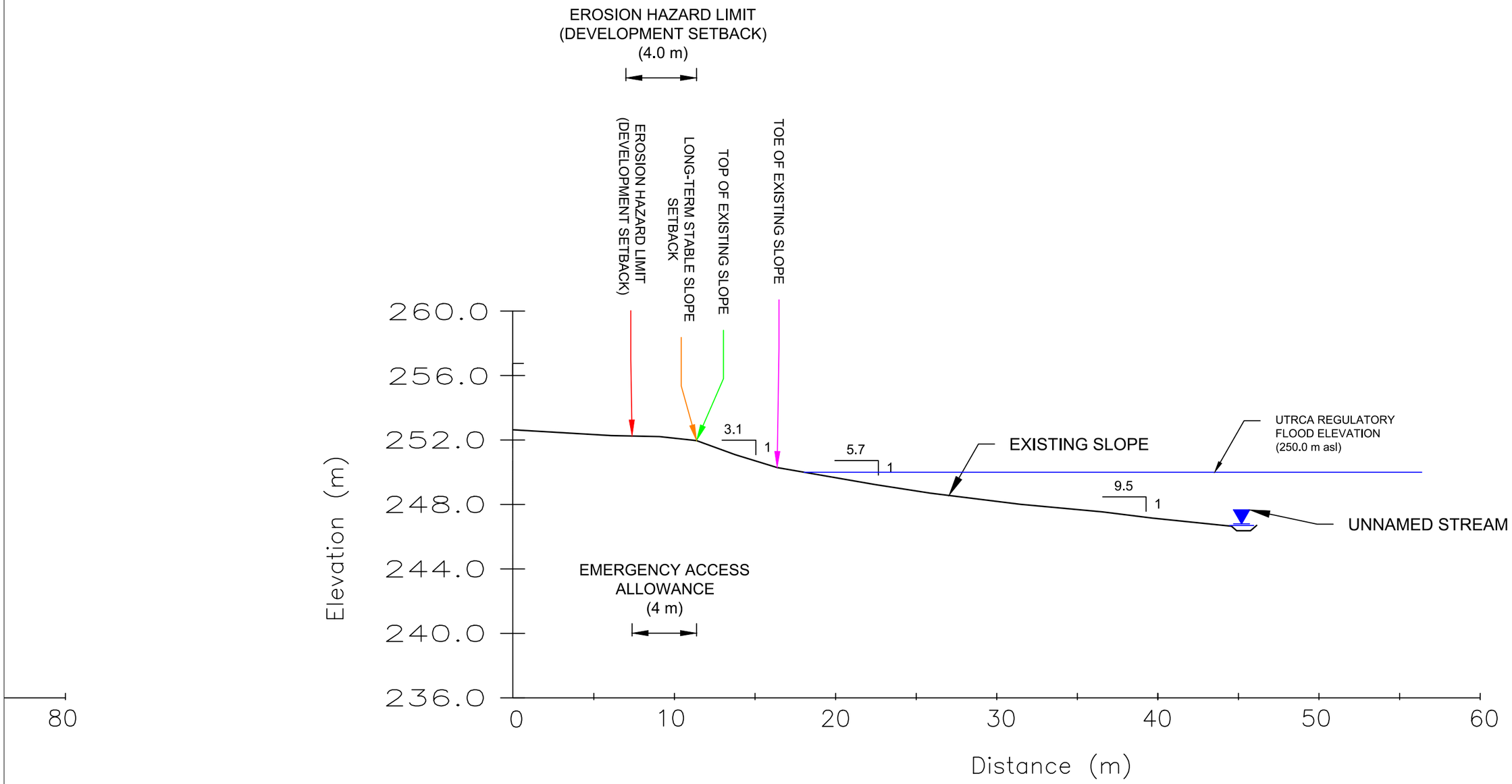
1494 Commissioners Road West,
London, Ontario

CLIENT	David Moubarak
TITLE	Cross Section A-A'
Prepared By: M.B.	Reviewed By: A.S.

EXP Services Inc.
15701 Robin's Hill Road, London, ON, N5V 0A5

DATE	SCALE	PROJECT NO.	DWG.
OCTOBER 2022	1:250	LON-22006399-A0	2

CROSS SECTION B-B'



-NOTES-

1. The cross section diagram should be read in conjunction with EXP Geotechnical Report LON-22006399-A0.

2. Refer to Drawing 1 for cross section location.

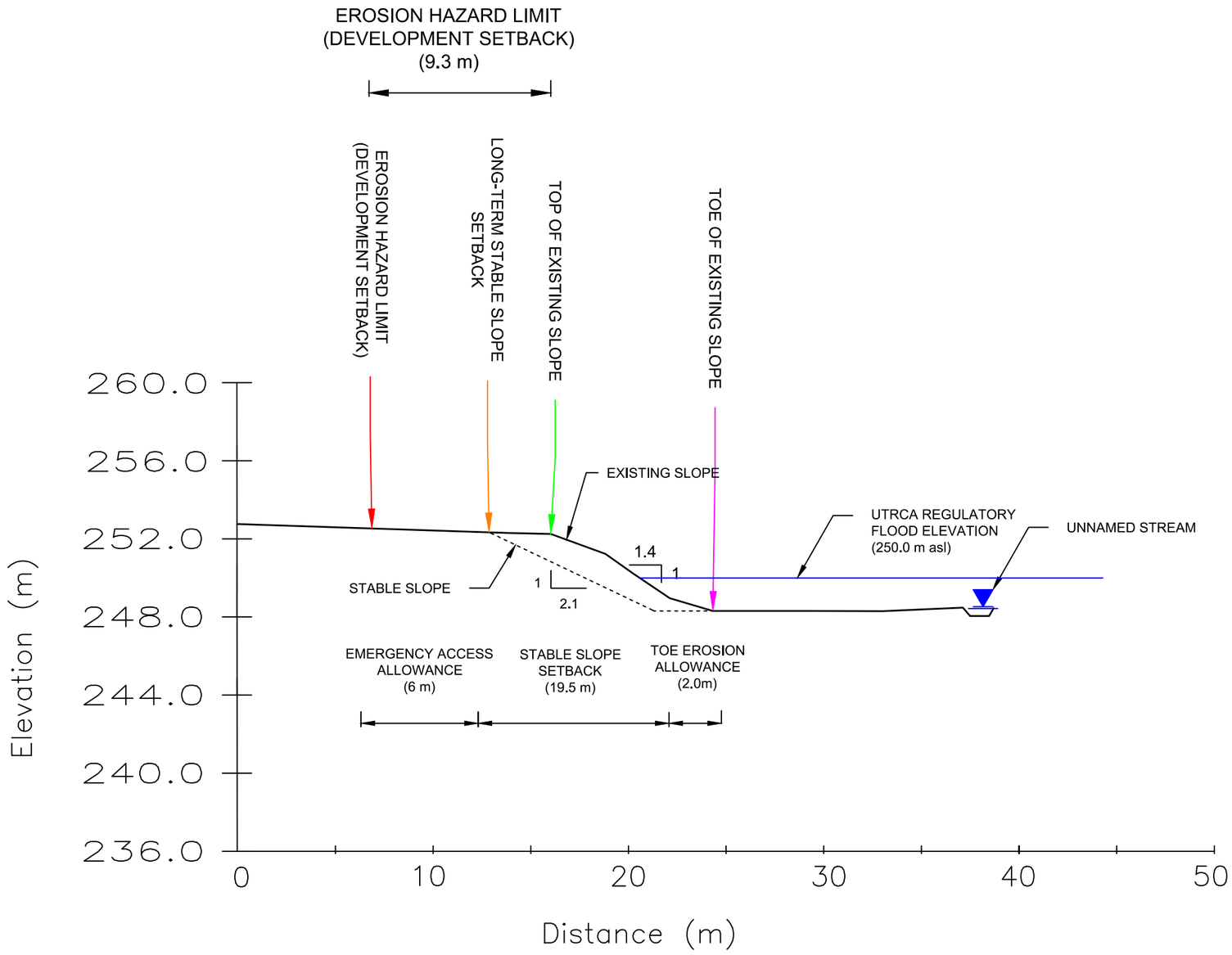
Geotechnical Investigation

Proposed Apartment Building

1494 Commissioners Road West,
London, Ontario

CLIENT	David Moubarak
TITLE	Cross Section B-B'
Prepared By: M.B.	Reviewed By: A.S.
	EXP Services Inc. 15701 Robin's Hill Road, London, ON, N5V 0A5
DATE: OCTOBER 2022	SCALE: 1:250
PROJECT NO.: LON-22006399-A0	DWG.: 3

CROSS SECTION C-C'



