Auburn Developments Inc.

Geotechnical Investigation

Project Name
Proposed Residential Subdivision – 3924 Colonel Talbot Rd, London, ON

Project Number
LON-00013527-GE / LON-22022544-A0

Prepared By: EXP Services Inc.

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Date Submitted
January 15, 2015
Updated August 18, 2022

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Geotechnical Investigation Report Update

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Prepared By:

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1 Introduction

As requested, EXP Services Inc. (EXP) is providing a geotechnical report update to the January 2015 geotechnical report for a proposed residential subdivision to be located at 3924 Colonel Talbot Road in London, Ontario. It is understood that the subdivision will have full municipal servicing and will be accessed by local roadways. This updated 2015 report summarizes the results of that investigation and provides geotechnical discussion and recommendations to support the design and construction of the proposed subdivision development. At this time, only 4.3 ha are being developed and will include 28 single family residential lots and one medium density residential block covering about 2.6 ha.

1.1 Terms of Reference

Authorization to proceed with the original investigation was received from Mr. Stephen Stapleton, of Auburn Developments Inc. Authorization to proceed with the updated report was received from Ms. Maria Reyes of Auburn Developments Inc. on August 16, 2022.

The purpose of the updated report is to review the previous findings and current site conditions and to determine if the recommendations from the 2015 report are still applicable. The 2015 investigation examined the subsoil and groundwater conditions at the site by advancing a series of test pits at the locations illustrated on the attached Test Pit Location Plan (Drawing 1). Test Pits TP9 through TP12 along with BH4/MW inclusive are located within the current 4.3 ha area of development as shown in Drawing 2.

Based on an interpretation of the factual test hole data, and a review of soil and groundwater information from test holes advanced at and near the site, EXP Services Inc. has provided engineering guidelines to assist with the preliminary design and construction of the proposed residential subdivision. More specifically, this report provides comments on excavations, dewatering, site preparation, foundations, bedding, backfill and pavement recommendations.

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.

2 Methodology

2.1 Original Geotechnical Investigation

The fieldwork for the 2015 report was carried out on December 10th of 2014. At that time, twelve (12) test pits were advanced, using a backhoe, at the locations denoted on Drawing 1 as TP1 to TP12 inclusive.

Water level observations were made in the test pits during the course of the fieldwork, and upon completion. The test pits were backfilled with excavated materials.

The fieldwork was supervised by a member of EXP's field technical staff who directed the excavating and sampling operation, and logged the samples. All samples recovered were transported to EXP's London laboratory for detailed examination and selective testing. Laboratory testing for this investigation comprised of routine moisture content determinations, with results presented on the detailed Test Pit Logs, attached.

Samples remaining after the classification testing will be stored for a period of three months following the date of sampling (i.e., until March 2015). After this time, they will be discarded unless prior arrangements have been made for longer storage.

Ground surface elevations, at each test pit location, have been inferred from City of London Digital Mapping 2012.

2.2 2021 Hydrogeological Investigation

A hydrogeological assessment was initiated in March 2021. As a part of that assessment, additional drilling and monitoring wells were installed throughout the entire site. Monitoring well MW4 was located within the current development area. The borehole log for this monitoring well is provided in Appendix A, Borehole Logs and the location of the well is shown on Drawing 1, Test Pit Location Plan.

2.3 Current Site Review

A site reconnaissance visit was conducted on August 17, 2022 to review the current site conditions. The site appears consistent with the appearance in 2015. No change to the overall topography was observed. The current area of development is still being used for agricultural purposes.

3 Site and Subsurface Conditions

3.1 Site Description

The current study area (4.3 ha of the overall ~27 ha) is located on the west side of Bostwick Road. The study area is characterized by agricultural land. A woodlot is located to the west of the current study area, a church property to the north and new residential development to the south.

3.2 Soil Stratigraphy from 2014 Investigation

The detailed stratigraphy encountered in each test hole and the results of routine laboratory tests carried out on representative samples of the subsoils are presented on the Test Pit Summary (see Appendix A), and summarized in the following paragraphs.

It must be noted that boundaries of soil conditions indicated in the Test Pit Summary are inferred from non-continuous sampling and observations during excavation. These boundaries are intended to reflect transition zones for the purposes of geotechnical recommendations, and should not be interpreted as exact planes of geological change.

3.2.1 Topsoil

Each test pit was surfaced with a layer of topsoil. The topsoil, generally described as brown/black, loose and moist, extended to depths ranging between about 250 mm and 400 mm. Thicker areas of topsoil may be anticipated in areas where trees or thick vegetative cover is present.

It should be noted that topsoil quantities should not be established from the information provided at the test hole locations only. If required, a more detailed analysis (involving shallow test pits) is recommended to accurately quantify the amount of topsoil to be removed for construction purposes.

3.2.2 Silt

With the exception of TP8, a layer of silt was encountered beneath the topsoil at each test hole location. The silt was generally described as brown, with trace to some sand and gravel, and occasionally containing trace clay. The silt was typically found to be in a loose to compact state, based on tactile observations and observed excavator resistance. Based on laboratory testing, the in situ moisture content of the silt ranged between 19 and 23 percent, generally indicative of very moist to wet conditions.

3.2.3 Sandy Silt

A layer of sandy silt was encountered beneath the silt layer at test pits TP3, TP4, and TP5 and underlying the topsoil at TP8. The sandy silt was generally described as brown, with trace to some clay and trace to some gravel. The compactness of the sandy silt was typically found to be loose to compact, based on tactile observations and observed excavator resistance. Based on laboratory testing, the in situ moisture content of the sandy silt was found to be about 23 percent, generally indicative of very moist to wet conditions

3.2.4 Clayey Silt

Each test pit was found to terminate within a layer of clayey silt. The clayey silt was described as brown, with trace to some sand and gravel throughout it's depth. Coarse gravel and cobbles were observed throughout the depth of the clayey silt layer in test pits TP10, TP11, and TP12. The consistency of the clayey silt could be described as ranging from firm to stiff, as determined by tactile observations and excavator resistance. The *in situ* moisture content of the clayey silt ranged between about 13 and 22 percent, generally indicative of damp to moist conditions.