-NOTES-

1. The cross section diagram should be read in conjunction with EXP Geotechnical Report LON-22006399-A0.

2. Refer to Drawing 1 for cross section location.

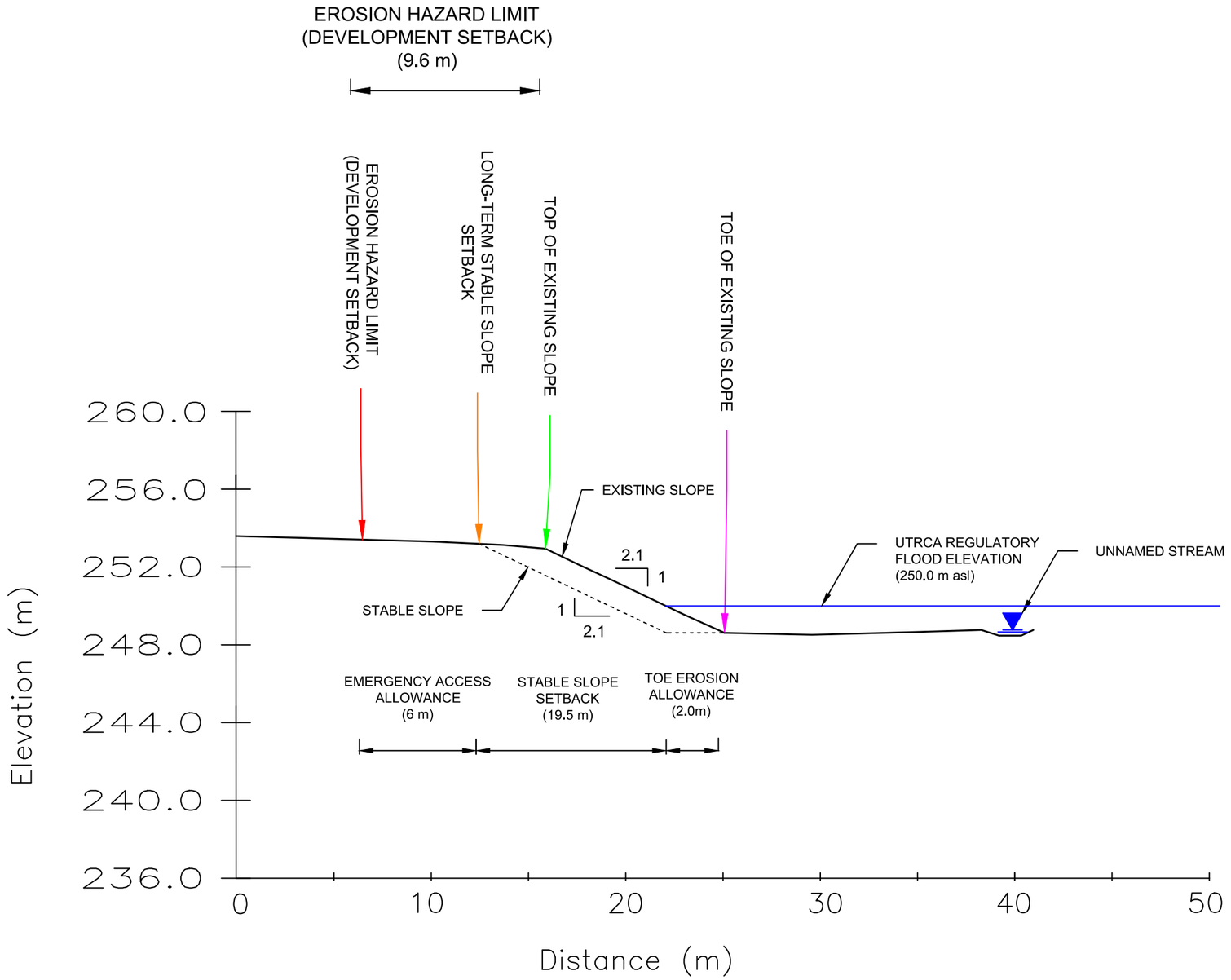
Geotechnical Investigation

Proposed Apartment Building

1494 Commissioners Road West,
London, Ontario

CLIENT	David Moubarak
TITLE	Cross Section C-C'
Prepared By: M.B.	Reviewed By: A.S.
EXP Services Inc.	15701 Robin's Hill Road, London, ON, N5V 0A5
DATE: OCTOBER 2022	SCALE: 1:250
PROJECT NO.: LON-22006399-A0	DWG.: 4

CROSS SECTION D-D'



-NOTES-

1. The cross section diagram should be read in conjunction with EXP Geotechnical Report LON-22006399-A0.

2. Refer to Drawing 1 for cross section location.

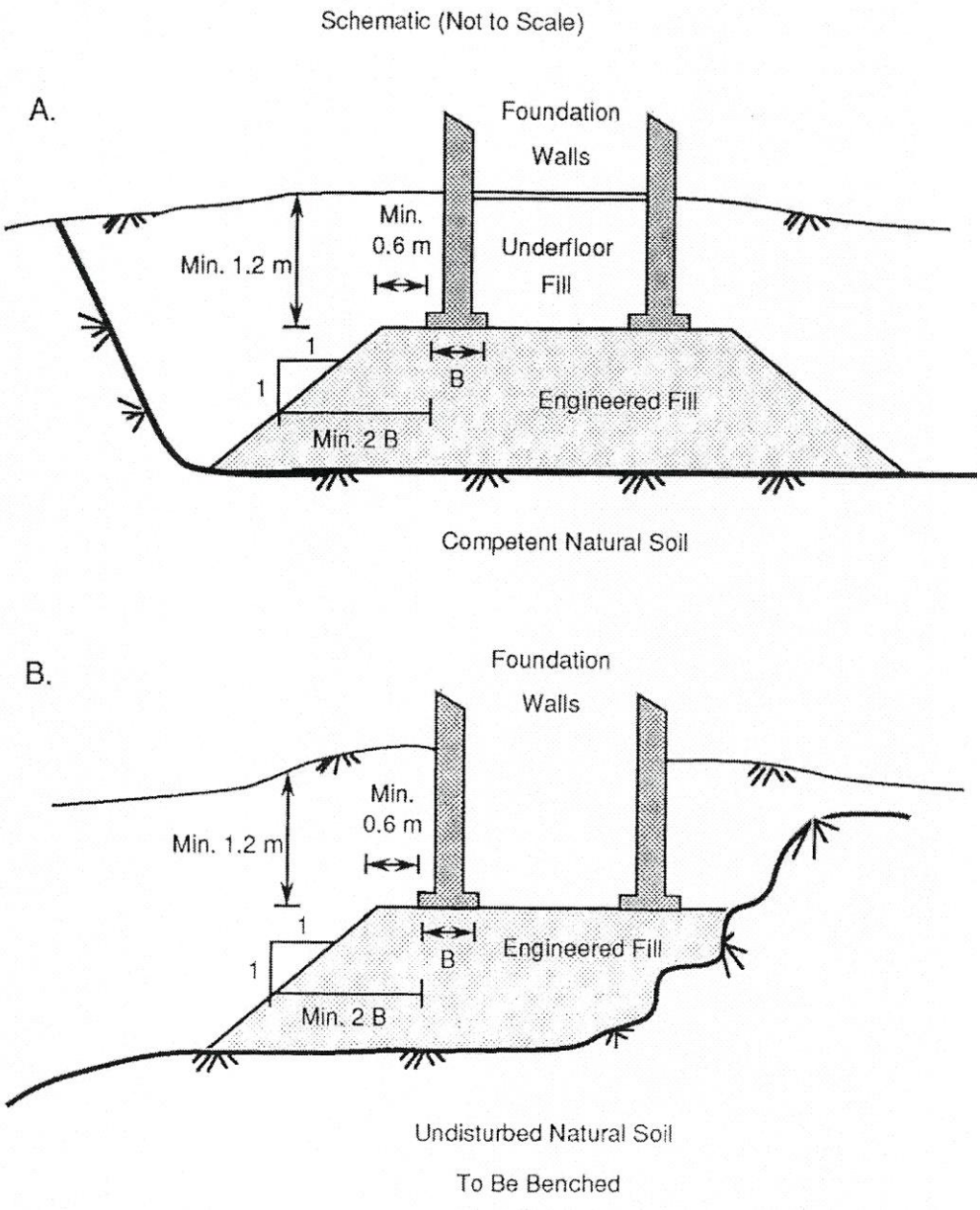
Geotechnical Investigation

Proposed Apartment Building

1494 Commissioners Road West,
London, Ontario

CLIENT	David Moubarak
TITLE	Cross Section D-D'
Prepared By: M.B.	Reviewed By: A.S.
	EXP Services Inc. 15701 Robin's Hill Road, London, ON, N5V 0A5
DATE: OCTOBER 2022	SCALE: 1:250
PROJECT NO.: LON-22006399-A0	DWG.: 5

DRAWING 6 – GEOMETRIC REQUIREMENTS FOR FOUNDATIONS ON ENGINEERED FILL



SECTION VIEW

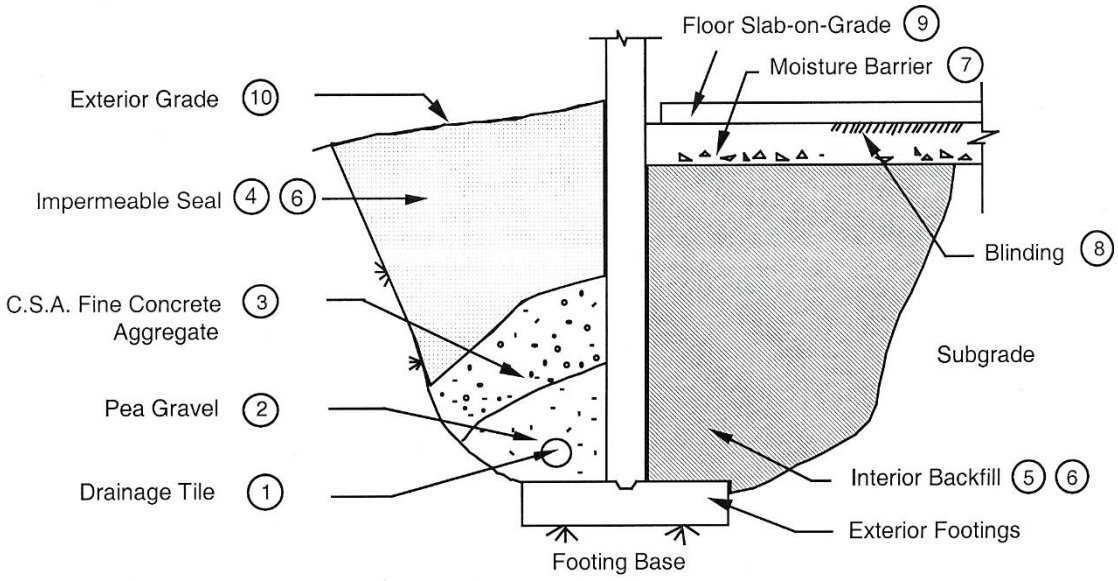
Section A – Typical Section of Slab-on-Grade Building
Section B – Typical Section of Building with Basement

Refer to Detailed Notes on following page.

NOTES FOR ENGINEERED FILL PLACMENT:

1. The area must be stripped of all topsoil contaminated fill material, and other unsuitable soils, and proof rolled. Soft spots must be dug out. The stripped natural subgrade must be examined and approved by an EXP Engineer prior to placement of engineered fill.
2. In areas where engineered fill is placed on a slope, the fill should be benched into the approved subgrade soils. EXP would be pleased to provide additional comments and recommendations in this regard, if required.
3. All excavations must be carried out in accordance with the Occupational Health and Safety Regulation of Ontario (Construction Projects - O.Reg. 213.91)
4. Material used for engineered fill must be free of topsoil, organics, frost and frozen material, and otherwise unsuitable or compressible soils, as determined by a Geotechnical Engineer. Any material proposed for use as engineered fill must be examined and approved by EXP, prior to use onsite. Clean compactable granular fill is preferred.
5. Approved engineered fill should be placed in maximum 300 mm thick lifts, and uniformly compacted to 100% Standard Proctor dry density throughout. For best compaction results, engineered fill should be within 3 percent of its optimum moisture content, as determined by the Standard Proctor density test. Imported fill should satisfy the MECP regulations and requirements.
6. Full time geotechnical monitoring, inspection and *in situ* density (compaction) testing by EXP is required during placement of the engineered fill.
7. Site grades should be maintained during area grading activities to promote drainage, and to minimize ponding of surface water on the engineered fill mat. Rutting by construction equipment should be kept to a minimum, where possible. Additional work to ensure suitability of engineered fill may be required if fill is placed in extreme (hot/cold) weather.
8. The fill must be placed such that the specified geometry is achieved. Refer to sketches (previous page) for minimum requirements. Proper environmental protection will be required, such as providing frost penetration during construction, and after the completion of the engineered fill mat.
9. An allowable bearing pressure of 145 kPa (3000 psf) may be used provided that all conditions outlined above, and in the Geotechnical Report are adhered to.
10. These guidelines are to be read in conjunction with the attached Geotechnical Report. (EXP Project No. LON-22006399-A0)
11. For foundations set on engineered fill, footing enhancement and/or concrete reinforcing steel placement is recommended. The footing geometry and extent of concrete reinforcing steel will depend on site specific conditions. In general, consideration may be given to having a minimum strip footing width of 500 mm (20 inches), containing nominal steel reinforcement. Alternatively, concrete reinforcement may be recommended in the top and bottom of the foundation wall strip. The final footing geometry and extent of reinforcement is best determined in the field, by a Geotechnical Engineer.

DRAWING 7 – DRAINAGE AND BACKFILL RECOMMENDATIONS (NOT TO SCALE)

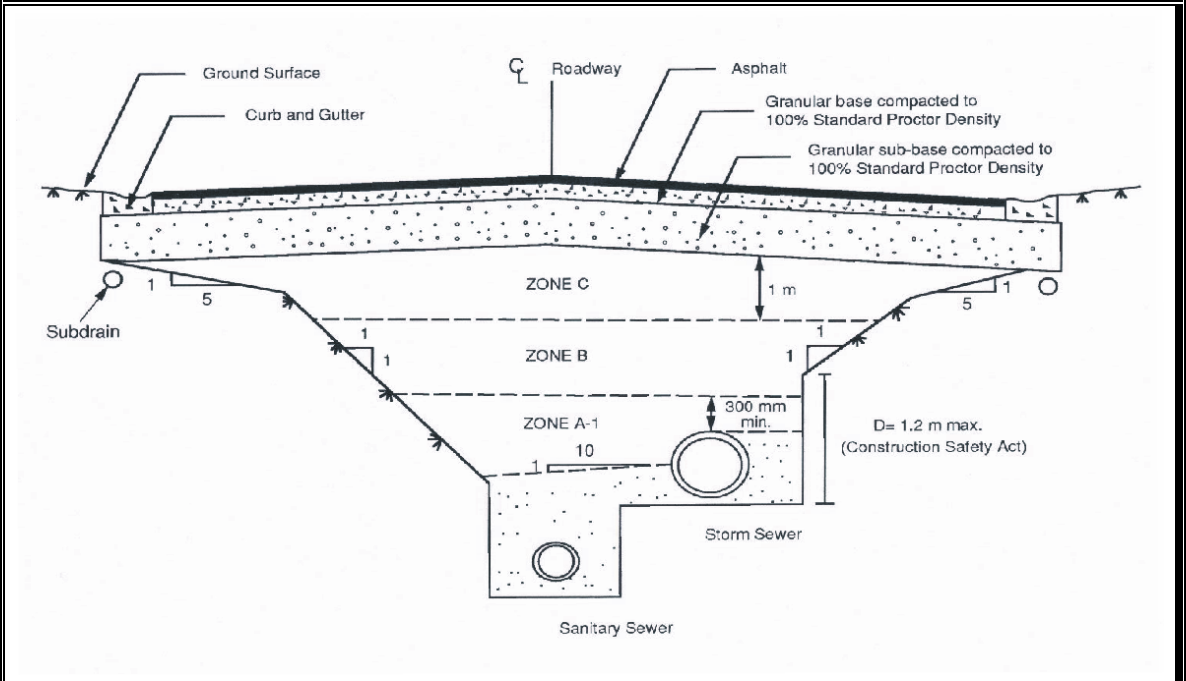


NOTES:

1. Drainage tile to consist of 100 mm (4 in.) diameter weeping tile or equivalent perforated pipe leading to a positive sump or outlet. Invert to be minimum of 150 mm (6 in.) below underside of interior floor slab.
2. Pea gravel 150 mm (6 in.) top and sides of drain. If drain is not on footing, place 100 mm (4 in.) of pea gravel below drain. 20 mm (3/4 in.) clear stone may be used provided if it is covered by an approved porous geotextile fabric membrane (Terrafix 270R or equivalent).
3. C.S.A. fine concrete aggregate to act as filter material. Minimum 300 mm (12 in.) top and side of drain. This may be replaced by an approved porous geotextile membrane (Terrafix 270R or equivalent).
4. Impermeable backfill seal of compacted clay, clayey silt or equivalent. If original soil is free-draining, seal may be omitted. Compact backfill to 95 percent Standard Proctor Maximum Dry Density.
5. The interior fill may be any clean, inorganic soil which may be compacted to at least 95 percent Standard Proctor density in this confined space.
6. Do not use heavy compaction equipment within 450 mm (18 in.) of the wall. Do not fill or compact within 1.8 m (6 ft) of wall unless fill is placed on both sides simultaneously.
7. Moisture barrier to be at least 200 mm (8 in.) of compacted 20 mm (3/4 in.) clear, crushed stone or equivalent free-draining material.
8. If the 20 mm (3/4 in.) clear stone requires surface binding, use 60 mm (1/4 in.) clear stone chips.
9. Slab on grade should not be structurally connected to wall or footing.
10. Exterior grade to slope away from building.

This system is not normally required if the floor is at least 300 mm (1 ft.) above exterior grade.

DRAWING 8 – TYPICAL BACKFILL DETAIL
STORM AND SANITARY SEWER (COMMON TRENCH)



SECTION VIEW

NOTES:

ZONE A
Granular bedding satisfying current OPS Standards compacted to 95% Standard Proctor maximum dry density.

ZONE A-l
To be compacted to 95% Standard Proctor maximum dry density.

ZONE B
To be compacted to 95% Standard Proctor maximum dry density.

ZONE C
To be compacted to 98% Standard Proctor maximum dry density.

The excavations shown above are for Type 1 or 2 soils. Where excavations extend through Type 3 soils, the side walls should be sloped back at a maximum inclination of 1 horizontal to 1 vertical from the base (Reference O.Reg 219/31).

DRAWING 9 – TRENCH BACKFILL REQUIREMENTS

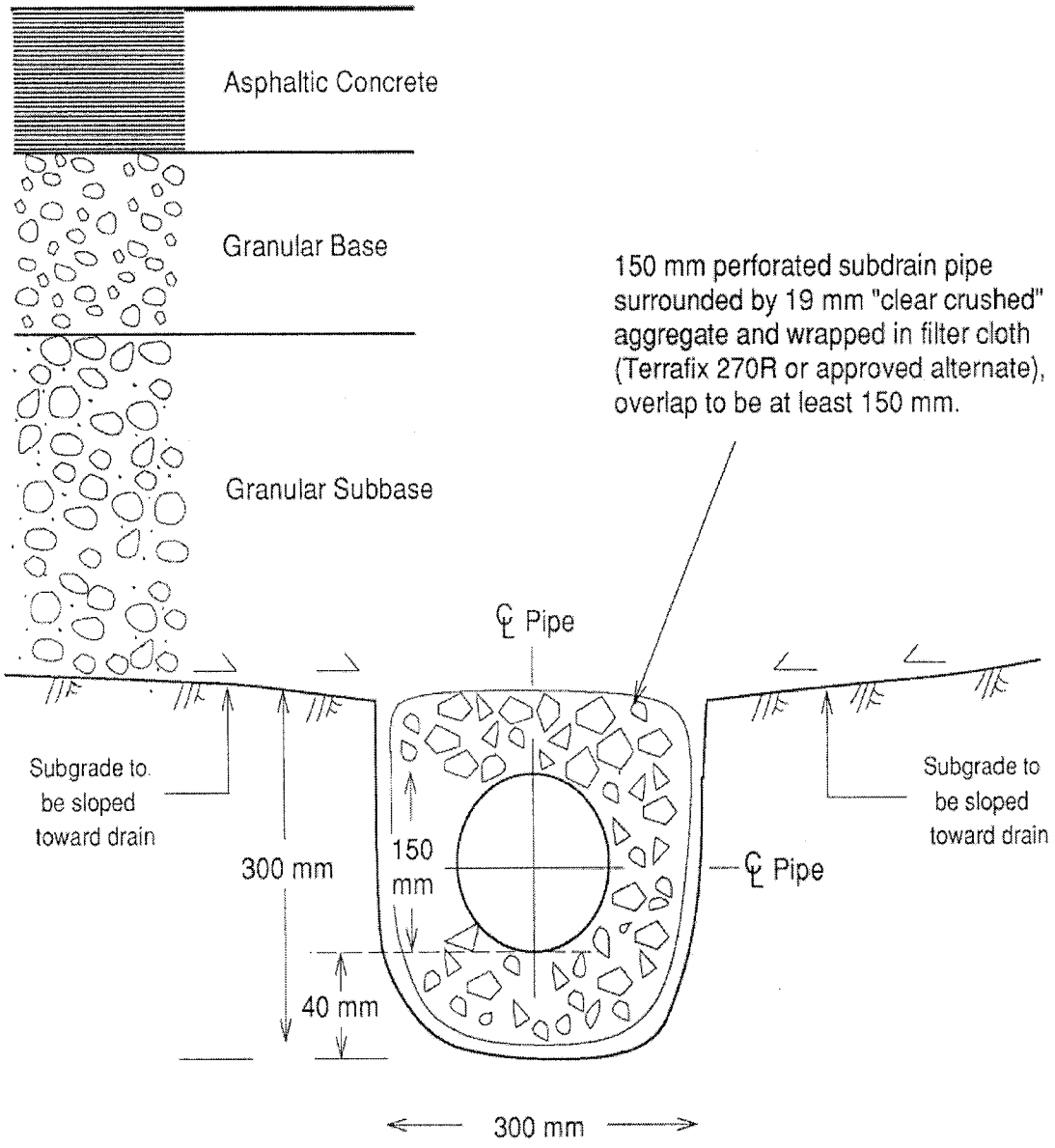
Requirements for backfill in service trenches, etc. should conform to current OPSS requirements. A summary of the general recommendations for trench backfill is presented on **Drawing 8**.