3.3 Groundwater Conditions

During the 2014 fieldwork, minor groundwater seepage was observed within test pits TP3, TP4, TP5, and TP8 at depths ranging between about 0.6 m and 1.2 m below existing grades. Measurement of water level and moisture contents of selected samples are recorded on the attached Test Pit Summary. It is noted that insufficient time was available for the measurement of the depth to the stabilized groundwater table prior to backfilling the test pits. In this regard the shallow groundwater encountered within the test pits, is most likely perched in the silt and sandy silt soils overlying the less permeable clayey silt.

Water level readings in the monitoring well BH4/MW (with a ground surface elevation of 270.2 m) from the hydrogeological assessment, have varied between 263.5 m and 264.3 m during the period of April 30, 2021 to June 13, 2022.

It is further 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. Capillary rise effects should also be anticipated within fine-grained deposits.

4 Discussion and Recommendations

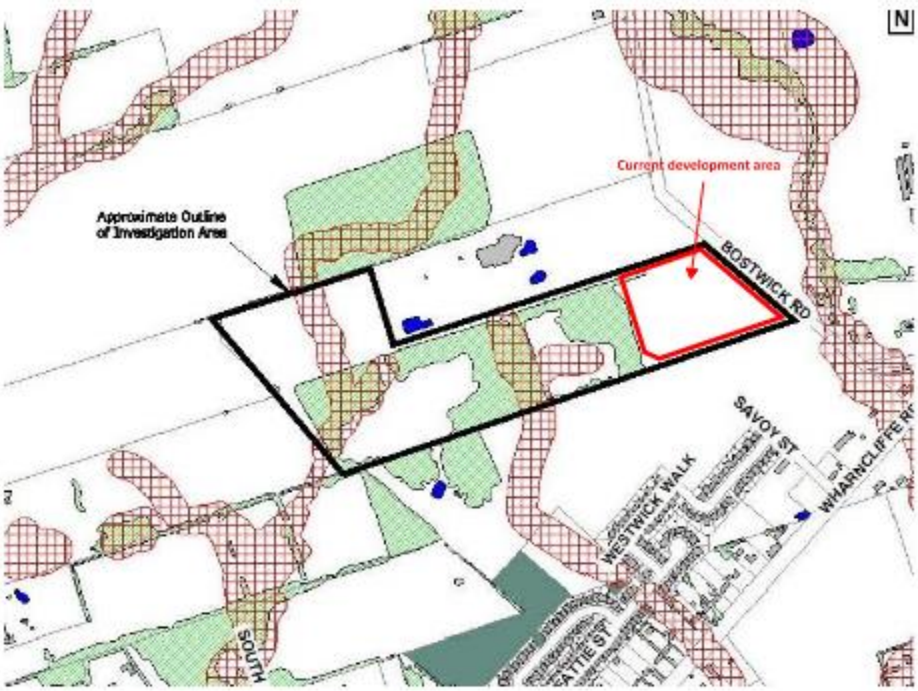
4.1 General

It is understood that a residential subdivision development is proposed for the subject site, complete with municipal servicing and asphalt surfaced access roadways. Based on our understanding of the proposed development, and the results of the 2014 investigation, this report provides geotechnical comments and discussion regarding site preparation, excavations and dewatering, foundations and basement design, and pavement design.

4.2 Regulatory Approval

As shown by the City of London mapping (refer to image, below), the Upper Thames River Conservation Authority (UTRCA) has regulated lands (hatched area) within the entire site boundary, but **not** the current 4.3 ha under consideration for development (see red outlined area below). As a result approvals from UTRCA may be required for proposed development within the site limits.

Figure 1 – UTRCA Regulated Lands



2015 City of London online mapping

In May 2006, Ontario Regulation 157/06 came into effect, 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 157/06 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 and/or a letter of clearance from the local Conservation Authority 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 may be subject to the above referenced Regulation. Accordingly, consultation with the local Conservation Authority for review of site-specific development plans is recommended in this regard.

4.3 Site Preparation

Prior to placement of foundations, pipe bedding and/or engineered fill, all surficial topsoil, vegetation and/or otherwise deleterious materials should be stripped. Thicker areas of topsoil (than that which was encountered at the test hole locations) 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.

During the field work, there was no observed evidence of previous development within the site. In the event that old agricultural structures (farm home, barn, silos, etc.) are encountered during construction; all remnants of any previous structures should be completely removed (including foundation walls and concrete floor slabs) from the site. In the event that former wells are present, it is recommended that the wells be properly decommissioned (in accordance with Ontario Regulation 903), by a licensed well drilling contractor.

Following the removal of the topsoil 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.

In the building areas where the grade will be raised, the fill material should be comprised of imported granular or approved 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). The geometric requirements for engineered fill are provided on Drawing 2. When the engineered fill placement is complete, the City of London will require a verification letter from the geotechnical consultant identifying lots which contain engineered fill.

Based on the subsurface soil conditions encountered throughout the site, select material may be suitable for reuse as engineered fill but 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 onsite excavated soils, or imported granular fill approved by an engineer. The fill should be placed in maximum 300 mm (12 inch) thick lifts and uniformly compacted to 98 percent SPMDD (as required by City of London) in order 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 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 standards for placement and transportation. The removal of excavated materials from the site must conform to the MECP Guidelines and requirements and O. Reg. 406/19. Exp can be of assistance if an assessment of the materials is required.

4.4 Excavation and Dewatering

4.4.1 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.

4.4.2 General

Side slopes of temporary excavations must conform to Regulation 213/91 of the Occupational Health and Safety Act of Ontario. The clayey silt soils encountered at the site might be classified as Type 2 soils but are more likely classified as Type 3 soils based on the observed consistency, and the sandy silt and silt soils are classified as Type 3 soils. Temporary excavation sidewalls which extend through and terminate in Type 2 soil may be cut vertical in the bottom 1.2 m (4 ft), and must be cut back at an inclination of 1 horizontal to 1 vertical (1H:1V) or flatter above that level. Where excavations extend through Type 3 soil, the excavation sidewalls must be cut back at a maximum inclination of 1H:1V from the base of the excavation. Where groundwater egress loosens the sidewalls, flatter slopes may be required.

Excavations that cut through both Type 2 and Type 3 soils should be considered as Type 3 soils.

It should be noted that the presence of cobbles and boulders in the clayey silt were encountered and may influence the progress of excavation and construction.

4.4.3 Excavation Support

During excavation for the proposed development, care should be taken to not undermine any existing foundations. In the event that soils below existing foundations are disturbed, some method of temporary support or underpinning may be required. Exp can provide additional assistance in this regard, if necessary. Additionally, when excavating, care should be taken to not undermine or damage any existing buried utilities or structures.