The bedding materials for the services designated as Zone A on the attached drawings should consist of approved granular material satisfying the current OPSS minimum standards and specifications. (Class B bedding should provide adequate support for the pipes). These materials should be uniformly compacted to 95 percent of standard Proctor dry density. Some problems may be encountered in maintaining alignment when bedding pipes in wet sandy soil. If Granular 'A' or other sandy material is used for bedding, they may become 'spongy' when saturated. If significant amounts of clear stone are used to stabilize the base, a geotextile should be incorporated to avoid problems with migration of fine grained materials and differential settlement under the pipes as the groundwater rises after backfilling. For minor local use of crushed stone without a geotextile filter, a graded HL3 stone is preferable.

The backfill in Zone B will consist of the native material. This material should be placed in loose lifts not exceeding 300 mm (12 inches) and be uniformly compacted to 95 percent of the standard Proctor maximum dry density. Material wetter than 5 percent above optimum must be allowed to dry sufficiently or should be discarded or used in landscaped areas.

The upper 1 meter of the general backfill (i.e. Zone C) should be placed in loose lifts not exceeding 300 mm (12 inches) and be uniformly compacted to at least 98 percent of the standard Proctor maximum dry density. To achieve satisfactory compaction, the fill material should be within 3 percent of standard Proctor optimum moisture content at placement.

DRAWING 10 – PAVEMENT SUBDRAIN DETAIL



NOTES:

1. All dimensions in millimetres.
2. All sub drains to be set on at least 1% grade draining to a positive outlet.
3. Subgrade soil conditions should be verified onsite, during subgrade preparation works, following site servicing installations.

Scale: NTS

Appendix A – Borehole Log

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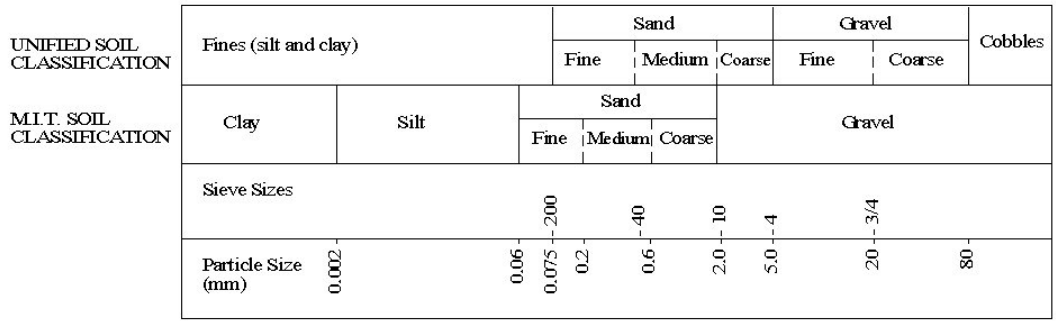
NOTES ON SAMPLE DESCRIPTIONS

1. All descriptions included in this report follow the 'modified' Massachusetts Institute of Technology (M.I.T.) soil classification system. The laboratory grain-size analysis also follows this classification system. Others may designate the Unified Classification System as their source; a comparison of the two is shown for your information. Please note that, with the exception of those samples where the grain size analysis has been carried out, all samples are classified visually and the accuracy of the visual examination is not sufficient to differentiate between the classification systems or exact grain sizing. The M.I.T. system has been modified and the EXP classification includes a designation for cobbles above the 75 mm size and boulders above the 200 mm size.



2. **Fill**: Where fill is designated on the borehole log, it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description therefore, may not be applicable as a general description of the site fill material. All fills should be expected to contain obstructions such as large concrete pieces or subsurface basements, floors, tanks, even though none of these obstructions may have been encountered in the borehole. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact and correct composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. The fill at this site has been monitored for the presence of methane gas and the results are recorded on the borehole logs. The monitoring process neither indicates the volume of gas that can be potentially generated or pinpoints the source of the gas. These readings are to advise of a potential or existing problem (if they exist) and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic waste that renders the material unacceptable for deposition in any but designated land fill sites; unless specifically stated, the fill on the site has not been tested for contaminants that may be considered hazardous. This testing and a potential hazard study can be carried out if you so request. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common, but not detectable using conventional geotechnical procedures.

3. **Glacial Till**: The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process, the till must be considered heterogeneous in composition and as such, may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (75 to 200 mm in diameter) or boulders (greater than 200 mm diameter) and therefore, contractors may encounter them during excavation, even if they are not indicated on the borehole logs. It should be appreciated that normal sampling equipment can not differentiate the size or type of obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited area; therefore, caution is essential when dealing with sensitive excavations or dewatering programs in till material.

BOREHOLE LOG

BH101
Sheet 1 of 1

CLIENT **David Moubarak** PROJECT NO. **LON-22006399-A0**
PROJECT **1494 Commissioners Road West** DATUM **Geodetic**
LOCATION **London, ON** DATES: Boring **May 4, 2022** Water Level

DEPTH (m bgs)	ELEVATION (~m)	STRATA DESCRIPTION	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N VALUE (blows)	MOISTURE CONTENT (%)
0	252.8						
	252.5	**TOPSOIL** - 300 mm					
		FILL - silty sand, dark brown/black, trace organics, very loose, moist	SS	S1	400	1	13
1			SS	S2	300	2	9
2	250.7						
		CLAYEY SILT TILL - brown, trace gravel, trace sand, very stiff, moist	SS	S3	350	16	18
	249.9						
3		**SANDY SILT** - brown, occasional sand layering, dilatant, compact to dense, wet	SS	S4	300	20	19
4							
		- clayey silt layering encountered near 4.3 m bgs	SS	S5	400	35	20
5							
6			SS	S6	300	58	18
7	245.7						
		SILT TILL - grey, occasional dilatant layering, very dense, moist	SS	S7	400	50*	15
8							
9	243.7		SS	S8	400	51	10
		End of borehole at 9.1 m bgs.					
10							

WELL LOG: ▽

SHEAR STRENGTH
S Field Vane Test (#=Sensitivity)
▲ Penetrometer ■ Torvane
100 200 kPa

Atterberg Limits and Moisture
W_P W W_L
● SPT N Value × Dynamic Cone
10 20 30 40

NOTES

1) Borehole Log interpretation requires assistance by EXP before use by others. Borehole Log must be read in conjunction with EXP Report LON-22006399-A0.
2) Borehole open to 6.6 m bgs and water was measured near 6.6 m bgs upon completion of drilling.
3) * denotes 50 blows per less than 150 mm split spoon sampler penetration.
4) bgs denotes below ground surface.

SAMPLE LEGEND
☒ AS Auger Sample ▨ SS Split Spoon ■ ST Shelby Tube
▥ Rock Core (eg. BQ, NQ, etc.) ▥ VN Vane Sample

OTHER TESTS

G Specific Gravity	C Consolidation
H Hydrometer	CD Consolidated Drained Triaxial
S Sieve Analysis	CU Consolidated Undrained Triaxial
γ Unit Weight	UU Unconsolidated Undrained Triaxial
P Field Permeability	UC Unconfined Compression
K Lab Permeability	DS Direct Shear

WATER LEVELS
▽ Apparent ▼ Measured ▲ Artesian (see Notes)

BOREHOLE LOG

BH102
Sheet 1 of 1

CLIENT **David Moubarak** PROJECT NO. **LON-22006399-A0**
PROJECT **1494 Commissioners Road West** DATUM **Geodetic**
LOCATION **London, ON** DATES: Boring **May 4, 2022** Water Level

DEPTH (m bgs)	ELEVATION (~m)	STRATA DESCRIPTION	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N VALUE (blows)	MOISTURE CONTENT (%)
	253.3						
0	253.1	**TOPSOIL** - 200 mm					
		FILL - silty sand, dark brown, trace organics, very loose, very moist					
1			SS	S1	400	2	15
	251.6						
		SILTY SAND - brown, occasional sand layering, loose to compact, moist	SS	S2	450	9	13
2							
			SS	S3	400	14	11
	250.4						
3	250.1	**SAND & GRAVEL** - brown, dense, damp					
		SILT TILL - brown, trace to some clay, some sand to sandy, trace gravel, occasional cobbles, dense, moist	SS	S4	300	42	6
4							
5			SS	S5	400	46	16
6		-becoming wet near 6.0 m bgs					
	246.8		SS	S6	400	40	21
		End of borehole at 6.6 m bgs.					
7							
8							
9							
10							

SHEAR STRENGTH
S Field Vane Test (#=Sensitivity)
Penetrometer Torvane
100 200 kPa
Atterberg Limits and Moisture
W_P W W_L
SPT N Value Dynamic Cone
10 20 30 40

NOTES

1) Borehole Log interpretation requires assistance by EXP before use by others. Borehole Log must be read in conjunction with EXP Report LON-22006399-A0.
2) Borehole open to 5.5 m bgs and water was measured near 5.5 m bgs upon completion of drilling.
3) bgs denotes below ground surface.

SAMPLE LEGEND
AS Auger Sample SS Split Spoon ST Shelby Tube
Rock Core (eg. BQ, NQ, etc.) VN Vane Sample

OTHER TESTS
G Specific Gravity C Consolidation
H Hydrometer CD Consolidated Drained Triaxial
S Sieve Analysis CU Consolidated Undrained Triaxial
Unit Weight UU Unconsolidated Undrained Triaxial
P Field Permeability UC Unconfined Compression
K Lab Permeability DS Direct Shear

WATER LEVELS
Apparent Measured Artesian (see Notes)

BOREHOLE LOG

BH103
Sheet 1 of 1

CLIENT **David Moubarak** PROJECT NO. **LON-22006399-A0**
PROJECT **1494 Commissioners Road West** DATUM **Geodetic**
LOCATION **London, ON** DATES: Boring **May 4, 2022** Water Level

DEPTH (m bgs)	ELEVATION (~m)	STRATA DESCRIPTION	STRATA PLOT	WELL LOG	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N VALUE (blows)	MOISTURE CONTENT (%)
0	253.5								
	253.4	**GRANULAR** - 110 mm							
		FILL - silty sand, brown to black, some organics, very loose, moist			SS	S1	300	2	12
1									
	251.8				SS	S2	450	3	14
2		**SILTY SAND** - brown, occasional silt layering, loose to dense, moist							
					SS	S3	300	4	13
3									
					SS	S4	400	5	16
4		-becoming wet near 3.5 m bgs							
				▽	SS	S5	450	16	23
5									
6									
	247.0				SS	S6	450	38	22
		End of borehole at 6.6 m bgs.							
7									
8									
9									
10									

SHEAR STRENGTH
S Field Vane Test (#=Sensitivity)
Penetrometer Torvane
100 200 kPa
Atterberg Limits and Moisture
W_P W W_L
SPT N Value Dynamic Cone
10 20 30 40

NOTES

1) Borehole Log interpretation requires assistance by EXP before use by others. Borehole Log must be read in conjunction with EXP Report LON-22006399-A0.
2) Borehole open to 5.2 m bgs and water was measured near 5.2 m bgs upon completion of drilling.
3) bgs denotes below ground surface.

SAMPLE LEGEND
AS Auger Sample SS Split Spoon ST Shelby Tube
Rock Core (eg. BQ, NQ, etc.) VN Vane Sample

OTHER TESTS
G Specific Gravity C Consolidation
H Hydrometer CD Consolidated Drained Triaxial
S Sieve Analysis CU Consolidated Undrained Triaxial
γ Unit Weight UU Unconsolidated Undrained Triaxial
P Field Permeability UC Unconfined Compression
K Lab Permeability DS Direct Shear

WATER LEVELS
▽ Apparent ▼ Measured ▲ Artesian (see Notes)

BOREHOLE LOG

BH1
Sheet 1 of 1

PROJECT **1494 Commissioners Road West** PROJECT NO. **LON00011327-GE**
CLIENT **David Moubarak** DATUM **Geodetic**
DRILL TYPE/METHOD **Solid Stem Auger** DATES: Boring **June 6, 2011** Water Level **June 6/11**

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	STRATA PLOT	WELL LOG	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm) or (%)	SAMPLES N VALUE (blows) or RQD (%)	OTHER TESTS
0	253.35								
	253.20	**TOPSOIL**, brown, silty sand loam, loose, moist							
		FILL - SAND, brown, fine grained, some silt, trace to some topsoil inclusions, trace gravel, loose, moist							
1						S1	400	7	
						S2	400	8	
	251.55								
2		**SAND**, brown, fine to medium grained, some gravel, some silt, compact, moist				S3	400	19	
3		-becoming dense sand and gravel below 3.1 m depth				S4	300	48	
4		-some fine gravel with trace clay layering and cobbles below 3.8 m depth				S5			
		-some silt layering below 4.5 m depth							
	248.45					S6	400	32	
5		**SILT**, brown/grey, dilatant, some fine grained sand, dense, wet							
6		-becoming grey below 6.1 m depth				S7	460	38	
7									
	245.45					S8	460	87	
8	245.27	**SILT TILL**, grey, some fine sand, trace clay, trace fine gravel, very dense, moist							
		End of Borehole at 8.08 m depth							

SHEAR STRENGTH
✚ S Field Vane Test (#=Sensitivity)
▲ Penetrometer ■ Torvane
100 200 kPa
Atterberg Limits and Moisture
W_P W W_L
● SPT N Value × Dynamic Cone
10 20 30 40

NOTES

1) Borehole interpretation requires assistance by Trow before use by others. Borehole Logs must be read in conjunction with Trow Report LON00011327-GE. For definition of terms used on logs, see sheets prior to logs.

2) Borehole open to 5.2 m and dry upon completion of drilling.

3) Ground surface elevation surveyed by Whitney Engineering Inc.

SAMPLE LEGEND
☒ AS Auger Sample ▨ SS Split Spoon ■ ST Shelby Tube
▥ Rock Core (eg. BQ, NQ, etc.) ▣ VN Vane Sample

OTHER TESTS

G Specific Gravity	C Consolidation
H Hydrometer	CD Consolidated Drained Triaxial
S Sieve Analysis	CU Consolidated Undrained Triaxial
γ Unit Weight	UU Unconsolidated Undrained Triaxial
P Field Permeability	UC Unconfined Compression
K Lab Permeability	DS Direct Shear

WATER LEVELS
▽ Apparent ▼ Measured ▲ Artesian (see Notes)

Appendix B – Site Photographs

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Photo 1 –Slope Profile Near Cross Section A-A'

Photo 2 – Shallow Slope Profile Near Cross Section B-B'

Photo 3 – Slope Profile Near Cross Section B-B'

Photo 3 – Southern Slope Profile (Cross Sections C-C' and D-D')

Appendix C – Slope Stability Rating Charts

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Slope Stability Rating Chart

Geotechnical Principles for Stable Slopes
Ontario Ministry of Natural Resources

Cross Section A-A'

Site Location: 1494 Commissioners Road West	**Project No.:** LON-22006399-A0
Town/City: London, ON	**Inspection Date:** March 2, 2022
Inspected by: V.C	**Weather:** Overcast, -2ºC

	Rating Value	Slope Rating
Slope Inclination		
18 degrees or less (3H:1V or flatter)	0	0
18 to 27 degrees (2H:1V to 3H:1V)	6	
27 degrees or more (steeper than 2H:1V)	16	
Soil Stratigraphy		
shale / limestone	0	10
sand, gravel	6	
till	9	
clay, silt	12	
fill	18	
leda clay	24	
Seepage from Slope Face		
none, or near bottom only	0	0
near mid-slope only	6	
near crest only, or from several levels	12	
Slope Height		
2 m or less	0	2
2.1 to 5 m	2	
5.1 to 10 m	4	
more than 10 m	8	
Vegetation Cover on Slope Face		
well vegetated: heavy shrubs or forested with mature trees	0	4
light vegetation: grass, weeds, occasional trees, shrubs	4	
no vegetation: bare	8	
Table Land Drainage		
table land flat, no apparent drainage over slope	0	0
minor drainage over slope, no active erosion	2	
drainage over slope, active erosion, gullies	4	
Proximity of Watercourse to Slope Toe		
15 m or more from slope toe	0	0
Less than 15 m from slope toe	6	
Previous Landslide Activity		
No	0	0
Yes	6	
Slope Instability Rating		16

Low Potential	< 24	Site Inspection only, confirmation, report letter
Slight Potential	25-35	Site Inspection and surveying, preliminary study, detailed report
Moderate Potential	> 35	BH Investigation, piezometers, lab tests, surveying, detailed report

Is there is a water body (stream, creek, river, pond, bay, lake) at the toe of slope?
If YES - the potential for toe erosion and undercutting should be evaluated in detail.

Slope Stability Rating Chart

Geotechnical Principles for Stable Slopes
Ontario Ministry of Natural Resources

Cross Section B-B'

Site Location: 1494 Commissioners Road West	**Project No.:** LON-22006399-A0
Town/City: London, ON	**Inspection Date:** March 2, 2022
Inspected by: V.C	**Weather:** Overcast, -2ºC

	Rating Value	Slope Rating
Slope Inclination		
18 degrees or less (3H:1V or flatter)	0	0
18 to 27 degrees (2H:1V to 3H:1V)	6	
27 degrees or more (steeper than 2H:1V)	16	
Soil Stratigraphy		
shale / limestone	0	10
sand, gravel	6	
till	9	
clay, silt	12	
fill	18	
leda clay	24	
Seepage from Slope Face		
none, or near bottom only	0	0
near mid-slope only	6	
near crest only, or from several levels	12	
Slope Height		
2 m or less	0	2
2.1 to 5 m	2	
5.1 to 10 m	4	
more than 10 m	8	
Vegetation Cover on Slope Face		
well vegetated: heavy shrubs or forested with mature trees	0	4
light vegetation: grass, weeds, occasional trees, shrubs	4	
no vegetation: bare	8	
Table Land Drainage		
table land flat, no apparent drainage over slope	0	2
minor drainage over slope, no active erosion	2	
drainage over slope, active erosion, gullies	4	
Proximity of Watercourse to Slope Toe		
15 m or more from slope toe	0	0
Less than 15 m from slope toe	6	
Previous Landslide Activity		
No	0	0
Yes	6	
Slope Instability Rating		18

Low Potential	< 24	Site Inspection only, confirmation, report letter
Slight Potential	25-35	Site Inspection and surveying, preliminary study, detailed report
Moderate Potential	> 35	BH Investigation, piezometers, lab tests, surveying, detailed report

Is there is a water body (stream, creek, river, pond, bay, lake) at the toe of slope?
If YES - the potential for toe erosion and undercutting should be evaluated in detail.

Slope Stability Rating Chart

Geotechnical Principles for Stable Slopes
Ontario Ministry of Natural Resources

Cross Section C-C'

Site Location: 1494 Commissioners Road West	**Project No.:** LON-22006399-A0
Town/City: London, ON	**Inspection Date:** March 2, 2022
Inspected by: V.C	**Weather:** Overcast, -2ºC

	Rating Value	Slope Rating
Slope Inclination		
18 degrees or less (3H:1V or flatter)	0	6
18 to 27 degrees (2H:1V to 3H:1V)	6	
27 degrees or more (steeper than 2H:1V)	16	
Soil Stratigraphy		
shale / limestone	0	10
sand, gravel	6	
till	9	
clay, silt	12	
fill	18	
leda clay	24	
Seepage from Slope Face		
none, or near bottom only	0	0
near mid-slope only	6	
near crest only, or from several levels	12	
Slope Height		
2 m or less	0	2
2.1 to 5 m	2	
5.1 to 10 m	4	
more than 10 m	8	
Vegetation Cover on Slope Face		
well vegetated: heavy shrubs or forested with mature trees	0	4
light vegetation: grass, weeds, occasional trees, shrubs	4	
no vegetation: bare	8	
Table Land Drainage		
table land flat, no apparent drainage over slope	0	2
minor drainage over slope, no active erosion	2	
drainage over slope, active erosion, gullies	4	
Proximity of Watercourse to Slope Toe		
15 m or more from slope toe	0	0
Less than 15 m from slope toe	6	
Previous Landslide Activity		
No	0	0
Yes	6	
Slope Instability Rating		24

Low Potential	< 24	Site Inspection only, confirmation, report letter
Slight Potential	25-35	Site Inspection and surveying, preliminary study, detailed report
Moderate Potential	> 35	BH Investigation, piezometers, lab tests, surveying, detailed report

Is there is a water body (stream, creek, river, pond, bay, lake) at the toe of slope?
If YES - the potential for toe erosion and undercutting should be evaluated in detail.