In areas adjacent to existing structures and 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 cohesionless 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, shoring such as sheeting or soldier piles and lagging can be considered. 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.

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.

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 should 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 them to the engineer for review and comment.

4.4.4 Dewatering

At this time the proposed depth to underside of footing for structures and the proposed invert levels for site services have not been provided to EXP. When finalized design drawings have been prepared, EXP should be afforded the opportunity to review the design to ensure that suitable geotechnical recommendations have been provided and properly interpreted. The following comments have been provided based on the assumption that underside of footing elevation for residential structures with basements and invert levels for site services will be set at conventional depths ranging between about 2.5 m to 3.0 m below existing grades.

Based on the results of the field investigation, significant groundwater infiltration should not be anticipated within building and service trench excavations extending to depths ranging between about 2.5 m to 3.0 m below existing grades. However, if encountered, groundwater infiltration can likely be accommodated using conventional sump pumping techniques.

Where groundwater infiltration persists, more extensive dewatering measures may be required and consultation with a specialist dewatering contractor is recommended.

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.

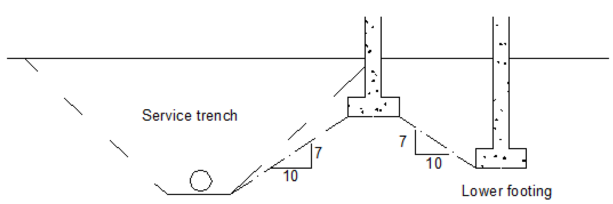
Although not anticipated for this project, it should be noted that for projects requiring positive groundwater control with a removal rate more than 50,000 litres per day, an Environmental Activity and Sector Registry (EASR) or Permit to Take Water (PTTW) will be required. PTTW applications are required for removal rates more than 400,000 L per day and will need to be approved by the MECP according to 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 PTTW application. Accordingly, a detailed hydrogeological assessment from a quantitative point of view may be required to estimate the quantity of water to be removed. EXP can assist if the need arises.

4.5 Building Foundations

The proposed residential units can be supported on conventional spread and strip footings founded directly on the native mineral subgrade soils, or approved engineered fill. An allowable bearing pressure of 145 kPa (3000 psf) can be used for design below a typical depth of approximately 1.2 m (4 ft) below existing grade throughout the site. 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.

If the grades are to be raised or restored due to unsuitable soils, engineered fill can be used over the competent subgrade, as discussed previously in Section 4.3. The geometric requirements for the fill placement are shown on Drawing No. 2, appended. 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.

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 excavations, 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.

It should be noted that the recommended bearing capacities have been calculated by EXP from the test hole 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 test holes when foundation construction is underway the interpretation between the test holes 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.

4.6 Basements

The basement floors can be constructed using cast slab-on-grade techniques provided the subgrade is stripped of all topsoil and other obviously objectionable material. The subgrade should then be thoroughly proof-rolled. Any soft spots detected during the proof-rolling should be dug out and replaced with clean compactable material, placed in accordance with the requirements outlined in Section 4.2.

A minimum 200 mm (8 inch) thick compacted layer of 19 mm (¾ inch) clear stone should be placed between the prepared subgrade and the floor slab to serve as a moisture barrier.

The installation and requirement of vapour barrier under the slab, where applicable, should conform to the flooring manufacturer's and designer's requirements. Relative humidity and/or moisture emission testing may be required to determine the concrete condition prior to flooring installation. Ongoing liaison from this office is available, upon request.

All basement walls should be damp-proofed and must be designed to resist a horizontal earth pressure 'p' at any depth 'h' below the surface as given by the following expression:

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

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

Installation of perimeter drains is recommended for basements at the site. The above expression assumes that the perimeter drainage system prevents the build-up of any hydrostatic pressure behind the wall.

Based on available groundwater measurements from BH4/MW, groundwater was measured to vary between 6.1 m bgs and 6.7 m bgs at that location. As previously mentioned, insufficient time was available for the measurement of the depth to the stabilized groundwater table prior to backfilling the test pit holes. In the event that excavations for basement construction extend below the groundwater table, it is recommended that basement construction should be completed with active groundwater control (i.e. sump pumps, footing drains, under floor drains..etc.) in conjunction with waterproofing (i.e. water proof membranes and sealants..etc.). Suggestions for permanent perimeter drainage are given on Drawing 3.

4.7 Pipe Bedding and Trench Backfill

At the time of the current investigation design depths for the proposed site services were not available. The subgrade soils beneath the water and sewer pipes installed to conventional depths (less than 3m) which will service the site are expected to comprise of silt, sandy silt or clayey silt. No bearing problems are anticipated for flexible or rigid pipes founded on the natural deposits or compacted onsite soils.

Consideration should be given to placing the bedding in accordance with the specifications outlined in City of London Drawing SR-1.0. The bedding course may be thickened if portions of the subgrade become wet during excavation. The bedding aggregate should be placed around the pipe to at least 300 mm (12 inch) above the pipe. The bedding aggregate should 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.

Clear stone or crushed stone bedding may be used in the service trenches as bedding below the spring line of the pipe if necessary to assist groundwater control and provide stabilization to the excavation base in wet silty soils. A graded stone such as HL4 stone is recommended if this is needed. Geotextile should be wrapped around the stone bedding to minimize migration of fines. The potential locations for use of stone bedding should be identified during construction and is expected to vary across the site due to seasonal conditions and variations in the perched groundwater.

Requirements for backfill in service trenches, etc. should also have regard for City of London requirements. A summary of the general recommendations for trench backfill is presented on Drawing 4 and 5. 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 onsite excavated soils may be used for construction backfill provided 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. Stockpiling of material for prolonged periods of time should be avoided. This is particularly important if construction is carried out in wet, 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. The use of any imported material is subject to review and approval by the contract administrator and geotechnical consultant.

Removal of excavated materials off site should conform to current MECP O. Reg. 406/19 guidelines.

4.8 Pavement Design

Within the new subdivision, 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 by large drum vibratory compactor. Any soft spots 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.