Slope Stability Rating Chart

Geotechnical Principles for Stable Slopes
Ontario Ministry of Natural Resources

Cross Section D-D'

Site Location: 1494 Commissioners Road West	**Project No.:** LON-22006399-A0
Town/City: London, ON	**Inspection Date:** March 2, 2022
Inspected by: V.C	**Weather:** Overcast, -2ºC

	Rating Value	Slope Rating
Slope Inclination		
18 degrees or less (3H:1V or flatter)	0	6
18 to 27 degrees (2H:1V to 3H:1V)	6	
27 degrees or more (steeper than 2H:1V)	16	
Soil Stratigraphy		
shale / limestone	0	10
sand, gravel	6	
till	9	
clay, silt	12	
fill	18	
leda clay	24	
Seepage from Slope Face		
none, or near bottom only	0	0
near mid-slope only	6	
near crest only, or from several levels	12	
Slope Height		
2 m or less	0	2
2.1 to 5 m	2	
5.1 to 10 m	4	
more than 10 m	8	
Vegetation Cover on Slope Face		
well vegetated: heavy shrubs or forested with mature trees	0	4
light vegetation: grass, weeds, occasional trees, shrubs	4	
no vegetation: bare	8	
Table Land Drainage		
table land flat, no apparent drainage over slope	0	2
minor drainage over slope, no active erosion	2	
drainage over slope, active erosion, gullies	4	
Proximity of Watercourse to Slope Toe		
15 m or more from slope toe	0	0
Less than 15 m from slope toe	6	
Previous Landslide Activity		
No	0	0
Yes	6	
Slope Instability Rating		24

Low Potential	< 24	Site Inspection only, confirmation, report letter
Slight Potential	25-35	Site Inspection and surveying, preliminary study, detailed report
Moderate Potential	> 35	BH Investigation, piezometers, lab tests, surveying, detailed report

Is there is a water body (stream, creek, river, pond, bay, lake) at the toe of slope?
If YES - the potential for toe erosion and undercutting should be evaluated in detail.

Appendix D – Slope Stability Analyses

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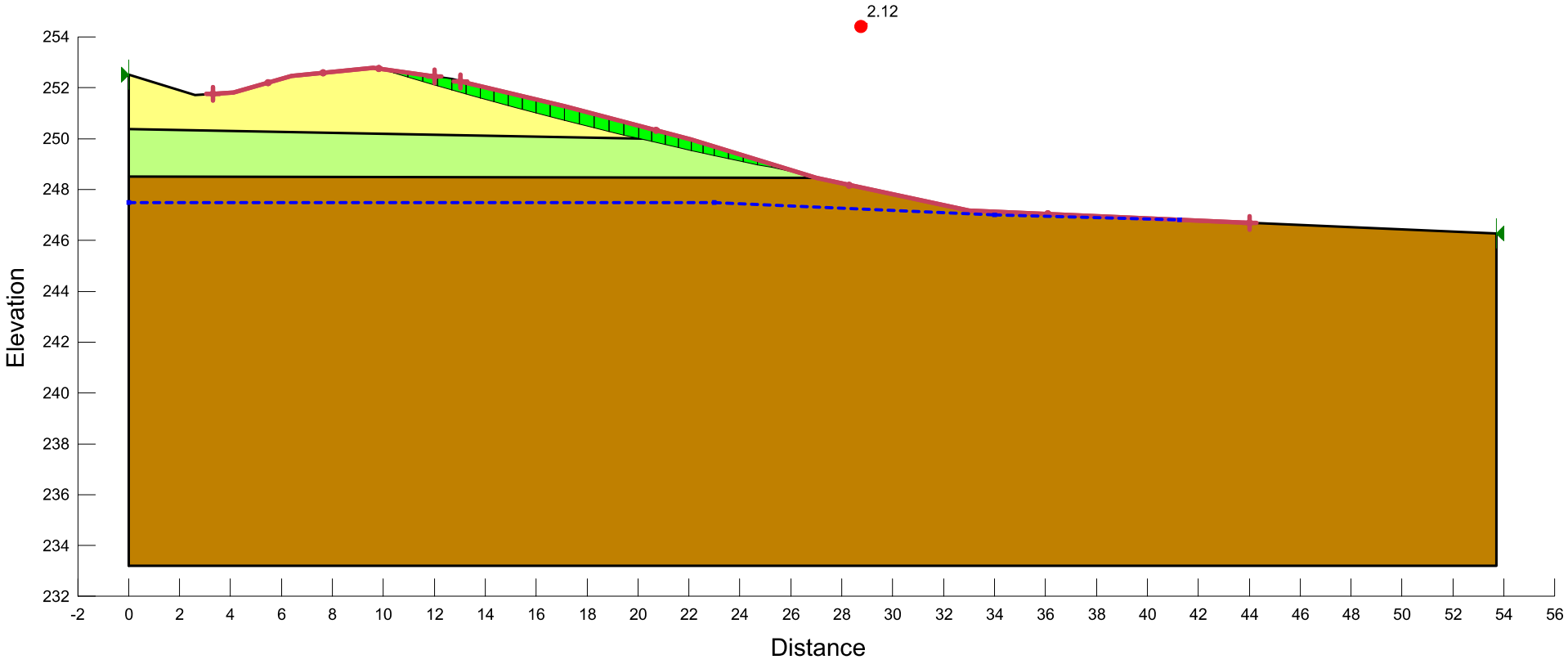
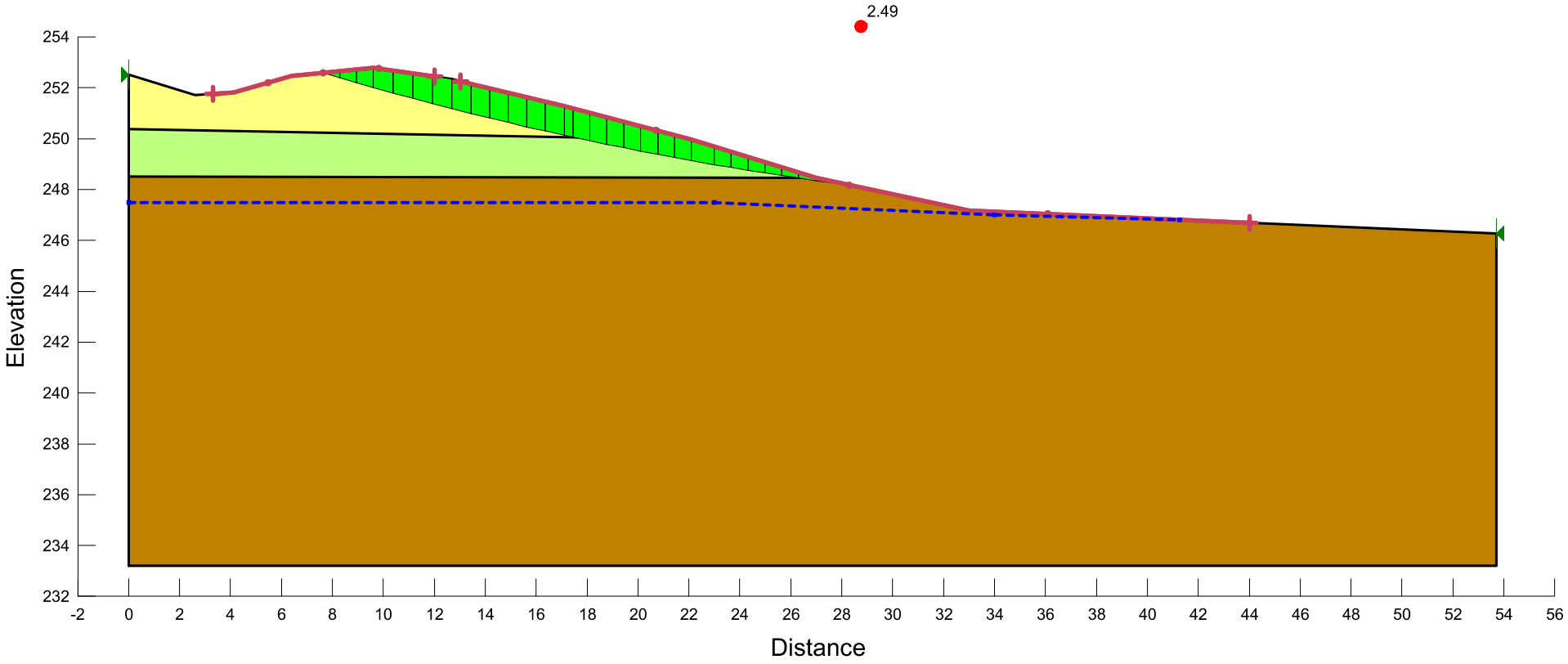
Cross Section A-A' - Shallow Failure

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Fill	18	0	27
	Silt Till	21.5	2	33
	Silty Sand	18.5	0	30



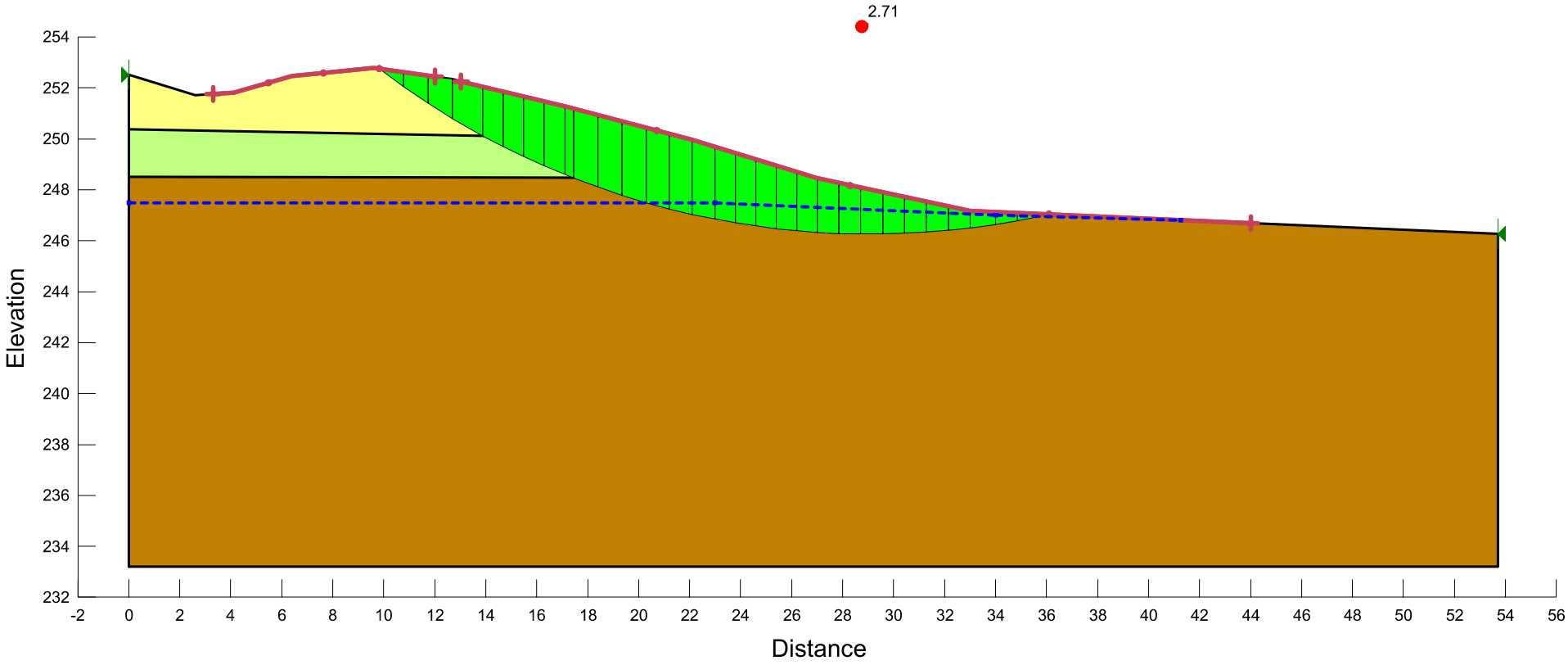
Cross Section A-A' - Moderate Failure

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Fill	18	0	27
	Silt Till	21.5	2	33
	Silty Sand	18.5	0	30