The design of streets in the City of London is based on the maximum spring rebound of the pavement as measured by the Benkelman Beam. This rebound must be limited to values which have been found to be acceptable for various classifications of streets. Provided the preceding recommendations are followed, the pavement thickness design requirements given in the following table are recommended for the anticipated specified street classifications and subgrade conditions. It is anticipated that the subdivision will consist of neighbourhood and neighbourhood connector streets as per City of London street classification.

Recommended Pavement Structure Thickness

Pavement Layer	Compaction Requirements	Neighbourhood Street	Neighbourhood Connector
Asphaltic Concrete	97% Marshall Density	40 mm HL-3 50 mm HL-8	50 mm HL-3 80 mm HL-8
Granular ‘A’ (Base)	100% SPMDD	150 mm	150 mm
Granular ‘B’ (Sub base)*	100% SPMDD	300 mm	450 mm

Notes:
1) SPMDD denotes Standard Proctor Maximum Dry Density.
2) The subgrade must be compacted to 98% SPMDD.
3) The above recommendations are minimum requirements.
4) Maximum Spring Benkelman Beam Rebound (mm) for Neighbourhood Street – 1.90; for Neighbourhood Connector – 1.25.
5) Traffic Category B for Neighbourhood Street and C for Neighbourhood Connector.
6) *Thickened granular sub base may be required depending on the moisture condition of the subgrade. The incorporation of a geotextile can be considered.

The recommended pavement structures provided in the above table are based on the natural 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.

Depending on the staging of the subdivision development, and possible areas of concentrated construction access routes, additional granular thicknesses may also be considered. If only a portion of the pavement will be in place during construction, the granular subbase may have to be thickened, and/or the subgrade improved with a geotextile separator or geogrid stabilizing layer. 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' aggregates should be checked for conformance to OPSS 1010 prior to use 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 1150. The asphalt should be placed in accordance with OPSS 310 and compacted to at least 97 percent of the Marshall mix design bulk density.

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 (at catch basin locations), subdrains should be installed to intercept excess subsurface moisture and prevent subgrade softening, as shown on Drawing 6. This is particularly important in heavier traffic areas at the site entrances. The locations and extent of subdrainage required within the paved areas should be reviewed by this office in conjunction with the proposed grading.

Where the roadway from the subdivision intersects the existing roads, the subgrade beneath the new pavement should be tapered to match the existing road subgrade to minimize differential frost heaving for the pavement structure.

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

The concrete for the curbs and gutters should be proportioned, mixed placed and cured in accordance with the requirements of OPSS 353, OPSS 1350 and City of London Requirements.

During cold weather, the freshly placed concrete should be covered with insulating blankets to protect against freezing.

The subgrade for the sidewalks should comprise undisturbed natural soil or well-compacted fill. A minimum 150 mm thick layer of compacted (minimum 98 percent SPMDD) Granular 'A' should be placed below the sidewalk slabs.

4.10 Inspection and Testing Recommendations

An effective inspection and testing program is an essential part of construction monitoring. The Inspection and Testing Program for residential developments typically include the following items:

- Subgrade examination prior to placement of engineered fill;

- Inspection and Materials testing during engineered fill placement (full-time supervision is recommended) and site servicing works, including soil sampling, laboratory testing (moisture contents and Standard Proctor density test on the pipe bedding, trench backfill and engineered fill material), monitoring of fill placement, and *in situ* density testing;

- Inspection and Materials testing during the road construction, including subgrade examination of the road subgrade soils following site servicing, laboratory testing (grain size analyses and Standard Proctor density tests on the Granular 'A' and 'B' material placed on site roadways), *in situ* density testing, and concrete sampling and testing for curbs;

- Inspection and Materials testing for base and surface asphalt, including laboratory testing on asphalt sampling to confirm conformance to project specifications and standards;

- Footing Base Examinations for residential footings set on engineered fill to confirm its suitability to support the design bearing pressures; and

- Visual examination of concrete reinforcing steel placement in footings set on engineered fill.

5 General Comments

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 test hole results, so that they may draw their own conclusions as to how the subsurface conditions may affect them.

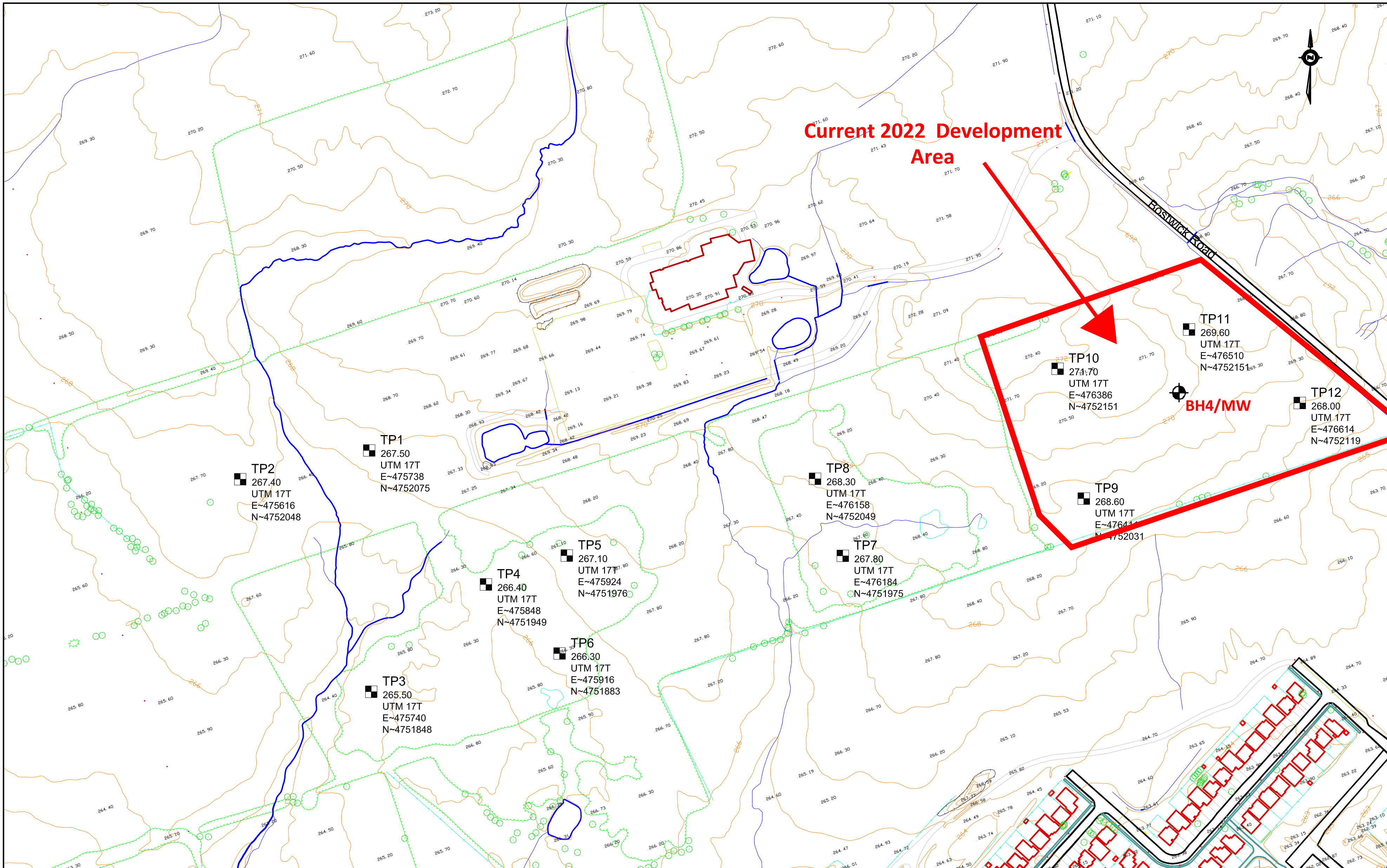
EXP Services Inc. should be retained for a general review of the final design and specifications to verify that this report has been properly interpreted and implemented. If not afforded the privilege of making this review, EXP Services Inc. will assume no responsibility for interpretation of the recommendations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

We trust that this report is satisfactory to your present requirements and we look forward to assisting you in the completion of this project. Should you have any questions, please contact our office.

All the foregoing and attachments respectfully submitted,

EXP Services Inc.

List of Drawings



-NOTES-

1. The boundaries and soil types have been established only at the test hole locations. Between test holes they are assumed and may be subject to considerable error.
2. Soil samples will be retained in storage for 3 months and then destroyed unless the client advised that an extended time period is required.
3. Topsoil quantities should not be established from the information provided at the test hole locations.
4. Ground surface elevations at each test pit location have been inferred based on information obtained from City of London Digital Mapping 2012.

-LEGEND-

TP1 267.50 UTM 17T E~475738 N~4752075	Approximate Test Pit Location Approximate Test Pit Elevation (m) Approximate UTM Coordinates (+/- 5 m)
BH4/MW	Approximate Elevation 270.2 m

CLIENT	Auburn Developments Inc.
PROJECT	3924 Colonel Talbot Road, Preliminary Geotechnical Investigation
TITLE	Test Pit Location Plan

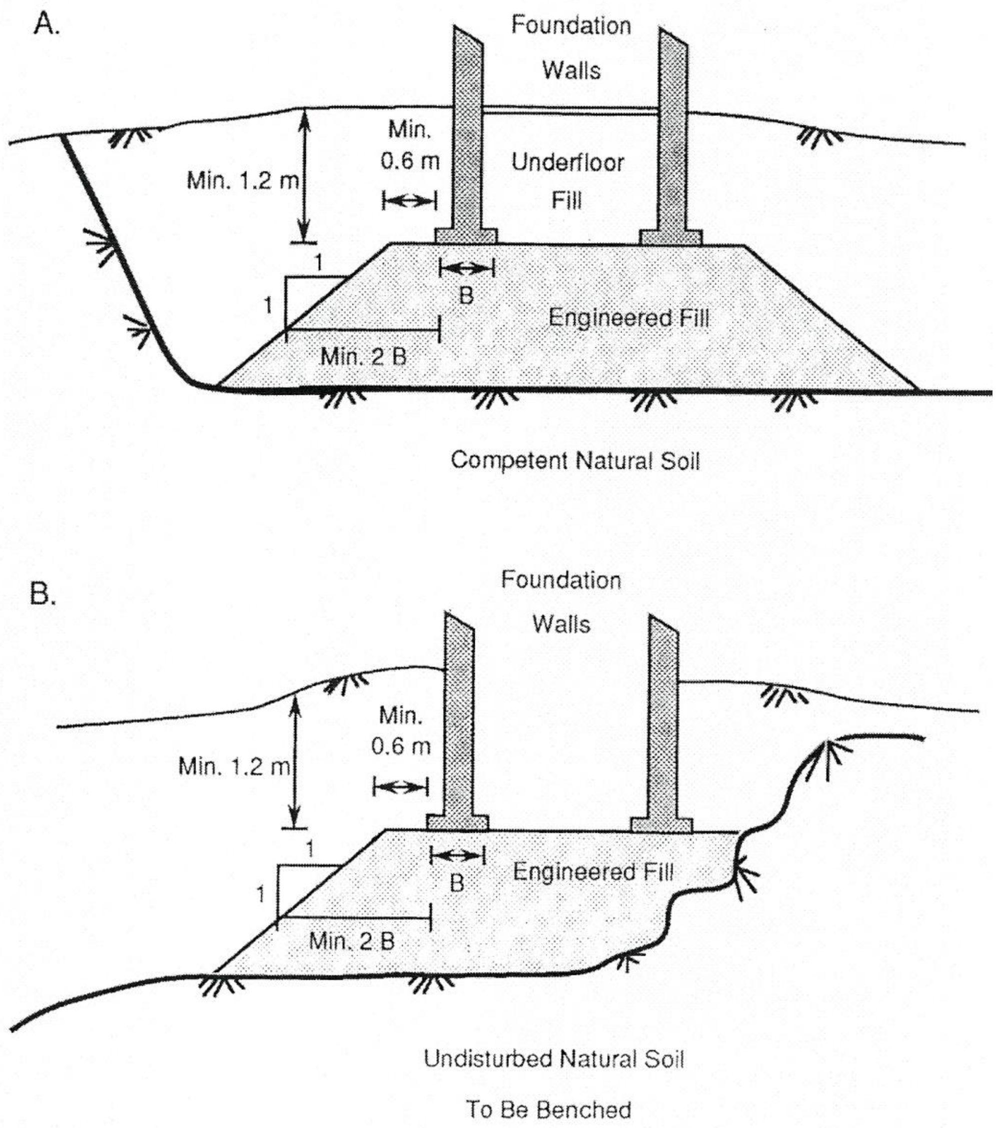
exp.