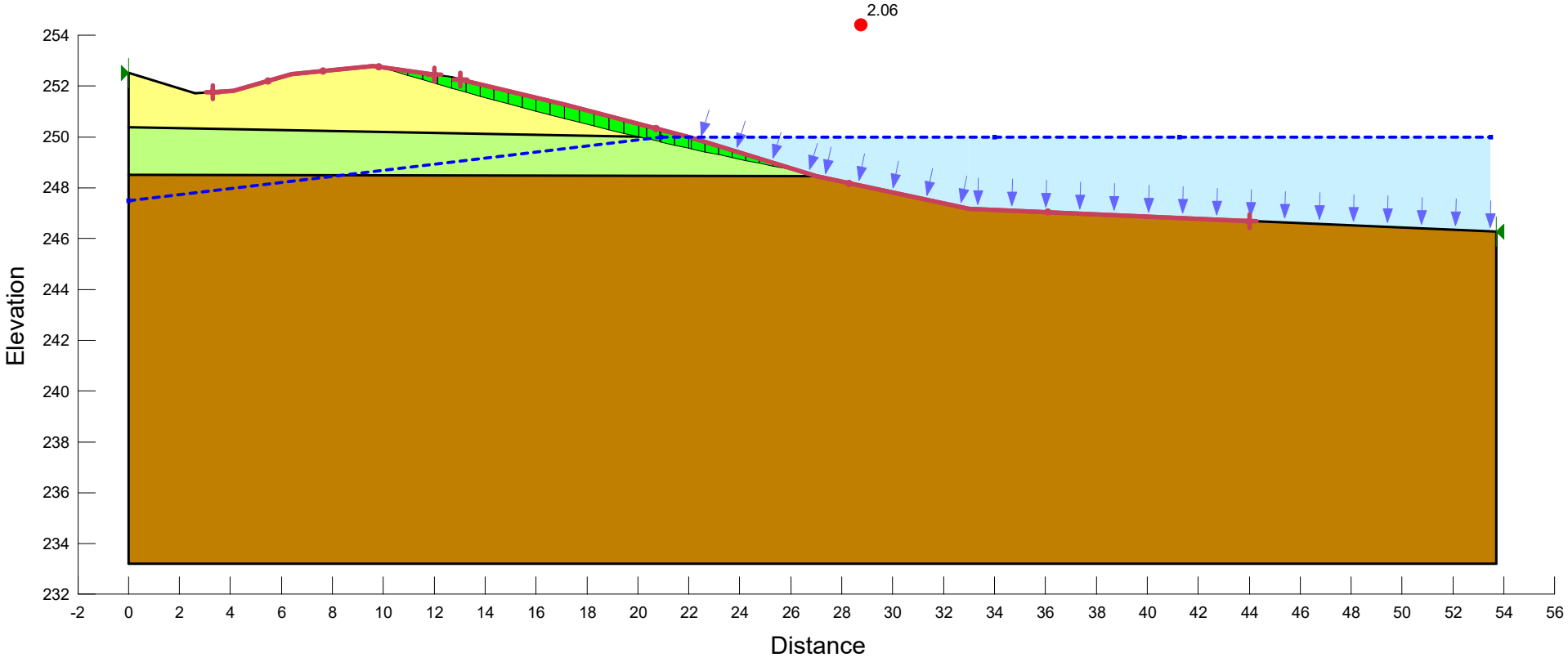
Cross Section A-A' - Deep Failure

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Fill	18	0	27
	Silt Till	21.5	2	33
	Silty Sand	18.5	0	30



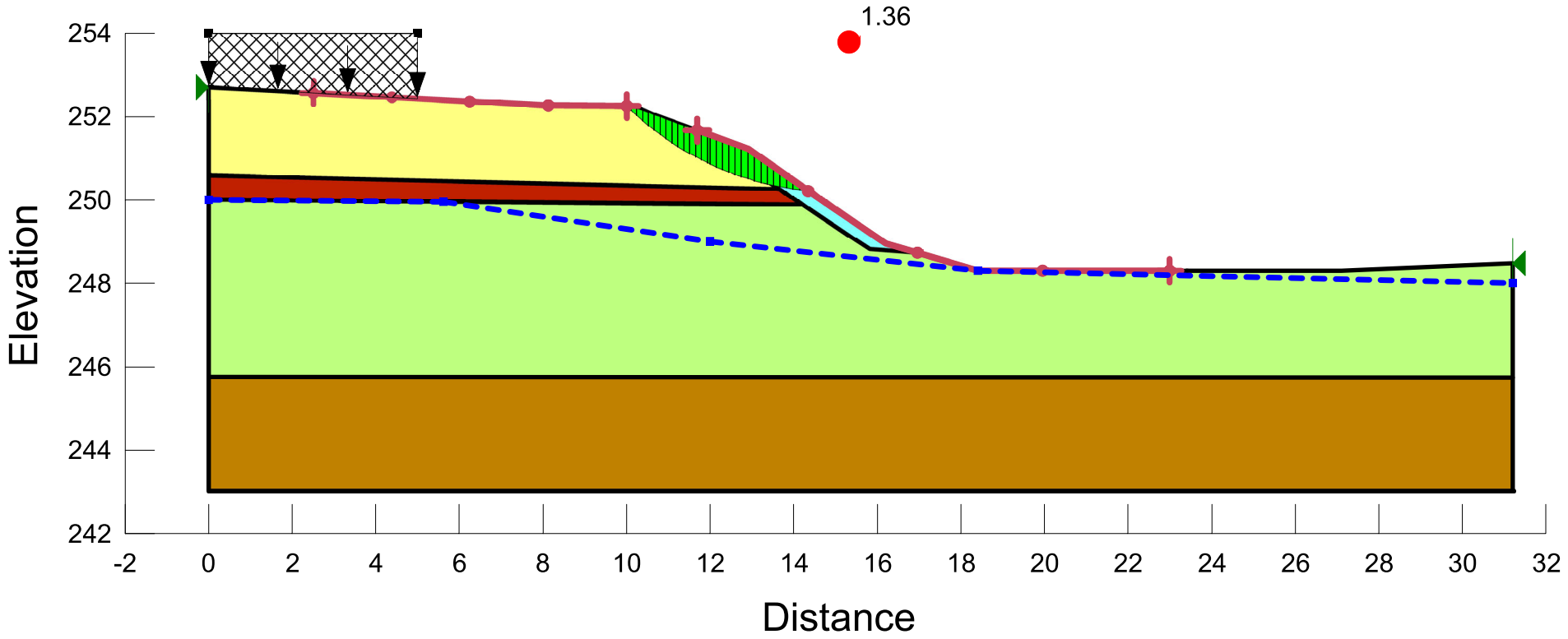
Cross Section A-A' - Flood Condition

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Fill	18	0	27
	Silt Till	21.5	2	33
	Silty Sand	18.5	0	30



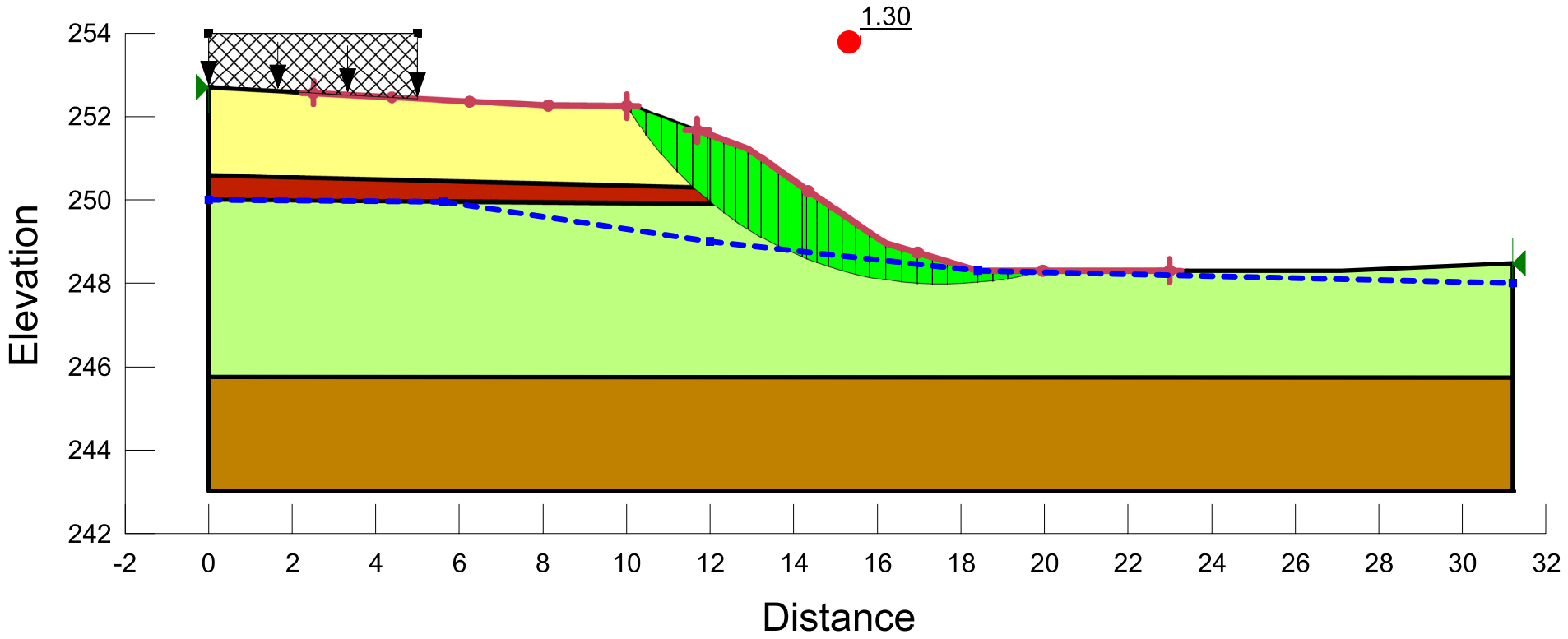
Cross Section C-C' - Shallow Failure

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Clayey Silt Till	21.5	5	31
	Compact to Dense Silty Sand	18.5	0	32
	Fill	18	0	27
	Silt Till	21.5	2	33
	Vegetated Surface	18	3	26