EXP Services Inc.
1507 Robins Hill Road, London, ON, N5V 0A5

DATE	SCALE	PROJECT NO.	DWG.
August 2022	NTS	LON-00013527-GE	1

DRAWING 2 – GEOMETRIC REQUIREMENTS FOR FOUNDATIONS ON ENGINEERED FILL

Schematic (Not to Scale)



SECTION VIEW

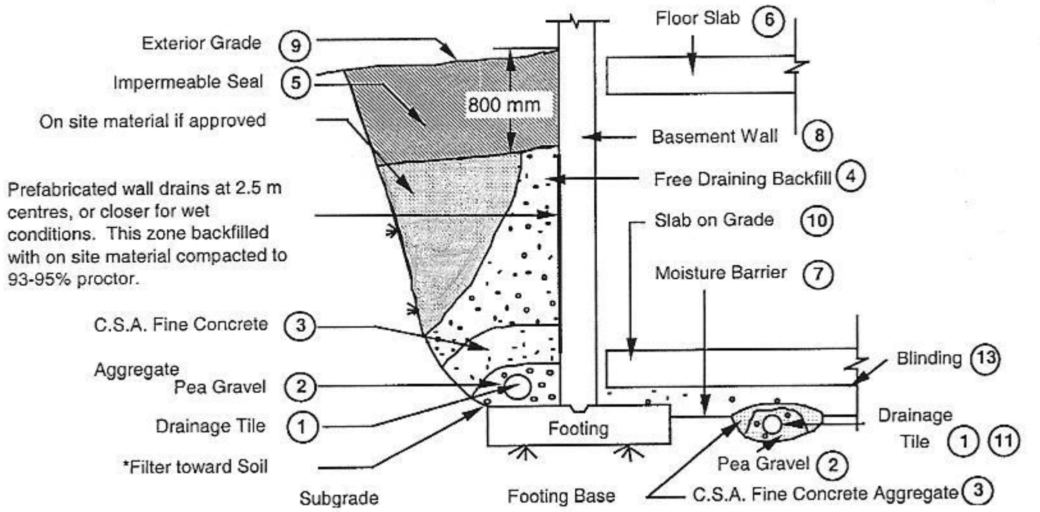
Section A – Typical Section of Slab-on-Grade Building
Section B – Typical Section of Building with Basement

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-00013527-GE / LON-22020544-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 3 – BACKFILL AND BASEMENT DRAINAGE DETAIL (NOT TO SCALE)

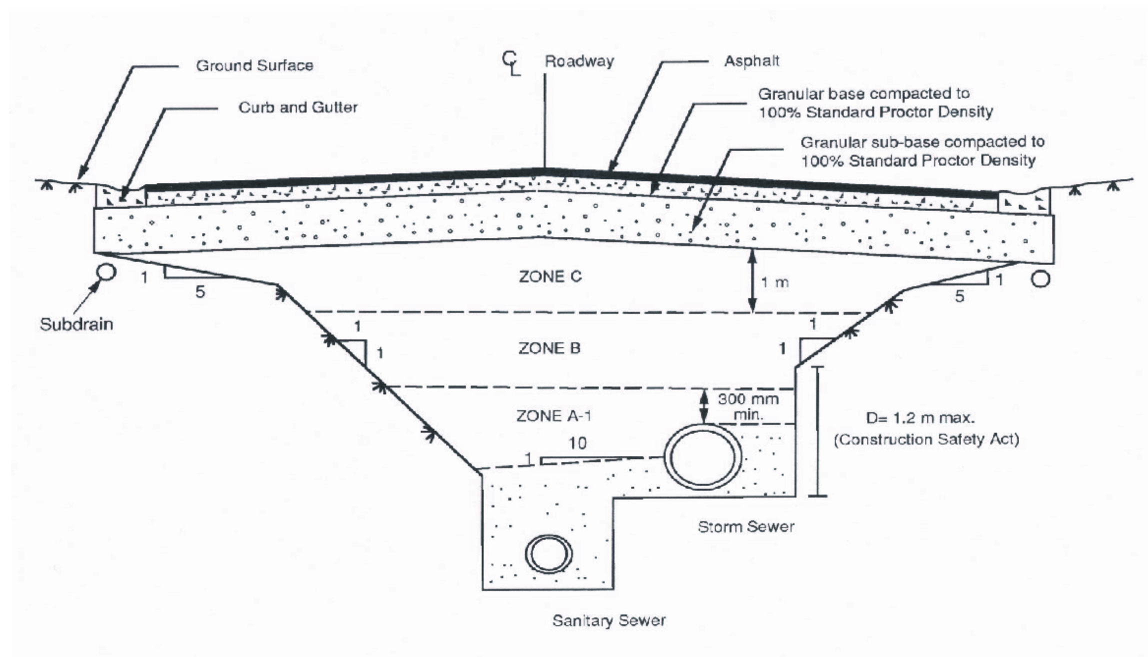


NOTES:

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 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. Free-draining backfill - OPSS Granular B or equivalent compacted to 93 to 95 (maximum) percent Standard Proctor density. Do not compact closer than l.8 m (6 ft) from wall with heavy equipment. Use hand controlled light compaction equipment within 1.8 m (6 ft) of wall.
5. Impermeable backfill seal of compacted clay, clayey silt or equivalent. If original soil is free-draining, seal may be omitted.
6. Do not backfill until wall is supported by basement and floor slabs or adequate bracing.
7. Moisture barrier to consist of compacted 20 mm (3/4 in.) clear, crushed stone or equivalent free-draining material. Layer to be 200 mm (8 in.) minimum thickness.
8. Basement walls to be damp-proofed.
9. Exterior grade to slope away from wall.
10. Slab on grade should not be structurally connected to wall or footing.
11. Underfloor drain invert to be at least 300 mm (12 in.) below underside of floor slab. Drainage tile placed in parallel rows 6 to 8 m (20 to 25 ft.) centres one way. Place drain on 100 mm (4 in.) of pea gravel with 150 mm (6 in.) of pea gravel top and sides. CSA fine concrete aggregate to be provided as filter material or an approved porous geotextile membrane (as in 2 above) may be used.
12. Do not connect the underfloor drains to perimeter drains.
13. If the 20 mm (3/4 in.) clear stone requires surface binding, use 6 mm (1/4 in.) clear stone chips.

Note:
- a) Underfloor drainage can be deleted where not required (see report).
- b) Free draining backfill, item 4 may be replaced by wall drains, as indicated, if more economical.

DRAWING 4 – 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 5 – TRENCH BACKFILL REQUIREMENTS

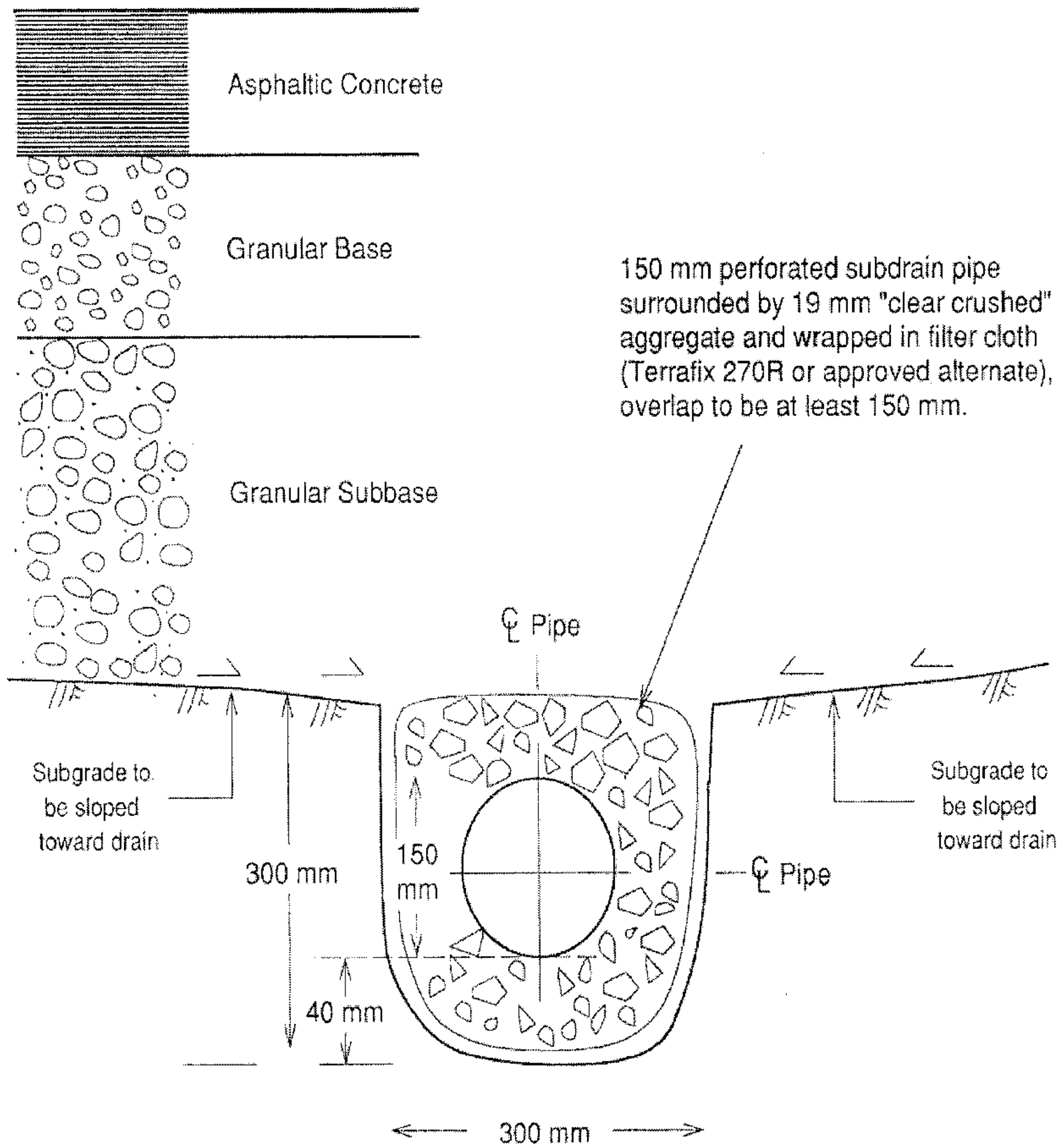
Requirements for backfill in service trenches, etc. should conform to current OPSS requirements. A summary of the general recommendations for trench backfill is presented on **Drawing 4**.

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 6 – PAVEMENT SUBDRAIN DETAIL



NOTES:

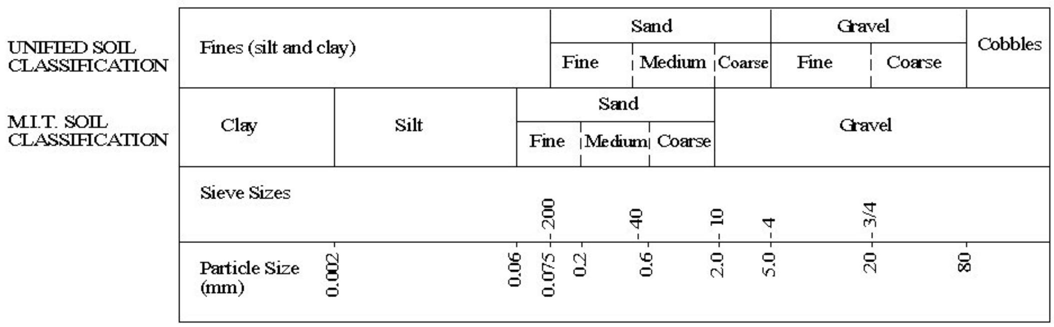
1. All dimensions in millimetres.
2. All sub drains to be set on at least 1% grade draining to a positive outlet.
3. Subgrade soil conditions should be verified onsite, during subgrade preparation works, following site servicing installations.

Scale: NTS

List of Appendices

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.