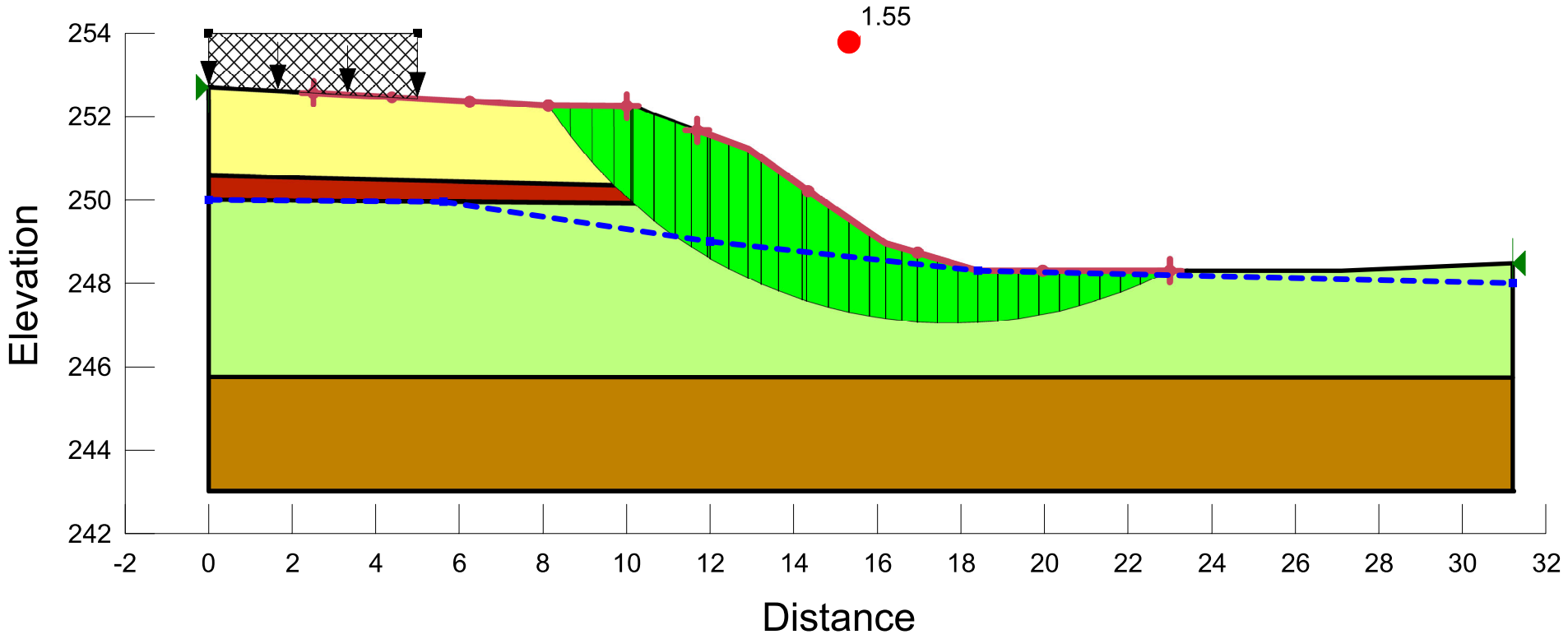
Cross Section C-C' - Moderate Failure

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Clayey Silt Till	21.5	5	31
	Compact to Dense Silty Sand	18.5	0	32
	Fill	18	0	27
	Silt Till	21.5	2	33
	Vegetated Surface	18	3	26



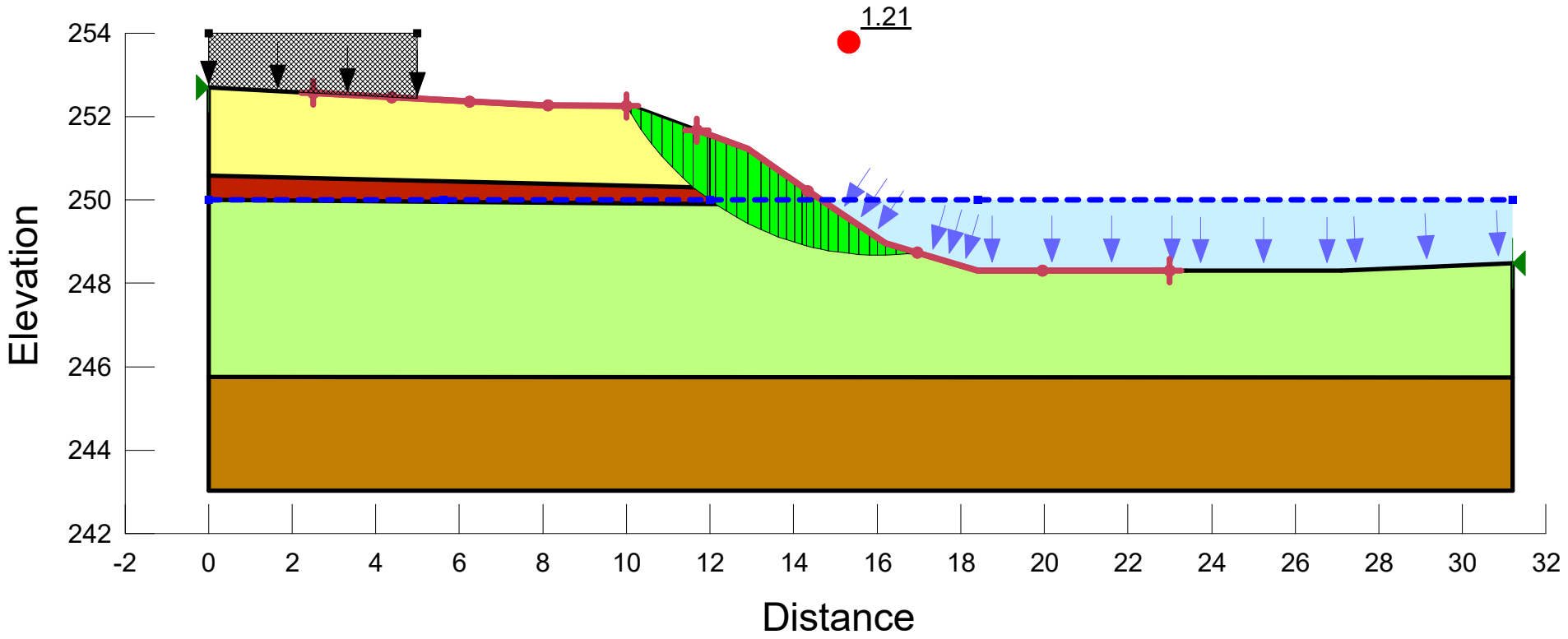
Cross Section C-C' - Deep Failure

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Clayey Silt Till	21.5	5	31
	Compact to Dense Silty Sand	18.5	0	32
	Fill	18	0	27
	Silt Till	21.5	2	33
	Vegetated Surface	18	3	26



Cross Section C-C' - Flood Condition

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Clayey Silt Till	21.5	5	31
	Compact to Dense Silty Sand	18.5	0	32
	Fill	18	0	27
	Silt Till	21.5	2	33
	Vegetated Surface	18	3	26



Appendix E - Limitations and Use of Report

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LIMITATIONS AND USE OF REPORT

BASIS OF REPORT

This report ("Report") is based on site conditions known or inferred by the geotechnical investigation undertaken as of the date of the Report. Should changes occur which potentially impact the geotechnical condition of the site, or if construction is implemented more than one year following the date of the Report, the recommendations of EXP may require re-evaluation.

The Report is provided solely for the guidance of design engineers and on the assumption that the design will be in accordance with applicable codes and standards. Any changes in the design features which potentially impact the geotechnical analyses or issues concerning the geotechnical aspects of applicable codes and standards will necessitate a review of the design by EXP. Additional field work and reporting may also be required.

Where applicable, recommended field services are the minimum necessary to ascertain that construction is being carried out in general conformity with building code guidelines, generally accepted practices and EXP's recommendations. Any reduction in the level of services recommended will result in EXP providing qualified opinions regarding the adequacy of the work. EXP can assist design professionals or contractors retained by the Client to review applicable plans, drawings, and specifications as they relate to the Report or to conduct field reviews during construction.

Contractors contemplating work on the site are responsible for conducting an independent investigation and interpretation of the borehole results contained in the Report. The number of boreholes necessary to determine the localized underground conditions as they impact construction costs, techniques, sequencing, equipment and scheduling may be greater than those carried out for the purpose of the Report.

Classification and identification of soils, rocks, geological units, contaminant materials, building envelopment assessments, and engineering estimates are based on investigations performed in accordance with the standard of care set out below and require the exercise of judgment. As a result, even comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations or building envelope descriptions involve an inherent risk that some conditions will not be detected. All documents or records summarizing investigations are based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated. Some conditions are subject to change over time. The Report presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or the Client has special considerations or requirements, these should be disclosed to EXP to allow for additional or special investigations to be undertaken not otherwise within the scope of investigation conducted for the purpose of the Report.

RELIANCE ON INFORMATION PROVIDED

The evaluation and conclusions contained in the Report are based on conditions in evidence at the time of site inspections and information provided to EXP by the Client and others. The Report has been prepared for the specific site, development, building, design or building assessment objectives and purpose as communicated by the Client. EXP has relied in good faith upon such representations, information and instructions and accepts no responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of any misstatements, omissions, misrepresentation or fraudulent acts of persons providing information. Unless specifically stated otherwise, the applicability and reliability of the findings, recommendations, suggestions or opinions expressed in the Report are only valid to the extent that there has been no material alteration to or variation from any of the information provided to EXP.

STANDARD OF CARE

The Report has been prepared in a manner consistent with the degree of care and skill exercised by engineering consultants currently practicing under similar circumstances and locale. No other warranty, expressed or implied, is made. Unless specifically stated otherwise, the Report does not contain environmental consulting advice.

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All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment form part of the Report. This material includes, but is not limited to, the terms of reference given to EXP by its client ("Client"), communications between EXP and the Client, other reports, proposals or documents prepared by EXP for the Client in connection with the site described in the Report. In order to properly understand the suggestions, recommendations and opinions expressed in the Report, reference must be made to the Report in its entirety. EXP is not responsible for use by any party of portions of the Report.

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