Depth (m)	Moisture Content (%)	Soil Description
TP #1		
0.00 – 0.30		TOPSOIL – brown/black, loose, moist.
0.30 – 0.50	21	SILT – brown, some sand and gravel, loose, very moist to wet
0.50 – 2.30		CLAYEY SILT – brown, trace sand and gravel, firm, moist
2.30		Test pit terminated.
		Test pit open and dry upon completion of excavation.
TP #2		
0.00 – 0.25		TOPSOIL – brown/black, loose, moist.
0.25 – 0.65		SILT – brown, trace to some sand, trace gravel, loose to compact, moist
0.65 – 2.40		CLAYEY SILT – brown, some sand and gravel, firm to stiff, damp
2.40		Test pit terminated.
		Test pit open and dry upon completion of excavation.
TP #3		
0.00 – 0.30		TOPSOIL – brown/black, loose, moist.
0.30 – 0.60	19	SILT – brown, trace sand and gravel, loose to compact, very moist to wet
0.60 – 1.20		SANDY SILT – brown, some clay, some gravel, loose to compact, very moist to wet - some clay to clayey below 0.60 m depth
1.20 – 3.30	21	CLAYEY SILT – brown to grey, trace sand and gravel, stiff to hard, moist
	18	
3.30		Test pit terminated.
		Test pit open upon completion of excavation; minor groundwater seepage observed at intermittent depths throughout the sandy silt layer.
TP #4		
0.00 – 0.30		TOPSOIL – brown/black, loose, moist.
0.30 – 0.60		SILT – brown, trace sand, some gravel, loose, wet
0.60 – 1.20		SANDY SILT – brown, trace clay, trace gravel, loose to compact, wet
1.20 – 3.30		CLAYEY SILT – brown, some sand and gravel, firm to stiff, damp to moist
3.30		Test pit terminated.
		Test pit open upon completion of excavation; minor groundwater seepage observed at intermittent depths throughout the sandy silt layer.

Depth (m)	Moisture Content (%)	Soil Description
TP #5		
0.00 – 0.30		TOPSOIL – brown/black, loose, moist.
0.30 – 0.60		SILT – brown, trace sand and gravel, loose to compact, very moist
0.60 – 1.20	23	SANDY SILT – brown, trace clay, some gravel, loose, wet
1.20 – 3.30	16	CLAYEY SILT – brown, some sand and gravel, firm to stiff, moist
3.30	14	Test pit terminated.
		Test pit open upon completion of excavation; minor groundwater seepage observed at intermittent depths throughout the sandy silt layer.
TP #6		
0.00 – 0.35		TOPSOIL – brown/black, loose, moist.
0.35 – 0.70		SILT – brown, trace clay, some sand and gravel, loose to compact, very moist
0.70 – 3.30		CLAYEY SILT – brown, trace sand and gravel, firm to stiff, moist
3.30		Test pit terminated.
		Test pit open and dry upon completion of excavation.
TP #7		
0.00 – 0.35		TOPSOIL – brown/black, loose, moist.
0.35 – 0.70		SILT – brown, trace clay, some sand and gravel, loose to compact, moist
0.70 – 3.30	18	CLAYEY SILT – brown, trace sand and gravel, firm to stiff, moist
	15	
3.30	15	Test pit terminated.
		Test pit open and dry upon completion of excavation.
TP #8		
0.00 – 0.30		TOPSOIL – brown/black, loose, moist.
0.30 – 0.60		SANDY SILT – brown, trace clay, some gravel, loose, very moist to wet
0.60 – 3.30		CLAYEY SILT – brown, some sand and gravel, firm to stiff, moist
3.30		Test pit terminated.
		Test pit open upon completion of excavation; minor groundwater seepage observed at intermittent depths throughout the sandy silt layer.
TP #9		
0.00 – 0.40		TOPSOIL – brown/black, loose, moist.
0.40 – 0.75	23	SILT – brown, trace sand and gravel, loose, moist
0.75 – 3.30	13	CLAYEY SILT – brown, intermittent sand and gravel layering, firm to stiff, moist
3.30	16	Test pit terminated.
		Test pit open and dry upon completion of excavation.

Depth (m)	Moisture Content (%)	Soil Description
TP #10		
0.00 – 0.30		TOPSOIL – brown/black, loose, moist.
0.30 – 0.55		SILT – brown, trace sand and gravel, loose to compact, moist
0.55 – 3.30		CLAYEY SILT – brown, some sand, coarse gravel and cobble throughout depth, firm to stiff, moist
3.30		Test pit terminated.
		Test pit open and dry upon completion of excavation.
TP #11		
0.00 – 0.30		TOPSOIL – brown/black, loose, moist.
0.30 – 0.60		SILT – brown, trace sand and gravel, loose to compact, moist
0.60 – 3.30	19	CLAYEY SILT – brown, some sand, coarse gravel and cobble throughout depth, firm to stiff, moist to very moist
	22	
3.30	21	Test pit terminated.
		Test pit open and dry upon completion of excavation.
TP #12		
0.00 – 0.25		TOPSOIL – brown/black, loose, moist.
0.25 – 0.45		SILT – brown, trace sand and gravel, loose to compact, moist
0.45 – 3.30		CLAYEY SILT – brown, some sand, coarse gravel and cobble throughout depth, firm to stiff, moist
3.30		Test pit terminated.
		Test pit open and dry upon completion of excavation.

BOREHOLE LOG

MW4

Sheet 1 of 1

CLIENT **Colonel Talbot Developments Inc.** PROJECT NO. **KCH- 21004909-A0**

PROJECT **Auburn Heathwoods** DATUM

LOCATION **London, Ontario** DATES: Boring **April 13, 2021** Water Level

DEPTH (m bgs)	ELEVATION (~m)	STRATA DESCRIPTION	SAMPLES TYPE	NUMBER	RECOVERY (mm)	N VALUE (blows)	MOISTURE CONTENT (%)
0	0.05	**TOPSOIL** - 50 mm					
		CLAYEY SILT TILL - brown, trace sand, trace gravel, stiff, damp					
~1.75			SS	S1	450	9	
2		0.05 m thin very moist seams observed at 1.83 m bgs					
		turns very stiff at 2.59 m bgs					
~3.3			SS	S2	450	16	
		turns stiff at 4.57 m bgs	SS	S3	450	12	
	4.93	**SAND** - brown, some silt to silty, trace gravel, compact, very moist to wet					
		turns trace silt with depth at 6.1 m bgs	SS	S4	450	27	
	6.86	**SAND AND SANDY SILT** - alternating layers of sand - brown, very stiff and sandy silt - brown, compact, wet	SS	S5	450	29	
	7.32	**End of Borehole at 7.32 m bgs.**					

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 EXP before the use by others. Borehole Logs must be read in conjunction with EXP Report KCH-21004909-A0.
2) bgs denotes below ground surface.
3) Borehole measured the water level at 6.1 m bgs upon the completion of drilling.

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)